Determining Spatial Distribution and Physical Properties of the Vashon Advance Outwash near Mountlake Terrace, WA

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Executive Summary

This study is aimed at determining the spatial distribution, physical properties, and groundwater conditions of the Vashon advance outwash (Qva) in the Mountlake Terrace, WA area. The Qva is correlative with the Esperance Sand, as defined at its type section; however, local variations in the Qva are not well-characterized (Mullineaux, 1965). While the Qva is a dense glacial unit with low compressibility and high frictional shear strength (Gurtowski and Boirum, 1989), the strength of this unit can be reduced when it becomes saturated (Tubbs, 1974). This can lead to caving or flowing in excavations, and on a larger scale, can lead to slope failures and mass-wasting when intersected by steep slopes. By studying the Qva, we can better predict how it will behave under certain conditions, which will be beneficial to geologists, hydrogeologists, engineers, and environmental scientists during site assessments and early phases of project planning.

In this study, I use data from 27 geotechnical borings from previous field investigations and C-Tech Corporation's *EnterVol* software to create three-dimensional models of the subsurface geology in the study area. These models made it possible to visualize the spatial distribution of the Qva in relation to other geologic units. I also conducted a comparative study between data from the borings and generalized published data on the spatial distribution, relative density, soil classification, grain-size distribution, moisture content, groundwater conditions, and aquifer properties of the Qva.

I found that the elevation of the top of the Qva ranges from 247 to 477 ft. I found that the Qva is thickest where the modern topography is high, and is thinnest where the topography is low. The thickness of the Qva ranges from absent to 242 ft. Along the northern, east-west trending transect, the Qva thins to the east as it rises above a ridge composed of Pre-Vashon glacial deposits. Along the southern, east-west trending transect, the Qva pinches out against a ridge composed of pre-Vashon interglacial deposits. Two plausible explanations for this ridge are paleotopography and active faulting associated with the Southern Whidbey Fault Zone. Further investigations should be done using geophysical methods and the modeling methods described in this study to determine the nature of this ridge.

The relative density of the Qva in the study area ranges from loose to very dense, with the loose end of the spectrum probably relating to heave in saturated sands. I found subtle correlations between density and depth. Volumetric analysis of the soil groups listed in the boring logs indicate that the Qva in the study area is composed of approximately 9.5% gravel, 89.3% sand, and 1.2% silt and clay. The natural moisture content ranges from 3.0 to 35.4% in select samples from the Qva. The moisture content appears to increase with depth and fines content.

The water table in the study area ranges in elevation from 231.9 to 458 ft, based on observations and measurements recorded in the boring logs. The results from rising-head

and falling-head slug tests done at a single well in the study area indicate that the geometric mean of hydraulic conductivity is 15.93 ft/d (5.62 x 10^{-03} cm/s), the storativity is 3.28x10^{-03}, and the estimated transmissivity is 738.58 ft^2/d in the vicinity of this observation well. At this location, there was 1.73 ft of seasonal variation in groundwater elevation between August 2014 and March 2015.

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Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
BGS	Below ground surface
Brightwater Project	Brightwater Treatment Plant Conveyance System
CL	Lean clay
D&M	Dames & Moore
DEM	Digital Elevation Model
GeoEngineers	GeoEngineers, Incorporated
GP	Poorly-graded gravel
GP-GM	Poorly-graded gravel with silt
GM	Silty gravel
GW	Well-graded gravel
ID	Inner Diameter
ML	Lean silt
M_W	Moment magnitude
Mya	Million years ago
N-Value	Standard Penetration Resistance
NAVD	North American Vertical Datum
OD	Outer Diameter
Qaf	Quaternary artificial fill
Qpfnmw	Interglacial mass wasting deposits (pre-Vashon)
Qpg	Glacial, grouped (pre-Vashon)
Qpgf	Glacial, fluvial (pre-Vashon)
Qpgl	Glacial, lacustrine (pre-Vashon)
Qpn	Interglacial, grouped (pre- Vashon)
Qpnf	Interglacial fluvial (pre- Vashon)
Qpnl	Interglacial lacustrine (pre- Vashon)

Qva	Vashon advance outwash
Qvlc	Vashon Lawton Clay
Qvr	Vashon recessional outwash
Qvt	Vashon till
SFZ	Seattle Fault Zone
SM	Silty sand
SP	Poorly-graded sand
SP-SM	Poorly-graded sand with silt
SPT	Standard Penetration Test
ST-LLE	Sound Transit Lynnwood Link Extension
SW	Well-graded sand
SWIF	Southern Whidbey Island Fault Zone
SW-SM	Well-graded sand with silt
USGS	United States Geological Survey
UW	University of Washington

1.0 Introduction

The purpose of this research project is to characterize the spatial distribution and physical properties of the Vashon advance outwash (Qva) near Mountlake Terrace, WA, and to compare these characteristics to more extensive and generalized properties of the Qva, as defined in previous works. The information and methods provided in this report will be beneficial to geologists, hydrogeologists, engineers, and environmental scientists during site assessments and early phases of project planning.

In general, Qva is a granular, well-sorted, and permeable glaciofluvial unit (Mullineaux *et al.,* 1965). According to Troost *et al.* (2005), the Qva is equivalent of the Esperance Sand of Mullineaux *et al.* (1965). Although the Qva has high frictional shear strength and low compressibility as the result of glacial consolidation (Gurtowski and Boirum, 1989), some of the unit's properties can facilitate increased geologic or environmental risks. For instance, the development of water pressure in the pore space between granular particles may significantly decrease the shear strength of the unit; this is a contributing factor to landslides in western Washington (Tubbs, 1974). The permeable properties of the Qva also pose difficulty to excavations where dewatering, shoring, or other procedures are required to prevent water-bearing sands from caving, flowing, or collapsing (Laprade and Robinson, 1989). Additionally, the Qva forms an extensive, unconfined aquifer that may act as a conduit for chemical pollutants (Bjerg and Christensen, 1993; Golder Associates, 2008). The properties described above make this hydrostratigraphic unit susceptible to contamination, erosion, seepage, and landslides. Understanding of both the spatial distribution and physical properties of Qva in a specific context can aid in developing improved mitigation practices and prediction of slope failures, more informed decisions in building design and practices, improved groundwater modeling, and more accurate mapping of areas susceptible to both geologic hazards and environmental contamination.

1.1 Study Area

The study area is in a mixed residential and commercial area in proximity to the community of Mountlake Terrace. Geographically, it is 12 mi north of Seattle's metropolitan center, 2.5 mi northwest of Lake Washington, and 1.5 mi east of the Puget Sound shoreline. Lake Ballinger is located towards the center of the study site. The topography of this area consists of gently rolling drumlin hills from the last glaciation. The relief at the study site ranges from approximately 289 to 492 ft in elevation. Geologic hazards at this site include landslide-prone areas and erosion/sedimentation hazards as defined by the City of Mountlake Terrace ordinance codes (City of Mountlake Terrace, 2015; GeoEngineers, 2015). The project site is about 2.95 sq mi, and includes 5 transect lines, totaling 8.84 lineal miles (Figure 1). The southern edge of the study area is approximately 75 ft south of the King/Snohomish County border. The eastern border of the study area is Interstate-5. The location and boundaries of the study site were determined based on the availability of quality data.

2.0 Scope of Work

This report characterizes and refines the spatial distribution, physical properties, and groundwater conditions of the Qva in the Mountlake Terrace area by:

1) documenting the spatial extent and thickness variations of Qva in cross-sections and three-dimensional models,
2) describing the spatial variation in density using standard penetration test (SPT) data from existing geotechnical boring logs,
3) describing variations in grain size and moisture content, using lab analyses of available soil samples, and
4) describing aquifer properties and groundwater conditions where data is available.

The work described above consisted of the following tasks:

1) obtaining and reviewing existing technical reports, geologic maps, topographic maps, soil survey data, laboratory test results, groundwater data, geospatial imagery, and other publications that aided in characterizing the subsurface conditions of the project site,
2) creating a database that includes the locations of the boreholes and the elevation of every geologic contact within each borehole,
3) generating cross-sections and three-dimensional models, using information in the above described database and C-Tech Corporation's *EnterVol* software, to illustrate the lateral and vertical distributions of the advance outwash, and
4) evaluating variations in the unit thickness, elevation, physical properties, and groundwater conditions.

3.0 Background

In this section, I discuss the previous investigations that have been done within the study area and give a general overview of the Qva.

3.1 Previous Investigations

This study incorporates data from 27 existing geotechnical borings, summarized in Table 1, and their corresponding geotechnical reports. These data were collected by local consulting firms and government agencies for various geotechnical investigations. The boring logs and geotechnical reports are publicly available through the Freedom of Information Act, and I obtained the data by directly contacting the firms and agencies that house the documents. The following paragraphs describe the investigations that were previously conducted in the study area, and the data from them that I used to supplement my research.

A large investigation was conducted in King and Snohomish Counties for the Brightwater Treatment Plant Conveyance System (Brightwater Project), which was completed in 2012. This project consisted of two geotechnical studies, which are discussed in the next two paragraphs.

In 2002, Shannon & Wilson and HWA Geoscience began the initial investigation for the Brightwater Project, which consisted of 27 geotechnical borings and laboratory testing of select soil samples (King County, 2002). The purpose of this investigation was to determine the subsurface conditions for conceptual engineering and environmental impact assessment. Shannon & Wilson used the mud rotary method to drill their borings, while HWA Geosciences used a combination of mud rotary and Becker Hammer methods. Both companies used a 2.42-inch inner diameter (ID), 3.25-inch outer diameter (OD), ring-lined Dames and Moore (D&M) split-barrel sampler with a 300 lb. hammer dropped 30-inches to obtain soil samples. The borings that I used from this study ranged from 352 to 446.5 ft in depth, and include MW-3, MW-4, MW-5, and MW-6 from HWA Geosciences, and BW-4, BW-5, and BW-6 from Shannon & Wilson (Table 1).

The second investigation for the Brightwater Project was completed by CDM Smith and various subconsultants in 2003. The purpose of this investigation was to provide geotechnical services for the design of the wastewater treatment facility. These services included land-based drilling, soil sampling, in-situ testing, hydrogeologic testing, gas monitoring, and geophysical explorations, as well as geologic, index, strength, and deformation testing in the laboratory (King County, 2004). This study included a total of 157 borings. The drilling methods used to complete the borings included hollow-stem auger, mud rotary, rotosonic coring, and wireline coring. Soil samples were collected using a D&M sampler with a 300 lb. or 140 lb. hammer. The borings that I used from this study include E-105, E-106, E-107, E-108, E-109, E110, and E211, which range from 260 to 566 ft in depth (Table 1). Index tests were not completed on any of the soil samples within the Qva from these six borings. However, geologic testing was done on select samples to determine the stratigraphic relationships between the soil units. This testing included radiocarbon dating, optically-stimulated luminescence dating, tephrochronology, x-ray diffraction mineral analysis, bulk geochemistry, and micro- and macro-paleontological analyses (of shells, diatoms, and pollen).

In 2008, Golder Associates conducted a study to provide an overview of the geology and hydrogeology near Mountlake Terrace for OTAK, Inc., and published their findings in a technical memorandum. They used a compilation of existing data, including the Brightwater Environmental Impact Statement, nearby monitoring wells, and city and county data, to determine the groundwater conditions in their study area. This study was particularly important for the groundwater analysis of my research because not a lot of groundwater data were readily available in my study area; however the Golder Associates (2008) study overlapped with a portion of my study area.

Another large investigation was completed in the Mountlake Terrace area. During the summer of 2014, GeoEngineers, Inc. (GeoEngineers) provided geotechnical consulting services for the Sound Transit Lynnwood Link Extension[1] (ST-LLE), which will extend the Link light rail from Seattle to Lynnwood. This investigation used hollow-stem auger and mud rotary methods to drill 84 boreholes ranging from 40 to 101.5 ft in depth (GeoEngineers, 2015). Samples were collected using a 2-inch OD split-barrel standard penetration test (SPT) sampler in accordance with the American Society for Testing and Materials (ASTM) standard D 1586, or with a 3-inch diameter Shelby tube sampler in accordance with ASTM D 1587. The SPT samples were obtained by driving the sampler 18 inches into the soil with a 140 lb. hammer free-falling 30-inches. The data that I used from this investigation includes: index test results, groundwater measurements, and boring logs from 13 geotechnical borings (Table 1).

3.2 Vashon Advance Outwash

In general, glacial advance outwash is a thick unit of fluvial sediments that are deposited by high-energy meltwaters ahead of an advancing glacier (Koloski *et al.,* 1989). These glaciofluvial sediments are then overridden by the glacier, resulting in post-depositional compaction (Easterbrook, 1969). Advance outwash is mostly composed of clean sand, although it often contains a wide range of grain sizes (Tubbs, 1974). As with other fluvial systems, coarser materials are deposited close to the source, and finer materials are sorted and carried away from the source; this process results in a coarsening-up sequence, by which silty sands are deposited farther away from the glacier, and gravel and coarser grained materials are deposited closer to the glacier (Moses, 2008). However, this coarsening up sequence is only a simplified facies model, and in actuality braided streams, point bars, and other fluvial features complicate the stratigraphy of these deposits (Troost and Booth, 2008).

The Qva is described as well-sorted, dense to very dense, fine to medium sand with lenses of gravel, silt, and clay (Mullineaux *et al.,* 1965). The Qva type section is an outcrop in the cliffs at Fort Lawton, in Discovery Park, Seattle, WA (Troost and Booth, 2008). Here, the unit is defined as outwash related to the advance of the Vashon Glacier and includes the transitional zone from the underlying Lawton Clay (Qvlc) (Mullineaux *et al.,* 1965). The transitional zone between the Qva and the Qvlc is typically tens of feet thick, and contains interbedded sand and silt/clay representing the transition from a proglacial lake to a stream environment

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[1] I contributed to various aspects of the project while interning at GeoEngineers. Tasks that I helped with included logging borings, taking piezometer and barometer measurements, observing slug tests, surveying, and conducting laboratory analysis of field samples.

(Kathy Troost, University of Washington (UW), personal communication, 2015). In areas where the Qvlc is absent, the onset of the Vashon Stade is marked by the Qva, which may be in contact with pre-Vashon glacial (Qpg) or interglacial deposits (Qpn) (King County, 2002; King County, 2004; Troost and Booth, 2008; GeoEngineers, 2015). About 50% of Qva is capped by Vashon glacial till (Qvt) (Kathy Troost, UW, written communication, 2015). The contact between the Qva and the Qvt varies between sharp and gradational (Laprade and Robinson, 1989; Troost and Booth, 2008). Exposures of Qva can be found bluffs and steep gullies that reach the upland (Kathy Troost, UW, written communication, 2015).

There is some variability in the bedding and depositional setting of the Qva; studies suggest that the Qva was deposited subaerially to subaqueously (Troost and Booth, 2008). Subaerial sedimentation is indicated by remnants of channels, gravel bars, and fine-grained lenses from braided streams, whereas subaqueous sedimentation is recognized by remnants of deltas, turbidites, and horizontal bedding in proglacial lakes, at the terminus of outwash streams (Troost and Booth, 2008). The Qva that is considered to have been subaqueously deposited contains foreset beds and cross-bedding that are steeply dipping at 30-40° (Kathy Troost, UW, personal communication, 2015). Cross-bedding is also common in subaerial deposits, but is generally not as tall as in the deltas (Kathy Troost, UW, written communication, 2015).

3.2.1 Hydrogeology

In the Mountlake Terrace area, the Qva forms an extensive, unconfined aquifer with a saturated thickness of about 100 ft, and an unsaturated thickness ranging from 20 to 100 ft (Golder Associates, 2008). The groundwater in the Qva discharges to surface water, primarily to Hall Creek and Lake Ballinger, via hydraulic connection with recessional outwash or alluvium (Golder Associates, 2008). Golder Associates (2008) states that Lake Ballinger appears to be underlain by Lawton Clay or pre-Fraser deposits, which have low permeability. Additionally, groundwater from the Qva may be recharging deeper aquifers in the area (Golder Associates, 2008). The rate of groundwater recharge ranges from 15 to 20 in/yr in areas where permeable outwash is exposed at the surface, and is less than 10 inches per year in areas that are capped by till or are urbanized (Golder Associates, 2008). Typical hydraulic conductivity data for glacial sediments, and a conceptual hydrogeologic model of geologic units located in the Mountlake Terrace area can be found in Appendix A.

As mentioned above, the basal portion of the Qva is often saturated with groundwater, which is retarded by the underlying less-permeable Qvlc, Qpf, or Qpg geologic units (Tubbs, 1974; Appendix A). If the contact between these units is exposed at the surface, the saturated zone in the Qva can be identified by seeps and springs (Miller, 1989). The contact between these hydrostratigraphic units has been identified as the location of frequent landslides in the Puget Lowland (Tubbs, 1974).

4.0 Geologic Setting

The following sections describe the regional, local, and structural geology in relation to the study area.

4.1 Regional Geology

The study area is located in the Puget Lowland section of the Salish Lowland physiographic province (Haugerud, 2004). The Puget Lowland is a structural and glacially-eroded trough centered between the Cascade Range to the east and the Olympic Mountains and Willapa Hills to the west (Troost and Booth, 2008; Moses, 2013; Figure 2). Major geographic features of the Puget Lowland include the San Juan Islands, the Puget Sound, and the Strait of Juan de Fuca. The Puget Lowland is characterized by a dynamic landscape that has been largely shaped by continental glaciations, tectonic activity, and volcanism (Troost and Booth, 2008). The geomorphic processes that occurred during glacial and interglacial periods have greatly influenced the modern topography of this region (Booth, 1994).

The Cordilleran Ice Sheet was a continental ice sheet that extended from southeastern Alaska, to northern Washington, and across to northwestern Montana during the Quaternary (about 2.59 million years ago (Mya) to present); there were been at least seven glacial advances during this time (Booth *et al.,* 2003; Troost and Booth, 2008). The Cordilleran Ice Sheet included the Puget, Okanogan, Columbia River, Purcell Trench, and Flathead Lobes, which extended into western Washington, north-central Washington, eastern Washington, northern Idaho, and northwestern Montana, respectively (Booth *et al.,* 2003). During the Vashon Stade of the Fraser Glaciation, the Puget Lobe extended farther south than Olympia, WA, and occupied the area between the Cascade Range and the Olympic Mountains (Thorson, 1979; Porter and Swanson, 1998; Troost and Booth, 2008; Figure 2). At its maximum extent, the Puget Lobe was as much as 3,300 ft (1,000 m) thick in the Seattle area, and 6,600 ft (2,000 m) in British Columbia (Porter and Swanson, 1998; Clague and James, 2002).

The surficial geology of the Puget Lowland consists predominantly of Vashon-aged (about 15,000 to 13,000 ya) glacial sediments, with intermittent exposures of Tertiary bedrock of Paleocene (about 66 to 56 Mya) to Oligocene (about 33.9 to 23 Mya) age (Moses, 2013). The generalized Quaternary section in the Puget Lowland consists of pre-Vashon glacial and interglacial deposits overlain by glaciolacustrine clays and silts, advance outwash sands, glacial till, and recessional outwash from the Vashon Stade (Galster and Laprade, 1991; Savage *et al.,* 2000; Figure 3). At least seven glacial advances have been documented in the Puget Lowland (Troost and Booth, 2008). Glacial loading has resulted in the over-consolidation of glacial and interglacial sediments, with the exception of Vashon recessional outwash, which was deposited as the glacier retreated (Galster and Laprade, 1991).

The slopes in the Puget Lowland are prone to landslides and other slope stability issues (Mullineaux *et al.,* 1965; Tubbs, 1975). There are several contributing factors for this, which include geologic and climatic conditions, as well as anthropogenic influences (Tubbs, 1974). The contact between the Qva and the less-permeable underlying units has been identified as the "slip-surface" for several large landslides in the Seattle area (Tubbs, 1974). Sixty-four percent of all historical (between 1909 and 1999) landslides in Seattle occurred within 150 ft of the Qva/Qvlc contact (Coe *et al.,* 2004). During periods of heavy precipitation, water can accumulate above silt and clay lenses within the Qva and above the confining layers that underlie the Qva (Miller, 1989). This occurrence consequently decreases the stability of the soils by elevating the pore fluid pressures between the grains in the Qva (Tubbs, 1974). The stratigraphic placement of the Qva, which is an aquifer, above less-permeable units, which create an aquitard, is a key factor in the landslides in this area (Tubbs, 1974).

4.2 Local Geology

The surficial geology in the vicinity of the project site is predominantly Vashon Stade glacial deposits, as is documented in the boring logs used in this study (King County, 2002; King County, 2004; GeoEngineers, 2015). A conceptual hydrogeologic model of the geologic units in the Mountlake Terrace area can be found in Appendix A (revised from Golder Associates, 2008). Glacial deposits of the Vashon Stade found in the study area include the following units: recessional outwash (Qvr), glacial till (Qvt), advanced outwash (Qva), and proglacial lacustrine deposits, which are formally referred to as the Lawton Clay (Qvlc). Also within the study reach is: Holocene alluvium (Qal), artificial fill (Qaf), and peat (Qp); pre-Fraser interglacial fluvial (Qpfnf), lacustrine (Qpfnl), wetland deposits (Qpfnw), and mass wastage deposits (Qpfnmw); and pre-Olympia glacial outwash (Qpogf), glaciolacustrine deposits (Qopgl), glaciomarine drift (Qpogm), glacial till (Qpogt, Qpogtm), and glacial diamict deposits (Qpogd). For the purposes of this paper, I amalgamated the pre-Fraser interglacial deposits and labeled them as Qpn. Similarly, I grouped the pre-Olympia glacial deposits together and labeled them as Qpg. In summary, the geology documented in the boring logs used in this study exemplify cycles of glacial and interglacial erosion and deposition.

4.3 Structural Geology

Tectonic activity in this area is occurring at both regional and local scales (Atwater *et al., 1995;* Pratt *et al.,* 1997). At the regional scale, the convergence of the Juan de Fuca plate and the North American plate form the Cascadia Subduction Zone, which is capable of producing up to moment magnitude (M_W) 9.0 earthquakes (Wells *et al.,* 1998; Nedimovic *et al.,* 2003). Additionally, the northward movement of the Pacific plate is causing complex seismic strain (north-south shortening) to accumulate throughout western Washington and Oregon (Pratt *et al.,* 1997; Wells *et al.,* 1998; WA-DNR, 2015). This strain, in combination with glacial isostatic adjustment, has created several large fault systems in western Washington (Figure 2). These faults produce more than 1,000 earthquakes each year (Lasmanis, 1991). Thick

Quaternary deposits of glacial and interglacial sediments conceal many of these faults. Furthermore, dense vegetation and widespread urbanization obscure active fault traces, making it difficult to study faults in this area.

There are two major fault zones in proximity to the study site, the Seattle Fault Zone (SFZ) to the south, and the Southern Whidbey Island Fault Zone (SWIF), which may run through the project site (Blakely *et al.,* 2004; Troost and Booth, 2008; Barnett *et al.,* 2010). Both of these fault zones are poorly located, for reasons described above.

The SFZ is composed of a series of west-trending, south-dipping thrust faults that have resulted from north-south compression due to the convergence of the Pacific, Juan de Fuca, and North American plates (Johnson *et al.,* 2004; Lamb *et al.,* 2012). The Seattle fault is thought to be around 30 Myrs old, and is considered an active fault (Nelson *et al.,* 2014). There is evidence for several significant ruptures in the past 15,000 years, including 20 feet of vertical displacement during an earthquake dated 1,100 years ago (Atwater and Moore, 1992). The SFZ is about 31 mi long and is capable of producing up to M_W 7.0 earthquakes (Blakely *et al.,* 2002; Nelson *et al.,* 2014). The SFZ is recognized by Eocene (about 56 to 33.9 Mya) bedrock juxtaposed against Quaternary (about 2.59 Mya to present) glacial deposits, and large geophysical anomalies (Lasmanis, 1991; Blakely *et al.,* 2002). Three east-trending strands of the fault have been identified, although the exact boundaries of the SFZ are still under investigation (Johnson *et al.,* 1999; Blakely *et al.,* 2002).

The SWIF is another active fault in the Puget Lowland, and is capable of producing up to M_W 7.1 earthquakes (Sherrod *et al.,* 2008). Unlike the Seattle fault, the SWIF has a northwest-trend and a steep northeast-dip (Johnson *et al.,* 1996). The SWIF is thought to have originated in the early Eocene (about 56 to 47.8 Mya) as an arc-parallel strike-slip fault (Liberty and Pape, 2006). The SWIF may be as long as 93 mi long, originating in Victoria and extending to Seattle, where it may merge with the SFZ (Sherrod *et al.,* 2008). It has been identified through the use of seismic-reflection surveys, borehole data, and gravity and magnetic anomalies (Sherrod *et al.,* 2008). The SWIF is composed of several strands across a zone that is 3.75 to 6.8 mi wide (Johnson *et al.,* 1996). The strands have inferred dextral strike-slip, reverse, and thrust displacement (Johnson *et al.,* 1996). The SWIF was conceptualized by Johnson *et al.,* (1996) as an oblique, right-lateral strike-slip fault, that sometimes form transpressional flower structures, and by Brocher *et al.,* (2005) as an advancing wedge bound by roof and floor thrusts. Paleoseismological evidence suggests that the SWIF last ruptured about 2,700 years ago, and has produced at least four significant earthquakes since the retreat of the Vashon Glacier (Sherrod *et al.,* 2008). Evidence for recent activity includes stratigraphic offset and disruption, structural relief, displacement in Quaternary sediments, Quaternary folds, liquefaction features, and minor historical seismicity (Johnson *et al.,* 1996).

5.0 Methods

In this section I describe the methods that I used to obtain and analyze data, and create two- and three-dimensional subsurface models. In addition to studying the Qva in the study area for this project, the modeling methods described in this section can be applied to various other subsurface studies.

5.1 Data Acquisition

I began this study by reviewing existing data about the geology, topography, and hydrogeology of the area. During this stage, I gathered LiDAR images (U.S. Geological Survey, 2001), aerial photographs (Google Earth Pro, 2012), geologic maps (Booth *et al.*, 2004), and technical reports (King County, 2002; King County, 2004; Golder Associates, 2008; GeoEngineers, 2015). I used the Subsurface Geology Information System[2] published by the Washington State Department of Natural Resources (WA-DNR) to view available borehole information. I used the locations of boreholes with sufficient data to determine the boundaries of the study area and to draw the transect lines for the cross-sections. I contacted the appropriate consulting firms and government agencies to obtain the boring logs and geotechnical reports that were pertinent to my study. The boring logs and geotechnical reports that I used in my study were from GeoEngineers for the ST-LLE Project, and from Shannon & Wilson, HWA Geosciences, and CDM Smith for the Brightwater Project. These projects are described in detail in *Section3.1*, and a summary of the borings used in this study can be found in Table 1. From the boring logs, I was able to obtain data on stratigraphic unit descriptions, soil classifications, elevations, blow counts, laboratory index test results, and groundwater observations. However, not all boring logs had this complete set of information. The boring logs also identified the geologic units that were observed while drilling, based on visual-manual classifications, laboratory testing, and/or age-determination. I used the labels found in the boring logs as a reference for identifying the Qva in my study.

5.1.1 Unit Thickness

To determine the thickness and variability of the Qva, I created a table of geologic contact elevations (Table 2) based on the information from the boring logs, which can be found in Appendix B. The vertical extent of this study was bound between the ground surface and 100 ft elevation, though not all borings reached this depth and many went deeper. Although the lower limit of the Qva is much shallower than 100 ft elevation, I chose to terminate the vertical extent of the study at this elevation because it provides sufficient context for the paleotopography that might influence the thickness of the Qva. I used Table 2 to develop five cross-sections, a block diagram, and a fence diagram, which are described in *Section 5.3*.

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[2] The Subsurface Geology Information System originated from a database compiled by Kathy Troost and Aaron Wisher at the Pacific Northwest Center for Geologic Mapping Studies (GeoMapNW) at the University of Washington.

5.1.2 Relative Density

The soil density values that I used in this study were estimated using field data (N-values[3]) that were recorded at various depths during previous investigations. The N-values recorded for the ST-LLE Project were acquired using a SPT sampler, and were done in accordance with ASTM D 1586. However, the N-values recorded for the Brightwater Project were acquired using a D&M sampler. Although the D&M sampling method is different from the standard test, the blow counts still provide a relative indication of soil density and consistency (King County, 2002). SPT and D&M sampling are considered to be correlative with respect to blow counts, so long as the hammer weight is adjusted to the sampler size, so that the energy delivered to the subsurface is equivalent (Kathy Troost, UW, personal communication, 2015).

There are several variables that affect the integrity of N-value data; this includes drilling method, sampling method, and soil conditions. Different types of drilling methods influence the disturbance in the soil samples in different ways. For the purposes of this study, I analyzed N-value data from samples that were acquired during mud rotary drilling for the following reasons. Soil heave often occurs while drilling in water-bearing sands that are under confining pressures; this compromises the integrity of blow counts and soil samples (Nielsen, 2005). Mud rotary drilling reduces the pressure gradient by adding mud inside the auger, which minimizes heave in water-bearing sands, such as the Qva (Munch and Killey, 1985). Sampling method also effects the N-value. In this study, I use data collected by SPT and D&M sampling methods. Additionally, soil conditions influence the accuracy of blow counts. An inaccurate measure of the soil density can be measured if the soil sampler hits a large gravel or boulder that prevents the sampler from being driven into the soil. Also, if the refusal was met (i.e. the sampler did not penetrate 6-inches into the soil after 50 blows by the hammer), the N-value is recorded as the inches driven per 50 blows (ex: 50 blows for 4-inches), rather than the number of blows taken to drive the sampler the final 12- of 18-inches. For these reasons, I did not include N-values for samples that hit refusal. Only 14 of the 196 SPT and D&M samples were collected during mud rotary drilling, and were not met with refusal. These 14 samples provide the most reliable N-value data.

5.1.3 Laboratory Test Results

I used the information provided in the boring logs from previous investigations and their corresponding geotechnical reports to obtain laboratory test results of select Qva samples (King County, 2002; King County, 2004; GeoEngineers, 2015). The tests on these samples

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[3] Standard penetration resistance (N-value) is the number of blows it takes a 140 pound hammer, free-falling 30 inches, to drive a 2-inch OD SPT sampler the final 12- of 18-inches. The N-values provide a general understanding of the resistance to penetration and is a measure of the relative soil density.

were completed using the following standards: ASTM D 1140, for Percent Fines[4] Determination; ASTM D 422 for Grain Size Distribution; ASTM D 2216, for Moisture Content Determination; and ASTM D 2487, for Classification of Soils.

5.1.4 Groundwater Conditions

My analysis of the groundwater conditions is limited by the amount of data that were readily available. I used information from the boring logs and geotechnical reports to obtain groundwater elevations. Some of the groundwater data in the boring logs and geotechnical reports were based on observations while drilling, while other data were measured with a vibrating wire piezometer (VWP), pressure transducer, or other measuring instruments. The approximate groundwater elevations, dates of record, and methods of measurement are annotated on the cross-sections (Figures 4-8) where data was available.

Single-well field hydraulic conductivity tests (slug tests) were performed at two wells in the study area, BW-6 and LLE-B11P, by Shannon & Wilson for the Brightwater Project and by GeoEngineers for the ST-LLE Project, respectively. The semi-log plots of water level versus time for the BW-6 slug test were provided in the King County (2002) geotechnical report. However, no interpretation or analysis of the test was provided.

5.2 Data Analysis

I used scatter plots to examine if the density, fines-content, and moisture content directly influenced each other. I plotted the N-values obtained during mud rotary drilling (see *Section 5.1.2*) against various other variables (percent fines, depth, and elevation) to determine if any of these variables directly influence the density of the soil. As a comparison, I evaluated the N-values obtained during mud rotary, Becker hammer, and hollow-stem auger drilling methods. I also evaluated moisture content and percent fines in relation to each other, to elevation, and to depth from ground surface. In addition, I conducted a volumetric analysis of the soil classifications within the Qva for all 27 borings.

5.3 Modeling

One of the main purposes of this research is to determine the three-dimensional (lateral and vertical) extent of the Qva. To accomplish this, I used *ArcGIS* and *EnterVol* to add a third dimension to previously completed two-dimensional studies. The following sections describe the methods that were used to generate a cross-section for each of the five transect lines, a block diagram, a fence diagram, and an isopach map of the Qva thickness. These models help illustrate the spatial variability of the Qva in the study area.

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[4] Fine grained sediments are defined by ASTM D 1140 as material finer than 75 µm, or as particles that can pass through a No. 200 sieve.

5.3.1 Cross-Sections

I used borehole data and various extensions of *ArcGIS* to create five cross-sections. The purpose of creating the cross-sections is to illustrate the spatial variability in two-dimensions along a transect line. I began this phase of modeling by marking and exporting the location of each borehole and transect line in *Google Earth* (Figure 1). I then collaborated with Gene Lohrmeyer at GeoEngineers to complete the following steps using *ArcGIS*. We first imported the locations of the borings and transect lines in *ArcGIS*. We then created a shapefile for each borehole and transect line, which we projected to the *NAD 1983 State Plane Washington North (ft)* coordinate system. We used a 10-meter digital elevation model (DEM) from the U.S. Geological Survey as an elevation datum (U.S. Geological Survey, 2001). We then interpolated the lines using their positions along the DEM to create an elevation profile for each of the five transects. I then digitally drew the stratigraphy for each cross-section, using data from the boring logs to infer the subsurface geology. I did this for each of the five cross-sections, shown in Figures 4-8.

5.3.2 Three-Dimensional Models

I collaborated with Gene Lohrmeyer at GeoEngineers to create block and fence diagrams, and an isopach map of the Qva, using *EnterVol*, which is an extension of *ArcGIS*.

To create the block diagram, we first georeferenced the borehole locations to the *NAD 1983 State Plane Washington North (ft)* coordinate system in *ArcGIS-ArcScene*, ESRI's three-dimensional viewing platform, and exported the data into our *EnterVol* map. We then created two new models to define the lateral and vertical extents of the study area. The first model used a shapefile with an xy-grid to define the two-dimensional (lateral) extent of the area to be analyzed. Next, we used elevation data to define the three-dimensional (vertical) extent of the area to be modeled; the top of the borings served as the upper extent and the bottom of the borings as the lower extent. We then added a third model to assign stratigraphic values to the three-dimensional model, based on the borehole data in Table 2. We automated the block diagram in *EnterVol* using an inverse distance weight algorithm and the three models described above. We then created a fence diagram by making slices of the block diagram along each of the five transect lines.

We also created an isopach map of the unit thickness. We did this by first isolating the Qva in the block diagram. Then we converted this segment of the diagram to a point cloud, and saved it as a shapefile. Next, we opened the shapefile in *ArcMap*, and added x and y values to the points. We used the natural neighbor interpolation to create a surface from these points based on elevation, using a 10 m grid cell size to match the DEM used in earlier steps. Finally, we converted the interpolated raster surface to 25 ft vector contours to illustrate the thickness of the Qva, as modeled by *EnterVol*.

6.0 Observations

6.1 Spatial Distribution

The surface of the Qva in the study area is found at a maximum elevation of 477 ft at boring LLE-B17 and at a minimum elevation of 247 ft at boring E-108 (Table 2, Figures 4-8). The depth to the top of the Qva varies from 0 to 109.8 ft below ground surface (bgs). The bottom of the Qva ranges in elevation from 406 ft at boring LLE-B17 to 178.5 ft at boring BW-4. The depth to the bottom of the Qva ranges from 53 to 279 ft bgs. The thickness of this unit varies from 21 to 242 ft in the three-dimensional models (Figures 9-12), and from 0 to 242 ft in the geotechnical boring logs (Table 1). The Qva thins to the east between borings BW-4 and BW-6, along Transect 1 (Figure 4). The thickness and continuity of the Qva is impacted by an apparent ridge at boring E-109, along Transect 2 (Figure 5). At this location the Qva pinches out, and pre-Fraser interglacial deposits (Qpn) are exposed at the surface. Along Transects 3 through 5, the Qva is thickest where the modern topography is high, and is thinnest where the topography is low (Figures 6-8, respectively).

The block diagram in Figure 9A shows the extent of the Qva, as modeled in *EnterVol*, and Figure 9B shows the block diagram with a vicinity map overlay for reference. There are discrepancies between the three-dimensional models created in *EnterVol* and the cross-sections (Figures 4-8). Similar to the cross-sections, the block and fence diagrams shows the Qva thinning to the east (Figures 9A and 10). However, there is no surface expression of the ridge that pinches out the Qva in the three-dimensional models. Similar to the cross-sections, the Qva in the block and fence diagrams is thickest where the topography is greatest (Figures 9A and 10). Figures 11A and 11B combine the Qva unit from the block diagram with the fence diagram to help illustrate the extent of the Qva in relation to other geologic units.

The three-dimensional models show that the Qva is thickest at the southwestern extent of the study area, as is illustrated in Figure 12. The Qva appears to thin to the east along Transects 1 and 2, to the north along Transect 3, and to the south along Transects 4 and 5 (Figure 12). The thickness of the Qva appear to decrease as a function of elevation along Transects 3, 4, and 5, which trend north-south. The Qva is thinnest in valleys and other topographic lows, and is thickest at modern topographic highs.

6.2 Physical Properties

6.2.1 Relative Density

The relative density of the Qva in the study area was evaluated based on review of SPT and D&M blow count data collected during the drilling of geotechnical borings. The relative density ranges from dense (N-value range: 30-50) to very dense (N-value: 50+), based on the 14 N-values collected during mud rotary drilling, described in *Section 5.2* (Appendix C). As a comparison, the relative density data collected during all drilling methods ranged from loose

(N-values range: 4-10) to very dense (N-values: 50+). There appears to be a slight correlation between density and fines content (Figures 13). I did not find a correlation between density and elevation (Figure 14). However, relative density appears to increase with depth from the ground surface (Figure 15). All N-Values recorded within the Qva can be found in the boring logs (Appendix B). Data regarding fines content, elevation, and depth can be found in the boring logs in Appendix B and in the borehole data summary sheet in Appendix C.

6.2.2 Grain Size

A wide range of grain sizes were recorded for the soil samples that had sieve analyses. The following is a summary of the content of soil samples that were collected from the Qva: gravel content ranged from 0 to 48.2%, the sand content ranged from 40.9 to 97.6%, and the fines content ranged from 1.3 to 36%. Silt and clay lenses are located throughout the Qva. The sample with the highest fines content (36%) was located 40 ft bgs and 7 ft below the top of the Qva, at boring LLE-10S. Results from sieve analyses can be found in Appendix C.

A volumetric analysis of the Qva show that this unit is composed of the following soil groups: 6.6% well-graded gravel (GW), 1.9% poorly-graded gravel (GP), 0.9% poorly-graded gravel with silt (GP-GM), 0.1% silty gravel (GM), 3.5% well-graded sand (SW), 2.7% well-graded sand with silt (SW-SM), 33% poorly-graded sand (SP), 37.3% poorly-graded sand with silt (SP-SM), 12.8% silty sand (SM), 0.9% lean silt (ML), and 0.3% lean clay (CL) (Figure 16A). The soil classifications follow ASTM D 2487, which is summarized in Appendix D. A volumetric analysis of the soil groups within the Qva of each boring is shown in Figure 16B and is summarized in Table 3.

I found a slight correlation between the fines content and the relative soil density (Figure 13). Additionally, all samples with greater than 10% fines content were dense to very dense. I did not find a correlation between fines content and depth nor elevation (Figure 17). Lab test results from sieve analysis and fines content determination can be found in the boring logs (Appendix B), and in the borehole data summary sheet (Appendix C).

6.2.3 Moisture Content

The natural moisture content of select samples from the Qva range from 3.0 to 35.4% natural moisture, by weight. There is a slight trend (exponential, $R^2 = 0.3226$) correlating depth from the ground surface to an increase in moisture content (Figure 18). Likewise, there is a slight linear trend ($R^2 = 0.2730$) correlating elevation and moisture content (Figure 18). The moisture content also appears to increase with an increase in fines content (Figure 19).

6.3 Groundwater Conditions

I found that the top of the water table in the Qva aquifer ranged from 231.9 to 458 ft in elevation, based on the 16 groundwater measurements that were recorded in the geotechnical boring logs (Appendix B). Rising head and falling head slug tests[5] were done at LLE-B11P on August 04, 2014. The results of the slug tests indicate that the geometric mean of hydraulic conductivity is 15.93 ft/d (5.62 x 10^{-03} cm/s), the storativity is 3.28 x 10^{-03}, and the estimated transmissivity is 738.58 ft^2/d in the vicinity of this observation well (GeoEngineers, 2015). The groundwater at LLE-B11P changed from an elevation of 354.83 ft on August 12, 2014 to an elevation of 355.04 on March 13, 2015. During this time period, the lowest groundwater elevation was recorded at 354.74 ft on September 23, 2014, and the peak groundwater elevation was recorded on February 08, 2015 at 356.47 ft, for a difference of 1.73 ft between the summer and winter seasons. The groundwater elevation at LLE-B11P increased after significant precipitation events (Figure 20).

7.0 Analysis & Discussion

In this section I discuss the observations from this study in relation to data found in published literature (Table 4). I will also discuss how and why my findings deviate from published data on the Qva. These comparisons will help geologist, hydrogeologists, engineers, and environmental scientists conceptualize local variations in the Qva that may affect slope stability, groundwater dynamics, engineering properties, and migration of contaminants.

7.1 Spatial Distribution

In a previous study, it was determined that the Qva ranges from 50 to 200 feet in thickness in proximity to Lake Ballinger (Golder Associates, 2008). Additionally, Mullineaux *et al.* (1965) commented that glacial advance outwash is typically greater than 100 ft thick, and Troost and Booth (2008) found that the Qva ranges from absent to 400 ft thick. I found that the thickness of the Qva in the study area ranges from 0 to 242 ft. This is comparable to findings from published data (Table 4), although the thickness is greater than reported by Golder Associates (2008).

The elevation of the top of the Qva in the study area ranges from 247 to 477 ft. Troost and Booth (2008) found that the top of the Qva was deposited between elevations of 400 and 600 ft, and that the top of this unit is locally lower where subsequent erosion has occurred. At boring E-108, where the top of the Qva is at 247 ft elevation, there is a thick deposit of Qvr overlying the Qva (Figures 5 and 11A). This depression in the Qva may be an erosional feature formed by the advancing glacier, and later filled in with recessional outwash as the glacier retreated. It is also possible that this abnormality was caused by geomorphic or tectonic processes.

The automated three-dimensional models in this study show that the base of the Qva is not flat due to preexisting topography (Figures 4-9A). Troost and Booth (2008) found that the

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[5] I observed these tests, which were part of the ST-LLE project, while interning at GeoEngineers.

Qva fills paleotopographic valleys and channels, some of which are below sea level. The bottom elevation of the Qva in the study area ranges from 178 to 406 ft. Figures 11A-11B show the extent of the Qva in relation to other units.

The thickness of the Qva is greatest at topographic highs (Figures 4-8); Troost (2006) found this to be true over much of the Puget Lowland. This is likely due to a combination of pre-existing topography at the time of deposition and preservation from erosional forces. According to the models generated in this study, the topographic highs in the study area are capped by till, which is conceivably shielding the Qva from erosion. However, further explorations are needed to verify the location of the till in the study area.

7.1.1 Variability in Unit Thickness

The thickness of the Qva is impacted by an apparent ridge at boring E-109 on Transect 2 (Figure 5). There are two plausible explanations for the nature of this ridge. The first possibility is that the ridge represents a paleotopographic high, and that the Qva was either eroded or was never deposited at this location. Evidence for erosion includes the contact between Qvr and Qva, and the absence of Qvt at boring E-108 on Transect 2. A second hypothesis is that this ridge represents vertical displacement from a conjugate of the SWIF, which is proximal to the study area. Supporting evidence for this hypothesis includes: indications of off-set and movement recorded in boring logs, differences in stratigraphy between Transects 1 and 2, and geologic mapping of the SWIF close to the study sight. Slickensides, fractures, and other indications of movement are documented in boreholes BW-4, BW-5, and BW-6, on Transect 1, and in E-105, MW-4, E-106, E-107, E-108, MW-5, E-109, E-110, and E-211 on Transect 2. Interglacial mass wasting deposits (Qpfnmw) are also recorded in boring E-108 on Transect 2 (Figure 5, Appendix B). Slickensides represent past shearing displacement between two surfaces, and may indicate faulting, persistent landslide movement, or stress relief from isostatic rebound as the result of glacial ice melting (Miller, 1989). The slickensides found in this area could have formed under any one of the three conditions listed above, or by a combination of those conditions. However, it is also possible that the slickenslides, which were recorded in the Qvlc, Qpn, and Qpg, were created while drilling. The stratigraphic relationships along Transects 1 and 2 are not consistent (Figures 4 and 5, respectively). Transect 1 shows that the bottom of the Qva is in contact with Qvlc and Qpg, and that Qpg overlies Qpn. However, in Transect 2, the bottom of the Qva is in contact with Qvlc and Qpn, which overlie Qpg. The ages of the Qpn and Qpg have not been determined, so it is unclear if the stratigraphic relationship between the Qpn and Qpg in these two transects is undisturbed, or if it represents an unconformity or off-set. Finally, Sherrod *et al*. (2008) identified lineaments of the SWIF close to the study site using magnetic and gravity anomalies. However, the exact locations of the lineaments are not well-constrained. In summary, there are two possibilities to define the nature of the ridge that the

Qva pinches out against. However, further research is needed to determine the nature of this ridge.

7.2 Physical Properties

The relative density of the 14 Qva samples measured in the study area are consistent with values published by Glaster and Laprade (1991). I found that the density of the Qva generally increases with increasing fines content. Theoretically, this makes sense. "Clean" sands could have a lower blow count than "dirty" sands, because fine-grained sediments can fill void space and give the sands cohesion. However, the sample size that I used in this study was limited, and this correlation may be due to random chance. I also found that the density of the Qva generally increases with depth. This correlation can be explained by the increase in compressive forces on the sediment with depth, making them more compact. However, not all of the very dense (N-value of 50+) soil samples contained a significant percentage of fine-grained material, and some of the samples were located near the surface. Therefore, factors other than fines content and depth influence the density of the Qva. Weathering, bioturbation, stress relief, and downslope movement are a few factors that may reduce soil density, while cobbles and boulders may prevent the sampler from advancing or may increase blow counts.

I found that the Qva in the study area is composed of about 89.3% sand, 9.5% gravel, 0.9% silt, and 0.3% clay. I did not find a correlation between fines content and depth. Despite the coarsening-up facies model of the Qva, I would not expect there to be a correlation between fines content and depth because the depositional environments (high-energy braided streams with subaqueous termini) were dynamic and complex; therefore, the sediments were not uniformly distributed based on grain size.

I found that the natural moisture content of samples collected for the Qva in the study area increase with an increase in fines content and depth, and a decrease in elevation. I would expect these correlations for the following reasons: the fines content likely aids in water retention via adsorption and cohesion, and moisture content probably increases with depth and decreases with elevation as the result of gravity and proximity to groundwater.

7.3 Groundwater Conditions

Variations in the top and bottom elevations of the Qva will influence the flow patterns of groundwater. The thickness of the Qva may also influence the depth to water (see boring E-107, Figure 5). I found that the saturated thickness of the Qva ranges from 0 to 102 ft within the study area. This is comparable to the findings in Golder Associates (2008), which states that the saturated thickness ranges from 10 to 100 ft in the Mountlake Terrace area (Table 4). I found that the depth to the saturated Qva aquifer ranged from 7 to 221 ft bgs in the study area. It was reported in the King County (2002) geotechnical report that the groundwater elevation varies, although they found that soils 20 to 70 ft bgs were generally saturated (King County, 2002).

Golder Associates (2008) states that the potential for infiltration is good in areas where the Qva is exposed at the surface and a sufficient unsaturated thickness exists. At boring LLE-B11P, the Qva is exposed at the ground surface. However, the groundwater was recorded at 7.4 ft bgs on August 12, 2014. The Qva at this location is 46.5 ft thick; therefore, approximately 84% of the total thickness of the unit is saturated at LLE-B11P. The groundwater elevation at boring LLE-B11P peaked following large precipitation events (Figure 20). This suggests that the aquifer is responding to meteoric water. However, the seasonal variations in water level are less than 2 ft at this location. This low seasonal flux is likely attributed to the aquifer being semi-confined, either by silt lenses within the Qva or by a nearby Qvt cap. The Qva at this location ranges in group classification from SP-SM to SM; the silt content may attribute to the semi-confined aquifer conditions. These data were recorded between August 12, 2014 and February 08, 2015; a longer study may show larger seasonal variation in groundwater flux.

8.0 Conclusions

The characteristics of the Qva make it an important geologic unit. The Qva has high frictional shear strength and low compressibility, which provides good support for foundations and other developments (Gurtowski and Boirum, 1989). The Qva is also an important hydrostratigraphic unit because it forms an extensive, unconfined aquifer (Golder Associates, 2008). However, the Qva is also susceptible to slope instability, erosion, seepage, and contamination. Studying the spatial distribution and physical properties of the Qva will benefit geologists, hydrogeologists, engineers, and environmental scientists with respect to decision making, prediction, and mitigation.

Understanding the spatial distribution of the Qva is significant to geologists, hydrogeologists, engineers, and environmental scientists. The contact between the Qva and the Qvlc is a known “slip-surface” for several large landslides in the Seattle Area (Tubbs, 1974), so documenting the location of this contact is important for geologists working on slope stability issues. Additionally, anomalies in the Qva, such as the one found at boring E-109, may provide insight to other geologic concerns. The top and bottom elevations of the Qva significantly influence the flow patterns of groundwater, and consequently, the migration of any contaminants that leach into the groundwater. Likewise, the variability in thickness of the Qva will directly affect the hydraulic conductivity, storativity, and transmissivity of groundwater in the aquifer. Knowledge of the spatial distribution of the Qva is also significant to engineers for the purposes of construction design and feasibility planning.

The spatial distribution of the Qva in the study area is comparable to generalized published data for the Qva across the Puget Lowland. The top of the Qva ranges in elevation from 247 to 477 ft. This is consistent with Troost and Booth (2008), which states that the top of the Qva ranges from 400 to 600 ft in elevation, and at lower elevations where there has been subsequent erosion. The thickness of the Qva ranges from 0 to 242 ft in the study area, which is within the limits of Qva measured in other studies (Table 4). The three-dimensional models generated using *EnterVol* show that the Qva is not a homogeneous unit in terms of lateral and vertical distribution (Figures 9A-11B). The Qva thins to the east in Transect 1 (Figure 4), and pinches out against a ridge in Transect 2 (Figure 5). In addition to locally affecting groundwater flow patterns and aquifer properties, this apparent anomaly in the Qva on Transect 2 may have broader geologic implications relating to paleotopography or a regional fault system.

The physical properties (density, grain size distribution, and moisture content) of the Qva also have significant implications on the geology, hydrogeology, engineering, and environmental sciences. For example, the hydraulic conductivity of the Qva aquifer will be directly affected by the porosity of the soil it is traveling through. Additionally, silt and clay lenses within the Qva may create perched aquifers or cause seepage, which creates the potential for issues relating to slope stability and erosion. The density and grain size distribution will also affect engineering properties, such as excavatability, angle of repose, and cohesion.

I found that the relative density of samples analyzed in this study ranged from loose to very dense (Appendix C), with the loose end of the range probably resulting from heave. I found that all samples that had greater than 10% fines content were either dense or very dense (Figure 13). Although the Qva is primarily composed of sand, I found that this unit contains an assortment of grain sizes. Individual soil samples contained as much as 48.3% gravel, 97.6% sand, and as much as 36% fine sediment (Appendix C). A volumetric analysis of the soil groups show that the Qva is composed of the following classifications, listed from greatest to least volume: 37.3% SP-SM, 33% SP, 12.8% SM, 6.6% GW, 3.5% SW, 2.7% SW-SM, 1.9% GP, 0.9% GP-GM, 0.9% ML, 0.3% CL, and 0.1% GM (Figures 16A-B). I also found that the natural moisture content from samples collected in the study area range from 3.0 to 35.4%, and increase as a function of depth and fines content (Figures 18-19).

Groundwater dynamics considerably influence the geology and engineering properties of the Qva. Elevated pore-pressures caused by large precipitation events are known to destabilize slopes (Tubbs, 1975). Groundwater also affects the feasibility of developing in the Qva. Although groundwater data were scarce, I found that the elevation of the water table in the Qva ranges from 231.9 to 458 ft. The saturated thickness of the Qva (0-102.13 ft) is comparable to findings from other investigations (Table 4). However, I found that the depth to the saturated aquifer (7.59-221.3 ft bgs) was much greater in the study area than was reported in the King County (2002) geotechnical report, which states that the depth to groundwater is generally 20-70 ft bgs. The results of rising- and falling-head slug tests at boring LLE-B11P determined the following groundwater characteristics at this location: mean hydraulic conductivity (15.93 ft/d), storativity (3.28 x 10^{-3}), and transmissivity (738.58 ft^2/d). The seasonal variation in groundwater elevation at boring LLE-B11P was 1.73 ft, as recorded between August 12, 2014 and March 13, 2015. The Qva at this location is silty. The silt content at this location could be partially confining the aquifer, and thus minimizing the seasonal flux. However, data from a pressure transducer installed at this location shows that the aquifer is responding to precipitation events.

Subsurface models can be used to gain a better understanding the relationships between geologic units. In this study, I used *EnterVol* to try to model the spatial variability of the Qva. While this program has some limitations, I found that it useful for creating three-dimensional models that illustrate the relationships between the Qva and the other geologic units. Overall, *EnterVol* produced what I needed, and I would recommend it for other subsurface studies.

9.0 Limitations and Assumptions

This study is limited to publicly available data, and the accuracy of those data. The data include, but are not restricted to: geotechnical boring logs, geologic maps, technical reports, memorandums, aerial photographs, and geospatial data.

Although the available subsurface data were sufficient, this study could have benefited from additional borehole data. Transects 1, 2, and 5 are the most reliable, because these transects have a greater concentration of borehole data. Transects 3 and 4 incorporate only 2 boreholes each, leaving much more room for interpretation. Additionally, groundwater data were not as abundant nor as readily available as I had anticipated; my analysis could have been made stronger by additional data in this field.

I assume in my analysis of soil density that the blow counts recorded using SPT and D&M sampling methods are correlative, although the hammer weight, sampler size, and sample depth may affect the consistency of the data.

The final product of this research project will be applicable to the Qva only within the study area, and should not be considered representative of the Qva elsewhere in the Puget Lowland. However, the methods used in this study could be applied to other investigations.

9.1 Software Limitations

While the usability and viability of *EnterVol* was satisfactory for this study, the software has some limitations. This program automates subsurface models based on borehole data input by the user. However, the ability for the user to make interpretations or add corrections to the models is somewhat limited. This issue was encountered in my models, at boring E-109. Although the data that I input showed that the Qpn was exposed at the surface in boring E-

109, the automated model showed the Qva at the surface instead. Additionally, the isopach map (Figure 12) show "bulls-eye" patterns; this is an unusual geologic pattern that might actually be an artifact of the interpolation algorithm used to make the models. It is possible that the geology was too complex to be modeled in this area. It is also possible that the algorithm used to interpolate the geology did not capture every fine detail. Discrepancies between the actual and modeled values of the thickness of the Qva could have been reduced if more borehole information were available. "Dummy" borings can be used as an aid to increase the user's ability to make interpretations, or to fill in voids where borehole information is scarce; however, I did not use this approach because I wanted to compare the automated models to the hand-drawn cross-sections. I am uncertain of the complexity of the models that *EnterVol* is able to produce. I am also uncertain of the full capabilities of this program, which should be explored in future studies.

10.0 Recommended Future Studies

10.1 Local Characterization of the Vashon Advance Outwash

Additional studies should be conducted to compare the engineering properties (bulk density, coefficient of friction, cohesion, etc.) of the Qva locally to that of generalized published data (Table 4). Additional engineering properties that could be tested include: triaxial shear strength, residual strength, dry and wet densities, and stability of cut slopes. It would also be useful to determine the angle of internal friction with relation to fines content. The angle of internal friction is significantly less in silts than it is in sands (Koloski *et al.,* 1989). This information would be useful to engineers who have project designs in the Qva, so that they can determine how the fines content may affect the stability of a slope or excavation.

10.2 Locating Southern Whidbey Island Fault Traces

There is potential evidence for a segment of the Southern Whidbey Island Fault in Transect 2, where the Qva pinches out along a ridge. This hypothesis is supported by the presence of slickensides, brecciated textures, shear zones, and mass wasting deposits along the same transect (Figure 5). However, locating strands of the SWIF was not in the scope of my research, so I did not investigate this in great detail. I recommend that future studies be done using new and existing geotechnical borings, and the *ArcGIS/EnterVol* modeling methods described above, to locate strands of the SWIF near the King/Snohomish County border or elsewhere. Future research should also incorporate geophysical methods to identify and locate the fault, should it exist here. Ideal locations for the geophysical research would be in the Holyrood Cemetery, which intersects Transect 2, and at the Nile Golf Course, which is located between Lake Ballinger and Transect 5. These areas are minimally developed, and will not have much interference from underground utilities. Since the SWIF has obscure boundaries and is an active fault capable of producing up to M_W 7.1 earthquakes, I think it is in the best interest of the community to locate and constrain the lineaments of this fault.

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12.0 Figures

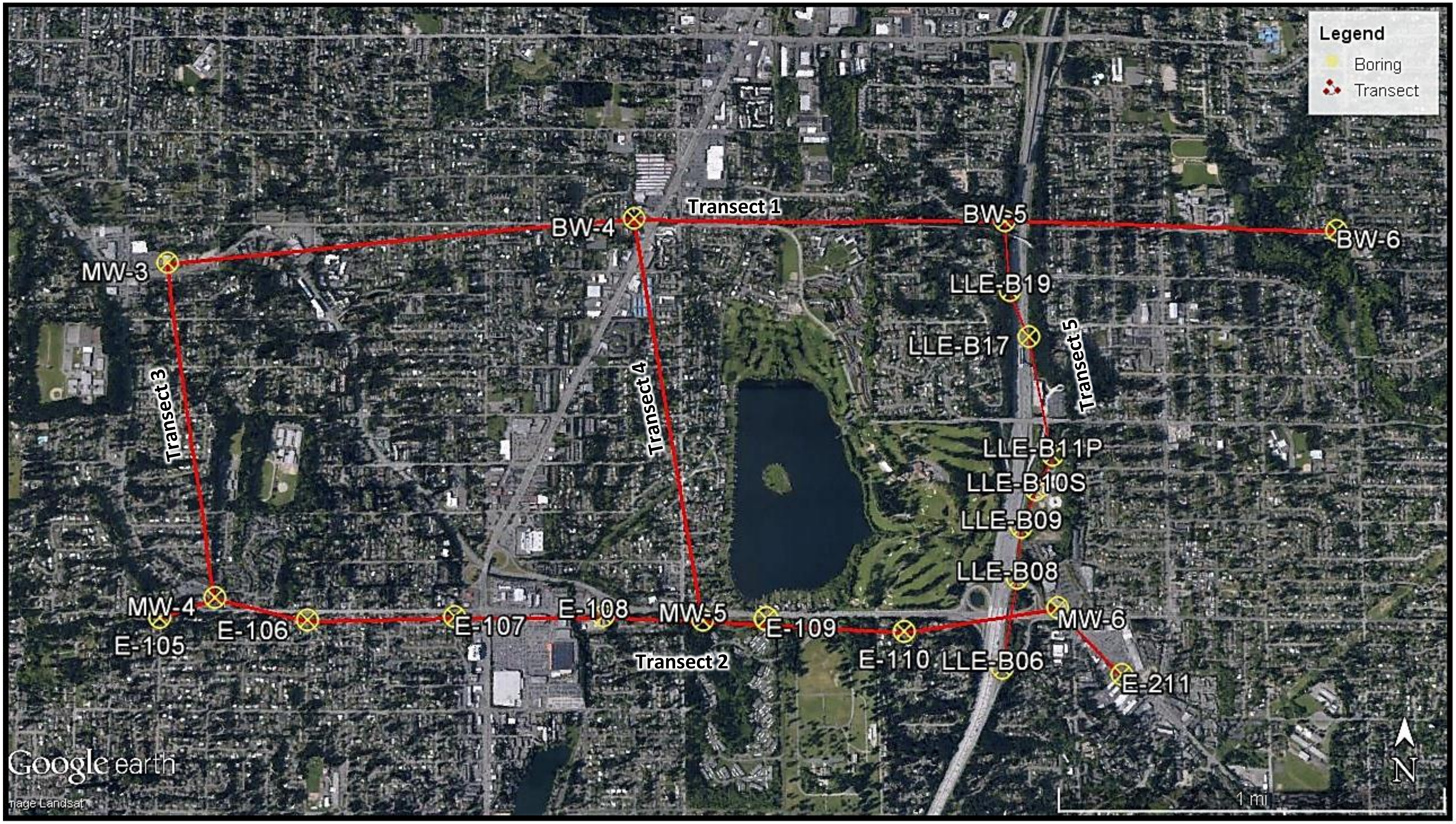


Figure 1, Vicinity Map. *Transect lines are shown in red and significant borings are represented by a yellow cross in a circle. Borings prefixed with MW- were completed by HWA Geosciences for the Brightwater Project in 2002, with a BW- by Shannon & Wilson for the Brightwater Project in 2002, with an E- by CDM Smith for the Brightwater Project in 2003, and with an LLE-B by GeoEngineers for the Sound Transit-LLE Project in 2014. Lake Ballinger is located near the center of the study area. Interstate-5 is located at the eastern edge of the study area, along Transect 5.*

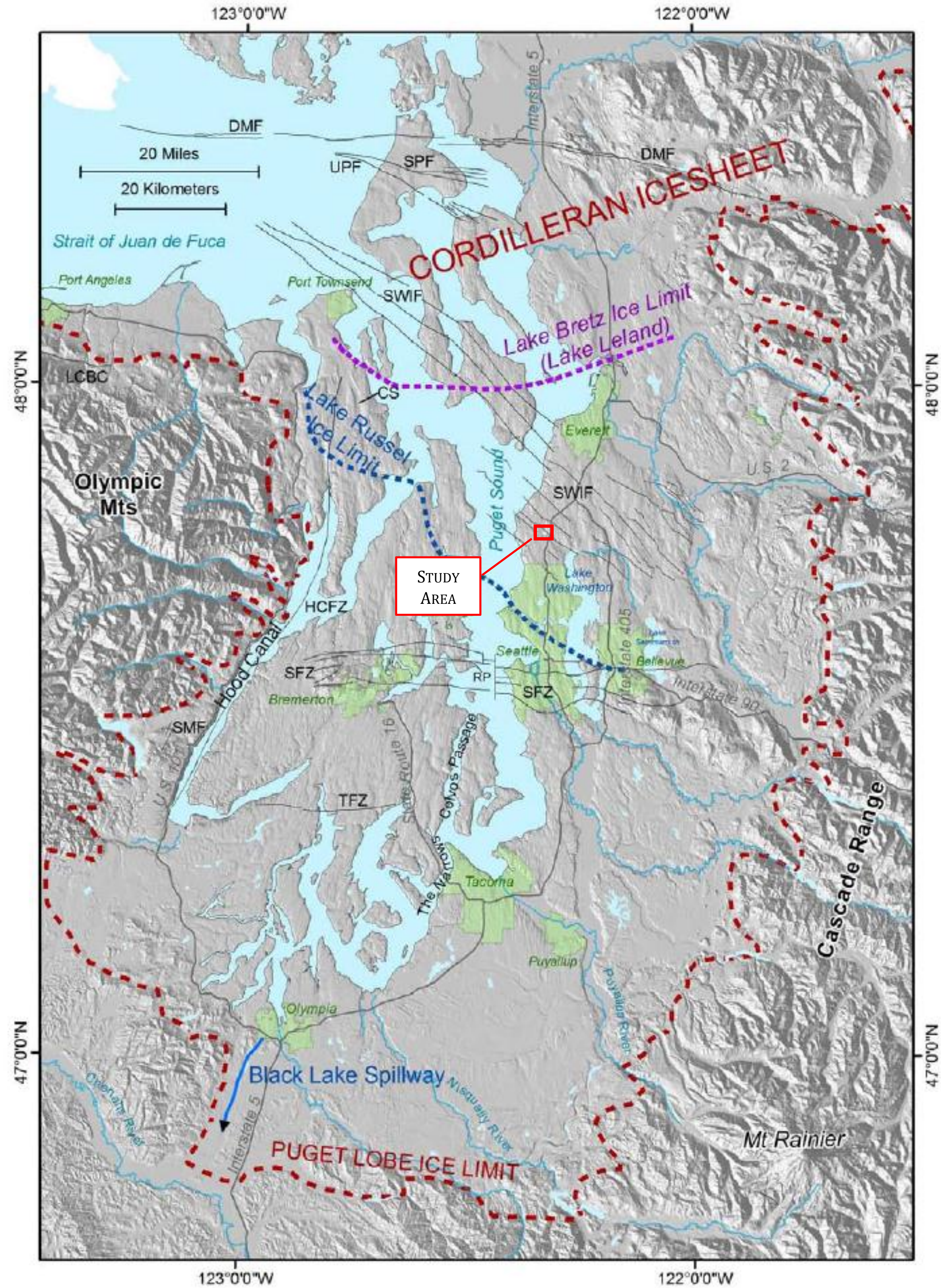


Figure 2, Regional Map. *The study area is outlined in red. Highly populated cities are shown in green. The extent of the Puget Lobe of the Cordilleran Ice Sheet is indicated by the dark red, dashed line. Quaternary fault traces and lineaments are labeled and shown as gray lines. Notice the proximity of the Southern Whidbey Island Fault Zone (SWIF) to the study area. Other abbreviations listed on the map are: CS – Chimacum spillway, DMF – Devils Mountain fault zone, HCFZ – Hood Canal Fault Zone, LCBC – Lake Creek-Boundary Creek fault, RP – Restoration Point, SFZ – Seattle fault zone, SMF – Saddle Mountain fault, SPF – Strawberry Point fault, TFZ – Tacoma fault zone, and UPF – Utsalady Point fault. (Image modified from Troost and Booth, 2008)*

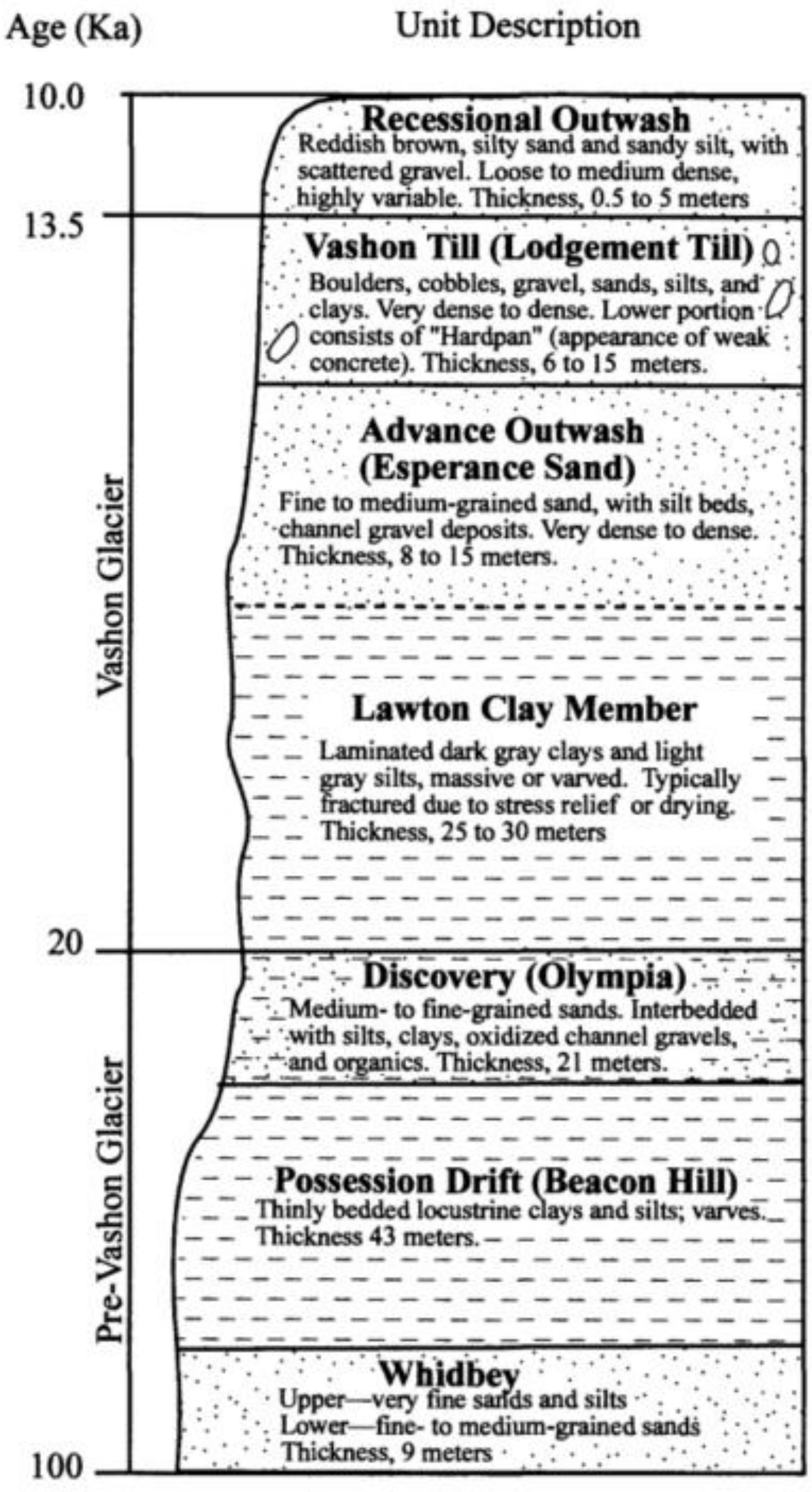
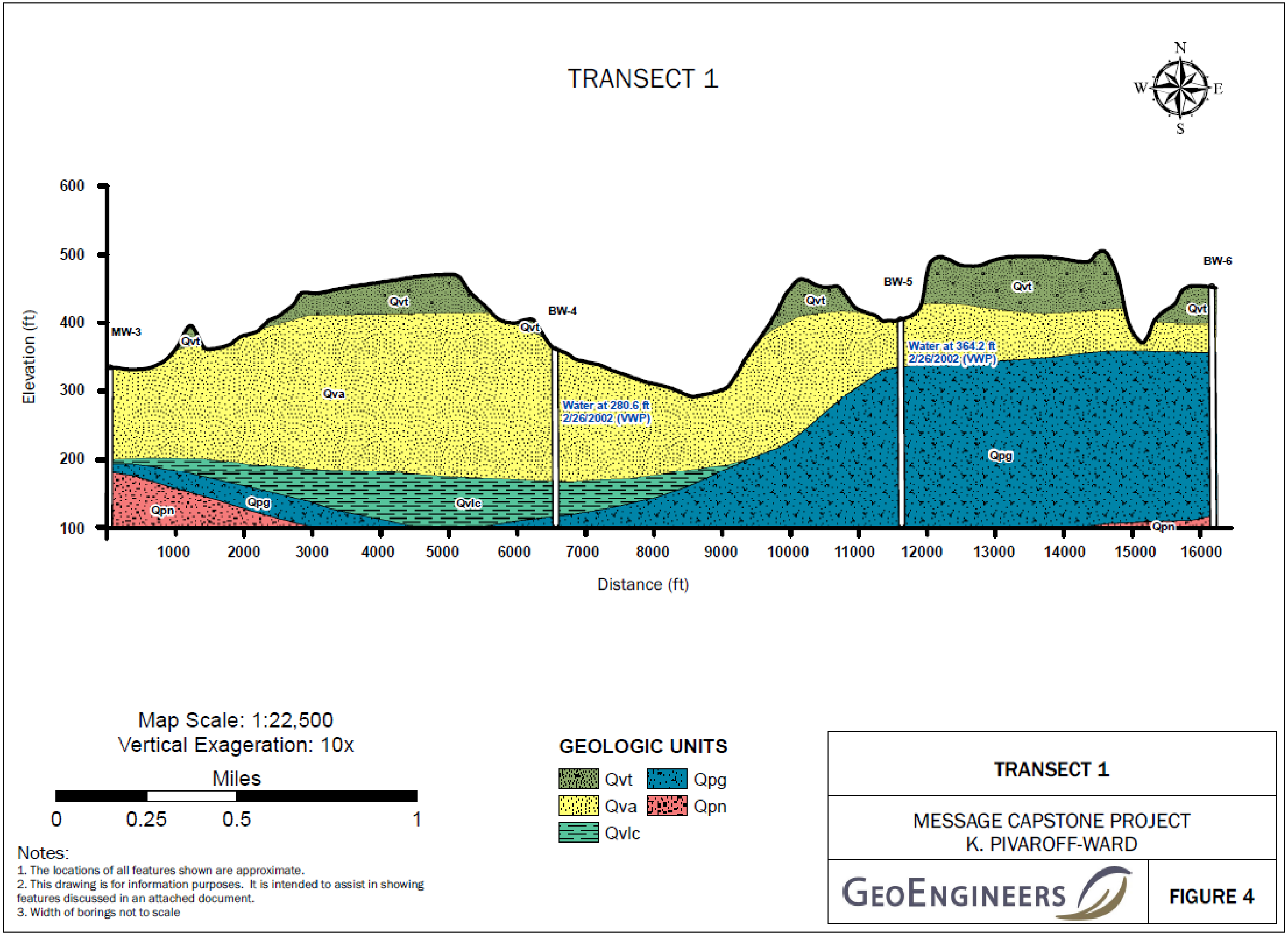


Figure 3, Generalized Quaternary Geologic Section. (Image from Galster and Laprade, 1991)



Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document.
3. Width of borings not to scale

Figure 4, Cross-Section 1. *Transect 1 is approximately 3.1 mi in length, and includes borings MW-3, BW-4, BW-5, and BW-6. The Qva thins to the east, where there appears to be a paleotopographic ridge composed of pre-Olympia glacial deposits.*

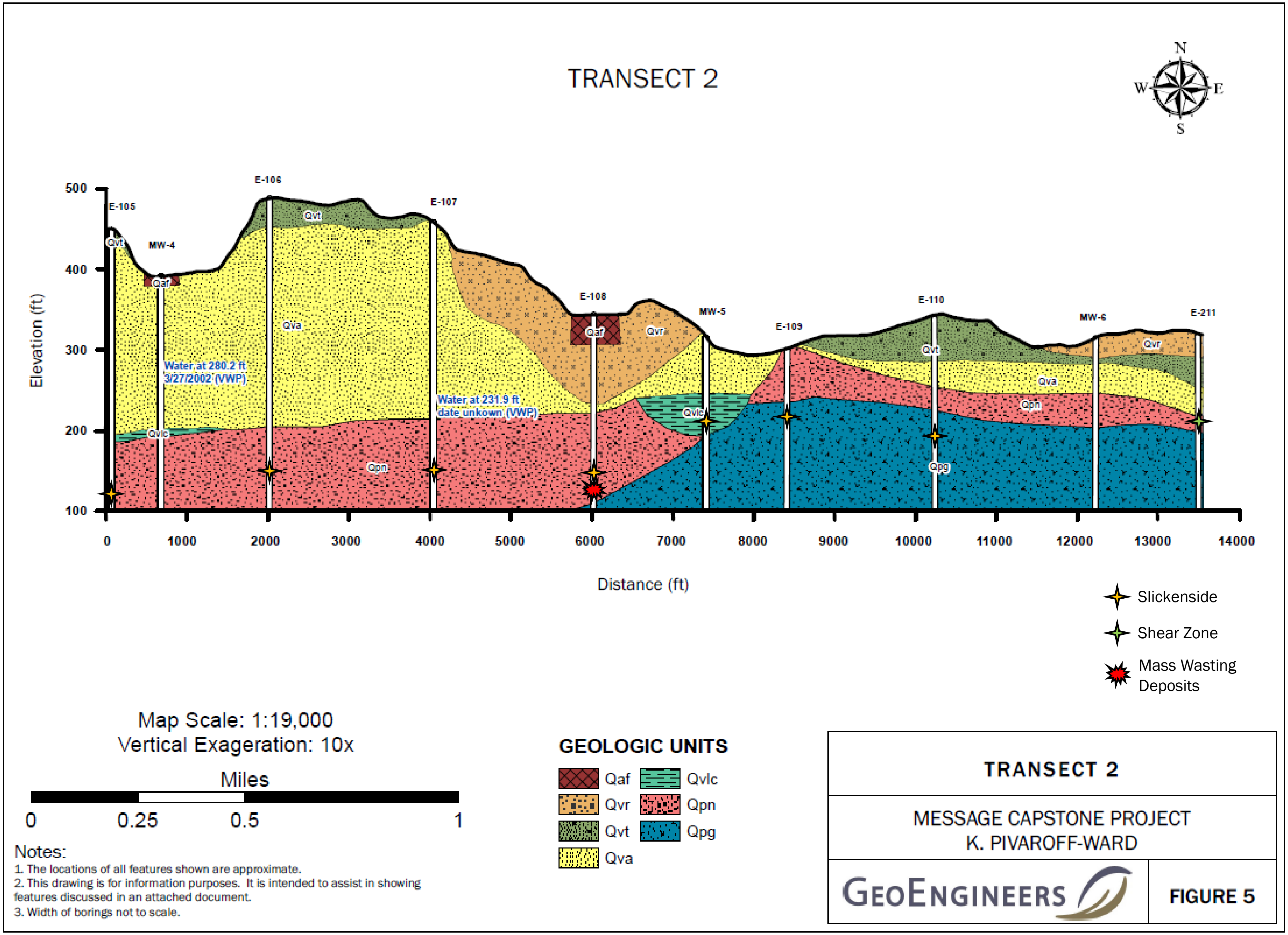


Figure 5, Cross-Section 2. *Transect 2 is approximately 2.56 mi in length, and includes borings E-105, MW-4, E-106, E-107, E-108, MW-5, E-109, E-110, MW-6, and E-211. The Qva pinches out against a ridge composed of pre-Fraser interglacial deposits. There is significant evidence for soil disturbance along this transect, including slickensides, brecciated textures, shear zones, mass wasting deposits, and fractures. It is unclear whether this ridge is a paleotopographic feature, or whether it was formed from active tectonics. Further research should be done to determine the nature of this ridge.*

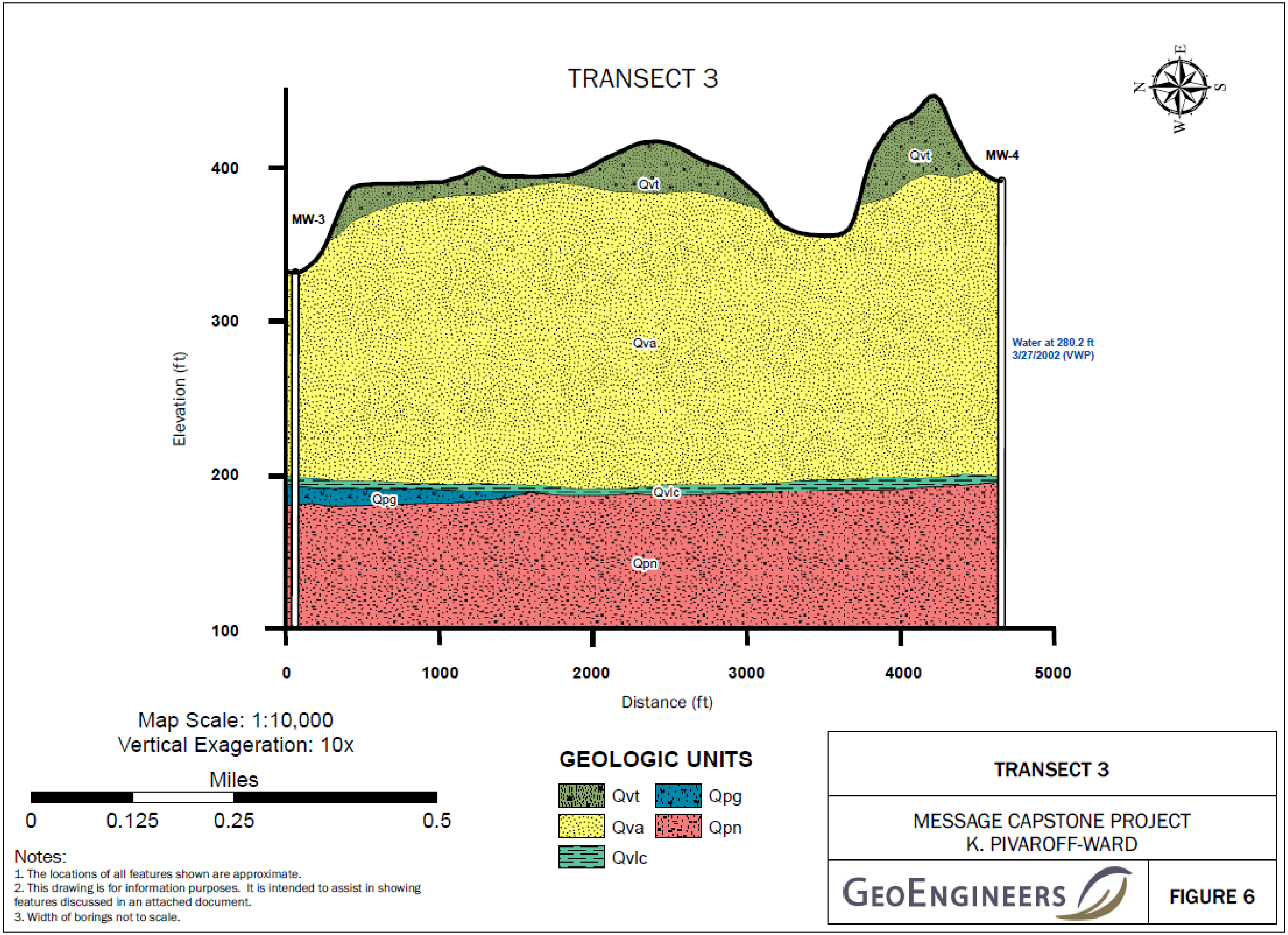


Figure 6, Cross-Section 3. *Transect 3 is approximately 0.88 mi in length, and includes borings MW-3 and MW-4.*

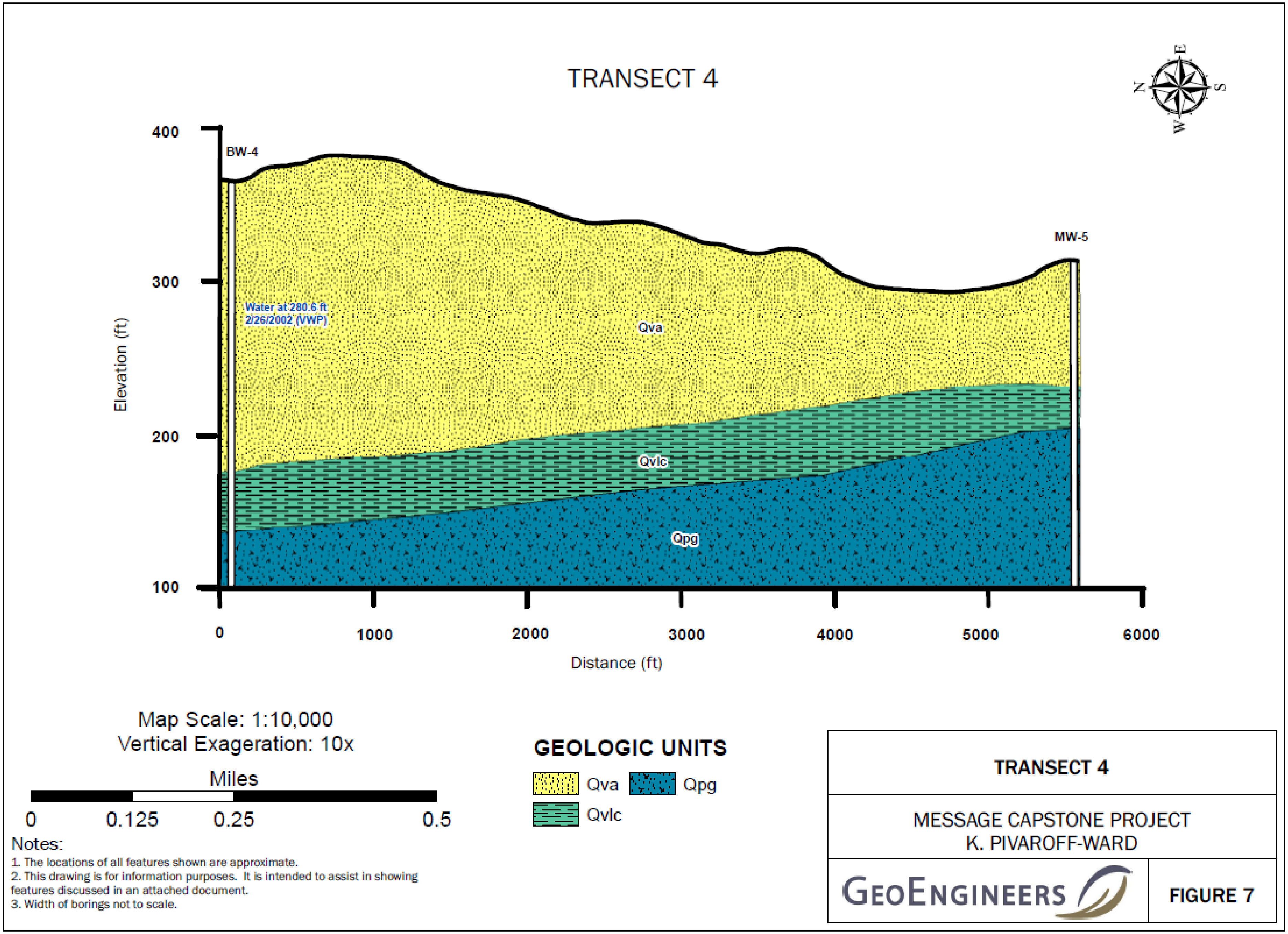


Figure 7, Cross-Section 4. *Transect 4 is approximately 1.1 mi in length, and includes borings BW-4 and MW-5.*

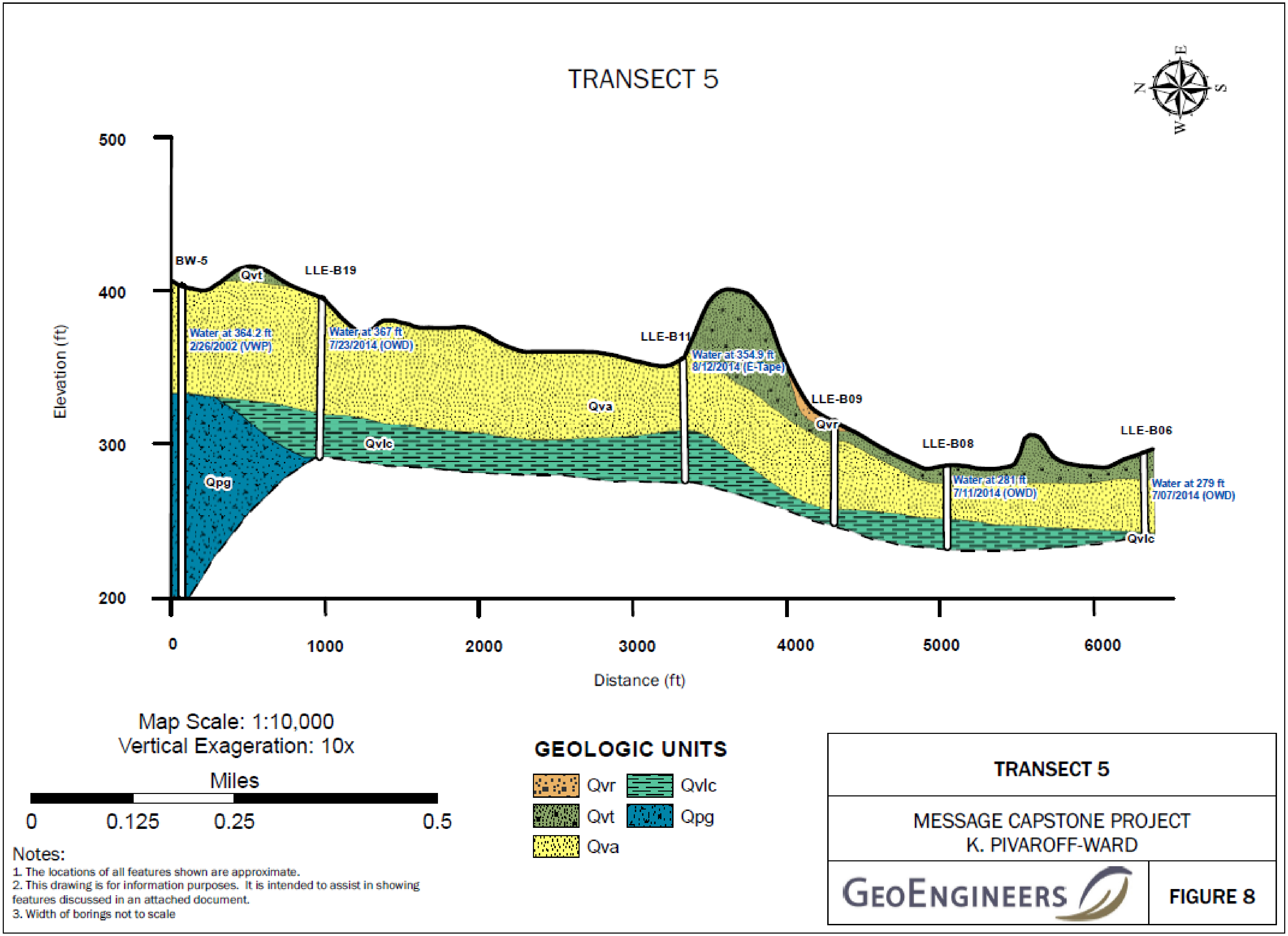


Figure 8, Cross-Section 5. *Transect 5 is approximately 1.20 mi in length, and includes borings BW-5, LLE-B19, LLE-B17, LLE-B11, LLE-B09, LLE-B08, and LLE-B06. The apparent bend at boring LLE-B11P may represent a fold.*

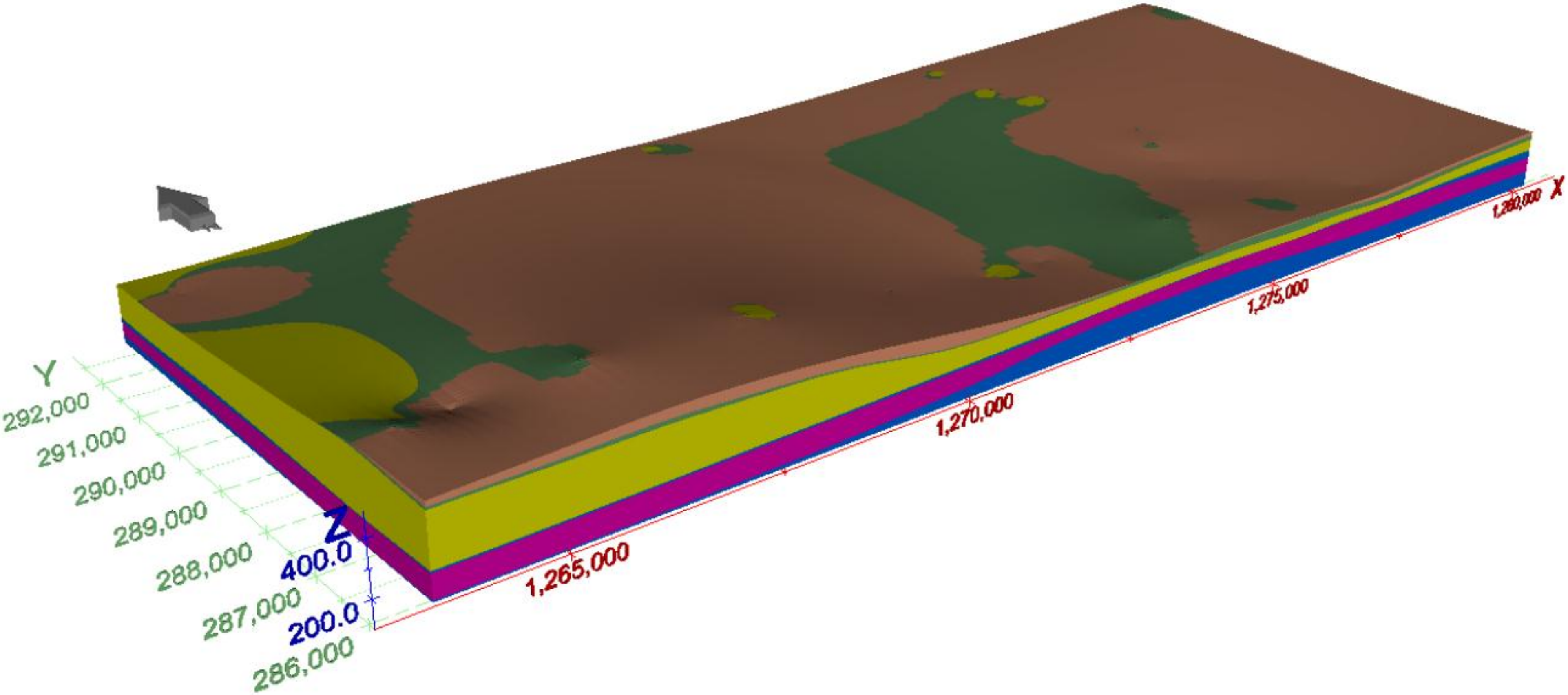


Figure 9A, Block Diagram. *This block diagram was produced using EnterVol and the geologic contacts database (Table 2) that I constructed using borehole data. The units on the y- and x- axes are northing and easting, respectively. The unit on the z-axis is elevation (ft). The geologic units shown are: pre-Olympia glacial (Qpg) in blue, pre-Fraser interglacial (Qpn) in pink, Lawton clay (Qvlc) in teal, Vashon advance outwash (Qva) in yellow, Vashon till (Qvt) in green, and recessional outwash (Qvr) in orange. This view shows Transect 2 paralleling the x-axis, and Transect 3 paralleling the y-axis.*

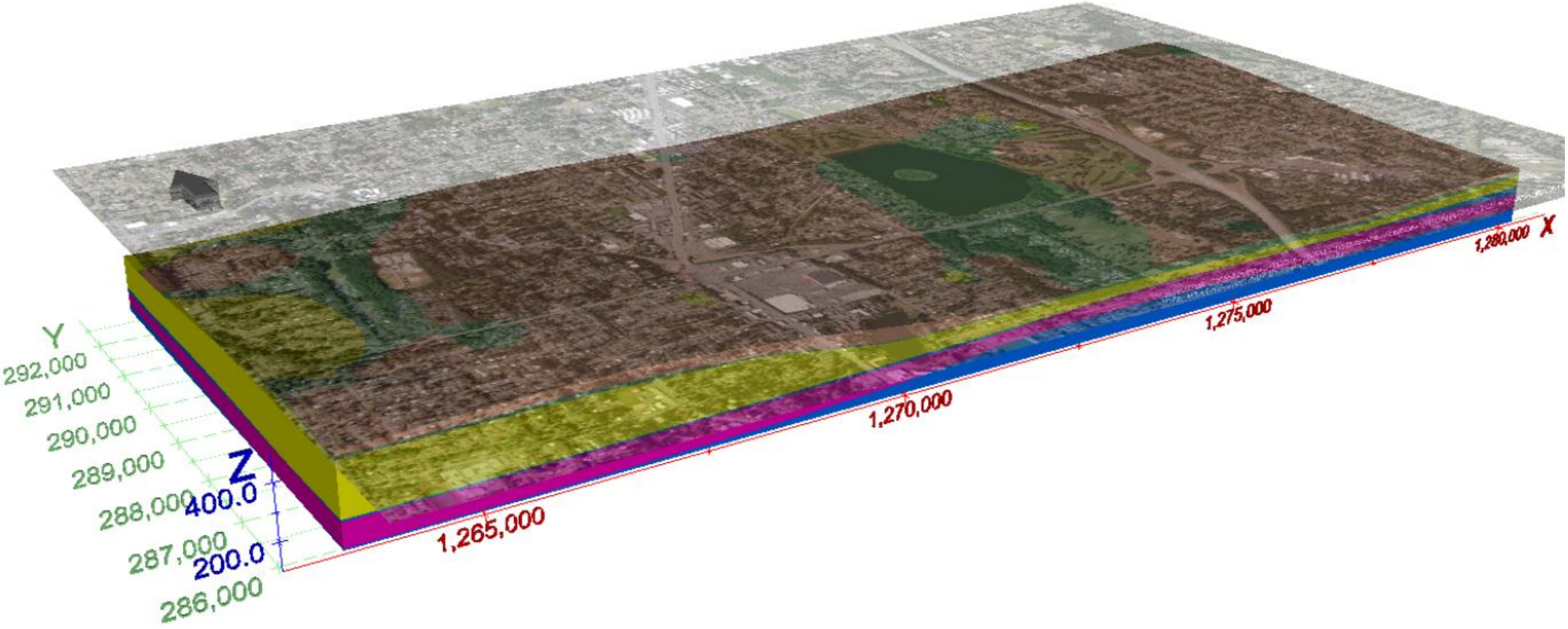


Figure 9B, Block Diagram with Vicinity Map Overlay. *This block diagram was produced using EnterVol and the geologic contacts database (Table 2) that I constructed using borehole data. The units on the y- and x- axes are northing and easting, respectively. The unit on the z-axis is elevation (ft). The geologic units shown are: pre-Olympia glacial (Qpg) in blue, pre-Fraser interglacial (Qpn) in pink, Lawton clay (Qvlc) in teal, Vashon advance outwash (Qva) in yellow, Vashon till (Qvt) in green, and recessional outwash (Qvr) in orange. This view shows Transect 2 paralleling the x-axis, and Transect 3 paralleling the y-axis. Lake Ballinger is located near the center of the map, with Interstate-5 located east of the lake.*

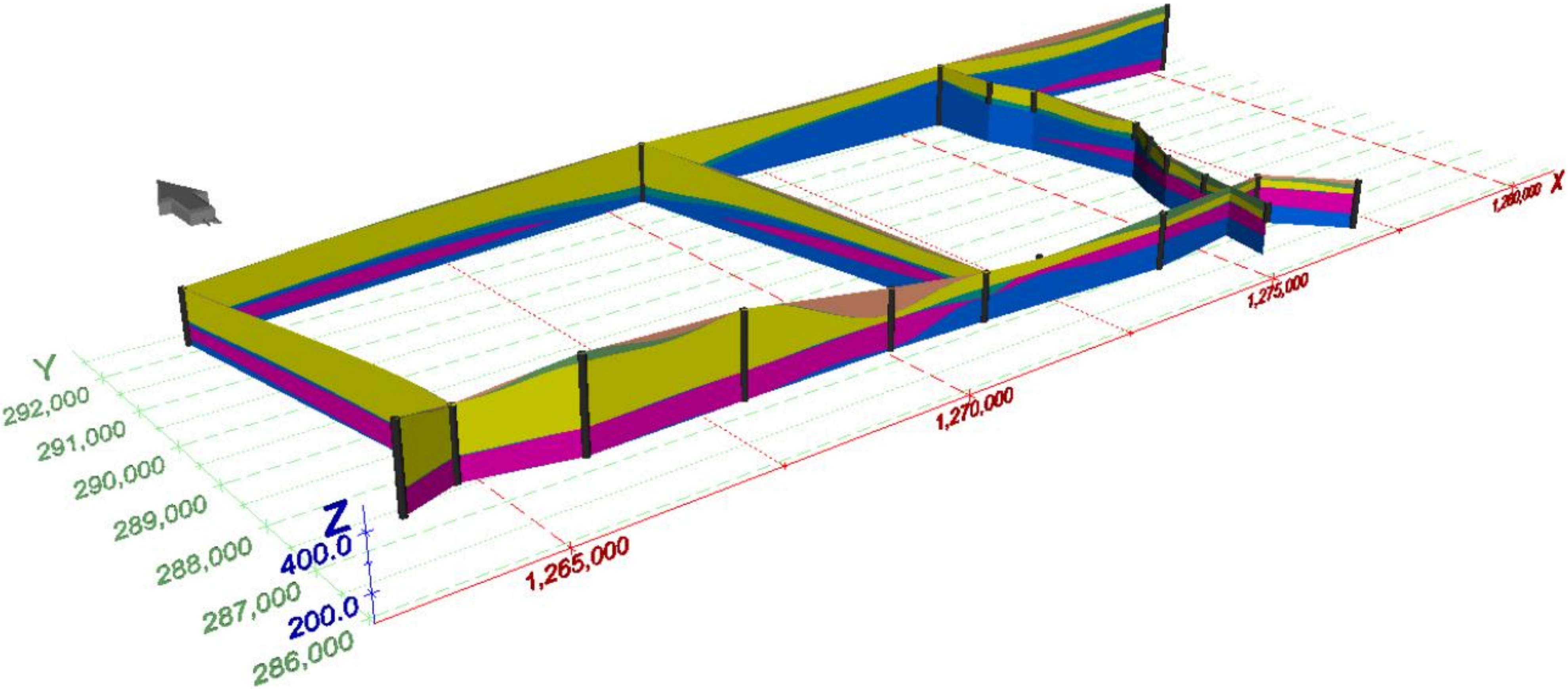


Figure 10, Fence Diagram. *This fence diagram was produced using EnterVol and the geologic contacts database (Table 2) that I constructed from borehole data. The units on the y- and x- axes are northing and easting, respectively. The unit on the z-axis is elevation (ft). The geologic units shown are: pre-Olympia glacial (Qpg) in blue, pre-Fraser interglacial (Qpn) in pink, Lawton clay (Qvlc) in teal, Vashon advance outwash (Qva) in yellow, Vashon till (Qvt) in green, and recessional outwash (Qvr) in orange. The black bars show the location and depth of each of the boreholes used in this study. This view shows Transect 1 as the northern-most cross-section, Transect 2 paralleling the x-axis, Transect 3 paralleling the y-axis, Transect 4 in the center, and Transect 5 on the far right.*

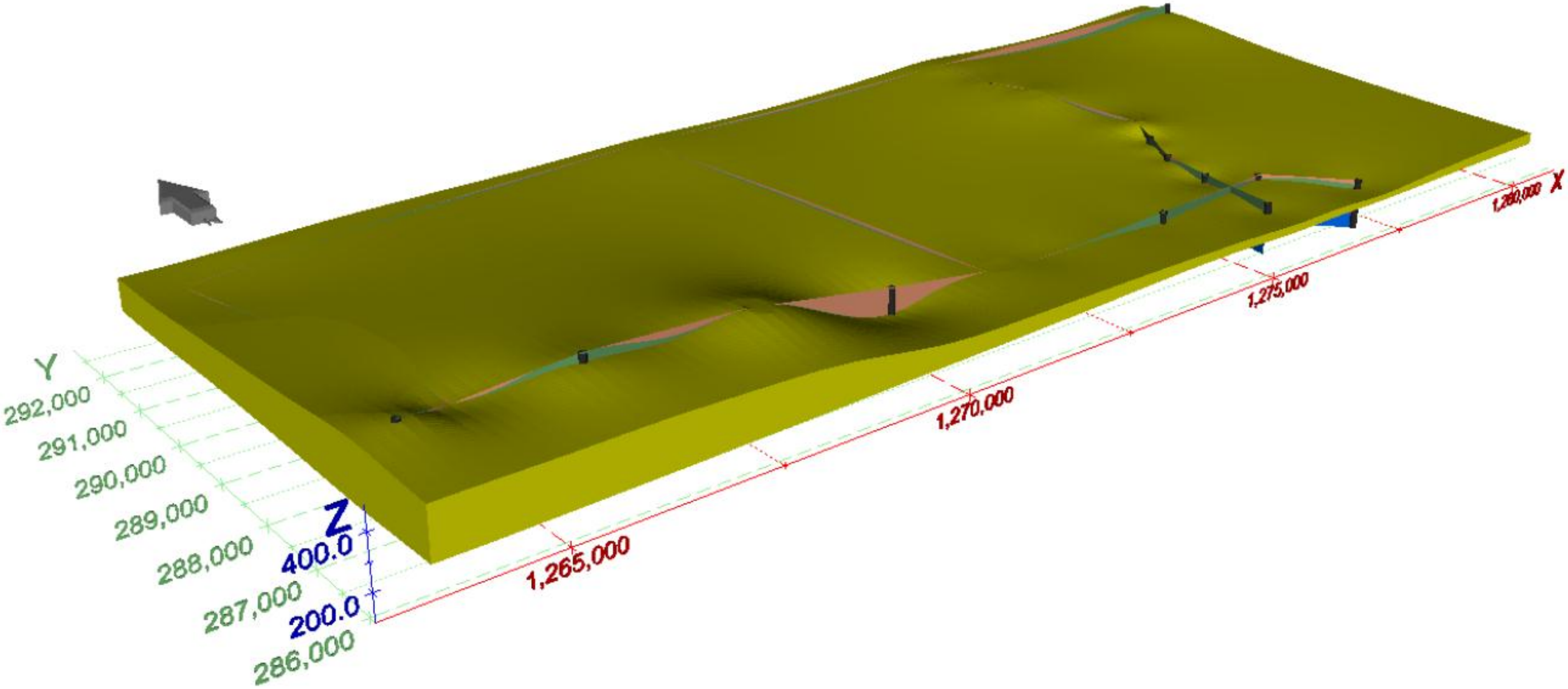


Figure 11A, Qva with Fence Diagram (From Above). *This diagram was produced using EnterVol and the geologic contacts database (Table 2) that I constructed from borehole data. The units on the y- and x- axes are northing and easting, respectively. The unit on the z-axis is elevation (ft). The geologic units shown are: pre-Olympia glacial (Qpg) in blue, Vashon advance outwash (Qva) in yellow, Vashon till (Qvt) in green, and recessional outwash (Qvr) in orange. The black bars show the location and depth of each of the boreholes used in this study. This view shows Transect 1 as the northern-most cross-section, Transect 2 paralleling the x-axis, Transect 3 paralleling the y-axis, Transect 4 in the center, and Transect 5 on the far right. This view helps illustrate the extent of the Qva in relation to the Qvr and Qvt.*

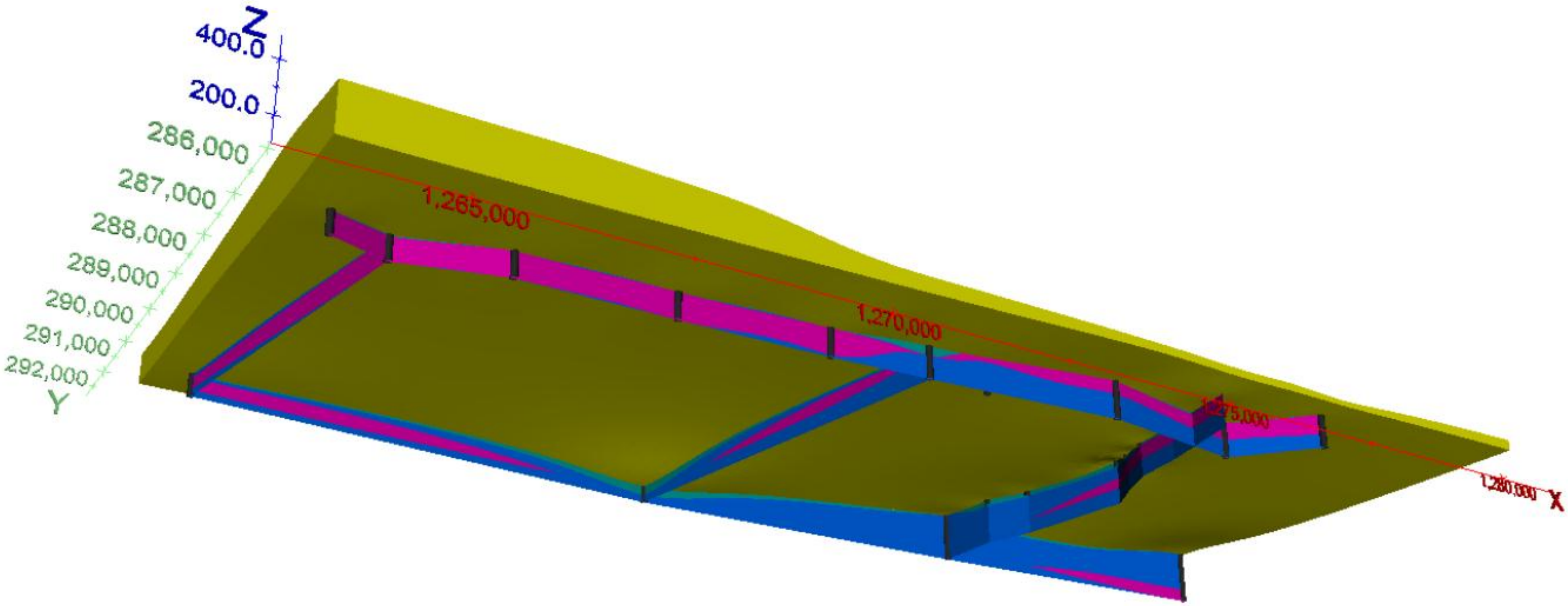


Figure 11B, Qva with Fence Diagram (From Below). *This diagram was produced using EnterVol and the geologic contacts database (Table 2) that I constructed from borehole data. The units on the y- and x- axes are northing and easting, respectively. The unit on the z-axis is elevation (ft). The geologic units shown are: pre-Olympia glacial (Qpg) in blue, pre-Fraser interglacial (Qpn) in pink, Lawton clay (Qvlc) in teal, and Vashon advance outwash (Qva) in yellow. The black bars show the location and depth of each of the boreholes used in this study. This view shows Transect 1 as the northern-most cross-section, Transect 2 paralleling the x-axis, Transect 3 paralleling the y-axis, Transect 4 in the center, and Transect 5 on the far right. This view helps illustrate the extent of the Qva in relation to the Qvlc, Qpn, and Qpg.*

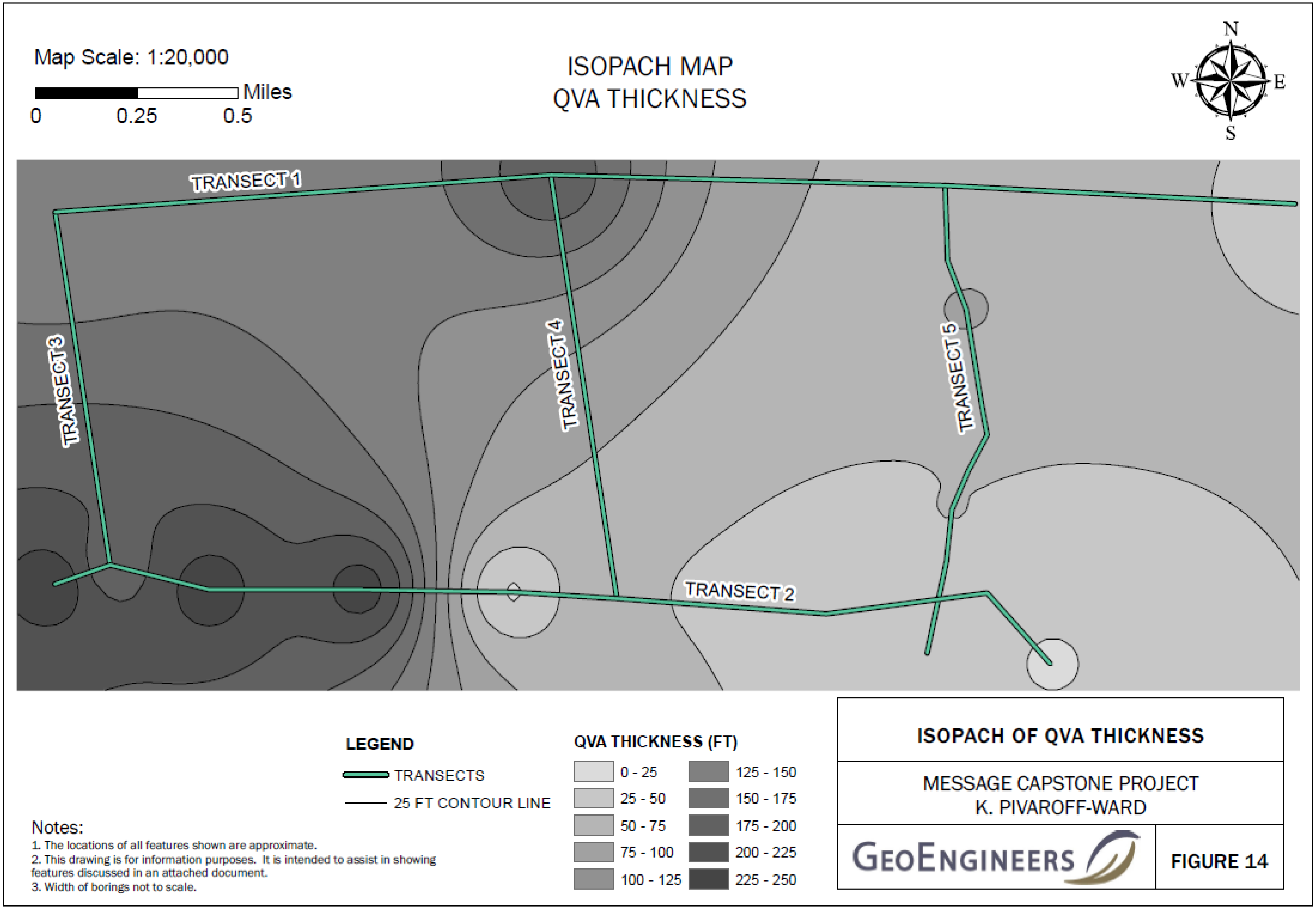


Figure 12, Isopach Map of Qva Thickness. *The thickness of the Qva is mapped using 25 ft contours, which are based on the model produced in EnterVol. The Qva is thickest in the western corner of the study area, and thins to southeast. There is a steep gradient intersecting Transect 2, between Transects 3 and 4; at this location, there is a thick deposit of Qvr. The Qva is thickest where modern topography is high. The circular contours on the isopach map may indicate topographic highs and lows; however, they could also be artifacts of the model, which would indicate that the EnterVol did not accurately depict the thickness of the Qva.*

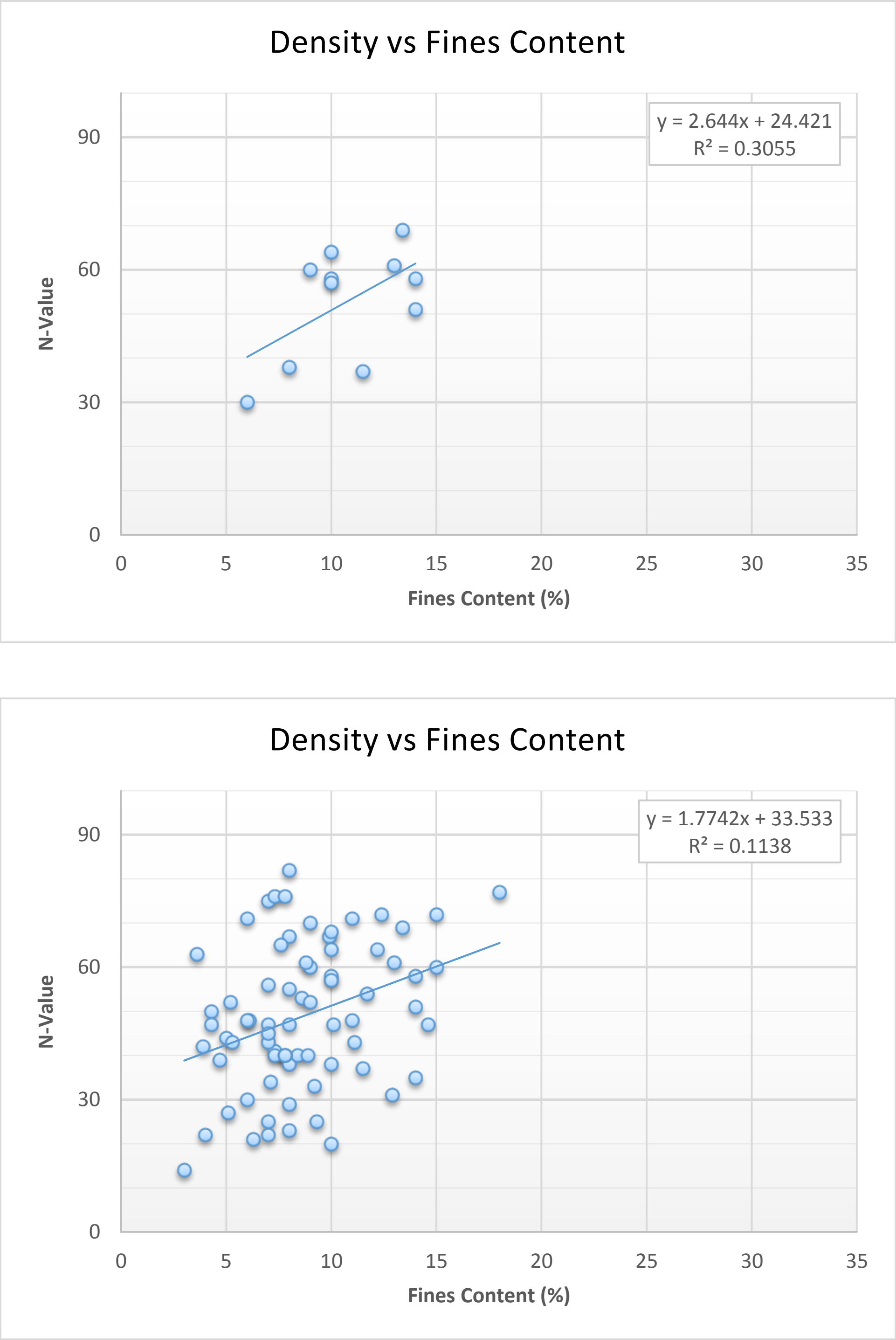
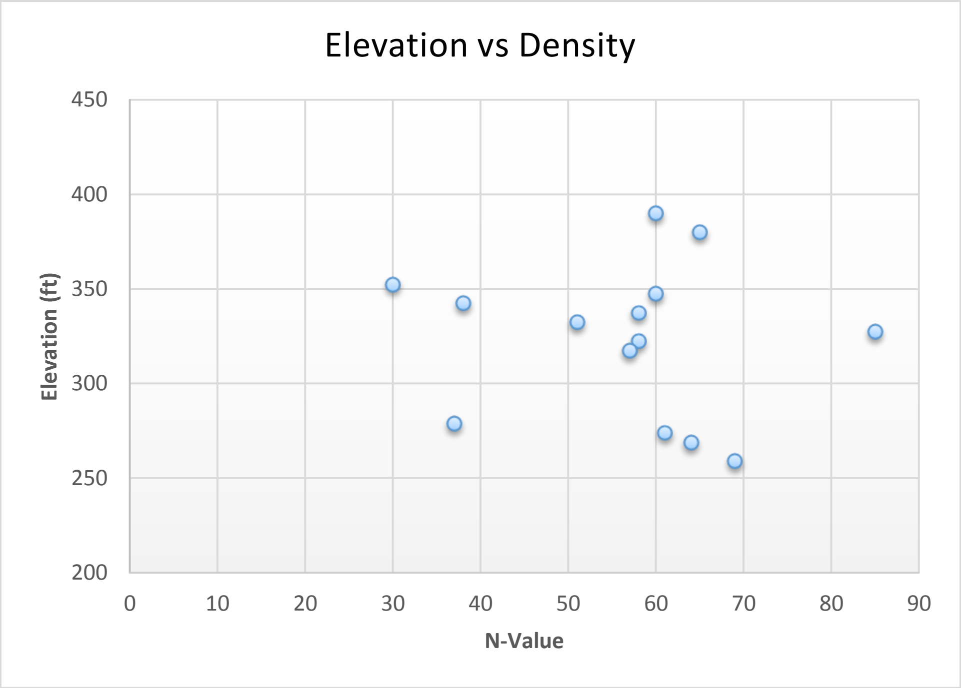


Figure 13, Density vs. Fines Content. *These figures show the relative density of select soil samples as a function of fines content in the soil. Only samples collected using mud rotary drilling methods, which provide the most reliable density data in water-bearing sands, are shown in the top figure. Samples collected using mud rotary, Becker hammer, and hollow stem auger drilling methods are shown in the lower figure. For both of these figures, I used a linear regression line to show the trend in these datasets.*



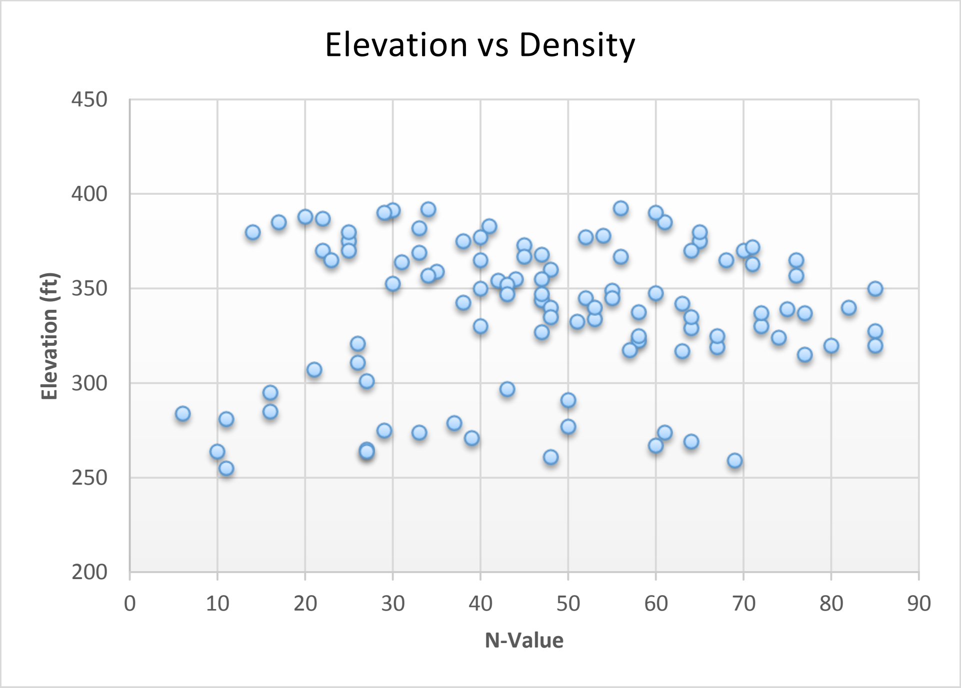
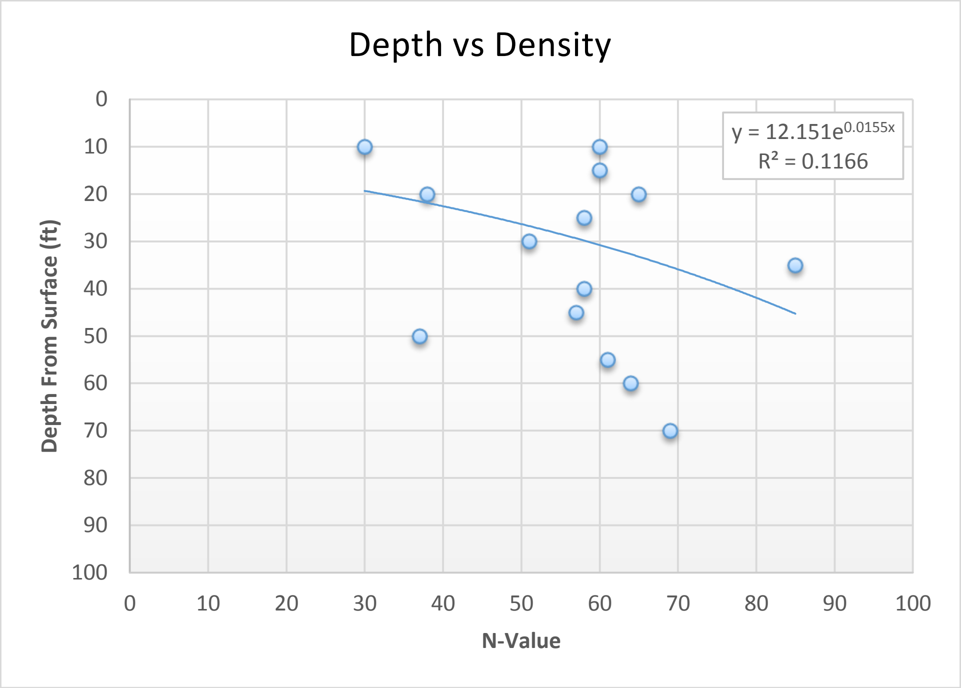


Figure 14, Elevation vs. Density. *These figures show the relative density of select soil samples as a function of elevation (NAVD88 datum). Only samples collected using mud rotary drilling methods, which provide the most reliable density data in water-bearing sands, are shown in the top figure. Samples collected using mud rotary, Becker hammer, and hollow stem auger drilling methods are shown in the lower figure.*



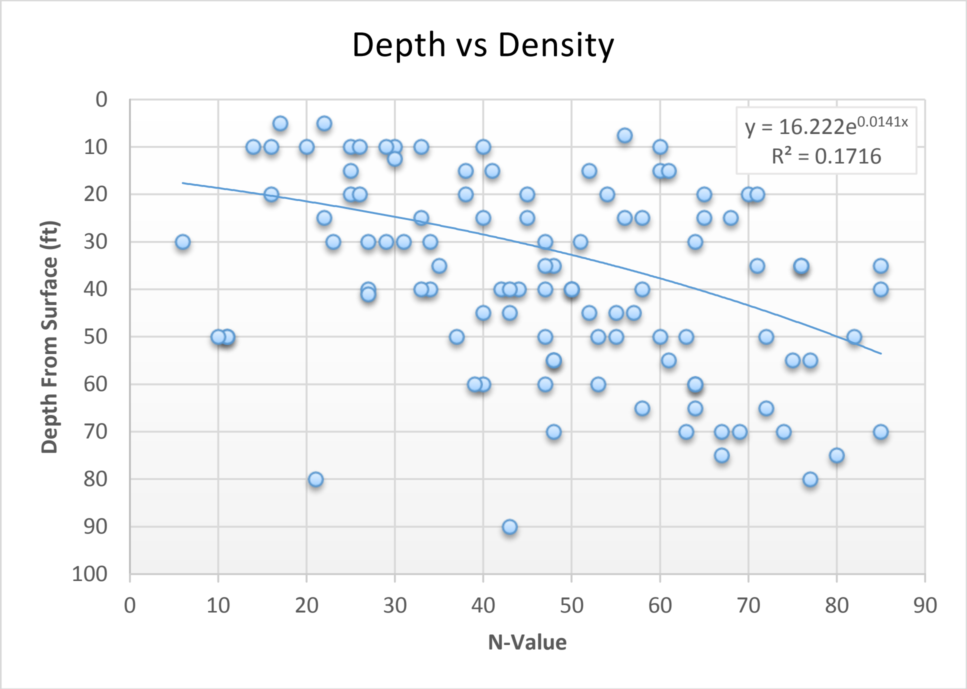


Figure 15, Depth vs. Density. *These figures show the relative density of select soil samples as a function of depth from the surface of the ground. Only samples collected using mud rotary drilling methods, which provide the most reliable density data in water-bearing sands, are shown in the top figure. Samples collected using mud rotary, Becker hammer, and hollow stem auger drilling methods are shown in the lower figure. For both of these figures, I used an exponential regression curve to show the trend in these datasets.*

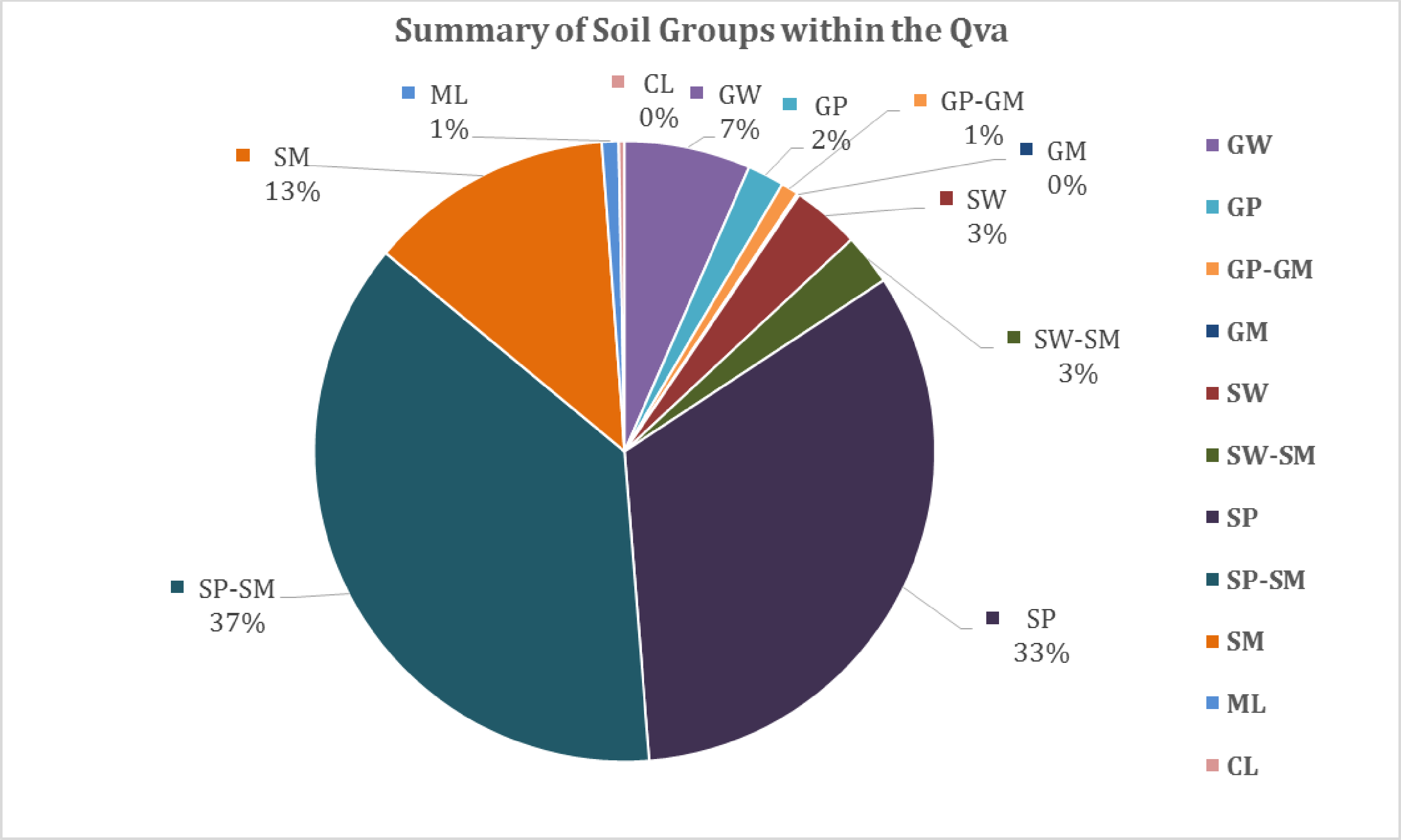


Figure 16A, Summary of Soil Classifications within the Qva. *This chart summarizes the percentages of the soil groups found within the Qva, as recorded in the geotechnical boring logs. Gravel comprises about 9.5% of the total volume of the Qva, sand about 89.3%, and silt/clay about 1.2%. The abbreviations are as listed: well-graded gravel (GW), poorly-graded gravel (GP), poorly-graded gravel with silt (GP-GM), silty gravel (GM), well-graded sand (SW), well-graded sand with silt (SW-SM), poorly-graded sand (SP), poorly-graded sand with silt (SP-SM), silty sand (SM), lean silt (ML), and lean clay (CL).*

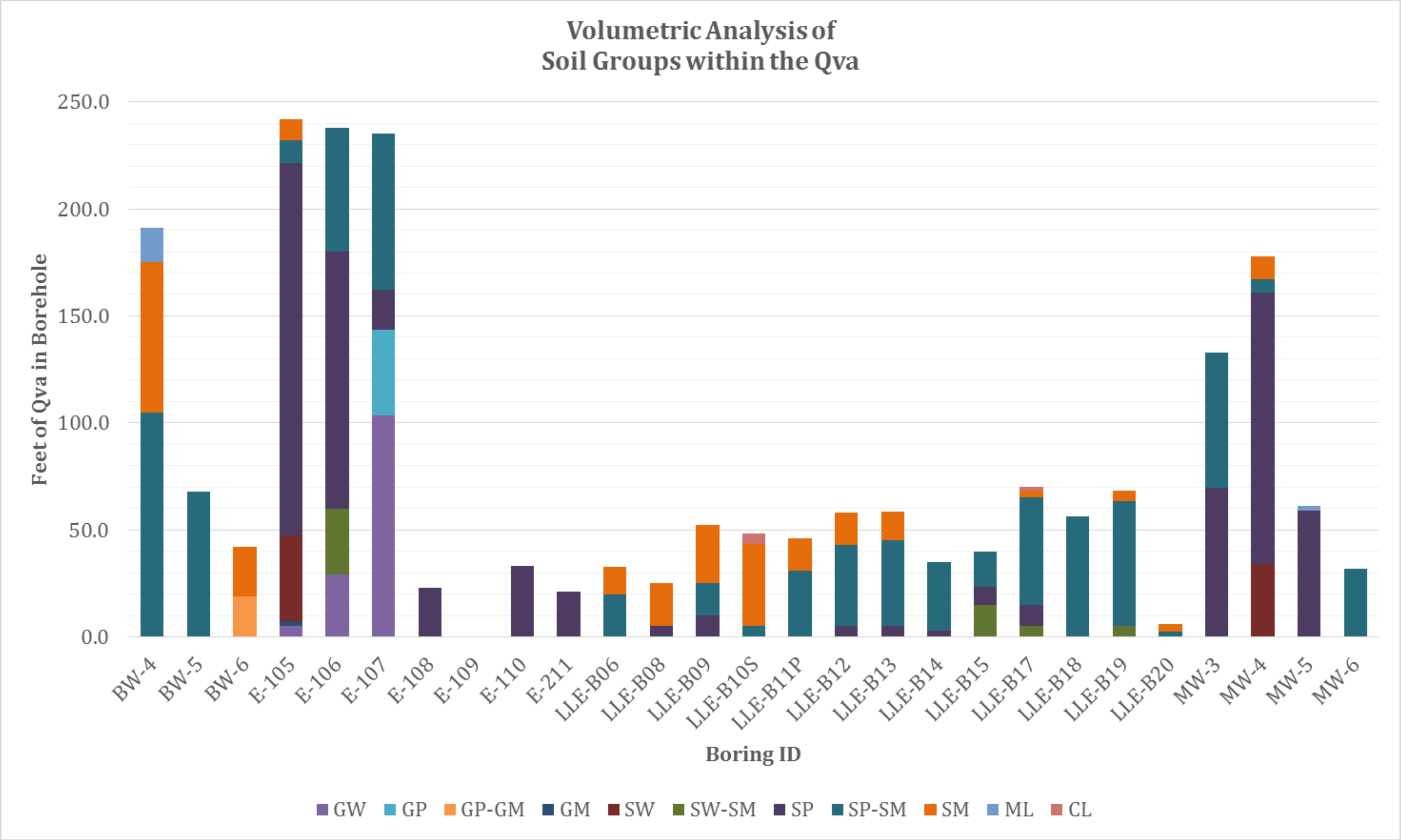
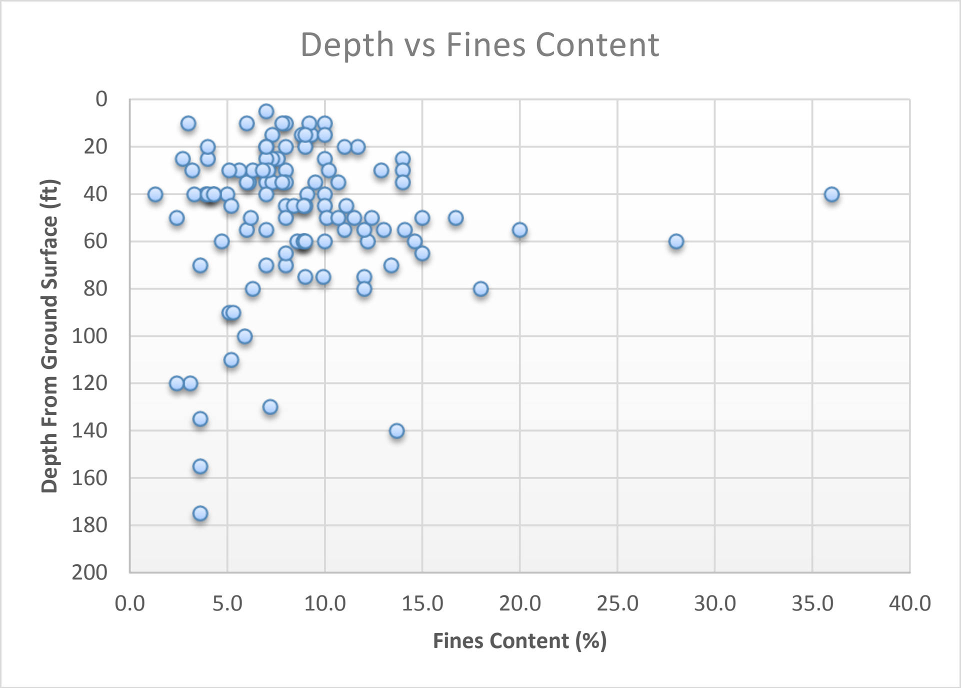


Figure 16B, Summary of Soil Classifications within the Qva. *This chart summarizes the percentages of the soil groups found within the Qva, as found in each borehole. Gravel comprises about 9.5% of the total volume of the Qva, sand about 89.3%, and silt/clay about 1.2%. The abbreviations are as listed: well-graded gravel (GW), poorly-graded gravel (GP), poorly-graded gravel with silt (GP-GM), silty gravel (GM), well-graded sand (SW), well-graded sand with silt (SW-SM), poorly-graded sand (SP), poorly-graded sand with silt (SP-SM), silty sand (SM), lean silt (ML), and lean clay (CL).*



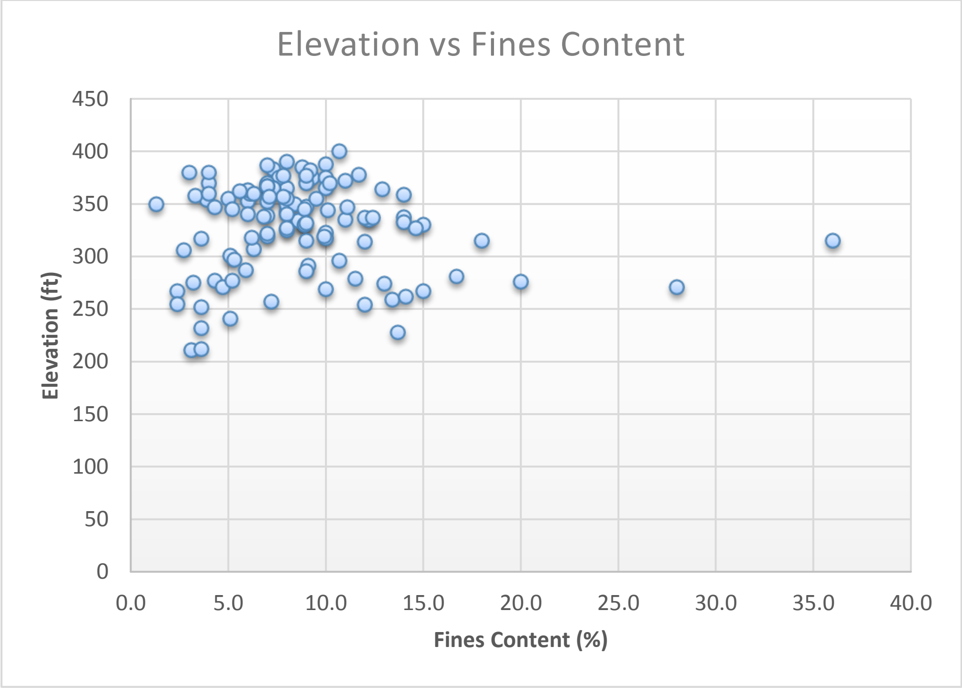
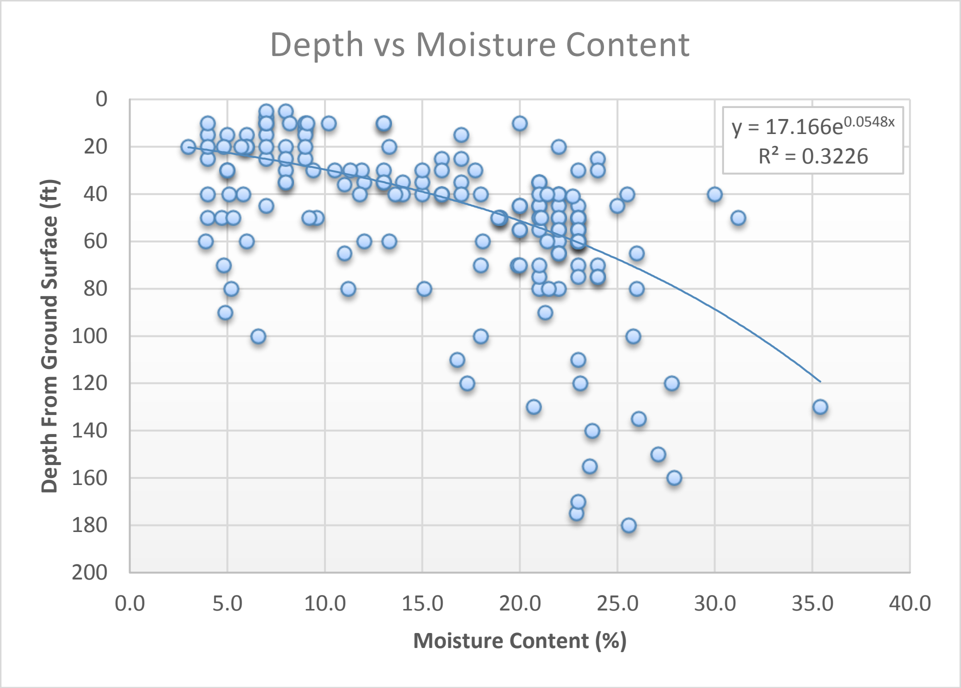


Figure 17, Depth and Elevation vs. Fines Content. *These figures show the relationship between depth and fines content (top), and elevation and fines content (bottom), in select samples from within the Qva.*



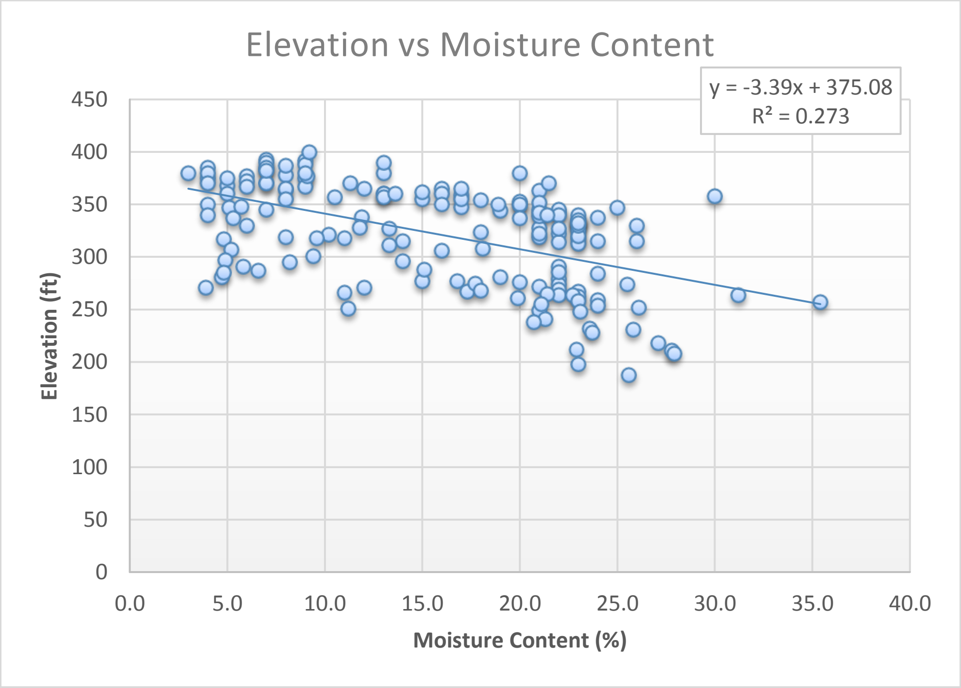


Figure 18, Depth and Elevation vs. Moisture Content. *These figures show the relationship between depth and moisture content (top), and elevation and moisture content (bottom), in select samples from within the Qva. In the top chart, I used an exponential regression curve to show the relationship between depth and moisture content. In the bottom chart, I used an order-two polynomial line to show the trend.*

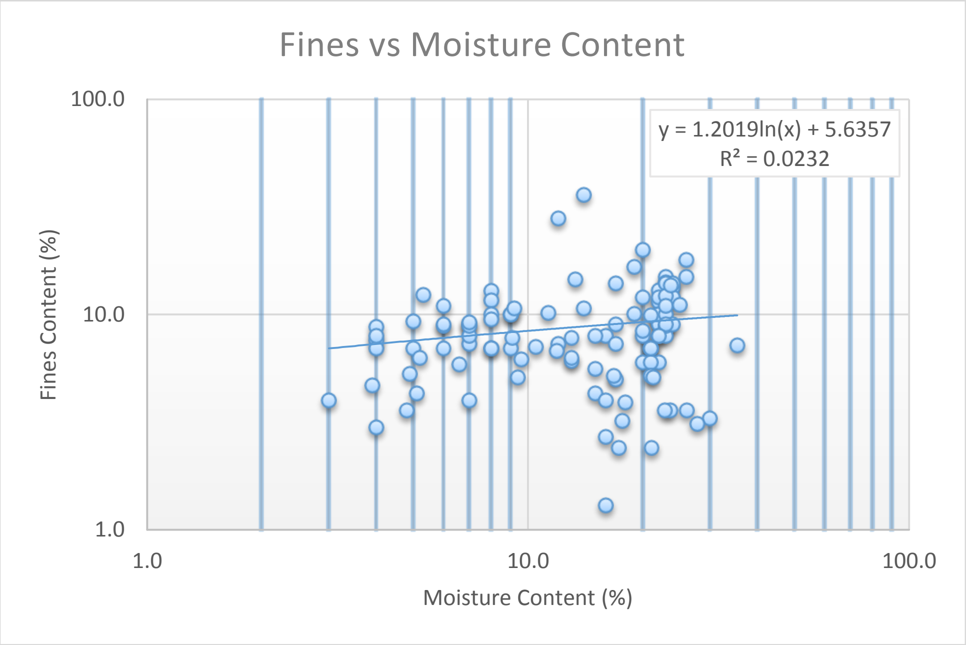


Figure 19, Fines Content vs Moisture Content. *This figure shows the relationship between fines content and moisture content in select samples from within the Qva. This chart is best viewed on a log-log scale. I used a logarithmic trend line to show the subtle relationship between fines content and moisture content.*

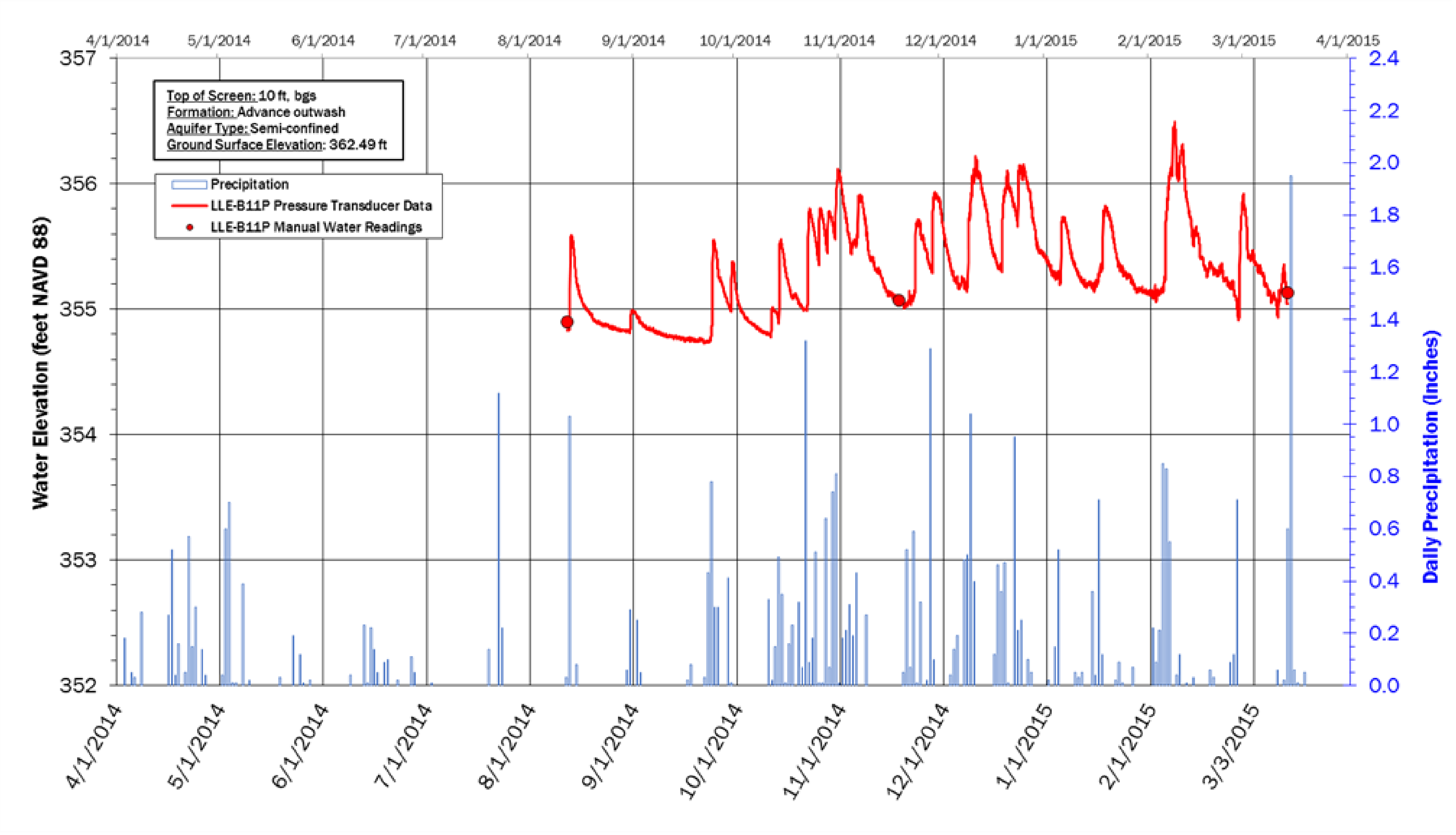


Figure 20, Groundwater Observations at Boring LLE-B11P. *Groundwater observations were recorded using a pressure transducer at a well that was installed at boring LLE-B11P. The well is positioned in the advance outwash, and the top of the screen is 10 ft bgs. The surface elevation is 362.49 ft at this location. The chart shows that the peak groundwater elevation at this location was recorded at 356.47 ft on February 08, 2015, and the minimum groundwater elevation was recorded at 354.74 ft on September 23, 2014. The groundwater elevation appears to increase following large precipitation events. (Image from GeoEngineers, 2015).*

13.0 Tables

Table 1, Summary of Geotechnical Borings. *This table is a summary of the existing geotechnical borings that were used in this study.*

Boring ID	Surface Elevation (NAVD88, ft)	Borehole Depth (ft)	Drilling Method	Qva Thickness (ft)	Contractor, Project (Year)
BW-4	368.0	366.4	Mud Rotary	191.0	Shannon & Wilson, Brightwater Project (2002)
BW-5	400.0	391.2	Mud Rotary	68.0	
BW-6	450.0	430.5	Mud Rotary	42.0	
E-105	452.7	535.0	Rotosonic Coring	242.0	CDM Smith and Subconsultants, Brightwater Project (2003)
E-106	485.6	566.0	Wireline	238.0	
E-107	453.2	548.0	Wireline/Mud Rotary	235.0	
E-108	356.8	346.0	Wireline Coring	23.0	
E-109	298.7	260.0	Wireline Coring	0.0	
E-110	348.4	438.0	Wireline Coring	33.0	
E-211	317.1	280.0	Wireline Coring	21.0	
LLE-B06	329.0	80.4	Mud Rotary	--	GeoEngineers, Inc., Sound Transit - LLE (2014)
LLE-B08	317.0	81.5	Hollow Stem Auger	25.0	
LLE-B09	331.0	81.5	Hollow Stem Auger	52.5	
LLE-B10S	354.0	81.5	Mud Rotary	--	
LLE-B11P	362.5	81.5	Mud Rotary	46.0	
LLE-B12	394.0	81.0	Hollow Stem Auger	--	
LLE-B13	395.0	81.5	Hollow Stem Auger	--	
LLE-B14	398.0	41.0	Hollow Stem Auger	--	
LLE-B15	400.0	41.5	Hollow Stem Auger	--	
LLE-B17	484.0	101.5	Hollow Stem Auger	70.0	
LLE-B18	390.0	61.0	Hollow Stem Auger	--	
LLE-B19	392.0	101.5	Hollow Stem Auger	68.5	
LLE-B20	432.0	41.5	Hollow Stem Auger	--	
MW-3	331.0	369.0	Becker Hammer	133.0	HWA Geosciences, Brightwater Project (2002)
MW-4	387.0	446.5	Becker Hammer	178.0	
MW-5	305.0	352.0	Becker Hammer	61.0	
MW-6	314.0	360.5	Becker Hammer	32.0	

Table 2, Geologic Contacts Database. *This table shows the location of each boring, and the elevation of the bottom of each geologic unit with respect to each boring. I terminated this study at an elevation of 100 ft, although not all borings reached this depth. Blank spaces in the table indicate the absence of a geologic unit within a boring. Notice the anomalous nature of boring E-109, which does not contain any deposits from the Vashon Stade, but instead shows that Qpn is observed in the first 71 ft of the boring.*

Boring ID	Northing	Easting	Surface Elevation (ft)	Qvr	Qvt	Qva	Qvlc	Qpg_1	Qpn_1	Qpnmw	Qpn_2	Qpg_2	Bottom Elevation (ft)
BW-4	292702.53	1270571.18	368			177	136	100					100
BW-5	292558.92	1275711.57	400			331		100					100
BW-6	292329.00	1280284.89	450		407	366		164	100				100
E-105	287350.73	1264077.49	453		438	196	193		100				100
E-106	287281.71	1266085.31	486		445	207			100				100
E-107	287286.32	1268070.00	454			214			100				100
E-108	287250.64	1270073.56	357	247		224			141	116	101	100	100
E-109	287168.00	1272288.00	299						228			100	100
E-110	286963.17	1274157.64	349		297	272			213			100	100
E-211	286326.37	1277098.94	317	295	274	253			164			100	100
LLE-B08	287645.34	1275729.20	317		279	254	236						236
LLE-B09	288336.35	1275804.25	331	318	308	256	250						250
LLE-B11P	289308.55	1276263.13	363			310	281						281
LLE-B17	290943.92	1275989.00	484			406	382						382
LLE-B19	291584.06	1275750.55	392			320	291						291
MW-3	292217.63	1264080.88	331			198	194	181	129			100	100
MW-4	287602.69	1264800.59	387			201	197		100				100
MW-5	287165.87	1271424.47	305			242	201					100	100
MW-6	287239.93	1276263.15	314	295	292	260			181			100	100

Table 3, Summary of the soil groups found within the Qva in each boring. *The abbreviations are as follows: well-graded gravel (GW), poorly-graded gravel (GP), poorly-graded gravel with silt (GP-GM), silty gravel (GM), well-graded sand (SW), well-graded sand with silt (SW-SM), poorly-graded sand (SP), poorly-graded sand with silt (SP-SM), silty sand (SM), lean silt (ML), and lean clay (CL).*

Boring ID	Qva Measured in Boring (ft)	GW	GP	GP-GM	GM	SW	SW-SM	SP	SP-SM	SM	ML	CL
BW-4	191.0	--	--	--	--	--	--	--	105.0	70.0	16.0	--
BW-5	68.0	--	--	--	--	--	--	--	68.0	--	--	--
BW-6	42.0	--	--	19.0	--	--	--	--	--	23.0	--	--
E-105	242.0	5.0	--	--	2.5	40.0	--	174.0	10.5	10.0	--	--
E-106	238.0	29.0	--	--	--	--	31.0	120.0	58.0	--	--	--
E-107	235.0	103.5	40.0	--	--	--	--	18.5	73.0	--	--	--
E-108	23.0	--	--	--	--	--	--	23.0	--	--	--	--
E-109	0.0	--	--	--	--	--	--	--	--	--	--	--
E-110	33.0	--	--	--	--	--	--	33.0	--	--	--	--
E-211	21.0	--	--	--	--	--	--	21.0	--	--	--	--
LLE-B06	32.5	--	--	--	--	--	--	--	20.0	12.5	--	--
LLE-B08	25.0	--	--	--	--	--	--	5.0	--	20.0	--	--
LLE-B09	52.5	--	--	--	--	--	--	10.0	15.0	27.5	--	--
LLE-B10S	48.5	--	--	--	--	--	--	--	5.0	38.5	--	5.0
LLE-B11P	46.0	--	--	--	--	--	--	--	31.0	15.0	--	--
LLE-B12	58.0	--	--	--	--	--	--	5.0	38.0	15.0	--	--
LLE-B13	58.5	--	--	--	--	--	--	5.0	40.0	13.5	--	--
LLE-B14	35.0	--	--	--	--	--	--	3.0	32.0	--	--	--
LLE-B15	40.0	--	--	--	--	--	15.0	8.5	16.5	--	--	--
LLE-B17	70.0	--	--	--	--	--	5.0	10.0	50.0	3.5	--	1.5
LLE-B18	56.5	--	--	--	--	--	--	--	56.5	--	--	--
LLE-B19	68.5	--	--	--	--	--	5.0	--	58.5	5.0	--	--
LLE-B20	6.0	--	--	--	--	--	--	--	2.5	3.5	--	--
MW-3	133.0	--	--	--	--	--	--	69.5	63.5	--	--	--
MW-4	178.0	--	--	--	--	34.0	--	127.0	6.0	11.0	--	--
MW-5	61.0	--	--	--	--	--	--	59.0	--	--	2.0	--
MW-6	32.0	--	--	--	--	--	--	--	32.0	--	--	--
Total Feet:	**2094.0**	**137.5**	**40.0**	**19.0**	**2.5**	**74.0**	**56.0**	**691.5**	**781.0**	**268.0**	**18.0**	**6.5**
Percent Total:	**100.0%**	**6.6%**	**1.9%**	**0.9%**	**0.1%**	**3.5%**	**2.7%**	**33.0%**	**37.3%**	**12.8%**	**0.9%**	**0.3%**

Table 4, Comparative Results. *This table summarizes the findings from this study, and compares them to published sources.*

Parameter with Respect to Qva	Findings From This Study	Published Data (Source)	Notes
Elevation Range (Qva Surface)	477-247 ft	400-600 ft (Troost and Booth, 2008)	General glacial stratigraphy
Unit Thickness	0 - 242 ft	>100 ft (Mullineaux, 1965); 50-200 ft (Golder Associates, 2008); 0-400 ft (Troost and Booth, 2008)	General glacial stratigraphy; As observed in the Mountlake Terrace area; General glacial stratigraphy
Relative Density	dense to very dense	dense to very dense (Galster and Laprade, 1991)	General glacial stratigraphy
Friction Angle	N/A	30-40° (Koloski, *et al* , 1989); About 32° (Miller, 1989)	General glacial outwash properties; General glacial outwash properties
Cohesion	N/A	0-1000 psf (Koloski, *et al* , 1989)	General glacial outwash properties
Dry Density	N/A	115-130 pcf (Koloski, *et al* , 1989); 110 pcf (Miller, 1989)	General glacial outwash properties; General Qva properties
Wet Density	N/A	120 pcf (Miller, 1989)	General Qva properties
Relative Erodability	N/A	Low-Medium (Koloski, *et al* , 1989)	General glacial outwash properties
Excavation Difficulty	N/A	Low-Medium (Koloski, *et al* , 1989); Easy (Laprade and Robinson, 1989)	General glacial outwash properties; General glacial outwash properties
Moisture Sensitivity	N/A	Low-Medium (Koloski, *et al* , 1989)	General glacial outwash properties
Foundation Support	N/A	1500-3000 psf (Koloski, *et al* , 1989)	General glacial outwash properties
Cut Slopes	N/A	50-70% (Koloski, *et al* , 1989)	General glacial outwash properties
Aquifer Depth	7.59-221.3 ft bgs	20-70 ft bgs (King County, 2002)	General depth to saturated soils along Brightwater alignment
Saturated Thickness	0-102.13 ft	10-100 ft (Golder Associates, 2008)	Aquifer thickness in the Mountlake Terrace area during a 2008 study
Mean Hydraulic Conductivity	15.93 ft/day	40 ft/d (Golder Associates, 2008) 0.33-328 ft/d (Galster and Laprade, 1991)	As measured in the Mountlake Terrace area; General Qva properties
Groundwater Recharge Rate	N/A	15-20 in/yr where Qva exposed and <10 in/yr where Qva is capped by till or pavement (Golder Associates, 2008)	Recharge rate in the Mountlake Terrace area during a 2008 study
Permeability	N/A	0.01-10 ft/min (Koloski, *et al* , 1989) 0.0001-0.2 ft/min (Laprade and Robinson, 1989)	General glacial outwash properties

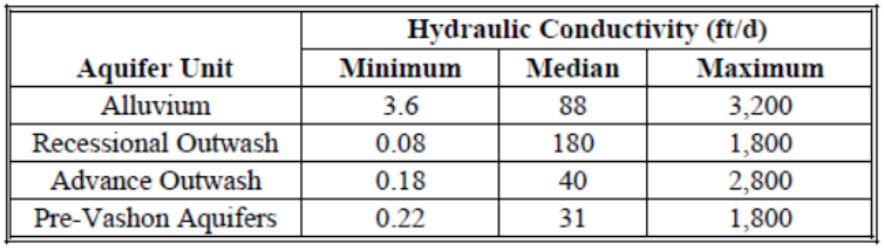
14.0 Appendices

Appendix A

Summary of Hydraulic Conductivity Data for Glacial Sediments and Conceptual Hydrogeologic Model (Adapted from Golder Associates, 2008)

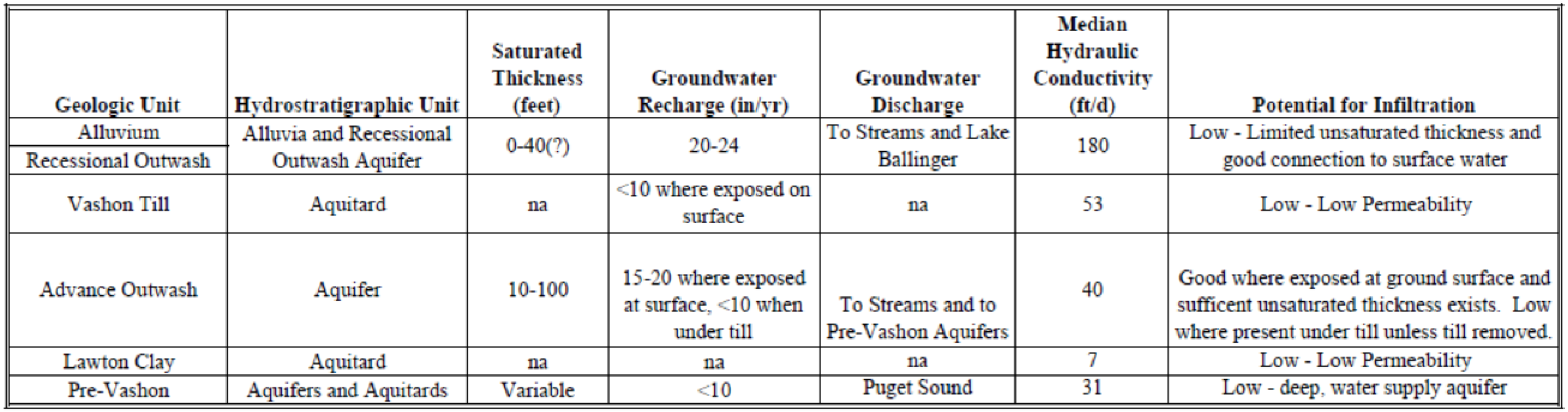
Appendix A, Summary of Hydraulic Conductivity Data for Glacial Sediments and Conceptual Hydrogeologic Model. *(From Golder Associates, 2008)*

Summary of Hydraulic Conductivity Data for Glacial Sediments



Aquifer Unit	**Hydraulic Conductivity (ft/d)**		
	Minimum	**Median**	**Maximum**
Alluvium	3.6	88	3,200
Recessional Outwash	0.08	180	1,800
Advance Outwash	0.18	40	2,800
Pre-Vashon Aquifers	0.22	31	1,800

Conceptual Hydrogeologic Model



Geologic Unit	**Hydrostratigraphic Unit**	**Saturated Thickness (feet)**	**Groundwater Recharge (in/yr)**	**Groundwater Discharge**	**Median Hydraulic Conductivity (ft/d)**	**Potential for Infiltration**
Alluvium Recessional Outwash	Alluvia and Recessional Outwash Aquifer	0-40(?)	20-24	To Streams and Lake Ballinger	180	Low - Limited unsaturated thickness and good connection to surface water
Vashon Till	Aquitard	na	<10 where exposed on surface	na	53	Low - Low Permeability
Advance Outwash	Aquifer	10-100	15-20 where exposed at surface, <10 when under till	To Streams and to Pre-Vashon Aquifers	40	Good where exposed at ground surface and sufficent unsaturated thickness exists. Low where present under till unless till removed.
Lawton Clay	Aquitard	na	na	na	7	Low - Low Permeability
Pre-Vashon	Aquifers and Aquitards	Variable	<10	Puget Sound	31	Low - deep, water supply aquifer

Appendix B

Geotechnical Boring Logs

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 3

Sheet 1 of 7

Date(s) Drilled	1/3/02 - 1/7/02	Geotechnical Consultant	HWA GeoSciences Inc.	Logged By	BKH, BWT	Checked By	MLR/SEG
Drilling Method/ Rig Type	Becker Hammer/ Truck	Drilling Contractor	Layne Christensen Company	Total Depth of Borehole	369.0 feet		
Drill Bit Size/Type	Dual Wall Reverse Circ.	Hammer Weight/Drop (lbs/in.)	300#, 30"	Ground Surface Elevation/Datum	331 feet / NAVD88		
Location	On Edmonds Way.	Coordinates	N. 47.79084 W. 122.36443	Elevation Source	Plan		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0						SP-SM	Brown, silty, fine to coarse gravelly, slightly silty fine to medium SAND, moist. (WEATHERED GLACIAL FLUVIAL, Qva)				
330												
	5											
	10	■	S-1	10 - 11 - 15 (26)	100		SP	Medium dense to very dense, yellowish brown to olive gray, slightly silty, fine to coarse gravelly, SAND, moist. (GLACIAL FLUVIAL, Qva)		M	10.2	
320												
	15											
	20	■	S-2	9 - 9 - 17 (26)	100					M	13.3	
310												
	25											
	30	■	S-3	4 - 13 - 14 (27)	100					M SA	9.4	
300												
	35											
	40	■	S-4	9 - 23 - 27 (50)	100					M	5.8	
290												
	45											
	50	■		5 - 7 - 4						M	4.7	

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Figure: A-4.1

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 3

Sheet 2 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	50	■	S-5	(11)	100							
280												
	55											
	60	■	S-6	5 - 16 - 23 (39)	100					M SA	3.9	
270												
	65											
	70	■	S-7	7 - 12 - 36 (48)	100		SP	Dense, grayish brown, gravelly, fine to coarse SAND, wet.		M	19.9	
260												
	75											
		✋	S-8				SP- SM	Dense, brown, slightly silty to clean, slightly gravelly, SAND, wet. Sand is fine to medium. Gravels are fine to coarse.		M	11.2	
	80											
250												
	85											
		✋	S-9							M SA	21.3	
	90											
240												
	95											
		✋	S-10							M	25.8	
	100											
230												
	105											

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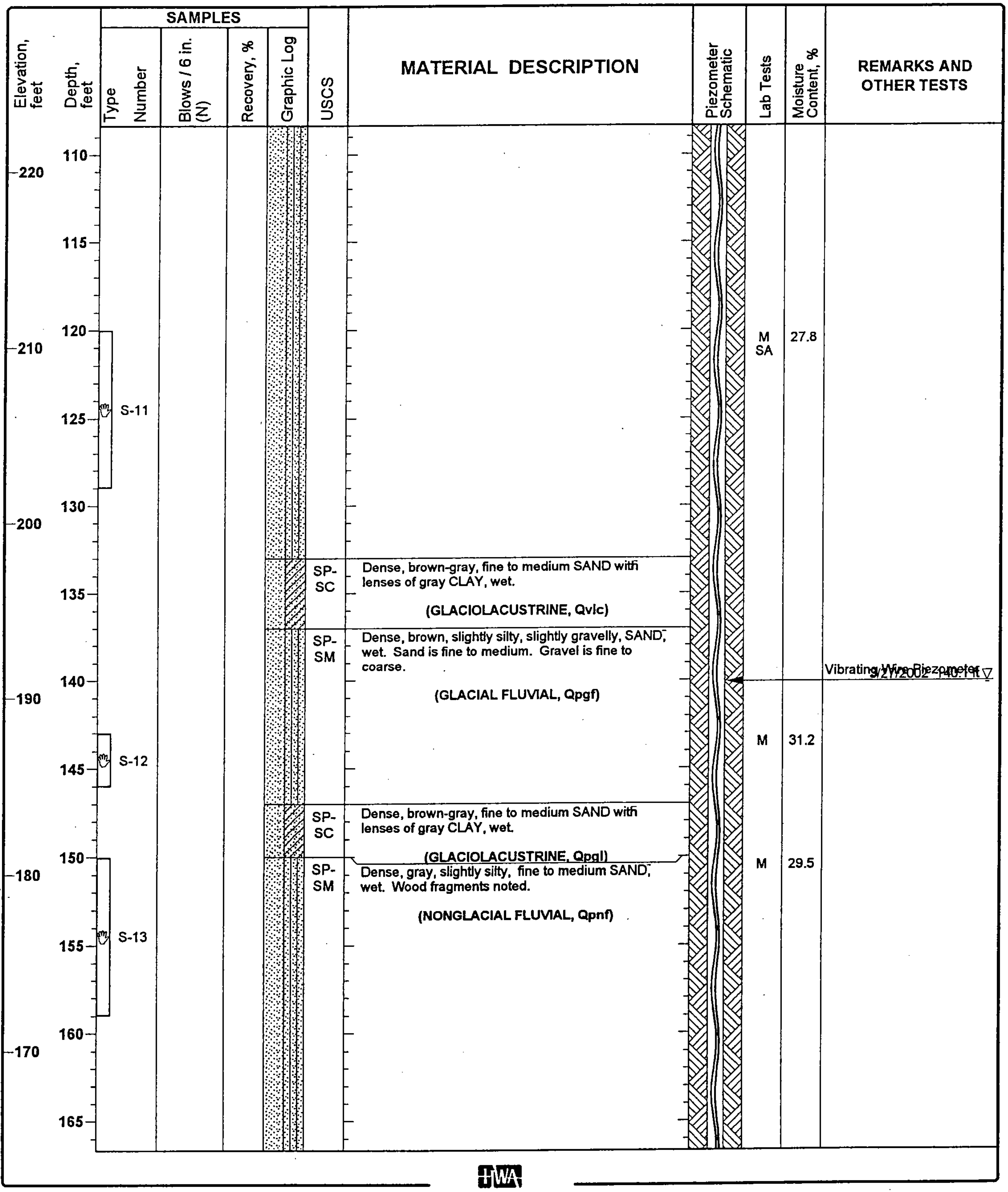
Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 3

Sheet 3 of 7



Number	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
S-11			M SA	27.8	
	SP-SC	Dense, brown-gray, fine to medium SAND with lenses of gray CLAY, wet. (GLACIOLACUSTRINE, Qvlc)			
	SP-SM	Dense, brown, slightly silty, slightly gravelly, SAND, wet. Sand is fine to medium. Gravel is fine to coarse. (GLACIAL FLUVIAL, Qpgf)			Vibrating Wire Piezometer 3/27/2002 140.1 ft ▽
S-12			M	31.2	
	SP-SC	Dense, brown-gray, fine to medium SAND with lenses of gray CLAY, wet. (GLACIOLACUSTRINE, Qpgl)			
S-13	SP-SM	Dense, gray, slightly silty, fine to medium SAND, wet. Wood fragments noted. (NONGLACIAL FLUVIAL, Qpnf)	M	29.5	

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Figure: A-4.3

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 3

Sheet 4 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
160	170					SP-SM	Dense, gray, slightly silty, fine SAND, wet.	M	33.2	
	175	✋	S-14							
150	180							M SA	39.1	
	185	✋	S-15			SP-SC	Dense, gray, slightly silty, fine SAND, wet with lenses of gray, clay. Wood chunks noted.			
						SP-SM	Dense, gray, slightly silty fine SAND, wet. Wood fragments noted.			
140	190									
	195									
130	200									
						CL-ML	Hard, gray, silty CLAY, wet. (GLACIOLACUSTRINE, Qpgl)	M	37.5	
	205	✋	S-16							
						CL	Hard, dark gray, CLAY, moist.			
120	210	■	S-17	8 - 14 - 23 (37)	100	CL-ML	Hard gray, SILT and CLAY, moist. Several thin interbedded fine SAND lenses.	M SA AL HA	23.1	
	215									
110	220	■	S-18	12 - 12 - 20 (32)	100			M SA HA	29.3	
	225									

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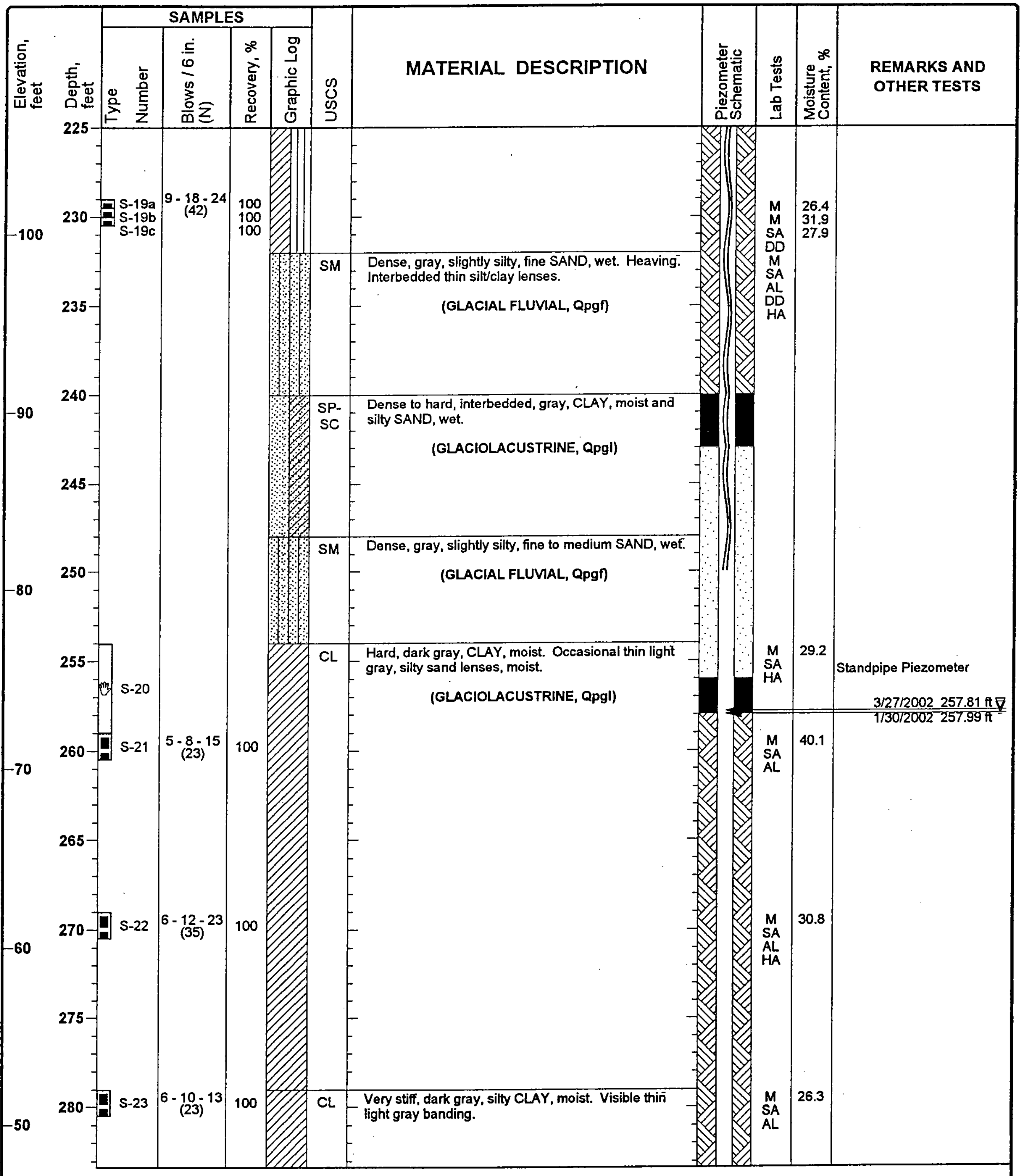
HWA GEOSCIENCES INC.

Figure: A-4.4

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 3

Sheet 5 of 7



Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	225									
-100	230	▦	S-19a S-19b S-19c	9 - 18 - 24 (42)	100 100 100			M M SA DD M SA AL DD HA	26.4 31.9 27.9	
	232					SM	Dense, gray, slightly silty, fine SAND, wet. Heaving. Interbedded thin silt/clay lenses. (GLACIAL FLUVIAL, Qpgf)			
-90	240					SP-SC	Dense to hard, interbedded, gray, CLAY, moist and silty SAND, wet. (GLACIOLACUSTRINE, Qpgl)			
-80	248					SM	Dense, gray, slightly silty, fine to medium SAND, wet. (GLACIAL FLUVIAL, Qpgf)			
	254					CL	Hard, dark gray, CLAY, moist. Occasional thin light gray, silty sand lenses, moist. (GLACIOLACUSTRINE, Qpgl)	M SA HA	29.2	Standpipe Piezometer
	256	☐	S-20							3/27/2002 257.81 ft ▽ 1/30/2002 257.99 ft
-70	260	▦	S-21	5 - 8 - 15 (23)	100			M SA AL	40.1	
-60	270	▦	S-22	6 - 12 - 23 (35)	100			M SA AL HA	30.8	
-50	280	▦	S-23	6 - 10 - 13 (23)	100	CL	Very stiff, dark gray, silty CLAY, moist. Visible thin light gray banding.	M SA AL	26.3	

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HWA GEOSCIENCES INC

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 3

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	285		S-24	6 - 9 - 12 (21)	100					M SA	27.7	
40	290		S-25	8 - 11 - 14 (25)	100					M SA AL HA	24.9	
	295		S-26a S-26b S-26c	8 - 18 - 36 (54)	100 100 100		SP-SM	Very dense, dark gray, slightly silty to silty, fine to medium SAND, wet. Heaving. (GLACIAL FLUVIAL, Qpgf) From 298 to 299, SILT present.		M SA M SA DS	18.6 23.1 25.2	
30	300		S-27	4 - 15 - 37 (52)	100					DD HA M M SA	22.8	
	305		S-28	0 - 0 - 0 (0)	100					M SA	25.8	
20	310		S-29	5 - 11 - 15 (26)	100		SP-SM	Medium dense, dark gray, slightly silty to clean, fine to medium SAND, wet. Heaving.		M SA	21.6	
	315		S-30	5 - 10 - 20 (30)	100					M	27.4	
10	320											
	325		S-31				SP	Medium dense, dark gray, clean, fine to coarse SAND, wet.		M	27.9	
			S-32							M SA	23.8	
0	330											
	335		S-33 S-34a S-34b S-34c S-34d S-35 S-36	12 - 16 - 32 (48)	100 100 100 100		CL SP-SM	Hard, dark olive gray to gray CLAY with fine sand lenses, moist. (NONGLACIAL LACUSTRINE, Qpnl) Dense, gray, clean to slightly silty, fine to medium SAND, wet. <<(NONGLACIAL FLUVIAL, Qpnf)		M M SA AL HA M SA M SA	23.7 20.8 22.2 24.5 23.2 25.5 25.9	
-10	340											

HWA GEOSCIENCES INC

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 3

Sheet 7 of 7

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
										AL M SA HA M M		
	345											
			S-37							M SA	26.2	
	350											
-20							OL	Hard, brown, SILT with chunks of compressed PEAT, wet. (OLDER PEAT, Qpnp)				
			S-38							M SA	37.2	
	355		S-39a	70	100					AL HA	30.4	
			S-39b		100					M	31.0	
			S-39c		100					SA	29.1	
			S-40				SP-SM	Medium dense, gray, clean to slightly silty, fine to medium SAND, wet. Occasional piece of decomposed wood. (NONGLACIAL FLUVIAL, Qpnf)		AL HA M SA M SA M SA	25.3	
	360											
-30												
			S-41							M	32.4	
	365							Encountered large piece of wood that appears to be driftwood.				
			S-42									
	370											
-40								Bottom of boring at 369 feet. 2" piezometer installed from 295 to 315 feet. Vibrating wire piezometer installed at 250 feet.				
	375											
	380											
-50												
	385											
	390											
-60												
	395											
	400											

HWA GEOSCIENCES INC.

Figure: A-4.7

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 3	S-1	9.0 - 10.5	10.2													SP-SM	yellowish-brown, poorly graded SAND with silt and gravel
MW- 3	S-2	19.0 - 20.5	13.3													SM	yellowish-brown, silty SAND with gravel
MW- 3	S-3	29.0 - 30.5	9.4									1.1	93.7	5.1		SP-SM	grayish-brown, poorly graded SAND with silt
MW- 3	S-4	39.0 - 40.5	5.8													SP	grayish-brown, poorly graded SAND with gravel
MW- 3	S-5	49.0 - 50.5	4.7													SP	grayish-brown, poorly graded SAND
MW- 3	S-6	59.0 - 60.5	3.9									6.3	89.0	4.7		SP	grayish-brown, poorly graded SAND
MW- 3	S-7	69.0 - 70.5	19.9													SP	dk. grayish-brown, poorly graded SAND
MW- 3	S-8	77.0 - 79.0	11.2													SP-SM	dk. grayish-brown, poorly graded SAND with silt
MW- 3	S-9	87.0 - 89.0	21.3									8.3	86.7	5.1		SP-SM	olive-brown, poorly graded SAND with silt
MW- 3	S-10	97.0 - 99.0	25.8													SP-SM	dk. grayish-brown, poorly graded SAND with silt
MW- 3	S-11	120.0 - 129.0	27.8									7.6	89.3	3.1		SP	grayish-brown, poorly graded SAND
MW- 3	S-12	143.0 - 146.0	31.2													SP-SM	dk. grayish-brown, poorly graded SAND with silt
MW- 3	S-13	150.0 - 159.0	29.5													SP-SM	gray, poorly graded SAND with silt
MW- 3	S-14	170.0 - 180.0	33.2													SP-SM	gray, poorly graded SAND with silt
MW- 3	S-15	180.0 - 190.0	39.1									0.1	7.7	92.1		CL	gray, lean CLAY
MW- 3	S-16	202.0 - 208.0	37.5													CL-ML	gray, silty lean CLAY
MW- 3	S-17	209.0 - 210.5	23.1							40	23		0.2	99.8		CL	gray, lean CLAY
MW- 3	S-18	219.0 - 220.5	29.3										1.5	98.5		CL	gray, lean CLAY
MW- 3	S-19a	229.0 - 229.5	26.4													SM	gray, silty SAND
MW- 3	S-19b	229.5 - 230.0	31.9	122.2	92.6									95.4		CL-ML	gray, silty CLAY

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF MATERIAL PROPERTIES

PAGE: 1 of 3

PROJECT NO.: 99153-490

FIGURE: A-4.21

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 3	S-19c	230.0 - 230.5	27.9	120.4	94.1					39	20		20.7	79.3	3.6	CL	gray, lean CLAY with sand
MW- 3	S-20	254.0 - 259.0	29.2										6.9	93.1		CL	gray, lean CLAY
MW- 3	S-21	259.0 - 260.5	40.1							84	30			99.7		CH	gray, fat CLAY
MW- 3	S-22	269.0 - 270.5	30.8			644				68	26		5.3	94.7	7	CH	gray, fat CLAY
MW- 3	S-23	279.0 - 280.5	26.3							42	21			99.9		CL	gray, lean CLAY
MW- 3	S-24	285.0 - 286.5	27.7											100.0		CL	gray, lean CLAY
MW- 3	S-25	289.0 - 290.5	24.9							45	26		0.0	100.0	5.4	CL	gray, lean CLAY
MW- 3	S-26a	295.0 - 295.5	18.6													SP-SM	dark gray, poorly graded SAND with silt
MW- 3	S-26b	295.5 - 296.0	23.1	131.8	107.1			10	39.8				37.6	62.4		ML	gray, SILT, sand lenses
MW- 3	S-26c	296.0 - 296.5	25.2													SP-SM	dark gray, poorly graded SAND with silt
MW- 3	S-27	299.0 - 300.5	22.8									0.0	85.2	14.7		SM	gray, silty SAND
MW- 3	S-28	305.0 - 306.5	25.8											35.9		SM	gray, silty SAND
MW- 3	S-29	309.0 - 310.5	21.6											9.8		SP-SM	dark gray, poorly graded SAND with silt
MW- 3	S-30	314.0 - 315.0	27.4													SP-SM	dark gray, poorly graded SAND with silt
MW- 3	S-31	325.0 - 326.0	27.9													SP-SM	gray, poorly graded SAND with silt
MW- 3	S-32	328.0 - 329.0	23.8									0.8	97.5	1.8		SP	dark gray, poorly graded SAND
MW- 3	S-33	334.0 - 335.0	23.7													CL	dark olive gray, lean CLAY, sand layers
MW- 3	S-34a	335.0 - 335.5	20.8							40	22			97.8	5	CL	gray, lean CLAY
MW- 3	S-34b	335.5 - 336.0	22.2										3.0	97.0		CL	olive gray, lean CLAY
MW- 3	S-34c	336.0 - 336.5	24.5							29	26			97.6		ML	gray, SILT, interbedded with lean CLAY

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF
MATERIAL PROPERTIES

PAGE: 2 of 3

PROJECT NO.: 99153-490

FIGURE: A-4.22

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 3	S-34d	336.5 - 337.0	23.2			472							1.3	98.7	2.3	ML	dark olive-gray, SILT
MW- 3	S-35	337.0 - 337.5	25.5													CL	olive gray, lean CLAY, sand layers
MW- 3	S-36	338.0 - 339.0	25.9													SP-SM	olive gray, poorly graded SAND with silt
MW- 3	S-37	347.0 - 348.0	26.2										92.3	7.7		SP-SM	gray, poorly graded SAND with silt
MW- 3	S-38	353.0 - 355.0	37.2							41	30		5.8	94.2	8.2	ML	olive-gray, SILT
MW- 3	S-39a	355.0 - 355.5	30.4							35	30		7.1	92.9	9.2	ML	olive gray, SILT
MW- 3	S-39b	355.5 - 356.0	31.0											91.6	2.8	ML	olive-gray, SILT
MW- 3	S-39c	356.0 - 356.5	29.1											97.8		ML	olive-gray, SILT
MW- 3	S-40	358.0 - 359.0	25.3									0.3	88.8	10.9		SP-SM	gray, poorly graded SAND with silt
MW- 3	S-41	364.0 - 365.0	32.4													SP-SM	olive gray, poorly graded SAND with silt, wood pieces
MW- 3	S-42	367.5 - 369.0															

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF
MATERIAL PROPERTIES

PAGE: 3 of 3

PROJECT NO.: 99153-490 FIGURE: A-4.23

Project: CSI Brightwater	**Log of Boring MW- 4**
Project Location: King and Snohomish Counties	Sheet 1 of 8
Contract Number: E83004E	

Date(s) Drilled	1/25/02 - 2/1/02	Geotechnical Consultant	HWA GeoSciences Inc.	Logged By	BKH	Checked By	MLR/SEG
Drilling Method/ Rig Type	Becker Hammer/ Truck	Drilling Contractor	Layne Christensen Company			Total Depth of Borehole	446.5 feet
Drill Bit Size/Type	Dual Wall Reverse Circ.	Hammer Weight/Drop (lbs/in.)	300#, 30"			Ground Surface Elevation/Datum	387 feet / NAVD88
Location	Firdale Village	Coordinates	N. 47.77823	W. 122.36113		Elevation Source	Plan

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0					SM	Brown, silty, fine to coarse gravelly, fine to medium SAND, moist. Cobbles present and ocasional gravel lenses.			
	5									
380										
						SM	Dense, olive brown, slightly silty, fine to coarse gravelly, fine to medium SAND, moist. A lense of coarse sandy gravel is present at the bottom of the sample. (GLACIAL FLUVIAL, Qva)			
	10	■	S-1	10 - 12 - 28 (40)	100			M SA	9.1	
	15									
370										
	20	■	S-2	19 - 24 - 21 (45)	100	SW	Dense, olive brown, clean to slightly silty, fine to coarse gravelly, fine to coarse SAND to fine to coarse sandy, fine to coarse GRAVEL, moist.	M SA	6.0	
	25									
360										
	30	■	S-3	8 - 12 - 22 (34)	100	SP-SM	Dense, olive brown, slightly silty, fine to coarse gravelly, fine to medium SAND, moist. Lenses of silty SAND are present.	M SA	10.5	
	35					SW	Dense, brown, slightly fine gravelly, fine to coarse, clean SAND, moist.			
350										
	40	■	S-4	10 - 21 - 26 (47)	100			M SA	5.1	
	45									
340										
		■		13 - 44 -				M	5.3	
	50									

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Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 4

Sheet 2 of 8

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	50	▬	S-5	28 (72)	100		SW	Very dense, grayish brown, silty, fine to medium SAND, moist. Large gravel/cobble present in middle of sampler.		SA		
	55											
330												
	60	▐	S-6	22 - 24 - 23 (47)	100		SP	Dense, brownish gray, slightly fine to coarse gravelly, fine to medium SAND, moist. Some coarse sand present. A large fractured cobble is present in the middle of the sampler. The bottom 3 inches of the sample becomes fine sand.		M SA	13.3	
	65											
320												
	70	▐	S-7	13 - 28 - 35 (63)	100		SP	Very dense, brownish gray, fine to medium SAND, moist.		M SA	4.8	
	75											
310												
	80	▐	S-8	8 - 13 - 8 (21)	100		SP	Medium dense, grayish brown, fine to medium SAND, moist.		M SA	5.2	
	85											
300												
	90	▐	S-9	9 - 19 - 24 (43)	100		SP	Dense, grayish brown, slightly fine gravelly, fine to medium SAND, moist.		M SA	4.9	
	95											
290												
	100	▐	S-10	18 - 36 - 50/6 (100+)	100		SP	Very dense, grayish brown, slightly fine gravelly, fine to medium SAND, moist to wet.		M SA	6.6	
	105											Vibrating Wire Piezometer
280												3/27/2002 106.8 ft ▽

HWA GEOSCIENCES INC.

Figure: A-5.2

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 4

Sheet 3 of 8

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	110	■	S-11	9 - 30 - 50/5 (100+)	100	SP	Very dense, grayish brown, fine to medium SAND, wet. Bottom 3 inches of sample was fine to coarse SAND, wet.	M SA	16.8	
	115									
270										
	120	■	S-12	4 - 24 - 50/5 (100+)	100	SP	Very dense, brown, slighty fine gravelly, fine to coarse SAND, wet. 3 feet of heave present at 119 feet.	M SA	17.3	
	125						Cuttings: fine to coarse gravelly, fine to coarse SAND, wet.			
260										
	130		S-13			SP	5 feet of heave present at 129 feet. No sample taken.	M SA	35.4	
	135	✋	S-14			SP	Brown, slightly fine gravelly, fine to medium SAND, wet.	M SA	26.1	
250										
	140									
							Cuttings: Brown, slightly fine to coarse gravelly, fine to medium SAND, wet.			
	145									
240										
	150					SP	Cuttings: Gray, slightly fine to coarse gravelly, fine to medium SAND, wet. Organics, including wood, and some coarse sand present.			
	155						Cuttings: Gray, slightly fine to coarse gravelly, fine to coarse SAND, wet. Wood pieces present.	M SA	23.6	
230		✋	S-15							
	160									
	165						Cuttings: Same as above - gray SAND, wet.			

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 4

Sheet 4 of 8

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
220												
	170							Cuttings: Gray, slightly fine to coarse gravelly, fine to medium SAND, wet.		M SA	22.9	
	175	✋	S-16									
210												
	180											
	185											
200							ML	Hard, dark gray, fine sandy, SILT, moist. (GLACIOLACUSTRINE, Qvlc)				
	190	■ ■	S-17a S-17b	8 - 22 - 28 (50)	100 100		SP-SM	Very dense, dark gray, slightly silty to silty, fine SAND, wet. (NONGLACIAL FLUVIAL, Qpnf)		M SA HA M SA	21.4 23.5	
	195							Cuttings: Gray, fine to medium SAND, wet. Pieces of wood present.				
190												
	200											
	205							Cuttings: Dark gray, slightly silty to silty, fine to medium SAND, wet.		M SA	28.3	
180		✋	S-18									
	210							Cuttings: Dark gray, slightly silty to silty, fine SAND, wet.		M SA	34.4	
	215	✋	S-19									
170												
	220							Cuttings: Similar as above - silty fine SAND, wet.				
	225											

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 4

Sheet 5 of 8

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	225											
-160		■	S-20	2 - 13 - 28 (41)	100			Dark gray, slightly silty, fine SAND, wet. Organics, including wood fragments, present.		M SA	26.5	
							ML	Hard, dark gray, fine sandy, SILT, moist. Lenses of organics present.				
	230							(NONGLACIAL LACUSTRINE, Qpnl)				
								Cuttings: Silty SAND to sandy SILT. Some organics present.				
	235											
-150												
							CL	Hard, dark gray, fat CLAY, moist.				
	240	■	S-21	9 - 18 - 30 (48)	100					M SA AL	24.2	
	245							Cuttings: hard, dark gray, CLAY with light gray seams.				
-140												
	250	■ ■	S-22a S-22b	9 - 13 - 28 (41)	93 133			Hard, dark gray, CLAY, moist.		M SA AL HA M SA	27.7 27.5	
							ML	Dense, dark gray, fine sandy SILT, moist to wet.				
							CL	Light gray seams and fine sandy clay lenses present.				
	255											
-130												
	260	■	S-23	5 - 10 - 34 (44)	100			Cuttings: Clay with sand and silt lenses.		M SA HA	29.7	
	265							Cuttings: Hard, dark gray, lean to fat CLAY, moist. Light gray seams present.				
-120												
	270	■	S-24	10 - 13 - 18 (31)	100			Hard, dark gray, lean CLAY, moist. Light gray seams present.		M AL	21.9	
								Cuttings are silty SAND, wet between 273 and 276 feet.				
	275											
-110												
	280	■ ■ ■	S-25a S-25b S-25c	8 - 8 - 12 (20)	100 100 100		CL SM ML SM	Very stiff, dark gray, CLAY, moist. Medium dense, dark gray, silty fine SAND, wet. Very stiff, dark gray, fine sandy SILT, moist to wet. Dark gray, SILT, wet.		M SA AL HA M	31.0 27.7 30.6	

HWA GEOSCIENCES INC.

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 4

Sheet 6 of 8

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
							CL	Hard, dark gray, lean CLAY, moist.		SA M SA		
	285											
100												
	290		S-26	8 - 12 - 18 (30)	100					M SA AL HA	22.7	
	295											
90												
	300		S-27	7 - 11 - 21 (32)	100		SM	Dense, dark gray, slightly silty, fine SAND, wet.		M	25.1	
								Cuttings: Dark gray, silty SAND, wet.				
	305						CL-ML	Hard, dark gray, lean to fat CLAY, moist.				
80												
	310		S-28	9 - 12 - 18 (30)	100					M SA AL HA	22.8	Standpipe Piezometer
												▽
												1/5/2002 314 ft ▽
	315							At 315, cuttings contain a thin lens of hard, greenish gray, laminated CLAY, moist. The Lens is very brittle.				
70												
	320		S-29	8 - 10 - 16 (26)	100			Very stiff, dark gray, CLAY, moist. Light gray seams present.		M	32.7	
	325		S-30	7 - 12 - 16 (28)	100			Very stiff, dark gray, CLAY, moist. Light gray seams present.		M SA AL HA	25.7	
60												
	330		S-31	8 - 18 - 40 (58)	100		ML	Very dense, dark gray, fine sandy SILT to silty fine SAND, wet.		M SA	45.7	
			S-32							M	33.7	
							CL	Very stiff, dark gray, lean CLAY, moist. Light gray seams present. At the top of the clay was a thin, hard, silt lens. The lens was about 1 mm thick and contained organics.				
	335		S-33	8 - 11 - 18 (29)	100					M SA AL HA	26.0	
50												
	340		S-34	9 - 13 - 18 (31)	100					M	26.4	

HWA GEOSCIENCES INC.

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 4

Sheet 7 of 8

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
							SP-SM	Dense, dark gray, silty fine SAND, wet.				
40	345		S-35a S-35b	4 - 11 - 22 (33)	100 100		ML	Hard, dark gray, SILT to fine sandy SILT, moist to wet.		M SA M SA HA	28.8 28.1	
	350		S-36	3 - 11 - 20 (31)	100		ML	Dense to hard, dark gray, silty fine SAND to sandy SILT, wet.		M SA	28.1	
	355		S-37a	5 - 13 - 23 (36)	93		SM	Dense, dark gray, silty fine SAND, wet. Lenses of organics present.		M SA	24.3	
30			S-37b		133		CL	Hard, dark gray, lean CLAY, moist.		M	23.4	
			S-38a	15 - 25 - 47 (72)	100					M	17.1	
	360		S-38b		100		ML	Hard, greenish gray, fine sandy SILT, moist to wet. Organics present.		SA AL	23.4	
			S-39				SP	Dark gray, fine to coarse gravelly, slightly silty, fine to medium SAND, wet. Organics, including pieces of wood, present. Lenses of silt/clay present in sand. (NONGLACIAL FLUVIAL, Qpnf)		M SA HA M SA	23.8	
20	365											
			S-40					5 feet of heave present at 369 feet.		M	23.8	
	370		S-41					Dark gray, fine to medium SAND, wet. Pieces of wood present.		M SA	25.0	
10	375											
	380											
			S-42				ML	Cuttings: Light greenish gray, SILT, moist with organics.		M SA HA	35.9	
0	385		S-43	7 - 12 - 27 (39)	100		SM	Very dense, gray, silty fine SAND, moist. Abundant organics, including pieces of wood, present.		M SA	31.0	
	390		S-44	16 - 50 - 50/3 (100+)	100			Dense, dark gray with light gray and greenish gray streaks, silty, fine SAND, moist. Abundant organics, including pieces of wood, present.		M SA HA	25.3	
-10	395		S-45				SP	Heaving sand present. No SPT sample taken. Cuttings consist of dark gray, fine to medium SAND, wet.		M SA	22.1	
	400									M	20.8	

HWA GEOSCIENCES INC

Project: CSI Brightwater
Project Location: King and Snohomish Counties
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Log of Boring MW- 4

Sheet 8 of 8

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	400		S-46					Heaving sand present. No SPT sample taken. Cuttings consist of dark gray, fine to medium SAND, wet.		SA HA		
			S-47				CL	Cuttings: Brown to gray, CLAY, moist. According to the driller, this clay lens is only 1.5 to 2 feet thick.		M SA	32.9	
	405		S-48				SP	35 feet of heave present at 405 feet. No SPT sample taken. Cuttings: Gray, gravelly, fine to coarse SAND, wet. Gravel is fine.		M SA	14.8	
-20												
	410		S-49				CL-ML	Cuttings: Gray, SILT, moist. (NONGLACIAL LACUSTRINE, Qngl)		M	28.9	
	415		S-50	11 - 35 - 50/5 (100+)	100			Hard, gray, organic SILT, moist. Abundant compressed peat layers present. Compressed peat is platey and breaks into sheets.		M AL	32.7	
-30												
	420						SP	Heaving sands present at 420 feet.				
	425											
-40												
			S-51a S-51b S51c	18 - 36 - 50/5 (100+)	100 100 100		OL	Hard, gray, organic SILT, moist. Abundant wood fragments/organics present.		M M SA M	25.6 34.9 32.7	
	430											
			S-52					Cuttings: Brown, compressed peat. Cuttings: Gray silt.		SA HA M	47.5	
	435		S-53	35 - 50/2 (100+)	83		GP	Cuttings: Dark gray, fine to coarse sandy, GRAVEL, wet.		M	7.7	
			S-54							M SA	8.2	
-50								(NONGLACIAL FLUVIAL, Qpnf)				
			S-55 S-56	30 - 50/3 (100+)	83			Very dense, gray, fine to coarse GRAVEL, wet. Cuttings: Dark gray, fine to coarse sandy, fine to coarse GRAVEL, wet.		M SA	4.9	
	440											
	445		S-57 S-58 S-59	7 - 16 16	100			Very dense, gray, fine sandy GRAVEL, moist.		M SA M SA	5.1 13.3	
-60								Bottom of hole at 446.5 feet. 2" piezometer installed from 404 to 424 feet. Vibrating wire piezometer installed at 226 feet.				
	450											
	455											
-70												

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Figure: A-5.8

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 4	S-1	9.0 - 10.5	9.1											7.8		SP-SM	olive-brown, poorly graded SAND withsilt and gravel
MW- 4	S-2	19.0 - 20.5	6.0									33.4	59.6	7.0		SP-SM	olive-brown, poorly graded SAND with silt and gravel
MW- 4	S-3	29.0 - 30.5	10.5											7.1		SP-SM	olive-brown, poorly graded SAND with silt
MW- 4	S-4	39.0 - 40.5	5.1									16.4	79.3	4.3		SP	grayish-brown, poorly graded SAND with gravel
MW- 4	S-5	49.0 - 50.5	5.3											12.4		SM	olive-brown, silty SAND
MW- 4	S-6	59.0 - 60.5	13.3									4.3	81.2	14.6		SM	grayish-brown, silty SAND
MW- 4	S-7	69.0 - 70.5	4.8											3.6		SP	grayish-brown, poorly graded SAND
MW- 4	S-8	79.0 - 80.5	5.2									2.6	91.1	6.3		SP-SM	lt. olive-brown, poorly graded SAND with silt
MW- 4	S-9	89.0 - 90.5	4.9											5.3		SP-SM	olive-gray, poorly graded SAND with silt
MW- 4	S-10	99.0 - 100.5	6.6									5.6	88.6	5.9		SP-SM	olive-gray, poorly graded SAND with silt
MW- 4	S-11	109.0 - 110.5	16.8											5.2		SP-SM	olive-gray, poorly graded SAND with silt
MW- 4	S-12	119.0 - 120.5	17.3									2.4	95.2	2.4		SP	olive-gray, poorly graded SAND
MW- 4	S-13	129.0 - 129.0	35.4											7.2		SP-SM	brown, poorly graded SAND with silt
MW- 4	S-14	133.0 - 136.0	26.1											3.6		SP	lt. grayish-brown, poorly graded SAND
MW- 4	S-15	155.0 - 160.0	23.6									0.6	95.9	3.6		SP	gray, poorly graded SAND
MW- 4	S-16	170.0 - 180.0	22.9									4.8	91.6	3.6		SP	gray, poorly graded SAND
MW- 4	S-17a	189.0 - 190.0	21.4							NP	NP		6.6	93.4	2.9	ML	gray, SILT
MW- 4	S17b	190.0 - 190.5	23.5											7.3		SP-SM	gray, poorly graded SAND with silt
MW- 4	S-18	205.0 - 209.0	28.3									5.0	79.1	15.9		SM	gray, silty SAND
MW- 4	S-19	210.0 - 219.0	34.4											10.0		SP-SM	gray, poorly graded SAND with silt

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF MATERIAL PROPERTIES

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PROJECT NO.: 99153-490

FIGURE: A-5.30

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 4	S-20	226.0 - 228.5	26.5											92.5		ML	gray, SILT
MW- 4	S-21	239.0 - 240.5	24.2							36	27			100.0		ML	gray, SILT
MW- 4	S-22a	249.0 - 250.2	27.7							59	25		0.0	100.0		CH	gray, fat CLAY
MW- 4	S-22b	250.2 - 250.5	27.5											99.4		ML	olive-gray, SILT
MW- 4	S-23	259.0 - 260.5	29.7							NP	NP		0.0	100.0		ML	olive-gray, SILT
MW- 4	S-24	269.0 - 270.5	21.9							39	21					CL	gray, lean CLAY
MW- 4	S-25a	279.0 - 279.5	31.0							57	25		5.3	94.7		CH	gray, fat CLAY
MW- 4	S-25b	279.5 - 280.0	27.7											29.8		SM	gray, silty SAND
MW- 4	S-25c	280.0 - 280.5	30.6											99.3		ML	dk. olive-gray, SILT
MW- 4	S-26	289.0 - 290.5	22.7							46	22		0.0	100.0	2.5	CL	gray, lean CLAY
MW- 4	S-27	299.0 - 300.5	25.1													SP-SM	gray, poorly graded SAND with silt
MW- 4	S-28	309.0 - 310.5	22.8							43	22			100.0	3.2	CL	gray, lean CLAY
MW- 4	S-29	319.0 - 320.5	32.7													CH	gray, fat CLAY
MW- 4	S-30	325.0 - 326.5	25.7							48	26		0.0	100.0	2.8	CL	gray, lean CLAY
MW- 4	S-31	329.0 - 330.5	45.7										34.6	65.4		ML	dark gray, sandy SILT
MW- 4	S-32	332.5 - 333.0	33.7													CL	gray, lean CLAY
MW- 4	S-33	335.0 - 336.5	26.0							50	26		0.9	99.1		CH	gray, fat CLAY
MW- 4	S-34	339.0 - 340.5	26.4													CL	gray, lean CLAY
MW- 4	S-35a	345.0 - 345.5	28.8											31.0		SM	dark gray, silty SAND
MW- 4	S-35b	345.5 - 346.5	28.1										3.8	96.2		ML	dk. olive-gray, SILT

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF
MATERIAL PROPERTIES

PAGE: 2 of 4

PROJECT NO.: 99153-490 FIGURE: A-5.31

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 4	S-36	349.0 - 350.5	28.1											95.3		ML	dk. olive-gray, SILT
MW- 4	S-37a	355.0 - 356.2	24.3											43.3		SM	dark gray, silty SAND
MW- 4	S-37b	356.2 - 356.5	23.4													CL	dk. olive-gray, lean CLAY
MW- 4	S-38a	359.0 - 359.5	17.1							36	21			99.9		CL	gray, lean CLAY
MW- 4	S-38b	359.5 - 360.5	23.4										8.8	91.2		ML	gray, SILT
MW- 4	S-39	362.0 - 365.0	23.8									1.0	93.5	5.5		SP-SM	gray, poorly graded SAND with silt
MW- 4	S-40	369.0 -	23.8													SP	gray, poorly graded SAND
MW- 4	S-41	370.0 - 374.0	25.0									0.0	92.6	7.4		SP-SM	gray, poorly graded SAND with silt
MW- 4	S-42	383.0 - 384.0	35.9										18.6	81.4		ML	gray, SILT with sand
MW- 4	S-43	385.0 - 386.5	31.0											86.6		ML	olive-gray, SILT
MW- 4	S-44	390.0 - 391.5	25.3										23.8	76.2		ML	olive-gray, SILT with sand
MW- 4	S-45	395.0 - 397.0	22.1											17.4		SM	olive-gray, silty SAND
MW- 4	S-46	399.0 - 401.0	20.8									0.8	89.7	9.6		SP-SM	gray, poorly graded SAND with silt
MW- 4	S-47	403.0 - 404.0	32.9											91.9		CL	olive-brown, lean CLAY
MW- 4	S-48	405.0 - 406.0	14.8									21.8	76.3	1.9		SP	gray, poorly graded SAND
MW- 4	S-49	411.0 - 412.0	28.9													ML	dk. grayish-brown, SILT with sand
MW- 4	S-50	415.0 - 416.5	32.7							45	38				12.2	ML	olive-gray, SILT with sand
MW- 4	S-51a	428.0 - 428.5	25.6							NP	NP					SP-SM	gray, poorly graded SAND with silt
MW- 4	S-51b	428.5 - 429.0	34.9											77.1		ML	dk. olive-gray, SILT with sand, thin interbedded organics
MW- 4	S51c	429.0 - 429.5	32.7										6.7	93.3		ML	dk. olive-gray, SILT, thin interbedded organic layers

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF MATERIAL PROPERTIES

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PROJECT NO.: 99153-490

FIGURE: A-5.32

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 4	S-52	432.0 - 433.0	47.5													ML	olive-gray, SILT, thin interbedded organic layers
MW- 4	S-53	435.0 - 435.7	7.7													GP	olive-gray, poorly graded GRAVEL with sand
MW- 4	S-54	436.0 - 437.0	8.2									68.0	31.1	1.0		GW	gray, well graded GRAVEL with sand
MW- 4	S-55	437.5 - 438.3														GW	olive-gray, well graded GRAVEL with sand
MW- 4	S-56	438.0 - 438.5	4.9									85.7	14.3	0.0		GW	gray, well graded GRAVEL with sand
MW- 4	S-57	444.0 - 444.5	5.1									75.3	24.7	0.0		GW	gray, well graded GRAVEL with sand
MW- 4	S-58	444.5 - 445.0	13.3									32.2	67.0	0.8		SW	gray, well graded SAND with gravel
MW- 4	S-59	445.0 - 446.5														GP	olive-gray, poorly graded GRAVEL with silt and sand

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

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HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF
MATERIAL PROPERTIES

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PROJECT NO.: 99153-490

FIGURE: A-5.33

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 5

Sheet 1 of 7

Date(s) Drilled	11/27/01 - 12/7/01	Geotechnical Consultant	HWA GeoSciences Inc.	Logged By	SEG, BKH	Checked By	MLR/SEG
Drilling Method/ Rig Type	Becker Hammer/ Truck	Drilling Contractor	Layne Christensen Company			Total Depth of Borehole	352.0 feet
Drill Bit Size/Type	Dual Wall Reverse Circ.	Hammer Weight/Drop (lbs/in.)	300#, 30"			Ground Surface Elevation/Datum	305 feet / NAVD88
Location	Lake Ballinger Pump Station	Coordinates	N. 47.77739	W. 122.33416		Elevation Source	Plan

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0							Asphalt				
							SP	Sandy Fill. (FILL, f)				
							SP	Medium dense, grayish brown, fine SAND with trace silt and gravel, moist.				
300	5							(GLACIAL FLUVIAL, Qva) Occasional gravel and minor silt seams present.				
	10	■	S-1	8 - 8 - 8 (16)	100					M	8.2	
							SP	Medium dense, grayish brown, fine to medium SAND with occasional gravels, dry. Contains minor silt seams.				
							SP	Medium dense, grayish brown, medium SAND, with gravel, moist.				
290	15											
	20	■	S-2	7 - 8 - 8 (16)	100					M	4.8	
							SP	Medium dense, grayish brown, medium SAND, trace gravel, moist.				
280	25							Becomes gray to brownish gray, medium SAND.				
								1 foot of heave present at 29 feet.				
	30	■	S-3	8 - 14 - 15 (29)	100					M SA	17.7	
							SP	Medium dense, dark gray, fine to medium SAND, wet. Trace fine gravel.				
270	35											
	40	■	S-4a	2 - 9 - 18 (27)	100					M	21.4	
		■	S-4b		100		ML	Stiff, grayish brown, fine sandy, SILT to SILT, moist. Laminated, non-plastic.		M	22.7	
							SP	Easy push of casing to 63 feet. Medium dense, gray, medium SAND, wet. Clean.				
260	45											
	50	■		1 - 5 - 6						M	21.1	

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Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 5

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Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	50		S-5	(11)	100			1' of heave present at 50 feet.		SA		
-250	55											
			S-6									
	60							5' of heave present at 60 feet. No sample taken.				
							ML	Stiff to hard, dark gray, massive to laminated, low plastic SILT, dry. (GLACIOLACUSTRINE, Qvlc)				
-240	65											
	70		S-7	7 - 10 - 15 (25)	100		ML	Hard, dark gray, slightly fine sandy SILT, moist. Laminated, non to slightly plastic.		M	28.4	
-230	75							Becomes drier, massive, more clayey with slightly wavy laminae.				
	80		S-8	5 - 9 - 14 (23)	100		CL	Hard, dark gray, lean CLAY, laminated, moist. low plastic.		M	25.3	
-220	85							A few gravels present at 86 feet.				
	90		S-9	7 - 8 - 10 (18)	100		ML	Hard, dark gray, SILT, moist. Laminated and minor slickensides present. Low plasticity.		M SA AL HA	26.1	
-210	95											
							CL	Stiff to hard, dark gray, massive to laminated, lean CLAY, dry.				
	100		S-10		100					M	24.4	
-200	105						SM	Very dense, gray, silty SAND with gravel (diamicton) with beds of interlaminated silty SAND and sandy SILT, wet. (GLACIAL TILL, Qpgt)				

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Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 5

Sheet 3 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	110	▮	S-11	8 - 20 - 15 (35)	100		SM	Very dense, dark gray, very silty, SAND with gravel, dry.		M SA	12.0	
190	115							Boulder encountered at 115 feet.				
	120	▮	S-12	5 - 18 - 18 (36)	100		SP-SM	Dense, dark gray to brownish gray, interbedded medium SAND with gravel to silty fine SAND, wet. Encountered water at 118 feet. (GLACIAL FLUVIAL, Qpgf)		M SA	13.3	
180	125											
	130		S-13					5 feet of heave present at 129 feet. No sample taken. Cuttings are silty SAND.				
170	135											
	140	▮	S-14	71	100		SM	Very dense, dark gray, silty SAND to sandy SILT with gravel, moist to wet. TILL-LIKE. (GLACIAL TILL, Qpgt)		M SA	15.2	
160	145											
	150	▮	S-15	81	100					M	9.7	
							GP	Becomes sandy gravel and wet at 152 feet.				
150	155						SM	Dense, dark gray, silty medium SAND to fine sandy SILT interbeds. Mostly massive with silty laminae. 6 feet of heave present at 158 feet.				Vibrating Wire Piezometer 3/27/2002 158 ft ▽ 1/30/2002 158.6 ft ▽
	160	▮	S-16	5 - 19 - 30 (49)	44					M SA	22.4	
140	165						ML	Hard, olive gray to dark gray, SILT, moist. Light and				Standpipe Piezometer 3/27/2002 165.9 ft ▽

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Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 5

Sheet 4 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
								dark draped laminations present. A few drop stones present. **(GLACIOLACUSTRINE, Qpgl)**				1/30/2002 166.79 ft ▽
	170	■	S-17	90	83					M	16.5	
-130	175							Becomes more clayey at 175 feet.				
	180	■	S-18	6 - 14 - 17 (31)	100		ML	Hard, dark gray, slightly sandy SILT, moist. Faintly laminated to massive. Low plasticity. Sand is fine to medium.		M SA AL HA	26.8	
-120	185							Becomes cobbley at 185 feet.				
							ML	Hard, dark gray, SILT, with trace fine sand, dry. Faintly laminated to massive.				
	190	■	S-19	70	100					M	23.8	
-110	195					░	SM	Between 194 and 196 feet, silty sand interbeds present.				
						▨	CH	Hard, dark gray, fat CLAY with trace fine sand, dry. Laminations are contorted. Moderate plasiticity when wet. Appears carbonacous.				
	200	■	S-20	10 - 18 - 27 (45)	100	▨				M SA AL HA	19.2	
-100	205					▨						
	210	▭	S-21		83	░	SM	Very dense, dark gray, silty, fine to coarse SAND, moist. Some cobbles present. Till-like. **(GLACIAL TILL, Qpgt)**		M	8.2	
-90	215					░						
	220	■	S-22	87	83	░				M	10.2	
-80	225											

Figure: A-6.4

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 5

Sheet 5 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	225									
			S-23			SM	At 227.5, soil becomes wet. Cuttings are soupy, dark gray, silty SAND. Blows counts decreased. (GLACIAL FLUVIAL, Qpgf) 7 feet of heave present at 229 feet. No sample taken.			
	230									
-70	235									
		■	S-24	40/1.5 feet	100		1.5 feet of heave present. Drove sampler 2 feet. Dense, dark gray, slightly silty, fine to medium SAND, wet.	M SA	20.9	
	240									
-60	245	▭	S-25	50	83	SM	Very dense, dark gray, fine to coarse gravelly, silty, fine SAND, moist. TILL-LIKE. (GLACIALTILL, Qpgt)	M	9.1	
						SM	Very dense, dark gray, silty, fine SAND, moist.			
	250	■	S-26	25 - 21 - 51 (72)	33	CL	Hard, dark gray, lean CLAY, moist. Fine sand lenses present. Between 250 and 254 feet, shells noted in cuttings.	M M	18.6 18.6	
-50	255	▭	S-27	50	83	SM	Very dense, dark gray, fine to coarse, silty fine to medium SAND, moist. Till like.	M	12.4	
	260	▭	S-28	50	83	ML	Very dense, dark gray, fine to coarse gray, silty SAND to sandy SILT, moist. TILL-LIKE.	M SA	12.6	
-40	265	▭	S-29	50	83	SM	Very dense, dark gray, fine to coarse gravelly, silty fine to coarse SAND, moist to wet. Betwwen 265 and 269, cuttings are wet.	M	10.5	
	270	■	S-30	33 - 50/5" (100+)	100			M	13.5	
						GP-GM	Very dense, dark gray, silty, sandy GRAVEL, wet. Abundant water. (GLACIAL FLUVIAL, Qpgf)			
-30	275	▭	S-31	50	83			M SA	3.9	
		▭	S-32	50/3" (100+)	0					
	280									

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Figure: A-6.5

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 5

Sheet 6 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
20	285	▬	S-33	50	83		SP-SM	Very dense, dark gray, slightly silty to silty, fine to coarse gravelly, fine to coarse SAND, wet. (Drift-like)		M SA	13.2	
			S-34					12 feet of heave present at 289 feet. No sample taken.				
	290											
10	295	■	S-35	83	117					M	20.2	
		▬	S-35b				SP-SM	Very dense, dark gray, slightly silty, fine to coarse gravelly, fine to medium SAND, wet.		M	8.8	
		■	S-36	72	83			4 feet of heave present. Driller pulled back casing and heave fell out, therefore, a sample was taken.		M SA	9.1	
	300						GP	Very dense, dark gray, fine to coarse sandy, silty, fine to coarse GRAVEL, wet.				
0	305	■	S-37	66	83		SW	Very dense, dark gray, slightly silty, fine to medium gravelly, fine to coarse SAND, wet. Ground water at 169.9 feet below ground surface at start of drilling the next day.		M	7.9	
	310	■	S-38	72	100		SW	Very dense, dark gray, slightly silty, fine to coarse gravelly, fine to coarse SAND, wet.		M	7.8	
-10	315	■	S-39	68	83			Very dense, dark gray, silty, fine to coarse sandy, fine to coarse GRAVEL, wet.		M SA	10.3	
	320	■	S-40	50	0			No recovery. Cuttings are silty, sandy gravel and cobbles.				
-20	325		S-41	75			GP	Very dense, dark gray, slightly silty to clean, fine to coarse sandy, fine to coase GRAVEL with cobbles, wet.		M	7.5	
	330		S-42					22 feet of heave present at 329 feet. No sample taken.				
-30	335		S-43					10 feet of heave present. Cuttings are sandy GRAVEL, wet.				
	340											

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Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 5

Sheet 7 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
							ML	Hard , dark gray, SILT, moist. Laminated and plastic.				
-40	345	■	S-44		83			(GLACIOLACUSTRINE, Qpgl)		M AL	26.3	
			S-45				GM	Cuttings become gravelly and wet. Lenses of silt and gravel.				
	350						ML	Silt present at 350'. Very hard to pull casing out.				
-50	355							Bottom of boring at 352'. 2" piezometer installed to 352'. Vibrating wire piezometer installed to 240'.				
	360											
-60	365											
	370											
-70	375											
	380											
-80	385											
	390											
-90	395											
	400											

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 5	S-1	9.0 - 10.5	8.2													ML	l. olive-brown, poorly graded sandy SILT
MW- 5	S-2	19.0 - 20.5	4.8													SP	l. olive-gray, poorly graded SAND
MW- 5	S-3	29.0 - 30.5	17.7									2.9	93.9	3.2	1.6	SP	olive-brown, poorly graded SAND
MW- 5	S-4a	39.0 - 40.0	21.4													SP-SM	gray, poorly graded SAND with silt and gravel
MW- 5	S-4b	40.0 - 40.5	22.7													SM	olive-gray, silty SAND
MW- 5	S-5	49.0 - 50.5	21.1										97.6	2.4	1.2	SP	olive-gray, poorly graded SAND
MW- 5	S-6	59.0 - 59.0															
MW- 5	S-7	69.0 - 70.5	28.4													ML	gray, SILT with sand
MW- 5	S-8	79.0 - 80.5	25.3													CL	gray, lean CLAY
MW- 5	S-9	89.0 - 90.5	26.1			699				40	25		0.3	99.7	3.8	CL	gray, lean CLAY
MW- 5	S-10	99.0 - 100.5	24.4													CL	gray, lean CLAY
MW- 5	S-11	109.0 - 110.5	12.0									20.9	37.0	42.1		SM	gray, silty SAND with gravel
MW- 5	S-12	119.0 - 120.5	13.3									25.6	59.3	15.1	1.6	SM	gray, silty SAND with gravel
MW- 5	S-13	129.0 - 129.0															
MW- 5	S-14	139.0 - 140.5	15.2									4.9	43.7	51.3		ML	gray, sandy SILT
MW- 5	S-15	149.0 - 150.5	9.7													SM	gray, silty SAND with gravel
MW- 5	S-16	159.0 - 160.5	22.4										53.7	46.3	1.8	SM	gray, silty SAND
MW- 5	S-17	169.0 - 170.3	16.5													ML	gray, SILT with gravel
MW- 5	S-18	179.0 - 180.5	26.8							40	26		0.0	100.0	4.0	ML	gray, SILT
MW- 5	S-19	189.0 - 190.0	23.8													ML	gray, SILT

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF MATERIAL PROPERTIES

PAGE: 1 of 3

PROJECT NO.: 99153-490

FIGURE: A-6.14

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 5	S-20	199.0 - 200.5	19.2			591				51	23	0.1	2.2	97.7	5.6	CH	gray, fat CLAY
MW- 5	S-21	209.0 - 209.4	8.2													SM	gray, silty SAND with gravel
MW- 5	S-22	219.0 - 219.9	10.2													SM	gray, silty SAND with gravel
MW- 5	S-23	229.0 - 229.0															
MW- 5	S-24	237.5 - 239.0	20.9									0.2	83.8	16.1	1.0	SM	gray, silty SAND
MW- 5	S-25	245.0 - 245.4	9.1													SM	gray, silty SAND with gravel
MW- 5	S-26a	249.0 - 249.5	18.6													SM	gray, silty SAND
MW- 5	S-26b	249.5 - 250.5	18.6													CL	gray, lean CLAY
MW- 5	S-27	254.0 - 254.4	12.4													SM	gray, silty SAND with gravel
MW- 5	S-28	259.0 - 259.5	12.6									4.6	48.6	46.8		SM	gray, silty SAND
MW- 5	S-29	265.0 - 265.3	10.5													SM	gray, silty SAND with gravel
MW- 5	S-30	269.0 - 270.0	13.5													SM	gray, silty SAND with gravel
MW- 5	S-31	275.0 - 275.3	3.9									71.4	23.2	5.4		GP-GM	gray, poorly graded GRAVEL with silt and sand
MW- 5	S-32	277.0 - 301.0															
MW- 5	S-33	285.0 - 285.5	13.2			425						21.4	64.2	14.5	1.2	SM	gray, silty SAND with gravel
MW- 5	S-34	289.0 - 289.0															
MW- 5	S-35a	295.0 - 296.0	20.2													SP	dark gray, poorly graded SAND with gravel
MW- 5	S-35b	296.0 - 296.3	8.8													SM	gray, silty SAND with gravel
MW- 5	S-36	299.0 - 299.9	9.1									35.6	56.3	8.0		SP-SM	gray, poorly graded SAND with silt and gravel
MW- 5	S-37	305.0 - 305.9	7.9													SW	gray, well graded SAND with gravel

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF
MATERIAL PROPERTIES

PAGE: 2 of 3

PROJECT NO.: 99153-490

FIGURE: A-6.15

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 5	S-38	309.0 - 310.0	7.8													SW	gray, well graded SAND with gravel
MW- 5	S-39	315.0 - 315.9	10.3									44.9	48.2	6.9		SP-SM	gray, poorly graded SAND with silt and gravel
MW- 5	S-40	319.0 - 320.0															
MW- 5	S-41	325.0 - 325.0	7.5													SW-SM	gray, well graded SAND with silt and gravel
MW- 5	S-42	329.0 - 329.0															
MW- 5	S-43	335.0 - 335.0															
MW- 5	S-44	345.0 - 346.4	26.3			622				35	26				4.6	ML	dark gray, SILT
MW- 5	S-45	349.0 - 349.0															

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF MATERIAL PROPERTIES

PAGE: 3 of 3

PROJECT NO.: 99153-490 FIGURE: A-6.16

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 6

Sheet 1 of 7

Date(s) Drilled	1/11/02 - 1/23/02	Geotechnical Consultant	HWA GeoSciences Inc.	Logged By	BKH, MBB	Checked By	MLR/SEG
Drilling Method/ Rig Type	Becker Hammer Drill/ Truck	Drilling Contractor	Layne Christensen Company	Total Depth of Borehole	360.5 feet		
Drill Bit Size/Type	Dual Wall Reverse Circ.	Hammer Weight/Drop (lbs/in.)	300#, 30"	Ground Surface Elevation/Datum	314 feet / NAVD88		
Location	North east of 1-5/SR 1-4 I/C	Coordinates	N. 47.77785 W. 122.31449	Elevation Source	Plan		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0					SP	Medium dense, brown, fine to coarse gravelly, fine to coarse SAND, moist. (RECESSIONAL FLUVIAL, Qvrf)			
310										
	5									
	10	■	S-1	4 - 6 - 7 (13)	100			M	6.9	
300										
	15									
	20	■	S-2	50/5 (100+)	100	SM	Very dense, olive gray, fine to coarse gravelly, silty, fine to medium SAND, moist. (GLACIAL TILL, Qvt)	M SA	5.6	
						SP-SM	Loose to dense, brown to brown gray, slightly silty to silty, fine SAND, moist to wet. (GLACIAL FLUVIAL, Qva)			
290										
	25									
	30	■	S-3	6 - 4 - 2 (6)	100			M	24.0	
280										
	35						Water present.			
	40	■	S-4	6 - 12 - 21 (33)	100			M	25.5	
270										
	45									
	50	■		1 - 1 - 9				M	31.2	

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 6

Sheet 2 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	50	■	S-5	(10)	100							
260												
	55						SM	Very dense, gray, interbedded fine to medium SAND and SILT, moist to wet. (NONGLACIAL FLUVIAL, Qpnf) Abundant wood chunks present.				
	60	■	S-6	11 - 22 - 38 (60)	100		SP-SM	Dense, rust mottled gray, very fine gravelly, slightly silty, coarse SAND, wet.		M SA	20.2	Vibrating Wire Piezometer 3/27/2002 61 ft ▽
250												
	65											
	70	■	S-7	6 - 9 - 12 (21)	100		CL	Very stiff, green gray and dark gray, lean CLAY, moist. Laminated with many interbedded thin light gray, fine sand and silt lenses. (NONGLACIAL LACUSTRINE, Qpnl)		M SA AL HA	26.4	1/30/2002 69.4 ft ▽
							CL	Hard, dark gray to green gray, fine sandy, lean CLAY, moist to wet. Organics present.				
240												
	75											
	80	■	S-8 S-9	8 - 16 - 25 (41)	100							
230												
	85											
	90	■	S-10	13 - 26 - 33 (59)	100					M SA	28.2	
220												
	95											
	100	■	S-11	5 - 9 - 13 (22)	100					M SA AL HA	26.7	
							CL	Hard, green gray, fine sandy, Lean CLAY, moist. Organics, wood and charcoal fragments present.				
210												
	105											

Figure: A-7.2

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 6

Sheet 3 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	110	■	S-12	7 - 12 - 26 (38)	100			M SA AL HA	17.0	
200	115									
			S-13					M	26.0	
	120	■	S-14	7 - 13 - 18 (31)	100		Large wood chunk present. Trace fine to coarse sand present in silt.	M SA AL HA	19.4	
190	125									
	130	■	S-15	7 - 12 - 16 (28)	100			M SA	19.8	
			S-16			ML	Hard, fine to coarse gravelly, fine to medium sandy, SILT to CLAY, contains some thin clay layers, moist. (GLACIOMARINE DRIFT, Qpgm)	M SA HA	9.2	
180	135									
	140	■	S-17	19 - 50/5 (100+)	100			M SA	19.1	
170	145									
						SM	Dark gray, silty fine SAND, wet. (GLACIAL FLUVIAL, Qpgf)			
	150	■	S-18	20 - 28 - 38 (66)	100	CL	Hard, dark gray, slightly fine sandy, lean CLAY, moist. Trace fine gravel. Some light gray banding. (GLACIOLACUSTRINE, Qpgl)	M SA AL HA	18.6	
						ML	Hard, dark gray, fine to coarse gravelly, fine to coarse sandy, SILT, moist. Some cobbles present. (GLACIAL TILL, Qpgt)			
160	155									
	160	■	S-19	30 - 50/6 (100+)	100	ML	Hard to very dense, dark gray, fine sandy SILT to silty fine SAND, becomes more clayey with depth, moist to wet. Trace coarse sand. (GLACIOLACUSTRINE, Qpgl)	M SA HA	21.3	Standpipe Piezometer 3/27/2002 160 ft ▽ 1/30/2002 160.59 ft ▽
150	165									

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 6

Sheet 4 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	170	■	S-20	29 - 50/6 (100+)	100					M SA	14.3	
140												
	175											
	180	■	S-21	38 - 50/3 (100+)	83		CL	Hard, dark gray, lean CLAY, moist.		M SA HA	19.7	
130												
	185											
	190	■	S-22	7 - 16 - 18 (34)	100					M SA AL HA	20.4	
120												
	195											
	200	■	S-23a S-23b S-23c	5 - 9 - 13 (22)	100 100 100					M SA AL DD M	26.1 30.3	
110												
	205											
	210	■	S-24	6 - 8 - 12 (20)	100		CL	Very stiff, dark gray, slightly fine to coarse gravelly, fine to coarse sandy, lean CLAY, moist. (GLACIAL TILL, Qpgt)		M	20.0	
100												
	215											
							SC	Very dense, gray, clayey SAND with gravel and cobbles, moist.				
	220	■	S-25	8 - 50/5 (100+)	100					M SA HA	9.9	
90												
	225											

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HWA GEOSCIENCES INC

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 6

Sheet 5 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	225						CL	Hard, dark gray, fine to coarse gravelly, fine to coarse sandy, lean CLAY, moist. Cobbles present. (GLACIOMARINE DRIFT, Qpgm)				
	230		S-26	11 - 23 - 39 (62)	100							
80												
	235		S-27a S-27b	12 - 25 - 48 (73)	100 100					M SA DD HA	20.7	
	240		S-28	10 - 40 - 42 (82)	100					M AL	16.4	
70												
	245		S-29a S-29b S-29c	13 - 18 - 27 (45)	100 100 100					M SA AL HA	18.1 17.1	
	250		S-30a S-30b	9 - 15 - 22 (37)	100 100		CH	Very stiff, dark gray, fat CLAY, moist. Light gray SILT partings.		M SA M SA AL M SA HA	19.8 16.4	
60												
	255		S-31c S-31a S-31b	12 - 18 - 23 (41)	100 100 100		GP	Gravel present in cuttings.		M SA HA	19.9 18.7	
	260		S-32a S-32b	10 - 19 - 25 (44)	100 100					M SA AL DD M SA AL M SA	16.3 21.6	
50												
	265		S-33a S-33b S-33c	9 - 18 - 21 (39)	100 100 100					M AL M SA M	20.7 21.6	
	270		S-34	8 - 12 - 16 (28)	100					M AL	19.8	
40												
	275		S-35a S-35b S-35c	10 - 14 - 14 (28)	100 100 100					M SA HA	24.6	
	280		S-36a S-36b S-36c	9 - 12 - 17 (29)	100 100 100		CH	Very stiff, dark gray, fat CLAY, moist. (GLACIOLACUSTRINE, Qpgl)		M SA DD HA M	21.0 21.8	

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HWA GEOSCIENCES INC.

Figure: A-7.5

Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 6

Sheet 6 of 7

Elevation, feet	Depth, feet	Type / Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
-30							DD AL		
	285	S-37a S-37c S-37b	7 - 12 - 13 (25)	100 100 100			M SA AL HA	26.0 30.4	
	290	S-38a S-38b S-38c	7 - 10 - 13 (23)	100 100 100			M SA M SA M SA AL DD HA	25.0 29.1	
-20									
	295	S-39	5 - 8 - 10 (18)	100			M SA AL	29.2	
	300	S-40a S-40b S-40c	5 - 8 - 13 (21)	100 100 100			M SA AL DD HA	30.3	
-10									
	305	S-41	7 - 9 - 11 (20)	100			M AL SA	27.2	
	310	S-42a S-42b S-42c	7 - 10 - 13 (23)	100 100 100			M SA AL DD HA	26.5	
-0									
	315	S-43	7 - 9 - 13 (22)	100			M SA	28.5	
	320	S-44c S-44a S-44b	6 - 9 - 22 (31)	100 100 100			M SA AL	17.9	
		S-45			GP	Dense, dark gray, sandy, fine to coarse gravel, moist. Gravel is sub-rounded to sub-angular. (GLACIAL FLUVIAL, Qpgf)	HA M SA	2.0	
-10									
	325	S-46			SP	Very dense, dark gray, fine to medium SAND, wet. Trace fine sub-rounded gravel and coarse sand. (GLACIAL FLUVIAL, Qpgf)	M SA	18.0	
	330	S-47	3 - 2 - 5 (7)	100					
		S-48					M SA	30.2	
-20									
	335	S-49					M SA	18.2	
	340								

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Project: CSI Brightwater
Project Location: King and Snohomish Counties
Contract Number: E83004E

Log of Boring MW- 6

Sheet 7 of 7

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
		✋	S-50							M SA	30.5	
-30	345	■	S-51	3 - 100/5 (100+)	100							
		■	S-52		100					M SA	21.4	
							CL	Hard, dark gray to olive gray, lean CLAY to clayey SAND, moist. Upper 1 foot portion is very gravelly. (GLACIOLACUSTRINE, Qpgl)				
	350	✋ ✋ ✋	S-53 S-54 S-55							M SA AL HA M SA	16.4 32.4	
-40		✋	S-56									
	355	✋	S-57				CL-ML	Very stiff, dark gray, slightly fine sandy SILT, moist.		M SA HA	27.9	
	360	■	S-58	4 - 9 - 19 (28)	100					M SA HA	27.2	
								Bottom of boring at 360.5 feet. 2" piezometer installed from 340 to 360 feet bgs. Vibrating wire piezometer installed at 180 feet.				
-50	365											
	370											
-60	375											
	380											
-70	385											
	390											
-80	395											
	400											

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HWA GEOSCIENCES INC.

Figure: A-7.7

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 6	S-1	9.0 - 10.5	6.9													SP	yellowish-brown, poorly graded SAND
MW- 6	S-2	19.0 - 19.5	5.6									28.9	48.9	22.3		SM	olive-gray, silty SAND with gravel
MW- 6	S-3	29.0 - 30.5	24.0													SP-SM	brown, poorly graded SAND with silt
MW- 6	S-4	39.0 - 40.5	25.5													SP-SM	grayish-brown, poorly graded SAND with silt
MW- 6	S-5	49.0 - 50.5	31.2													SP-SM	grayish-brown, poorly graded SAND with silt
MW- 6	S-6	59.0 - 60.5	20.2									3.2	88.5	8.3		SP-SM	dk. olive-gray, poorly graded SAND with silt
MW- 6	S-7	69.0 - 70.5	26.4			576				33	22		0.0	100.0	5.4	CL	olive-gray, lean CLAY
MW- 6	S-8	79.0 - 80.5														CL	olive-gray, lean CLAY
MW- 6	S-9	80.0 - 80.0														CL	olive-gray, lean CLAY
MW- 6	S-10	89.0 - 90.5	28.2											98.5		ML	olive-gray, SILT
MW- 6	S-11	99.0 - 100.5	26.7			352				28	22		10.7	89.3	8.2	CL	dk. greenish-gray, lean CLAY
MW- 6	S-12	109.0 - 110.5	17.0							33	22		0.1	99.9	4.6	CL	light gray, lean CLAY
MW- 6	S-13	117.0 - 117.0	26.0													CL	dark olive-gray, lean CLAY
MW- 6	S-14	119.0 - 120.5	19.4			201				36	21		2.0	98.0	5.0	CL	olive-gray, lean CLAY
MW- 6	S-15	129.0 - 130.5	19.8											90.4		CL	greenish-gray, lean CLAY
MW- 6	S-16	133.0 - 133.0	9.2									11.8	23.1	65.1		ML	lt. yellowish-brown, sandy SILT
MW- 6	S-17	139.0 - 140.0	19.1											83.9		CL	gray, lean CLAY
MW- 6	S-18	149.0 - 150.5	18.6							42	22		4.2	95.8	3.5	CL	olive-gray, lean CLAY
MW- 6	S-19	159.0 - 160.0	21.3										10.4	89.6		ML	olive-gray, SILT
MW- 6	S-20	169.0 - 170.0	14.3											87.5		CL	gray, lean CLAY

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF MATERIAL PROPERTIES

PAGE: 1 of 5

PROJECT NO.: 99153-490

FIGURE: A-7.36

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 6	S-21	179.0 - 179.9	19.7										12.3	87.7		ML	gray, SILT
MW- 6	S-22	189.0 - 190.5	20.4							45	22		2.1	97.9		CL	gray, lean CLAY
MW- 6	S-23a	199.0 - 199.5															
MW- 6	S-23b	199.5 - 200.0	26.1	122.8	97.4		8.7			45	23			95.8		CL	dark gray, lean CLAY
MW- 6	S-23c	200.0 - 200.5	30.3													CL	olive-gray, lean CLAY
MW- 6	S-24	209.0 - 210.5	20.0													CL	olive-gray, lean CLAY
MW- 6	S-25	219.0 - 220.0	9.9									19.4	36.1	44.5		SC	gray, clayey SAND with gravel
MW- 6	S-26	229.0 - 230.5															
MW- 6	S-27a	235.0 - 236.0															
MW- 6	S-27b	236.0 - 236.5	20.7	126.7	105.0		6.8						0.6	99.4		CL	mottled gray & dark gray, lean CLAY
MW- 6	S-28	239.0 - 240.5	16.4							44	19					CL	gray, lean CLAY
MW- 6	S-29a	245.0 - 245.5	18.1							47	20	0.9	4.9	94.2		CL	olive-gray, lean CLAY
MW- 6	S-29b	245.5 - 246.0															
MW- 6	S-29c	246.0 - 246.5	17.1											93.2		CL	dark gray, lean CLAY
MW- 6	S-30a	249.0 - 250.0	19.8							48	21			95.2		CL	gray, lean CLAY
MW- 6	S-30b	250.0 - 250.5	16.4			848						2.3	9.1	88.6	4.0	CH	gray, fat CLAY
MW- 6	S-31c	255.0 - 255.5															
MW- 6	S-31a	255.5 - 256.0	19.9			915						2.3	6.0	91.8	3.2	CH	dark gray, fat CLAY
MW- 6	S-31b	256.0 - 256.5	18.7	123.9	104.4					44	18			91.0		CL	dark gray, lean CLAY
MW- 6	S-32a	259.0 - 260.0	16.3							38	18			86.7		CL	dark brownish-gray, lean CLAY

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HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF
MATERIAL PROPERTIES

PAGE: 2 of 5

PROJECT NO.: 99153-490 FIGURE: A-7.37

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 6	S-32b	260.0 - 260.5	21.6									1.7	8.0	90.3		CL	gray, lean CLAY
MW- 6	S-33a	265.0 - 265.5	20.7							49	24					CL	gray, lean CLAY
MW- 6	S-33b	265.5 - 266.0	21.6											97.7		CL	gray, lean CLAY
MW- 6	S-33c	266.0 - 266.5				983											
MW- 6	S-34	269.0 - 271.0	19.8							49	23					CL	dark gray, lean CLAY
MW- 6	S-35a	275.0 - 275.5	24.6										0.0	100.0		CL	gray, lean CLAY
MW- 6	S-35b	275.5 - 276.0															
MW- 6	S-35c	276.0 - 276.5															
MW- 6	S-36a	279.0 - 279.5	21.0	128.7	106.4		9.1						0.0	100.0		CH	gray, lean CLAY
MW- 6	S-36b	279.5 - 280.0	21.8	125.5	103.0		5.7			31	20					CL	dark gray, lean CLAY
MW- 6	S-36c	280.0 - 280.5															
MW- 6	S-37a	285.0 - 285.5	26.0			1180				79	25		0.0	100.0	5.4	CH	gray, fat CLAY
MW- 6	S-37c	285.5 - 286.0															
MW- 6	S-37b	286.0 - 286.5	30.4											99.9		CH	dark olive-gray, fat CLAY
MW- 6	S-38a	289.0 - 289.5	25.0											100.0		CL	dark gray, lean CLAY
MW- 6	S-38b	289.5 - 290.0	29.1	84.3	65.3					74	26		0.0	100.0		CH	dark gray, fat CLAY
MW- 6	S-38c	290.0 - 290.5															
MW- 6	S-39	295.0 - 297.0	29.2							84	27			97.4		CH	dark gray, fat CLAY
MW- 6	S-40a	299.0 - 299.5														CH	dark gray, fat CLAY
MW- 6	S-40b	299.5 - 300.0	30.3	121.8	93.5	1070	13.2			70	27		0.0	100.0	4.6	CH	dark gray, fat CLAY

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HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF MATERIAL PROPERTIES

PAGE: 3 of 5

PROJECT NO.: 99153-490 FIGURE: A-7.38

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 6	S-40c	300.0 - 300.5														CH	dark gray, fat CLAY
MW- 6	S-41	305.0 - 306.5	27.2							68	24			100.0	6	CH	dark gray, fat CLAY
MW- 6	S-42a	309.0 - 309.5	26.5	124.1	98.1		12.1			53	25		0.1	99.9		CH	dark gray, fat CLAY
MW- 6	S-42b	309.5 - 310.0														CH	dark gray, fat CLAY
MW- 6	S-42c	310.0 - 310.5														CH	dark gray, fat CLAY
MW- 6	S-43	315.0 - 316.5	28.5											100.0		CH	olive-gray, fat CLAY
MW- 6	S-44c	319.0 - 319.5															
MW- 6	S-44a	319.5 - 320.0	17.9							41	20		4.3	95.7		CL	gray, lean CLAY
MW- 6	S-44b	320.0 - 320.5														CH	dark gray, fat CLAY
MW- 6	S-45	322.0 - 323.0	2.0									65.9	27.5	6.5		GW-GM	gray, well graded GRAVEL with silt and sand
MW- 6	S-46	325.0 - 326.0	18.0									5.3	92.2	2.5		SP	dark gray, poorly graded SAND
MW- 6	S-47	329.0 - 330.5															
MW- 6	S-48	331.0 - 332.0	30.2											1.2		SP	dark gray, poorly graded SAND
MW- 6	S-49	335.0 - 336.0	18.2									14.6	82.1	3.3		SP	dark gray, poorly graded SAND
MW- 6	S-50	342.0 - 343.0	30.5									0.5	96.7	2.8		SP	dark gray, poorly graded SAND
MW- 6	S-51	345.0 - 346.0															
MW- 6	S-52	346.0 - 347.0	21.4									0.1	98.8	1.1		SP	dark gray, poorly graded SAND
MW- 6	S-53	349.0 - 350.0	16.4							37	17	42.8	14.1	43.1		GC	dark olive-gray, clayey GRAVEL
MW- 6	S-54	350.0 - 351.0	32.4											61.1		CL	olive-gray, gravelly lean CLAY
MW- 6	S-55	351.0 - 352.0														SC	olive-gray, clayey SAND with gravel

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HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF
MATERIAL PROPERTIES

PAGE: 4 of 5

PROJECT NO.: 99153-490 FIGURE: A-7.39

EXPLORATION DESIGNATION	SAMPLE NUMBER	DEPTH (ft)	WATER CONTENT (%)	WET DENSITY (PCF)	DRY DENSITY (pcf)	SODIUM CONTENT (mg/kg dry)	UNCONF'D COMPR. STRENGTH (ksf)	COHESION (psi)	PHI ANGLE (degrees)	LIQUID LIMIT	PLASTIC LIMIT	% GRAVEL	% SAND	% FINES	ORGANIC CONTENT (%)	ASTM SOIL CLASSIFICATION	SAMPLE CLASSIFICATION
MW- 6	S-56	353.0 - 355.0														SC	gray, clayey SAND with gravel
MW- 6	S-57	355.0 - 356.0	27.9										3.3	96.7		ML	dark olive-gray, SILT
MW- 6	S-58	359.0 - 360.5	27.2										0.4	99.6		ML	dark olive-gray, SILT

Notes: 1. This table summarizes information presented elsewhere in the report and should be used in conjunction with the report text, other graphs and tables, and the exploration logs.

HWA GEOSCIENCES INC.

Brightwater Project
King and Snohomish Counties
Washington

SUMMARY OF MATERIAL PROPERTIES

PAGE: 5 of 5

PROJECT NO.: 99153-490 FIGURE: A-7.40

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-4

Sheet 1 of 4

Date(s) Drilled	12/28/01 - 1/11/02	Geotechnical Consultant	SHANNON & WILSON	Logged By	XDH/BMP	Checked By	TWH
Drilling Method/ Rig Type	mud rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.	Total Depth of Borehole	366.4 feet		
Drill Bit Size/Type	6-inch Tricone	Hammer Weight/Drop (lbs/in.)	300#/30"	Ground Surface Elevation/Datum	368 feet / NAVD88		
Location	228th St/Hwy 99	Coordinates	N 292703.0 E 1270572.0	Elevation Source	Topo		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0						SP-SM	Very dense, gray-brown, slightly silty, fine to medium SAND, trace of gravel; moist to wet; scattered gravelly layers; SP-SM. **(Qva)**				
360												
	10	▬	1	50/5"	0							
	20	■	2	99/10.5"	89					M	5.7	
340												
	30	▭	3	58/6"	100					M SA	11.9	
	40	▬	4	50/5"	74					M	11.8	
320												
	50	▭	5	57/6"	98					M SA	9.6	
	60	▭	6	87/6"	100					M	18.1	
300												
	70	▭	7	65/6"	0							
	80	▭	8	54/6"	100					M	15.1	
												VWP1 2/26/2002 87.37 ft ▼
280												
	90	▭	9	85/6"	0							
	100											

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-4

Sheet 2 of 4

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	100	▭	10	98/6"	33			Very dense SAND; SP-SM (cont.) **(Qva)**		M	18.0	
							SM	Very dense, gray-brown to gray, silty, fine SAND; wet; grades finer with depth, abundant wood fragments at bottom; SM. **(Qva)**				
260												
	110	▬	11	50/4.5"	83					M	23.0	
	120	▬	12	50/3"	42					M	23.1	
240												
	130	▬	13	50/3"	42					M	20.7	
	140	▭	14	114/6"	67					M SA AL	23.7	
220												
	150	▬	15	50/3.5"	52					M	27.1	
	160	▬	16	50/4"	83					M	27.9	
200												
	170	▭	17	150/5.8"	100					M	23.0	
							ML	Very dense, gray, fine sandy SILT grading to SILT, trace of clay and fine sand; moist to wet; abundant fine organic fragments; ML. **(Qva)**				
	180	▬	18	50/5"	94					M SA	25.6	
180												
	190	■	19	46	133					M	32.0	
							CL	Hard, gray, silty CLAY and clayey SILT, trace of fine sand; moist; interbedded, scattered seams of slightly clayey silt; CL/ML. **(Qvlc)**				
	200	■	20	33	133					M	25.5	
160												
	210	■	21	77/11"	128					M AL	31.3	
								Very dense, gray, fine sandy SILT to slightly fine				OW1 2/5/2002 215.79 ft ▽

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Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-4

Sheet 3 of 4

Elevation, feet	Depth, feet	SAMPLES: Type	SAMPLES: Number	SAMPLES: Blows / 6 in. (N)	SAMPLES: Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	220	□	22	50/3"	100	ML	sandy SILT, trace of clay; moist; interbedded; scattered seams of silty clay and seams of silty, fine sand; ML. **(Qvlc)**	M	22.8	
140										
	230	■	23	90/9"	100			M	24.6	
						CH	Hard, gray, silty CLAY and clayey SILT; moist; interbedded, abundant seams of fine sandy silt; CH/CL/ML. **(Qpgl)**			
	240	■	24	42	133			M AL	34.4	VWP2 2/26/2002 240.01 ft▼
120										
	250	■	25	91/9"	110			M	25.8	
	260	■	26	78/8"	100			M	21.9	
						SM	Very dense, gray, silty, fine SAND and fine sandy SILT to slightly clayey, fine sandy SILT; moist to wet; interbedded, scattered to abundant fine organic fragments; SM/ML. **(Qpgl)**			
100										
	270	■	27	50/5.5"	162			M	26.2	
	280	□	28	50/6"	83			M	20.8	
80										
	290	□	29	50/5"	1001			M	24.2	
						CL	Hard, blue-gray, fine sandy, silty CLAY to silty CLAY, trace of fine sand; moist; massive, oxidizes to green-gray, scattered white specks, scattered organics; CL. **(Qpgl)**			
		□	30	53	400			M	18.5	
	300	■	31	71	122			M AL	19.0	
		■	32	45	133			M	22.1	%Passing #200 Seive
60										
	310	■	33	49	133			M	24.1	
		■	34	69	111			M	18.6	
	320	■	35	74	133			M	16.4	
						CH	Hard, blue-gray to green-gray, silty CLAY, trace of gravel; moist; scattered gravelly zones; CH. **(Qpgm)**			
		■	36	73/11"	107			M	30.2	
40										
	330	—	37	150/2.5"	0					

Piezometer Schematic

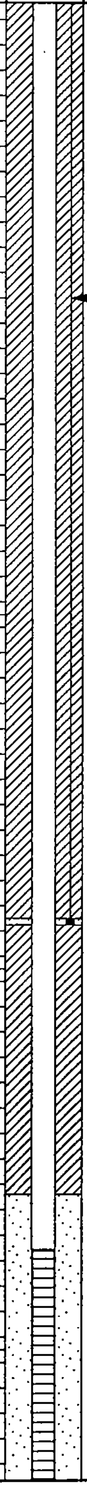

Figure: B-3.3

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-4

Sheet 4 of 4

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
		—	38	200/2.5"	0	▨		Hard, silty CLAY; CH (cont.) **(Qpgm)**				
	340	■	39	93/11"	115	▨	CL	Hard, gray to blue-gray, slightly fine sandy, silty CLAY to fine sandy, silty CLAY; moist; abundant sandy seams, trace of gravel locallly; CL. **(Qpgl)**	▨	M	21.7	
		▬	40	50/5"	200	▨			▨	M SA AL	19.5	
20	350	▭	41	69/6"	300	▨			▨	M AL	19.3	
		■	42	90	100	▨	CL	Hard, gray, silty CLAY, trace of sand; moist; massive, trace of gravel locally, scattered streaks of green-gray mottling; CL. **(Qpgl)**	▨	M	23.4	
	360	■	43	87/11"	107	▨			▨	M	21.9	
		■	44	87/11"	107	▨			▨	M	25.1	
0	370							BOTTOM OF BORING COMPLETED 1/11/2002				
	380											
-20	390											
	400											
-40	410											
	420											
-60	430											
	440											
-80	450											

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FIGURE B-3.7
LABORATORY TESTING SUMMARY FOR BW-4

SAMPLE DATA					GRAIN-SIZE ANALYSES				ATTERBERG LIMITS[d,e]				
Boring No.	Sample No.	Top Depth (feet)	Natural Water Content[a] (%)	% Gravel	% Sand	% Fines[b]	% < 2 mm[c]	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	USCS Symbol	Interpreted Geologic Unit	Soil Description[f]
BW-4	S-3	30.0	11.9	16.4	76.7	6.8					SP-SM	Qva	Gray-brown, slightly silty, fine gravelly, SAND
	S-5	50.0	9.6	1.7	92	6.2					SP-SM	Qva	Gray-brown, slightly silty, fine to medium SAND, trace of fine gravel
	S-14	140.0	23.7			13.7					SM	Qva	Gray, silty, fine SAND
	S-18	180.0	25.6			99.4	4.5				ML	Qva	Gray, slightly clayey, SILT, trace of sand
	S-21	210.0	31.3					42	23	19	CL	Qglc	Gray, silty CLAY
	S-24	240.0	34.4					67	31	36	CH	Qpgl	Gray, silty CLAY
	S-31	300.0	19.0					36	23	13	CL	Qpgl	Blue-gray, slightly sandy, silty CLAY
	S-32	305.0	22.1			93.7					CL	Qpgl	Gray-brown, slightly sandy, silty CLAY
	S-40	345.0	19.5	4.9	30.5	64.6	13.4				CL	Qpgl	Gray, sandy, silty CLAY, trace of fine gravel
	S-41	350.0	19.3					29	21	8	CL	Qpgl	Blue-gray, fine sandy, silty CLAY

Notes:

a Natural water content conducted on all samples and appears on boring logs.
b Particle size smaller than 0.075 mm.
c 1 mm = 1000 µm
d The numbers shown have been rounded (LL, PL, and PI)
e NP = non-plastic
f Soil descriptions have been abbreviated and simplified. For complete descriptions, see the boring logs in Appendix A.1.

Figure B-3.7

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-5

Sheet 1 of 3

Date(s) Drilled	12/6/01 - 12/20/01	Geotechnical Consultant	SHANNON & WILSON	Logged By	BMP	Checked By	TWH
Drilling Method/ Rig Type	mud rotary/ Mobile B-59	Drilling Contractor	Geo-Tech Explorations, Inc.	Total Depth of Borehole	391.2 feet		
Drill Bit Size/Type	6-inch Tricone	Hammer Weight/Drop (lbs/in.)	300#/30"	Ground Surface Elevation/Datum	400 feet / NAVD88		
Location	End of 227th Street SW, SE corner	Coordinates	N 292560.0 E 1275712.0	Elevation Source	Topo		

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
400	0						SP-SM	Very dense, gray-brown, slightly silty, fine to medium SAND; moist to wet; massive, scattered gravelly layers inferred from drill action; SP-SM. **(Qva)**				
	10	■	1	60	83					M	13.0	
380	20	■	2	65	81					M	9.0	
	30	▭	3	50/6"	100			- gravelly sand between 3 and 41 feet		M SA	11.3	VWP1 2/26/2002 35.8 ft ▼
360	40	▭	4	50/5"	111					M	13.6	VWP2 1/9/2002 43.79 ft ▼
								- light gray below 45 feet				
	50	▭	5	50/4"	93					M	18.9	
340	60	▭	6	50/4.5"	79					M	21.4	OW1 2/26/2002 60.3 ft ▽
	70	■	7	44	122		CL	Hard, gray-brown to gray, silty CLAY to clayey SILT, trace of fine sand; moist to wet; massive, scattered seams of fine sandy silt, abundant organics; CL/ML. **(Qpgl)**		M M AL	23.3 23.7	
							CH	Hard, green-gray to brown and gray, silty CLAY to clayey SILT; moist; massive to bedded, trace of sand locally, weathered at top; CH/MH/CL. **(Qpgl)**				
320	80	■	8	80	128					M AL M	23.5 23.8	
	90	■	9	33	133					M AL	33.2	
300	100	■	10	37	133					M	34.2	
							ML	Hard, light brown, silty CLAY grading to clayey SILT; moist; massive to bedded, abundant seams of silty, fine sand to fine sandy SILT, scattered gravel inferred from drill action; ML/CL. **(Qpgl)**				
	110	■	11	52	113					M	36.8	
280	120	■	12	73/11.8"	122					M AL	34.2	
	130	▭	13	50/3"	119							

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Figure: B-4.1

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-5

Sheet 2 of 3

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
								Hard, silty CLAY to clayey SILT; ML/CL (cont.) **(Qpgl)**		M M	30.2 20.7	
260	140		14	82/9"	100		CL	Hard, light gray-brown, sandy, gravelly, silty CLAY to very dense, silty, sandy GRAVEL, trace of clay; massive; scattered cobbles inferred from drill aciton; CL/GM. **(Qpgm)**		M	29.7	
	150		15	50/6"	67					M	17.8	
240	160		16	100/4"	97					M	13.3	
	170		17	100/5"	98		SM	Very dense, brown, silty, fine to medium SAND, trace of gravel; moist to wet; massive, scattered gravelly layers inferred from drill action; SM. **(Qpgf)**		M	17.6	
220	180		18	60/6"	60					M SA	20.9	
	190		19	100/4"	33		SM	Very dense, brown to gray-brown, silty, gravelly SAND; moist to wet; scattered slightly clayey layers, scattered layers of silty, fine sand; SM. **(Qpgf)**		M	15.9	
200	200		20	200/4.5"	31					M	8.8	
	210		21	200/4"	101					M	11.2	
180	220		22	125/6"	50					M SA	11.0	
	230		23	110/6"	25					M	14.4	
160	240		24	150/4"	78					M	11.5	
	250		25	150/6"	92					M	17.4	
140	260		26	150/4"	33					M	16.7	
	270		27	150/4.5"	125					M	7.3	
120	280		28	150/3"	100		SC	Very dense, gray, fine gravelly, silty, clayey SAND and hard, fine sandy, silty CLAY to clayey SILT;		M SA	12.4	

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-5

Sheet 3 of 3

Elevation, feet	Depth, feet	SAMPLES Type	SAMPLES Number	SAMPLES Blows / 6 in. (N)	SAMPLES Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
							SC/CL. **(Qpgm)**			
	290		29	150/5"	52			M AL	17.6	
100	300		30	150/3"	73			M	11.5	
	310		31	150/5"	99			M	18.3	
						CH	Hard, gray, silty CLAY, trace of sand and gravel to sandy, gravelly, silty CLAY; moist; massive; faintly sheared texture at top; gravelly, silty, clayey sand locally; CH/CL/SC. **(Qpgm)**			
80	320		32	50/6"	125			M	19.4	
	330		33	50/5.5"	133			M	16.5	
			34	50/6"	142			M AL	21.0	
60	340		35	50/6"	117			M SA	12.7	
			36	50/5"	137			M	13.3	
	350		37	50/5"	148			M	16.5	
			38	150/3.5"	194					
40	360		39	65/6"	133			M SA	9.0	
						CH	Hard, gray, silty CLAY; massive to bedded, trace of sand above 375 feet, scattered silt pockets and partings; CH/CL. **(Qpgl)**			
			40	85/6"	133			M	15.5	
	370		41	96/6"	133			M AL	15.7	
			42	65/6"	125			M	16.4	
20	380		43	50/4.5"	116			M	24.7	
			44	88/8"	152			M	29.4	
	390		45	50/5"	130			M	30.3	
							BOTTOM OF BORING COMPLETED 12/20/2001			
0	400									
	410									
-20	420									
	430									

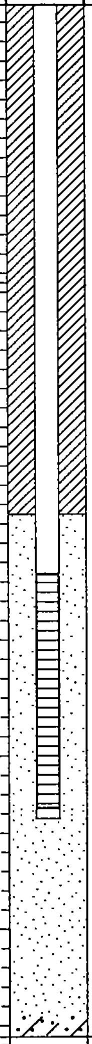

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FIGURE B-4.6
LABORATORY TESTING SUMMARY FOR BW-5

SAMPLE DATA					GRAIN-SIZE ANALYSES			ATTERBERG LIMITS[d,e]					
Boring No.	Sample No.	Top Depth (feet)	Natural Water Content[a] (%)	% Gravel	% Sand	% Fines[b]	% < 2 mm[c]	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	USCS Symbol	Interpreted Geologic Unit	Soil Description[f]
BW-5	S-3	30.0	11.3	0.1	89.6	10.2					SP-SM	Qva	Gray-brown, slightly silty, fine to medium SAND
	S-7B	71.0	23.7					32	23	9	CL	Qpgl	Gray, silty CLAY, trace of fine sand
	S-8	81.0	23.8					45	26	19	CL	Qpgl	Gray, silty CLAY
	S-9	90.0	33.2					54	31	23	MH	Qpgl	Light brown, clayey SILT
	S-12	120.0	34.2					39	28	11	ML	Qpgl	Gray, clayey SILT
	S-18	180.0	20.9	2.2	83.6	14					SM	Qpgf	Gray-brown, silty, fine to medium SAND, trace of gravel
	S-22	220.0	11.0	15.7	58.5	25.7					SM	Qpgf	Gray-brown, fine gravelly, silty SAND, trace of clay
	S-28	280.0	12.4	13.7	41.8	44.4					SC	Qpgm	Gray, fine gravelly, silty, clayey SAND
	S-29	290.0	17.6					34	22	12	CL	Qpgm	Gray, silty CLAY, trace of sand
	S-34	335.0	21.0					63	26	37	CH	Qpgm	Gray, silty CLAY, trace of sand and gravel
	S-35	340.0	12.7	5.5	31.1	63.3					CL	Qpgm	Gray, slightly gravelly, silty, sandy CLAY
	S-39	360.0	9.0	16.6	36.8	46.5					SC	Qpgm	Gray, fine gravelly, silty, clayey SAND
	S-41	370.0	15.7					43	21	22	CL	Qpgl	Gray, silty CLAY, trace of sand

Notes:

a Natural water content conducted on all samples and appears on boring logs.

b Particle size smaller than 0.075 mm.

c 1 mm = 1000 μm

d The numbers shown have been rounded (LL, PL, and PI)

e NP = non-plastic

f Soil descriptions have been abbreviated and simplified. For complete descriptions, see the boring logs in Appendix A.1.

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-6

Sheet 1 of 4

Date(s) Drilled: 12/13/01 - 12/28/01	Geotechnical Consultant: SHANNON & WILSON	Logged By: KGW	Checked By: TWH
Drilling Method/ Rig Type: mud rotary/ CME-85	Drilling Contractor: Gregory Drilling	Total Depth of Borehole: 430.5 feet	
Drill Bit Size/Type: 6-inch Tricone	Hammer Weight/Drop (lbs/in.): 300#/30"	Ground Surface Elevation/Datum: 450 feet / NAVD88	
Location: 228th and 48th Ave. W.	Coordinates: N 292329.0 E 1280286.0	Elevation Source: Topo	

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	0					GM	Gray-brown, silty, sandy GRAVEL; moist; scattered brick fragments; (Fill) GM.			
						SM	Very dense, gray, silty, gravelly SAND; moist; heterogeneous; SM. **(Qvtl)**			
440	10	■	1	61	100			M	10.5	
	20	▭	2	50/5"	83			M	10.2	
420	30	▭	3	50/5"	67			M	9.6	
	40	—	4	50/3"	100			M	8.2	
						GP-GM	Very dense, gray-brown, slightly silty to silty, sandy GRAVEL to silty, gravelly SAND; moist to wet; locally trace of clay; GP-GM. **(Qva)**			
400	50	▭	5	50/5"	67			M SA	9.2	
	60		6							
						SM	Very dense, gray-brown, silty, fine SAND grading to fine sandy SILT; moist; massive; scattered organic fragments; SM/ML. **(Qva)**			
380	70	■	7	50/5"	50			M	20.0	
	80	■	8	50/6"	42			M	21.5	
						GM	Very dense, gray-brown, slightly sandy, gravelly, silty CLAY to silty, sandy GRAVEL, trace of clay; moist; faintly bedded layers, gradational contact with unit above, scattered cobbles inferred from drill action; GM/CL. **(Qpgm)**			
360	90	■	9	70/9"	90			M AL	18.6	
	100									

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Figure: B-5.1

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-6

Sheet 2 of 4

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
	100		10	50/3"	83			Very dense, silty CLAY to sandy GRAVEL; GM/CL (cont.) **(Qpgm)**		M SA	10.0	
340	110		11	50/5"	83					M	5.1	
							ML	Hard, gray-brown to gray, clayey SILT, trace of sand and gravel, sandy, silty CLAY, trace of gravel; moist to wet; massive to faintly bedded; ML/CL. **(Qpgm)**				
	120		12	50/4"	104					M	19.8	
												VWP1 2/26/2002 124.63 ft ▼
												OW1 2/26/2002 126.6 ft ▽
320	130		13	50/5"	83			Gray below 130 feet.		M SA AL	14.9	
							SM	Very dense, gray, silty, fine SAND; wet; massive; scattered organic fragments; SM. **(Qpgf)**				
	140		14	50/5"	83					M	20.5	
							CH	Hard, gray, silty CLAY, trace of sand, to slightly sandy, silty CLAY, trace of gravel; moist; CH. **(Qpgm)**				
300	150		15	75/9"	120					M	18.4	
	160		16	50/5"	83			Layer of slightly clayey, fine sandy silt at 160 feet.		M	22.2	
280	170		17	74/11"	100					M	19.3	
								Gravelly layer inferred from drill action at 175 feet.				
	180		18	67/8"	136					M AL	20.6	
260	190		19	65/8"	136					M SA	17.6	
	200		20	50/4"	146					M	18.8	
240	210		21	50/6"	0							

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Figure: B-5.2

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-6

Sheet 3 of 4

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	220	▭	22	70/3"	100		SM	Very dense, gray, clayey, silty, gravelly SAND; moist; SM. **(Qpgm)**		M	9.7	
220	230	▭	23	67/4"	101		SP-SM	Very dense, gray, slightly silty, fine to medium SAND, trace of gravel, to fine to medium SAND, trace of silt; wet; scattered seams and layers of silty, fine sand to fine sandy, clayey silt; SP-SM/SP. **(Qpgf)**		M	16.0	
	240	▭	24	65/4"	69					M	17.9	
200	250	■	25	70	100					M	18.5	
	260	▬	26	50/5"	100					M	19.2	
								Gravelly layer inferred from drill action at 265 feet.				
180	270	▬	27	50/5"	83					M	17.2	
							GW-GM	Very dense, gray, slightly silty, sandy GRAVEL; wet; scattered to abundant cobbles inferred from drill aciton; GW-GM. **(Qpgf)**				
	280	▭	28	116/3"	83					M	10.4	
								Gravelly sand inferred from drill action below 282 feet.				
160	290	▬	29	50/4"	100		SM	Very dense, gray SILT, trace of fine sand and clay, to silty, fine SAND; moist; scattered to abundant organic and wood fragments, scattered slightly silty layers; SM/ML. **(Qpnl)**		M	28.6	
	300	▭	30	69/5"	83					M SA	21.7	
140	310	■	31	71/11"	95		CL	Hard, gray, clayey SILT to silty CLAY, trace of sand; moist; bedded, abundant organic to peaty seams and wood fragments; CL/ML. **(Qpnl)**		M AL	36.0	
	320	■	32	41	100					M	35.6	
120	330	▬	33	57/3"	100		SW-	Very dense, gray, slightly silty SAND, trace of gravel and slightly silty, fine SAND; wet; scattered		M M	27.8 24.5	

Figure: B-5.3

Project: Brightwater Project
Project Location: N. King County/S. Snohomish County
Contract Number:

Log of Boring BW-6

Sheet 4 of 4

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Moisture Content, %	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
							SM	organic fragments; SW-SM/SP. **(Qpnf)**				
	340		34	60/5.5"	67					M SA	16.9	
-100	350		35	40/6"	100					M	22.6	
	360		36	58/4"	101					M	11.0	
-80	370		37	50/5.5"	83					M SA	15.8	
			38	63/5"	21					M	10.4	
	380		39	65/8"	97		ML	Hard, dark gray, clayey SILT to silty CLAY, trace of fine sand; moist; massive to laminated; scattered peaty partings; scattered to abundant organic fragments; ML/CL. **(Qpntf)**		M	31.7	
			40	50/3"	95					M AL	23.3	
-60	390		41	50/3"	100					M	26.8	
			42	65/10"	100					M	23.0	
	400		43	86	94					M	24.3	
			44	50/4"	83		ML	Very dense, dark gray, slightly clayey, fine sandy SILT to fine sandy, clayey SILT; moist; interbedded, abundant organics and shell fragments; ML/CL-ML. **(Qpntf)**		M	20.0	
-40	410		45	74	89					M AL	23.2	
			46	50/5.5"	92					M	22.3	
	420		47	85/5.5	83		SP	Very dense, gray, fine to medium SAND, trace of silt, to slightly silty, fine to medium SAND; wet; SP/SP-SM. **(Qpnf)**		M	17.3	
			48	100/6"	100					M SA	18.9	
-20	430		49	92/6"						M	15.6	
								BOTTOM OF BORING COMPLETED 12/28/2001				
	440											
0	450											

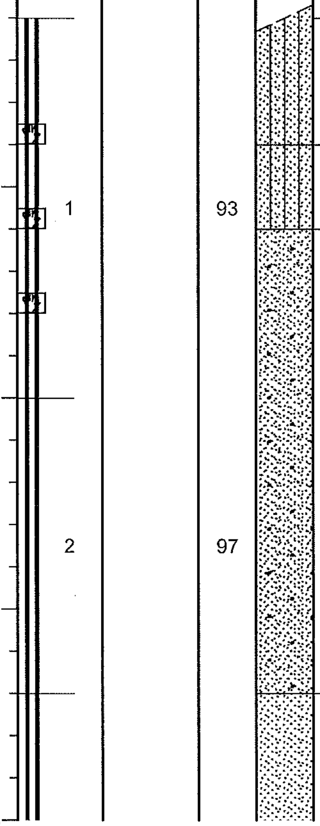
Figure: B-5.4

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

Log of Boring E-105

Sheet 1 of 16

Date(s) Drilled	3/3/03 - 4/3/03	Geotechnical Consultant	Camp Dresser & McKee Inc.	Logged By	TCB	Checked By	VJP 02-03-04
Drilling Method/Rig Type	Roto-Sonic/	Drilling Contractor	Cascade/Boart-Longyear	Total Depth of Borehole	535.0 feet		
Casing Size/Type	8"/6"/4"/Telescoping Casing	Hammer Weight/Drop (lbs/in.)	N/A	Ground Surface Elevation/Datum	549.0 feet / Metro		
Location	5th Ave SW, Shoreline	Coordinates	N 287349 E 1264077	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											0 to 6 feet excavated with vacuum truck, not sampled
545												
	5											
							SM	Medium dense, red brown, wet, slightly gravelly SILTY SAND (SM), fine to coarse sand, fine to coarse gravel, subround to round, numerous organics, wood debris, homogeneous **(af)**				Starting with 9-inch casing
540							SM	Medium dense, yellow red, gravelly silty SAND (SM), fine to medium sand, fine to coarse gravel, trace cobbles, subrounded to rounded, poorly-graded, matrix supported, scattered organics **(Qvt)**				
	10		1		93							
							SW	Dense, brown-olive-gray, moist, gravelly SAND (SW), well-graded, fine to coarse sand, fine to coarse gravel, subround to round, homogeneous **(Qva)**				
535												
	15							Grades brown, slightly gravelly, trace silt				
			2		97							
530												
	20											
							SP	Dense, brown-light gray, moist, gravelly SAND (SP), poorly-graded, trace silt, trace fine sand, medium to coarse sand, fine gravel, subround to round, homogeneous **(Qva)**				
525												
	25											

Groundwater Observation Data:

OW (FT BGS):

VWP1 (FT BGS):

VWP2 (FT BGS):

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

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

Log of Boring E-105

Sheet 2 of 16

		SAMPLES										
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		3		100		SW	Dense, brown to light gray, moist, gravelly SAND (SW), well-graded, trace silt, fine to coarse sand, fine gravel, subrounded to rounded, homogeneous **(Qva)**				
-520							SP-SM	Dense, light gray, moist, slightly silty gravelly SAND (SP-SM), poorly-graded, trace coarse sand, fine to medium sand, subround to round **(Qva)**				
	30						SP	Dense, red brown, moist to wet, slightly gravelly SAND (SP), poorly-graded, trace coarse sand, fine to medium sand, fine to coarse gravel, subround to round, homogeneous, trace silt **(Qva)**				
			4		91							
-515	35											
			5		100		SW	Dense, red brown, moist, gravelly SAND (SW), well-graded, fine to coarse sand, fine to coarse gravel, subround to round, homogeneous **(Qva)**				
-510	40						SP	Dense, red brown, moist, slightly gravelly SAND (SP), poorly-graded, trace silt, trace coarse sand, fine to medium sand, subround to round, homogeneous **(Qva)**				
							SW	As above at 40.0 feet below ground surface (bgs)				
							SP	Dense, red brown, moist, slightly gravelly SAND (SP), poorly-graded, trace silt, trace coarse sand, fine to medium sand, subround to round, homogeneous **(Qva)**				
-505			6		100							
	45							Dense, red brown, moist, slightly gravelly SAND (SP), poorly-graded, trace silt, trace coarse sand, fine to medium sand, subrounded to rounded, homogeneous **(Qva)**				
			7		100		SP-SM	Dense, gray, wet, slightly silty, gravelly SAND (SP-SM), poorly-graded, trace coarse sand, fine to medium sand, fine to coarse gravel, subround to round, scattered weathered silty nodules, brown yellow, homogeneous **(Qva)**				
-500							GM	Dense, gray, wet, silty sandy GRAVEL (GM), fine to oarse sand, fine to oarse gravel, subround to round, homogeneous **(Qva)**				
	50						SM	Dense, brown/gray, wet, slightly silty gravelly SAND (SM), trace coarse sand, fine to medium sand, subround to round, homogeneous, trace Fe(II) staining, weathered yellow brown silt clasts-scattered **(Qva)**				
-495			8		88			Becomes very dense, trace fine sand, medium to coarse sand				
	55							Decreasing silt with depth				
-490												
	60											

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

Log of Boring E-105

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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						SW	Dense, red brown, wet, gravelly SAND (SW), well-graded, trace silt, fine to coarse sand, fine to coarse gravel, subround to round, homogeneous **(Qva)**				
							GM	Very dense, light gray, wet, silty GRAVEL (GM), trace medium to coarse sand, fine sand, fine to coarse gravel (2-3 in. diameter), subround to round **(Qva)**				
-485							SP-SM	Dense to very dense, red brown, slightly silty, gravelly SAND (SP-SM), poorly-graded, layers of fine to coarse gravel, subrounded to rounded, homogeneous, fine to coarse sand **(Qva)**				
	65		9		100							
-480												
	70						SP	Very dense, red brown, wet, gravelly SAND (SP), poorly-graded, trace silt, trace fine sand, medium to coarse sand, subround to round, homogeneous, scattered oxidation **(Qva)**				
-475			10		100		GW	Very dense, red brown, wet, sandy GRAVEL (GW), well-graded, fine to coarse sand, fine to coarse gravel, subround to round, homogeneous, trace silt **(Qva)** Scattered, laminated clasts of dark brown/light brown silt				
	75											Photo labeled as E-115
							SP	Dense, brown, wet SAND (SP), poorly-graded, trace silt, trace medium to coarse sand, trace fine to coarse gravel, fine sand, subround to round, homogeneous **(Qva)**				
-470												
	80		11		100			Increasing medium to coarse sand				
-465												
	85							Grades slightly gravelly, fine sand, fine to coarse gravel, subrounded to rounded				
			12		100							
-460												
	90							Grades trace coarse sand, fine to medium sand				
-455												
	95											

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

Log of Boring E-105

Sheet 4 of 16

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
	95		13		100							
							SW	Dense, brown, wet, slightly gravelly SAND (SW), well-graded, fine to coarse sand, fine to coarse gravel, rounded to subrounded, homogeneous **(Qva)**				
							SP	Dense, brown, wet, slightly gravelly SAND (SP), poorly-graded, trace coarse and, fine to medium sand, fine to coarse gravel, surbrounded to rounded, homogeneous **(Qva)**				
450												
	100						SW	Dense, brown, moist, slightly gravelly SAND (SW), well-graded, fine to coarse sand, fine to coarse gravel, subround to round, homogeneous **(Qva)**				
			14		100		SP					
							SW	Dense, brown/light gray SAND (SP), poorly-graded, trace silt, trace medium to coarse sand, trace fine gravel, fine sand, subround to round, homogeneous **(Qva)**				
							SP	Very dense, brown, wet, gravelly SAND (SW), well-graded, trace silt, fine to coarse sand, fine to coarse gravel, subround to round **(Qva)**				
445												
	105											
			15		100		GW	Dense, brown, wet SAND (SP), poorly-graded, trace silt, trace medium to coase sand, trace fine to coarse gravel, fine sand, subrounded to rounded **(Qva)** Becomes very dense, gravelly SAND (SP), trace coarse sand, fine to medium sand, homogeneous				
							SP	Very dense, brown, moist, sandy GRAVEL (GW), well-graded, fine to coarse sand, fine to coarse gravel, subrounded to rounded, homogeneous **(Qva)**				
440												
	110											
			16		100			Dense, brown, moist, slightly gravelly SAND (SP), poorly-graded, trace medium to coarse sand, trace silt, fine sand, fine to coarse gravel, subround to round, homogeneous **(Qva)** Scattered clasts of gray sandy SILT				
435												
	115											
			17		100							
								Grades with increased coarse sand				
430												
	120						SW	Dense, brown, moist, gravelly SAND (SW), well-graded, trace silt, fine to coarse sand, fine to coarse gravel, subrund to round, homogeneous **(Qva)**				
							SP	Dense, brown, moist SAND (SP), poorly-graded, trace fine gravel, trace medium to coarse sand, fine sand, subrounded to rounded, homogeneous **(Qva)**				
425			18		96		SW					
							SP	Dense, brown, moist, gravelly SAND (SW), well-graded, trace silt, fine to oarse sand, fine to coarse gravel, subrund to round, homogeneous **(Qva)**				
	125						SW					
							SP	Dense, brown, moist SAND (SP), poorly-graded, trace fine gravel, trace medium to coarse sand, fine sand, subrounded to rounded, homogeneous **(Qva)**				
							SW	Dense, brown, moist, gravelly SAND (SW), well-graded, trace silt, fine to oarse sand, fine to coarse gravel, subrund to round, homogeneous **(Qva)**				
420												
	130											

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
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Log of Boring E-105

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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
	130		19		100		SP	Dense, brown, moist, slightly gravelly SAND (SP), poorly-graded, trace silt, trace coarse sand, fine to medium sand, fine to coarse gravel, subrounded to rounded, homogeneous, numerous silt/sand clasts **(Qva)**				
							SW	Dense, brown, moist, gravelly SAND (SW), well-graded, trace silt, fine to oarse sand, fine to coarse gravel, subrund to round, homogeneous **(Qva)**				
415							SP	Dense, brown, moist SAND (SP), poorly-graded, trace silt, trace fine gravel, trace coarse sand, fine to medium sand, subrounded to rounded, homogeneous **(Qva)**				
	135											
			20		100			Dense, brown, moist, gravelly SAND (SW), well-graded, trace silt, fine to coarse sand, fine to coarse gravel, subrund to round, homogeneous **(Qva)**				With numerous +2-inch rip-up clast of sandy SILT
			21		100							
410								Dense, brown, moist SAND (SP), poorly-graded, trace fine gravel, trace medium to coarse sand, fine sand, subrounded to rounded, homogeneous **(Qva)**				
	140		22		100			Layer of well-graded fine to coarse sand Grades slightly gravelly, fine to coarse gravel, subround to round, homogeneous				
			23		100			Laminated silt and sand				
405			24		100			Numerous 1/2-inch to 3/4-inch laminated sand/silt clasts				
	145							Slightly gravelly from 145 to 146 feet bgs				
			25		100							
400								Sand grades fine, trace fine gravel				
	150		26		100							
								Scattered laminated clasts of sand/silt				
395												
	155		27		100							
								Grades to slightly gravelly, fine to coarse gravel				
390												
	160							12-inch-thick, well-graded slightly gravelly SAND layer				
			28		100							
385												
	165											

Log of Boring E-105

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	165		29		100			+6 inch cobble				
								Scattered laminated clasts of sand/silt				
			30		23							
-380												
	170											
			31		100							
-375												
	175											
							SW	Very dense, brown gray, wet, slightly silty, gravelly SAND (SW), well-graded, fine to coarse sand, fine to coarse gravel, subrounded to rounded, homogeneous **(Qva)** 3-inch interbed of fine to medium sand				
-370			32		89							
	180											
							SP	Dense, brown, moist SAND (SP), poorly-graded, trace coarse sand, trace fine to coarse gravel, trace silt, fine to medium sand, subrounded to rounded, homogeneous **(Qva)** Grades slightly gravelly SAND (SP)				
-365												
	185											
			33		93			Grades trace fine to coarse gravel 187 to 190 feet bgs				
-360												
	190											
-355												
	195											
			34		91							
								Becomes wet				
-350												
	200											

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
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Log of Boring E-105

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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											
-345			35		125							
	205											
								Becomes very dense				
			36		100							
-340												
	210							Becomes dense, brown gray, moist to wet				
-335												
	215		37		100							
								Layers of very dense, fine sand (SP)				
-330												
	220											
			38		100							
			39		100							
-325												
	225											
			40		83							
-320												
	230											
								Grades dark gray, slightly silty				
-315												
	235											

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

Log of Boring E-105

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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
	235											
			41		94							
310												
	240											
								Grades moist, fine sand, trace medium sand, fine sand				
305												
	245											
			42		93							
300												
	250											
295							ML	Hard, dark gray, moist, clayey SILT (ML), trace fine sand, subrounded to rounded, medium plasticity, medium strength, massive **(Qvlc)**		MP		
	255											
			43		88		SP-SM	Very dense, dark gray, moist, slightly silty SAND (SP-SM), poorly-graded, trace medium sand, fine sand, homogeneous, micaceous, occasional organic fragments **(Qpfnf)**				
290												
	260											
			44		100							
285												
	265						SM	Dense, dark gray brown, wet, silty SAND (SM), fine sand, subrounded to rounded, homogeneous, rapid dilatancy, occasional organic fragments **(Qpfnf)**				
280								Rapid dilatancy				
												Perched zone
	270											

Project: King County WTD / Brightwater Conveyance System
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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
	270		45		100							
-275												
	275											
-270												
	280		46		100							
-265												
	285											
			47		100							
								Grades to sandy SILT				
-260												
	290											
								Grades to silty SAND				
			48		100							
-255												
	295						ML	Very stiff, dark gray, wet, clayey SILT (ML), trace fine sand, low plasticity, rapid dilatancy, massive, trace organics **(Qpfnl)**				295-305 foot sample was drilled on 3/11/03 end of day. Sample was lost while pulling rods. Redrilled and left rods in hole overnight to attempt retrieval
-250												
	300		49		99							
-245												
	305											

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

Log of Boring E-105

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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
	305											
								Increased plasticity, slow dilatancy				
			50		100							
240												
	310						CL	Hard, gray, moist, very silty CLAY (CL), low to moderate plasticity, medium dry strength, massive, slow dilatancy, occasional organics **(Qpfnl)**				Termination of 8-inch casing
235												
	315		51		95							
										MP		Petroleum hydrocarbon odor and apparent oil-like coating on surface of sample probably due to decaying organics Sample loss occurred approximately 320 to 322 feet. Driller required 250 to 300 psi to extrude sample
230												
	320							Laminated with light gray silt and fine sand partings/seams, slow to rapid dilatancy				
225			52		75			Grades moderate to hightly plastic		M AL		Slickensides
	325											
220								3-foot stratum grades very stiff, wet, slightly sandy to trace sand, fine sand, subround to round, low plasticity, massive to scattered inderbeds of fine sand				
	330											
			53		90							
215												
	335											
							SP-SM	Dense, dark gray, moist, slightly silty SAND (SP-SM), poorly-graded, fine to medium sand, subrounded to rounded, homogeneous, scattered (ML) layers **(Qpfnf)**				
												Begin with 6-inch casing and 4-inch core
210												
	340											

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
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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
	340		54		100		ML	Hard, dark gray, moist, clayey SILT (ML), low plasticity, non-dilatant, massive **(Qpfnl)**				
							SP-SM	Dense, gray green, moist, slightly silty SAND (SP-SM), poorly-graded, fine to medium, trace organics **(Qpfnf)**				
205							ML	Very stiff to hard, gray, moist, clayey SILT (ML), low plasticity, laminated, rapid dilatancy, organic odor **(Qpfnl)**				
	345							Rapid dilatancy, low strength Slow dilatancy, medium strength				
								Hard, non dilatant, medium strength				
			55		142							
200												
	350											
								Hard, non dilatant, medium strength, laminated/ interbedded light gray, fine sand seams		M AL MP		
195								Hard, gray, low to moderate plasticiy, medium strength, scattered laminated fine sand seams, slow dilatancy				354 to 360 foot sample fell out of core barrel during extraction
	355											
								Approximate 2.5-inch brown organic layer		AD		Conventional radiocarbon date 28,600 +/- 250 years B.P.
190			56		98							
	360							Trace medium to coarse sand				
												Occasional brown organic nodules
							SM	Dense, dark gray, moist, silty SAND (SM), fine sand, subround to round, poorly-graded, homogeneous, trace organics, scattered brown organic nodules **(Qpfnf)**		M SA		
185												
	365						ML	Stiff, dark gray, moist, sandy SILT (ML), trace medium sand, fine sand, subround to round, nonplastic, slow to rapid dilatancy, homogeneous **(Qpfnl)**				
			57		104					M SA		
180												
	370											
							ML	Hard, dark gray, wet, sandy SILT (ML), fine sand, subrounded to rounded, nonplastic to low plasticity, low strength **(Qpfnl)**				
			58		90		CL	Hard, dark gray, silty CLAY (CL), trace fine gravel, low plasticity, medium strength, massive, occasional partings of light gray fine sand **(Qpfnl)**		M SA AL	4	
175												
	375											

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
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Log of Boring E-105

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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
	375						ML	Stiff, dark gray, wet, slightly sandy, clayey SILT (ML), fine sand, subround to round, low plasticity, low strength, massive, slow dilatancy **(Qpfnl)**				
			59		100		SM	Dense, dark gray, wet, silty SAND (SM), sand fine, rapid dilatancy **(Qpfnf)**		M SA		
170							CH	Hard, dark gray, moist, silty CLAY (CH), trace fine sand and fine gravel, moderate to high plasticity, medium strength, non-dilatant, massive, scattered partings of fine sand, light gray **(Qpfnl)**				
	380											
			60		83							
165										M AL		
	385											
								Numerous partings/nodules of light gray fine sand/silt				
			61		87							
160												
	390											
								Stiff, wet, slightly sandy, fine sand, subround to round, nonplastic to low plasticity, massive, scattered brown organic nodules				
155			62		100							
	395									SA HA		
								18-Inch thick silty fine SAND stratum, numerous organics, rootlets/woody debris Hard, moist, slightly silty, trace fine sand, low plasticity, medium strength, numerous partings of light gray silt.				
150												
	400											
			63		98							
145										M		
	405							Increasing silt content				
							SM	Dense, dark gray, moist, silty SAND (SM), fine sand, subrounded to rounded, layers of silty sand with clay (CL) pockets, trace organics **(Qpfnf)**				
			64		100							
140												
	410											

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
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Log of Boring E-105

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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
	410							Dense, dark gray, moist, silty, clayey SAND (SC), fine sand, low to nonplastic **(Qpfnf)**				Run 65 drilled/sampled 3 times before brought up, TCB starts logging
							ML	Very stiff, dark gray, moist, sandy SILT (ML) **(Qpfnl)**				
										M SA		
135								Grades slightly clayey, trace tine sand, nonplastic, slow to rapid dilatancy, massive				
	415		65		80							
							SM	Dense, darj gray, moist, very silty SAND (SM), to very sandy SILT (ML), fine sand, trace organics **(Qpfnf)**				
130												
	420							Grades silty, trace clay, low toughness, nonplastic, fine sand				
								Decreasing silt				
125			66		79							
	425							Increasing silt				
								Grades silty SAND (SM) to sandy SILT (ML)		M SA MP		
							ML	Stiff, dark gray, moist, slightly sandy to sandy SILT (ML), trace medium sand, fine sand, subround to round, nonplastic, slow to rapid dilatancy, homogeneous **(Qpfnl)**				
120												Sample discovered to have slid out at 1615. 1 foot run lost. Drilling done for 3/15 at 1630.
	430											
			67		100					M SA		
115												
	435						SM	Dense, dark gray, wet, silty SAND (SM), fine to medium sand, subrounded to rounded, homogeneous **(Qpfnl)**				
110												
	440											
			68		93							
105												
	445											

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

Log of Boring E-105

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
	445											
							ML	Hard, dark gray, moist, slightly clayey SILT (ML), nonplastic, medium strength, numerous organics (dark brown), black and white organic nodules, massive **(Qpfnl)**				
-100							SM	Dense, dark gray, wet, silty to slightly silty SAND (SM), fine to medium sand, subround to round, homogeneous, scattered silt clasts **(Qpfnf)**				
	450		69		75							
												Recovery of Run 70 attempted approximately 6 times
-95	455											
			70		92							
-90												459 to 465 feet sample appears to be intact and not reoworked/drilled
	460									M SA		
-85	465						ML	Hard, gray, moist, slightly clayey SILT (ML), low plastsicity, low strength, massive, numerous black organic nodules **(Qpfnl)**				
							OL	Hard, dark brown, moist, organic SILT (OL), nonplastic to low plasticity, medium strength, numerous brown-black organics **(Qpfnw)**				
			71		100		ML	Hard, brown gray to gray, moist, clayey SILT (ML), low plasticity, medium strength, massive, numerous organic nodules **(Qpfnl)** Becomes sandy Trace fine sand, low plasticity, low strength, slow dilatancy Layer of rapid dilatancy at				
-80	470											
-75	475		72		92							
							OL	Hard, dark brown, moist, organic SILT (OL), nonplastic to low plasticity, medium strength, numerous brown-black organics **(Qpfnw)**				
							ML	Stiff, gray, wet, slightly clayey SILT (ML), trace fine sand, low plasticity, low strength, massive, scattered organics, slow dilatancy **(Qpfnl)**				
-70	480											

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Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
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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
	480						SP-SM	Dense, dark gray, wet, slightly silty SAND (SP-SM), fine to medium sand, subround to round, poorly-graded, homogeneous **(Qpfnf)** .				
								Grades silty, occasional organics				
							ML	Grades to very stiff, brown gray, mottled, silt (ML), trace fine sand, nonplastic to low plasticity, medium strength, numerous organics, slow to rapid dilatancy				
65							SM	Layer rapid dilatancy at 484 ft bgs **(Qpfnf)**				
	485		73		94			Dense, dark gray, wet, silty SAND (SM), fine to medium sand, subrounded to rounded, homogeneous, occasional organics **(Qpfnf)** Grades trace fine sand, nonplastic				
60							ML	Medium stiff, gray, wet, sandy SILT (ML), fine sand, nonplastic, homogeneous, rapid dilatancy **(Qpfnl)**				
	490							Grades very stiff, moist, slightly clayey, trace fine sand, numerous organic nodules				
							PT	Very stiff, dark brown, wet PEAT (PT), numerous partings of ash, fibrous, wood debris, 2 to 4-inch layers of gray SILT (ML) **(Qpfnw)**				
55			74		94		ML	Medium stiff, gray, wet, slightly sandy SILT (ML), fine sand, nonplastic, scattered organics, low strength, rapid dilatancy **(Qpfnl)**				
	495											
50							SM	Dense, dark gray, moist, silty SAND (SM), fine sand, subround to round, homogeneous **(Qpfnf)**				
	500											
										M SA		
45			75		100			Grades fine to medium sand, numerous silt clasts, trace fine gravel				
	505											
40								Grades gravelly, fine to coarse gravel, subround to round				
	510											
35								Grades slightly gravelly				
	515											

Project: King County WTD / Brightwater Conveyance System
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Log of Boring E-105

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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
	515		76		100							
							SP-SM	Dense, dark gray, moist, slightly silty SAND (SP-SM), fine to medium sand, subround to round poorly-graded, homogeneous, numerous silt clasts **(Qpfnf)**				
30												
	520											
							ML	Interbedded layers of stiff, dark gray/green gray, slightly clayey, slightly sandy SILT (ML), fine sand, nonplastic, low strength, trace brown organic nodules **(Qpfnl)**				
25												
	525											
							SP	Dense, dark gray, moist, slightly silty SAND (SP), poorly-graded, fine to medium, trace gravel **(Qpfnl)** Grades fine to coarse gravel, subround to round		MP		
			77		100							
20												
	530											
							SM	Dense, dark gray, moist, silty SAND (SM), fine sand, trace medium sand, homogeneous **(Qpfnf)**				
15												
	535							Terminated boring at 535 feet below ground surface				
10												
	540											
5												
	545											
0												
	550											

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

Log of Boring E-106

Sheet 1 of 17

Date(s) Drilled	4/11/03 - 4/22/03	Geotechnical Consultant	Camp Dresser & McKee Inc.	Logged By	RW
Checked By	VJP 02-03-04				
Drilling Method/Rig Type	Wireline/ T3	Drilling Contractor	Cascade Drilling, Inc.	Total Depth of Borehole	566.0 feet
Casing Size/Type	PQ (7"O.D.)	Hammer Weight/Drop (lbs/in.)	300# / 30"	Ground Surface Elevation/Datum	581.9 feet / Metro
Location	20357 Greenwood Ave	Coordinates	N 287281 E 1266085	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											0 to 6 ft bgs excavated with vacuum truck, not sampled
580												
	5											Drive 6-inch-diameter casing to 18 feet bgs
575							GW-GM	Dense, yellow-brown, moist, slightly silty, sandy GRAVEL (GW-GM), trace cobbles, well-graded, fine to coarse subangular gravel **(Qvtm)**				Soil description inferredd from drill action and cuttings
	10											
570												
	15											Driller reports hard drilling in cobbles and boulders
565		■	1	46 - 50/2" (100+)	0							No recovery, stone in sampling shoe
	20											Drillers use tri cone bit for drilling through formation from 21 to 37 feet bgs
560												
	25											

Groundwater Observation Data:

OW (FT BGS): 390.0 (Low) 388.9 (High)

VWP1 (FT BGS):

VWP2 (FT BGS):

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 E-106

Sheet 2 of 17

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											
555												
	30											
550												
												Hard drilling
	35											
545												
		■	2	19 - 50/5" (100+)	9		GW	Very dense, brown, moist, sandy GRAVEL (GW), well-graded, fine to coarse subangular gravel **(Qva)**				
	40											
							SW-SM	Very dense, brown, moist, slightly silty, gravelly SAND (SW-SM), well-graded, fine to coarse sand, fine to coarse subangular gravel **(Qva)**				Drilling smoother
540												
												Soil description inferredd from drill action and cuttings
	45											
535												
	50											
530												
	55											
525												
		■	3	55/6" (100+)	100							
	60											

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

Log of Boring E-106

Sheet 3 of 17

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											
520												
	65											
515												
	70											
510												Drill action suggests cobbles
							GW	Very dense, gray, moist to wet, sandy GRAVEL (GW), trace silt, well-graded, fine to coarse subangular to subrounded gravel **(Qva)**				
	75											
505		■	4	50/5" (100+)	40							
	80											
500												
	85											
495												
	90											
490												
	95											

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

Log of Boring E-106

Sheet 4 of 17

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
	95											
												Cobbles noticed by drillers
485		▬	5	50/4" (100+)	101		SP	Very dense, wet, olive gray, slightly gravelly to gravelly SAND (SP), poorly-graded, fine to coarse sand, fine to coarse subangular to subrounded gravel **(Qva)**				
												Soil description inferredd from drill action and cuttings
	100											
480												
	105											
475												
	110											
470												Drill action suggests some gravel
	115											
465		▬	6	50/4" (100+)	0							
	120											
460												
	125											
455												
	130											

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

Log of Boring E-106

Sheet 5 of 17

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
	130											
-450												
	135											
-445		▭	7	50/4" (100+)	0							Drill action suggests gravelly sand
	140											
-440												
	145											
-435												
	150											
-430												
								Grades brown				
	155											Soil description inferredd from drill action and cuttings
-425		■	8	50/5" (100+)	99							
	160											
-420												
	165											

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

Log of Boring E-106

Sheet 6 of 17

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
	165											
-415												
	170											
-410												
	175											
-405		▭	9	50/3" (100+)	0							Gravel in shoe, drillers assume sandy gravel to gravelly sand with cobbles
	180											
-400												
	185											
-395												
	190											
-390												
	195											
-385		■	10	50/5" (100+)	99			Grades gravelly				Soil description inferredd from drill action and cuttings
	200											

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

Log of Boring E-106

Sheet 7 of 17

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											
380												
	205											
375												
	210											
370												
	215											
365		■	11	50/6" (100+)	100		SP-SM	Very dense, brown, wet, slightly gravelly, slightly silty SAND (S-SM), poorly-graded, fine to coarse sand, fine subrounded gravel **(Qva)**				Soil description inferredd from drill action and cuttings
	220											
360												
	225											
355												
	230											
350												
	235											

CDM

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

Log of Boring E-106

Sheet 8 of 17

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
	235											
345		■	12	50/6" (100+)	100			Grades olive gray, sand, trace silt, trace gravel				Soil description inferredd from drill action and cuttings
	240											
340												
	245											
335												
	250											
330												
	255											
325		■	13	50/4" (100+)	76			Grades moist, fine to medium sand				
	260											
320												
	265											
315												
	270											

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

Log of Boring E-106

Sheet 9 of 17

		SAMPLES										
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
	270											
-310												
	275						GM	Silty sandy GRAVEL (GM) **(Qpfnf)**				Gravel infered by drill action and cuttings Soil description inferredd from drill action and cuttings
-305												Switch to wire-line Slough, outwashed sand
			14		40							
	280											
-300												
	285						ML	Stiff, olive gray, moist, slightly clayey, sandy SILT (ML), medium plasticity, scattered organics **(Qpfnl)**				
-295			15		67							
								Grades very stiff, no clay				
	290											Organic odor
-290							SP	Dense, olive gray, moist, SAND (SP), trace silt, poorly-graded fine to medium sand, occasional organics **(Qpfnf)**				
	295											
-285			16		100							
	300											
-280												
								Scattered organics				
	305											

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

Log of Boring E-106

Sheet 10 of 17

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
	305											
275			17		100							
								Wood fragment				
	310						ML	Stiff to very stiff, gray, moist SILT (ML), low plasticity **(Qpfnl)**				
270								Grades slightly sandy, hard, nonplastic				
	315							Occasional organic fragments				
265			18		100							
								Grades sandy				
	320							Trace sand, low plasticity				
260												
								Trace clay				
	325											
255			19		100							
								Grades slightly clayey				
	330											
250								Grades clayey silt, slickensided, homogeneous				
	335							1-foot fine sand layer				
245			20		100							
	340											

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

Log of Boring E-106

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Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	340											
								Trace sand				
240												Organic odor
								Frequent seams of lighter-colored silt				
								1-foot silty fine sand layer				
	345							Grades silt and clay				
235			21		84							
							SP	Dense, dark gray, moist, SAND (SM), trace silt, poorly-graded, fine to medium sand, scattered organics **(Qpfnf)**				
	350							Medium dense, olive gray				Organic odor
												Organic odor
230												
							ML	Very stiff, dark gray, moist, slightly clayey SILT (ML), fine sand seam at 355 ft bgs, low plasticity, homogeneous, slickensides **(Qpfnl)**				
	355											
225			22		90							
								1-foot fine sand layer				
	360						CH	Hard, dark gray, moist silty CLAY (CH), high plasticity **(Qpfnl)**				Organic odor
												Slickensides
220							SP	Dense, dark gray, moist, SAND (SP), trace silt, poorly-graded, fine to medium sand **(Qpfnf)**				
												Organic odor
	365											
215			23		79		CH	Very stiff, dark gry, moist, silty CLAY (CH), high plasticity, slickensides **(Qpfnl)**				
								Sand layers				
	370											
210												
								Grades stiff				
	375											

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

Log of Boring E-106

Sheet 12 of 17

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
	375							Grades, hard, sandy clay, scattered organics				Drill action suggests some gravel
205			24		100							
							SP	Very dense, dark gray, moist, SAND (SP), trace silt, poorly-graded fine sand, occasional organics **(Qpfnf)**				
	380											
200								Grades fine to medium				
	385							Becoming gray green				
195			25		100		CL	Hard, dark gray, moist, silty CLAY (CL), medium plasticity, slickensided, homogeneous, fine sand layers **(Qpfnl)**				
	390											Interbedded fine sand has strong organic odor
190							MH	Hard, dark gray, moist, clayey SILT (MH), medium to high plasticity **(Qpfnl)**		M AL		
	395											
185			26		98					M		
	400											
180							CH	Hard, dark gray, moist, silty CLAY (CH), medium to high plasticity **(Qpfnl)**				
										M AL	4	
	405											
175			27		100							
							SP	Dense, dark gray, moist SAND (SP), trace silty, poorly-graded sand, scattered organics **(Qpfnf)**				Strong organic odor in fine sand
	410											

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

Log of Boring E-106

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	410							M SA		
170						CL	Hard, dark gray, moist, silty CLAY (CL), medium plasticity, slickensided, homogeneous, fine sand layers **(Qpfnl)**			
						ML	Stiff, dark gray to gray green, moist, SILT (ML), trace sand, trace clay, low plasticity, scattered organics **(Qpfnl)**			
	415							M SA		Organic odor
165			28		59					
						SP	Very dense, dark gray, moist, SAND (SP), trace silt, poorly-graded fine sand, scattered organics **(Qpfnf)**			Organic odor
	420									
160							Grades dense, fine to medium sand			
	425							M SA		
155			29		95					
						ML	Hard, dark gray, moist, slightly sandy SILT (ML), scattered organics, nonplastic **(Qpfnl)**			
	430									Outwashed gravel
150						SP	Very dense, dark gray, moist, SAND (SP), trace silt, poorly-graded fine sand, scattered organics **(Qpfnf)**			
	435									
145			30		100					
							Grades fine to medium sand			
	440						Wood pieces			
						PT	Brown PEAT **(Qpfnw)**			
140						CL	Very stiff, dark gray, moist, silty CLAY (CL), medium plasticity **(Qpfnl)**			
						ML	Hard, gray olive, slightly clayey, sandy SILT (ML), low plasticity, occasional organics **(Qpfnl)**			
	445						Very dense, gray green, moist, SAND (SP), trace			

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

Log of Boring E-106

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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
	445		32		82		SP	silt, poorly-graded fine sand **(Qpfnf)**				
								Grades dense, dark gray, fine to coarse sand, trace fine gravel, poorly-graded sand				Hard drilling
-135												
	450		33		85		ML	Hard, gray, moist, sandy SILT (ML), low plasticity, scattered organics **(Qpfnl)** 6-inch laminated brown organic silt and sand		M		
-130							SP	Very dense, light gray, moist, SAND (SP), poorly-graded fine sand, homogeneous, occasional organics **(Qpfnf)**				
			34		100							
	455											
												Organic odor
-125							OL	Hard, gray brown, moist, organic SILT (OL), trace sand, trace clay **(Qpfnw)**				Hard drilling
										M		
			35		100		SM	Gray green to gray olive, moist, very silty SAND (SM), wood fragments **(Qpfnf)**				
	460									M		Organic odor
							ML	Very stiff, gray, moist, slightly sandy SILT (ML) scattered to numerous organics **(Qpfnl)**				
-120												
												Organic odor
	465							Layers of sandy silt and silty sand, numerous organics				
-115			36		100							
	470											Hard drilling
-110												
			37		43		SP	Dense, dark gray, moist, SAND (SP), trace silt, poorly-graded fine to coarse sand, occasional organics **(Qponf)**				
	475											Outwashed sand
-105												No recovery, outwashed sand
			38		0							
	480							Grades fine sand, scattered organics				

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

Log of Boring E-106

Sheet 15 of 17

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
	480							Wood pieces				
								Grades very stiff, sandy silt, low plasticity				
-100												
			39		80							
												Hard drilling
	485											
-95												Circulation mud: Fine to coarse sand, no recovery, outwashed sand
			40		0							
							GW-GM	Slightly silty, gravelly SAND (SW-SM) to slightly silty sandy GRAVEL (GW-GM) **(Qpfnb)**				Soil description inferredd from drill action and cuttings Circulation mud: Sandy gravel to gravelly sand shell fragments
	490											
-90												No recovery
												Gravelly drilling
			41		0							
	495											
-85												
	500											
												Gravelly drilling
-80												
												No recovery
			42		0							
	505											
-75												
	510											Gravelly drilling
-70												
			43		0							
	515											

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

Log of Boring E-106

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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
	515											
65												Coarse subrounded gravel infered by drill aciton and cuttings
			44		0							
	520											
60												
			45		17		SW	Very dense, dark gray, moist, SAND (SW), trace silt, trace fine gravel, well-graded fine to coarse sand, occasional organics **(Qpfnf)**				
	525											
55							CL	Very stiff, dark gray, moist, sandy, silty CLAY (CL), medium plasticity **(Qpfnl)**				
							GM	Very dense, slightly silty, sandy GRAVEL (GM), fine to coase sand, subrounded gravel **(Qpfnf)**				
	530											
50												
			46		53							
							CL	Stiff, dark gray, moist, sandy, silty CLAY (CL) medium plasticity **(Qpfnl)**				
	535						SP	Dense, dark gray, wet SAND (SP), trace silt, poorly-graded fine to coarse sand **(Qpfnf)**				
45												
							GW-GM	Slightly silty, gravelly SAND (SW-SM) to sandy GRAVEL (GW-GM) **(Qpfnf)**				Soil description inferredd from drill action and cuttings Gravelly drilling
			47		0							
	540											
40												
			48		70		SM	Very dense, dark gray, moist, very silty, slightly gravelly, SAND (SM), fine to coarse sand, fine to coarse subrounded gravel, scattered organics **(Qpogl)**				
	545											
35												
										M		
			49		70							
	550											

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

Log of Boring E-106

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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
	550											
-30												
			50		61							
	555											
-25												
	560											
-20			51		91							
	565											
			52		100					SA HA		
								Terminated boring at 566 feet below ground surface				
-15												
	570											
-10												
	575											
-5												
	580											
-0												
	585											

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

Log of Boring E-107

Sheet 1 of 16

Date(s) Drilled	3/19/03 - 3/24/03	Geotechnical Consultant	Camp Dresser & McKee Inc.	Logged By	RW
Checked By	VJP 02-03-04				
Drilling Method/Rig Type	D&M/Wireline/ T3	Drilling Contractor	Cascade Drilling, Inc.	Total Depth of Borehole	548.0 feet
Casing Size/Type	PQ (7"O.D.)	Hammer Weight/Drop (lbs/in.)	300# / 30"	Ground Surface Elevation/Datum	549.5 feet / Metro
Location	782 N. 204th SE	Coordinates	N 287288 E 1268071	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											0-8 feet excavated with vacuum truck, not sampled
545	5											
							GP	Very dense, brown, wet, sandy GRAVEL (GP), trace silt, poorly-graded fine to coarse sand, poorly-graded fine subangular gravel **(Qva)**				Drilling Mud Rotary 8 to 180 feet below ground surface (bgs)
540	10											Soil description inferred from drill action and cuttings Irregular drilling resistance in gravel
535	15											
530	20	■	1	50/3" (100+)	33							
525	25											

Groundwater Observation Data:

OW (FT BGS):

VWP1 (FT BGS)223.8 (Low) 221.3 (High)

VWP2 (FT BGS)223.9 (Low) 220.8 (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
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

Log of Boring E-107

Sheet 2 of 16

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											
520	30											
515	35											
510	40	■	2	50/5" (100+)	50		GW	Very dense, brown, wet, sandy GRAVEL (GW), well-graded to sandy GRAVEL (GP), poorly-graded, fine to coarse gravel, fine to coarse sand, subangular gravel **(Qva)**				Soil description partially inferred from drill action and cuttings
505	45											
500	50											
495	55											
490	60											

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

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Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	60	■	3	50/4" (100+)	0							Sand and gravel in circulation mud
485												
	65											
480												
	70											
475												
	75											
470												
	80	■	4	60/5" (100+)	0							Sand and gravel in circulation mud
465												
	85											
460												
	90											
455												
	95											

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

Log of Boring E-107

Sheet 4 of 16

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
	95											
-450	100	■	5	100/3" (100+)	0							Sample collected from cuttings of circulation mud (crushed gravel)
												Hard drilling in gravel and cobbles
-445	105											Drilling smooth
							SP-SM	Very dense, brown yellow, wet, slightly silty, gravelly SAND (SP-SM), poorly-graded fine to medium sand, fine subangular gravel **(Qva)**				Soil description inferred from drill action and cuttings
-440	110											
-435	115											
-430	120	■	6	50/5" (100+)	50							
-425	125											
-420	130											

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

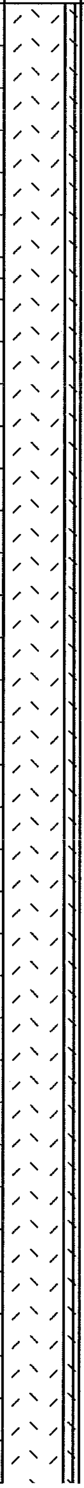
Log of Boring E-107

Sheet 5 of 16

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	130									
-415	135									
						GW	Sandy GRAVEL (GW), well-graded to sandy GRAVEL (GP), poorly-graded, fine to coarse gravel, fine to coarse sand, subangular gravel **(Qva)**			Soil description inferred from drill action and cuttings
-410	140	■	8	50/4" (100+)	0					
-405	145									
-400	150									
-395	155									
-390	160	■	9	50/5" (100+)	0					
-385	165									

Graphic Log

Piezometer Schematic



Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
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Log of Boring E-107

Sheet 6 of 16

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
	165											
380	170											
375	175						SP-SM	Very dense, brown yellow, wet, slightly silty gravelly SAND (SP-SM), poorly-graded fine to coarse sand, fine subangular gravel **(Qva)**				Soil description inferred from drill action and cuttings
370	180	■	10	50 - 50/1" (100+)	67							Switch from mud rotary to wire-line at 180 feet; no core recovery. Switch to Mud Rotary from 185 to 229 feet bgs
365	185											
360	190											
355	195											
350	200											

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

Log of Boring E-107

Elevation, feet	Depth, feet	Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	REMARKS AND OTHER TESTS
	200	■	11	50/4" (100+)	67		Transitions fine to medium sand, dropstones of coarse gravel	BG	
-345	205								
-340	210								
-335	215								
						SP	Very dense, olive gray, moist, SAND (SP), trace silt, trace gravel, poorly-graded fine to medium sand, homogeneous **(Qva)**		
		■	12	50/4" (100+)	50				
-330	220								
		■	13	75/5" (100+)	50				
-325	225						Transitions - no gravel		
		■	14	20 - 50/2" (100+)	67				
-320	230		15		100				Switch to wire-line drilling method
			16		94				
-315	235								

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

Log of Boring E-107

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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
	235		17		108		ML	Very stiff, olive gray to gray blue, moist, slightly sandy, slightly clayey SILT (ML), medium plasticity, homogeneous **(Qpfnl)** Occasional organics		BG		
310	240		18		50			Transitions hard, gray, clayey silt, low plasticity			4	
305	245		19		108			Transitions stiff, wet, trace clay		MP	2.6	
			20		90		SM	Dense, gray to gray green, wet, silty SAND (SM), fine sand, homogeneous, occasional organics **(Qpfnf)**				
300	250		21		98			Slightly silty				
295	255		22		96							
290	260		23		70							
							ML	Very stiff to hard, gray, moist SILT (ML), low plasticity, homogeneous **(Qpfnl)**				
285	265		24		70		CL	Very stiff, gray, moist, silty CLAY (CL), medium plasticity, homogeneous **(Qpfnl)**				
			25		120							
							ML	Very stiff, gray, moist, clayey SILT (ML), medium plasticity **(Qpfnl)**		MP		
280	270		26		76							

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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
	270						SP	Very dense, gray green, moist, SAND (SP), trace silt, poorly-graded fine sand, homogeneous, occasional organics **(Qpfnf)**				
								3.5-inch very stiff, sandy, silty clay layer				
			27		78							
275	275							Wood fragments				
			28		111			18-inch stratum wet, scattered organics and wood fragments		BG		
270	280							Transistions fine to medium sand				
			29		100							
265	285											
			30		104							
260	290											
			31		100		SM	Dense, gray, wet, slightly silty SAND (SM) **(Qpfnf)** 12-inch silty clay layer				
255	295							18-inch silty clay stratum			4.5	Slickensides
			32		80							
250	300											
			33		91		SP	Very dense, gray, wet, SAND (SP), trace silt, poorly-graded fine to medium sand, occasional organics, homogeneous **(Qpfnf)**				
245	305											

Project: King County WTD / Brightwater Conveyance System
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Contract Number: E23007E

Log of Boring E-107

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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
	305						SM	Very dense, gray, wet, silty SAND (SM), fine sand, occasional organics **(Qpfnf)**				
			34		104		CL	Very stiff, olive gray, moist, silty CLAY (CL), medium plasticity, sandy layers, massive **(Qpfnl)**			4.2	
240												Slickensides
	310											
			35		60							
235	315											
							SM	Very dense, olive gray, moist, silty SAND (SM), trace clay, fine to medium sand, homogeneous, occasional organics **(Qpfnf)**				
			36		100							
230	320									BG		
								Sandy silty clay layer				
			37		100							
							CH	Very stiff, olive gray, moist, silty CLAY (CH), medium to high plasticity **(Qpfnl)**				Slickensides
225	325											
			38		80							
220	330											
			39		44			12-inch sandy silt layer		BG MP		
								Transitions slightly silty clay				
215	335									M AL		
			40		64							
								Coarse gravel, subangular				
210							GC	Very dense, gray, wet, slightly sandy, silty, clayey GRAVEL (GC), fine to coarse subangular gravel				
	340											

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

Log of Boring E-107

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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
	340							**(Qpfnf)**				Gravel-size granite and sandstone
			41		2							
205	345		42		67							344 to 345.5 feet bgs, sample appears to be slough
							SP-SM	Very dense, gray green, wet, slightly silty SAND (SP-SM), poorly-graded fine to medium sand, homogeneous **(Qpfnf)**				
			43		108			6-inch gravelly, fine to coarse sand layer				348 to 350.5 feet - organic odor
200	350											
			44		88		CL	Hard, gray green, moist, sandy CLAY (CL), low plasticity, oxidized, scattered organics, dropstones (fine gravel) **(Qpfnl)**		M AL MP BG		
195	355							Transitions gray, occasional organics				Slickensides dip approximately 20 degrees from horizontal
			45		30							
190	360							Grades to clayey silt				
			46		82		GC	Very dense, gray, wet, clayey GRAVEL (GC), subrounded, in clayey matrix **(Qpfnf)**				
185	365							Silty sand layer 0.5 foot thick				Soil description inferred from drill action and cuttings
										M SA		
			47		0							Drill action infers gravel
180	370											
			48		0							
175	375											

Project: King County WTD / Brightwater Conveyance System
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Log of Boring E-107

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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
	375											
			49		20		SP-SM	Loose, gray green, wet, slightly silty SAND (SP-SM), trace gravel, poorly-graded fine sand, fine subrounded gravel, occasional organics, homogeneous **(Qpfnf)**				
-170	380											
							GW	Dense, gray, wet GRAVEL (GW), well graded, fine to coarse gravel, subrounded **(Qpfnf)**		M SA		
			50		43			Transitions wet, fine to medium gravel		M SA		
-165	385											
			51		78		ML	Stiff, gray green, wet, sandy SILT (ML), trace clay, low plasticity, homogeneous **(Qpfnl)**			3	
-160	390									M		
			52		100		SP-SM	Loose, gray green, wet, slightly silty SAND (SP-SM), poorly-graded fine to coarse sand, occasional organics, homogeneous **(Qpfnf)**				
-155	395											
			53		60							
							GW	Loose, gray green, slightly silty, sandy GRAVEL (GW), well-graded fine to coarse sand, well-graded fine to coarse gravel **(Qpfnf)**		M SA		
-150	400											
			54		10							
-145	405						SP	Medium dense, gray green, wet SAND (SP), trace silt, poorly-graded fine to medium, occasional organics, homogeneous **(Qpfnf)**				
			55		100							
							SM	Dense, gray olive, moist, silty SAND (SM), fine to medium sand, homogeneous **(Qpfnf)**				
-140	410											

Project: King County WTD / Brightwater Conveyance System
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Contract Number: E23007E

Log of Boring E-107

Sheet 13 of 16

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	410						SP	Medium dense, gray green, wet SAND (SP), trace silt, poorly-graded fine to medium sand, occasional organics, homogeneous **(Qpfnf)**				
			56		100							
										BG		
								Gray olive, silty sand layer				
-135	415											
												Organic odor
			57		100							
								Silty sand layer				
-130	420											
			58		58							
							GW	Dense, gray olive, wet, sandy GRAVEL (GW), trace silt, well-graded fine to coarse sand and well-graded fine to coarse subrounded gravel **(Qpfnf)**				
-125	425											Hard drilling
			59		30							
-120	430		58		0							Soil description inferred from drill action and cuttings
							SP-SM	Gray olive, wet, slightly silty SAND (SP-SM), poorly-graded fine to medium sand, occasional organics, homogeneous **(Qpfnf)**				Organic odor
			60		82					M SA		
-115	435											
										BG		Organic odor
			61		100							
-110	440											
								Sandy silt layer				
			62		96							
-105	445											

Project: King County WTD / Brightwater Conveyance System
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Log of Boring E-107

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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
	445											
								Trasitions gray green color				
								Occasional organics				
			63		96			Silty gravelly sand layer, occasional organics				
-100	450						ML	Hard, gray, moist, slightly clayey, sandy SILT (ML), trace fine gravel, low plasticity, occasional organics **(Qpfnl)**				
										MP		
			64		22							
-95	455							Transitions gravelly silt				
							SP	Dense, gray green, wet SAND (SP), trace silt, poorly-graded fine to medium sand **(Qpfnf)**				
			65		62			12-inch gravel layer **(Qpfnf)**				
-90	460											
								12-inch gravel layer				
			66		46							
-85	465											
								4-foot slightly gravelly stratum				
			67		100							
-80	470											Organic odor
			68		100							Organic odor
-75	475						SP-SM	Medium dense, gray green, wet, slightly silty SAND (SP), poorly-graded fine to medium sand **(Qpfnf)**				
										M SA		
			69		100							
-70	480											

Project: King County WTD / Brightwater Conveyance System
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Contract Number: E23007E

Log of Boring E-107

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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
	480											
												Organic odor
			70		70							
-65	485											
			71		100							
-60	490											
								Transitions gray olive, occasional organics				
			71		100							
								2-foot slightly silty stratum				
-55	495											
												Organic odor when cutting core from 495 to 520 feet bgs
			73		100							
-50	500											
			74		100							
-45	505											
								Silty sand layer		M SA		
			75		100							
-40	510											
			76		100							
-35	515											

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

Log of Boring E-107

Sheet 16 of 16

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
	515											
			77		100							
-30	520											
			78		90		ML	Very stiff, gray, moist, sandy SILT (ML), occasional organics **(Qpfnl)**				
-25	525											
			79		90							
-20	530											
												Loss of mud circulation
			80		60							
								Clayey silt layer		MP BG		
-15	535		81		70		SP	Dense, gray, wet SAND (SP), poorly-graded fine to medium sand **(Qpfnf)**				
			82		56							
-10	540											
								Wood fragments		M SA		
			83		34							
-5	545											Organic odor
			84		100							
								Terminated boring at 548 feet below ground surface				
0	550											

Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
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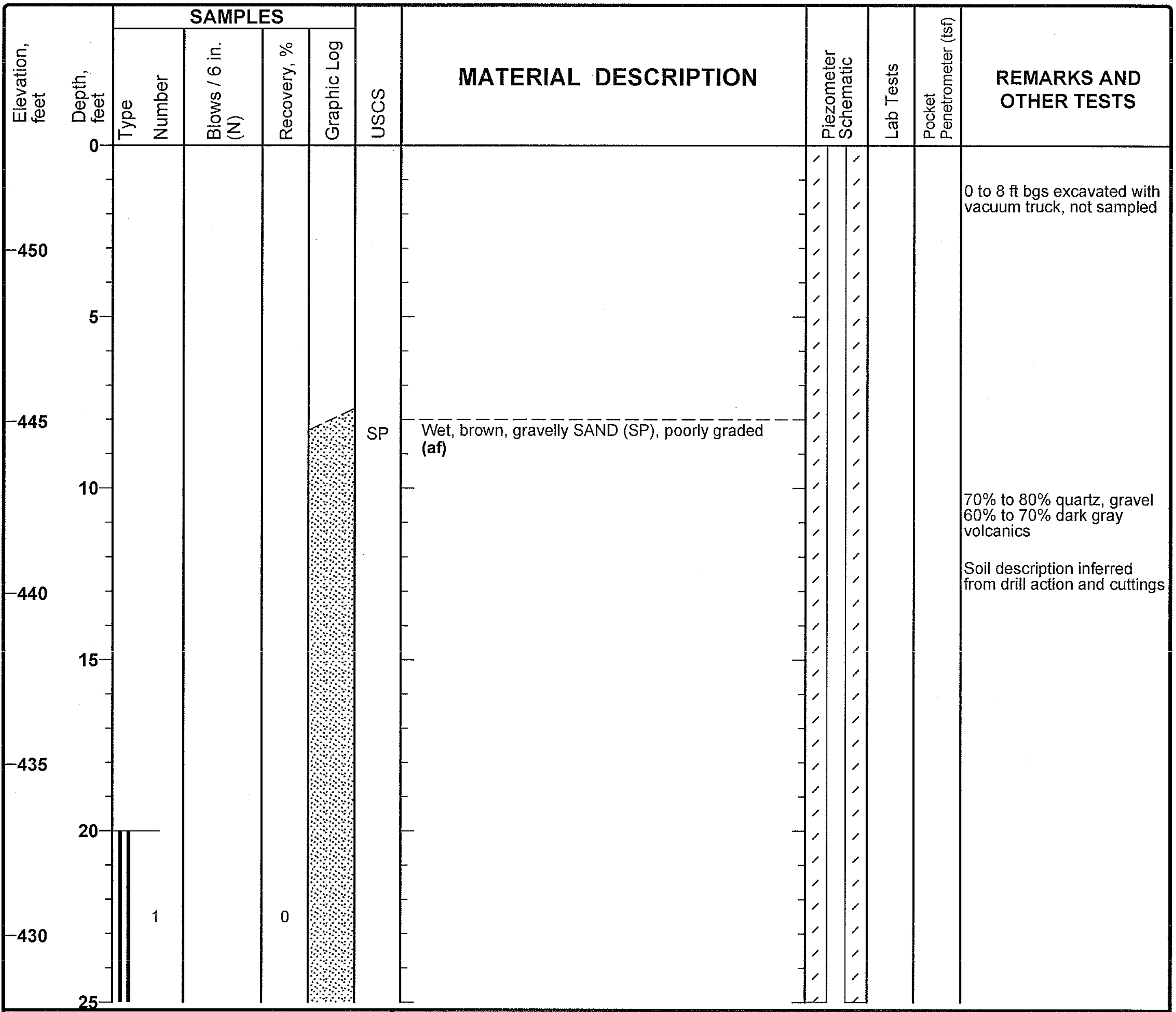
Log of Boring E-108

Sheet 1 of 11

Date(s) Drilled	**7/7/03 - 7/7/03**	Geotechnical Consultant	**Camp Dresser & McKee Inc.**	Logged By **SHE**	Checked By **RWS 2/03/04**
Drilling Method/Rig Type	**Wireline/ Porta-drill**	Drilling Contractor	**Gregory Drilling, Inc.**	Total Depth of Borehole	**346.0 feet**
Casing Size/Type	**PQ (7"O.D.)**	Hammer Weight/Drop (lbs/in.)		Ground Surface Elevation/Datum	**453.1 feet / Metro**
Location	**1621 N. 205th St**	Coordinates	**N 287249 E 1270073**	Elevation Source	**Survey**



0 to 8 ft bgs excavated with vacuum truck, not sampled

SP — Wet, brown, gravelly SAND (SP), poorly graded **(af)**

70% to 80% quartz, gravel 60% to 70% dark gray volcanics

Soil description inferred from drill action and cuttings

Groundwater Observation Data:

OW (FT BGS): 139.9 (Low) 137.8 (High)

VWP1 (FT BGS):

VWP2 (FT BGS):

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).

Project: King County WTD / Brightwater Conveyance System
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Log of Boring E-108

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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											
												Drill on something metallic at 27 ft bgs
-425												
							CL	Soft, yellow brown, moist CLAY (CL), occasional fine organics, wire and other debris **(af)**				
	30											Soil description inferred from drill action and cuttings
-420												
	35											
												Drilled out to 36 ft bgs
												Driller reports soft material consistent with soft clay
-415												
	40		2		0							
-410												
							SP-SM	Medium dense, dark brown, moist, slightly silty to silty, SAND (SP-SM), trace fine gravel, poorly-graded sand **(Qal/Qvrf)**				
	45											Soil description inferred from drill action and cuttings
												Driller report: sand beds
-405												
			3		0							
	50											
-400												
	55											
-395												
			4		0							
	60											Driller report: "loose" sand and gravel

Project: King County WTD / Brightwater Conveyance System
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Log of Boring E-108

Sheet 3 of 11

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											
-390												
	65											
												Intermittant heavy rattling (gravel or dense sand) Soil sample fell out of core barrel
-385												
			5		0							
	70											
-380												
	75											
-375												
			6		0							
	80											
-370												
	85											
-365												
			7		0							
	90											
-360												
	95											

Project: King County WTD / Brightwater Conveyance System
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Log of Boring E-108

Sheet 4 of 11

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											
-355												Driller report: "loose" sand
			8		0							
	100											
-350												
	105											
							SP	Dense, dark brown, moist to wet SAND (SP), trace silt, poorly-graded sand, homogeneous to laminated medium to coarse sand layers, scattered red brown bands and laminae **(Qva)**				
-345												Change in drill action infers increase in soil density
			9		74							
	110											
-340												
								Grades gray, wet, fine to medium sand				
	115											
-335												
			10		94							
	120											
-330												
	125											
-325												
			11		70							
							ML	Very stiff, olive gray, moist, clayey SILT (ML), medium plasticity, slow dilatancy, laminated to				
	130											

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

Log of Boring E-108

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	130							layered, sand layers at contact **(Qpfnl)**				
							CL	Very stiff, olive gray, moist, silty CLAY (CL), medium plasticity, slow to no dilatancy, laminated **(Qpfnl)**				
320												
										MP		Scattered fractures with off-sets
	135											
315												
			12		72							
	140											
310												
	145						SM	Olive gray, wet, silty SAND (SM), laminated, occasional organics, micaceous **(Qpfnf)**				
305												
			13		78							
	150						ML	Stiff, olive gray, wet, clayey SILT (ML), homogeneous **(Qpfnl)**				
300												
	155							Grades hard and moist			4.5	
295							CL	Hard, olive gray, moist, silty CLAY (CL) **(Qpfnl)**				
			14		86							
	160											
								Frequent seams of lighter colored silt				
290												
								6-inch silty sand layer				
	165											

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

Log of Boring E-108

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		SAMPLES										
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
	165											
								6-inch wet, silty sand layer				
285										MP		
			15		73		SM	Dense, dark gray, moist, silty SAND (SM), occasional organics, homogeneous, scattered mica **(Qpfnf)**				
	170											
280												
								18-inch silty clay stratum				
	175											
275												
			16		70			Laminated, silty clay and silt layers 177 to 178 ft bgs and 178.5 to 179 ft bgs				
	180											
270												
							CL	Hard, gray olive, moist, silty CLAY (CL), trace fine sand, frequent fine sand laminations **(Qpfnl)**				Sheared zones 184 to 185 ft bgs
	185											
265										MP		
			17		50							
	190											
260												
								1-foot yellow brown, silty gravel layer				Palesol
	195											
255												
			18		10							
	200											

Project: King County WTD / Brightwater Conveyance System
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Log of Boring E-108

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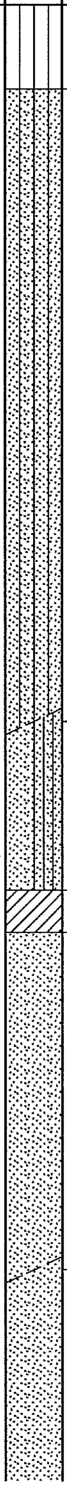
Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	200											
-250								Grades yellow brown and gray mottled, gravel layers, occasional organics			2.5	Blocky, fractured, slickensides 203 to 212 ft bgs
	205											
-245												
			19		25							
	210											
							SM	Dense, gray olive, moist to wet silty SAND (SM), fine sand, scattered gravel layers, clay coatings on gravel, occasional organics **(Qpfmw)**			2.5	Disturbed bedding, brecciated texture
-240												
								6-inch clayey silt layer				
	215											
-235												
			20		27							
	220											
								Grades wet, slightly silty				
-230												
	225										1.5	
							CL	Hard, mottled and streaked yellow red to gray green, dry to moist, silty CLAY (CL), trace gravel, coarse sand **(Qpfmw)**				
							ML	Hard, dark olive gray, moist, clayey SILT (ML), medium plasticity, slow dilatancy, gravelly layers **(Qpfmw)**				Lithologies granitic (diorite) and volcanic
-225												
			21		50							
	230											
-220										M AL		
								Mottled brown gray, gavelly				Brecciated texture 234 to 237 ft bgs
	235											

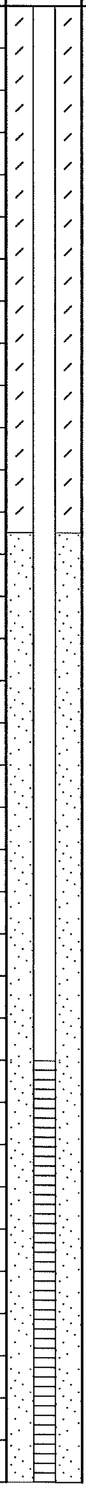
Project: King County WTD / Brightwater Conveyance System
Project Location: King & Snohomish Counties, Washington
Contract Number: E23007E

Log of Boring E-108

Elevation, feet: 215, 210, 205, 200, 195, 190, 185

Depth, feet: 235, 240, 245, 250, 255, 260, 265, 270





SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	22		61	SM	Dense, dark gray, wet, silty SAND (SM), homogeneous, occasional organics **(Qpfnf)**			Slight organic odor
					Grades sandy silt layers	M AL	4.6	
							0.25	
	23		88					
					Grades fine to medium sand, numerous organics,			
				SP-SM	Dense, dark gray, wet, slightly silty SAND (SP-SM), poorly-graded fine sand, homogeneous **(Qpogf)**	M SA HA AL M		
				CL	Hard, silty, gravelly CLAY (CL) **(Qpogd)**	MP		
	24		66	SP	Dense, dark gray, wet, silty SAND (SP) poorly-graded fine to medium sand, homogeneous, occasional organics **(Qpogf)**			
						M SA		
				SP	Dense, dark gray, wet SAND (SP), trace silt, poorly graded fine sand **(Qpogf)**			
	25		73					
						MP		

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

Log of Boring E-108

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
	270											
								Occasional organics, stems				
-180												
							CL	Hard, dark olive gray, moist, gravelly, silty CLAY (CL), trace fine sand **(Qpogd)**			4.5	Fractures, slickensides
	275											
			26		50							
-175												
	280											
-170												
								18-inch dense, wet, fine to coarse sand layer, occasional organics				
	285											
			27		56							
-165												
	290											
							CH	Hard, dark gray, moist, slightly silty CLAY (CH), high plasticity, scattered gravel and cobbles **(Qpogm)**			3	Sheared zones observed several layers, with slickensides, scattered planar fractures with slickensides
			28		84			3-inch brown, organic silt layer		MP	4	
-160												
	295											Cobble
								Slightly silty, clay from 296 to 300 ft bgs				Brecciated texture 296 to 304 ft bgs
								Scattered fine gravel dropstones				
-155												
	300											
			29		100							
-150												
	305											

CDM

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

Log of Boring E-108

Sheet 10 of 11

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	305											
								Grades trace fine gravel				
												Hydrogen sulfide odor
								Abundant clam shells				
-145												
										MP		
							SP	Dense, dark gray, wet, SAND (SP), poorly-graded fine sand, homogeneous, shell fragments **(Qpogm)**				
	310											
			30		100		ML	Hard, olive gray, moist, very gravelly, sandy SILT (ML), trace clay, low to medium plasticity, matrix supported **(Qpogd)**				
-140												
	315											
								Grading silt, trace fine sand, low plasticity, slow dilatancy				
							ML	Hard, olive gray, moist clayey SILT (ML) **(Qpogl)**				
-135												
	320							Gravelly bed				
			31		77							
-130												
	325											
							SP	Dense, olive gray, wet SAND (SP), trace silt, poorly-graded fine to medium sand, homogeneous **(Qpogf)**				
							CL-ML	Very stiff, olive gray, moist, clayey SILT (ML) homogeneous **(Qpogl)**			4	
-125												
	330											
			32		83							
								Sand layer				
-120												
	335											
								2-foot sand stratum				
-115												
	340											

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

Log of Boring E-108

Sheet 11 of 11

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
	340	▌	33		66	▨		Grading trace sand and fine gravel		MP		
110												
	345											
								Terminated boring at 346 feet below ground surface				
105												
	350											
100												
	355											
95												
	360											
90												
	365											
85												
	370											
80												
	375											

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

Log of Boring E-109

Sheet 1 of 8

Date(s) Drilled	7/29/03 - 7/30/03	Geotechnical Consultant	Camp Dresser & McKee Inc.	Logged By	RW	Checked By	VJP 02-03-04
Drilling Method/Rig Type	Wireline/ T3	Drilling Contractor	Cascade Drilling, Inc.	Total Depth of Borehole	260.0 feet		
Casing Size/Type	PQ (7"O.D.)	Hammer Weight/Drop (lbs/in.)	N/A	Ground Surface Elevation/Datum	395.0 feet / Metro		
Location	NE 205th St and 1st Ave	Coordinates	N 287168 E 1272288	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
395	0											0 to 6 feet excavated with vacuum truck, not sampled
390	5											
			1		38		GP-GM	Medium dense, brown, moist to wet, slightly silty, sandy GRAVEL (GP-GM), poorly-graded fine to coarse sand, fine to coarse subangular to subrounded gravel **(af)**				
385	10						GM	Loose, gray, wet, silty, sandy GRAVEL (GM), fine to coarse sand, fine to coarse subangular to subrounded gravel **(af)**				
380	15		2		15							
							SM	Hard, brown yellow to yellow red, gravelly, silty SAND (SM), scatered cobbles **(Qpfnf)**				
375	20						SW	Loose, brown, wet, gravelly, SAND (SW), well-graded fine to coarse sand, fine to coarse subangular gravel **(Qpfnf)**				
	25											

Groundwater Observation Data:

OW (FT BGS): 130.6 (Low) 115.0 (High)

VWP1 (FT BGS):

VWP2 (FT BGS):

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).

CDM

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

Log of Boring E-109

Sheet 2 of 8

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
370	25		3		25							
							ML	Hard, brown yellow, moist, sandy SILT (ML), low plasticity **(Qpfnl)** Grades dark gray, clayey, low to medium plasticity, laminated				
365	30											
360	35		4		85							
355	40							Soft to medium stiff, wet				
350	45		5		45							
							SM	Medium dense, dark gray, wet, silty to slightly silty, SAND (SM), fine sand, occasional organics **(Qpfnf)**				
345	50											
340	55		6		45							
								Dark brown, numerous organics				
							ML	Hard, dark brown to olive gray, moist, sandy SILT (ML), 0.5-foot layer of peat **(Qpfnl)**				Paleosol
	60							Transitions gray, wet, rapid dilatancy, no organics				

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

Log of Boring E-109

Sheet 3 of 8

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
-335	60											
-330	65		7		20							
							ML	Hard, gray, moist, sandy SILT (ML), fine sand, rapid dilatancy **(Qpogl)**				
												Blocky structure, scattered slickensides
-325	70											
-320	75		8		20							
-315	80											
											4	
-310	85		9		60							Scattered gravel dropstones
								Grades slightly gravelly, trace sand				
											4.6	
-305	90											
							GM	Medium dense to dense, dark gray, moist to wet, slightly sandy, silty GRAVEL (GM), fine to coarse subrounded gravel **(Qpogd)**				
	95											

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

Log of Boring E-109

Sheet 4 of 8

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
300	95		10		15							
295	100						SW	Medium dense, dark gray, wet, gravelly SAND (SW), well graded sand **(Qpogf)**				
			11		0							
290	105											
			12		0							
285	110											
							GM	Dense, gray, wet, sandy, silty GRAVEL (GM), fine to coarse subround gravel **(Qpogf)**				
280	115		13		24							
							SM	Medium dense, dark gray, wet, silty SAND (SM), fine sand **(Qpogf)**				
								Grades dense, moist, slightly gravelly				
275	120						GM	Dense, dark gray, moist, silty, sandy GRAVEL (GM) **(Qpogd)**				
270	125		14		30							
	130											

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

Log of Boring E-109

Sheet 5 of 8

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
265	130											
260	135		15		15						2.5	
255	140						ML	Hard, dark gray, moist, sandy SILT (ML), nonplastic to low plasticity, fequent shell fragments **(Qpogm)**			4	Scattered gravel dropstones
250	145		16		35							
245	150										4.6	
240	155		17		25							
235	160							Grades wet, slow to rapid dilatancy			4.6	
	165											

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

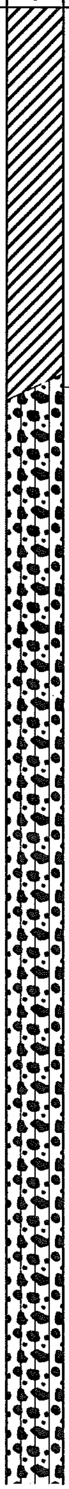
Log of Boring E-109

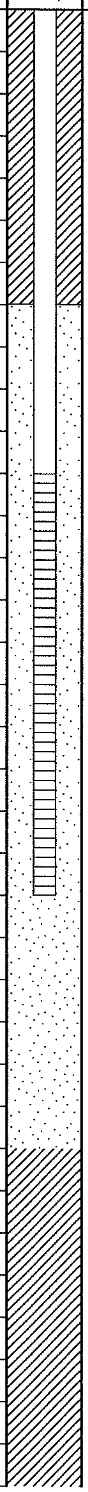
Sheet 6 of 8

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
230	165		18		53			Grades slightly gravel				High angle fracture at 70 degrees
							CL	Hard, dark gray, moist, silty CLAY (CL), low plasticity **(Qpogl)**				
												Scattered slickensides 30 to 40 degrees
225	170											
								Grades trace fine to coarse sand and fine gravel				
220	175		19		50							
							ML	Hard, dark gray, moist, sandy SILT (ML), low plasticity **(Qpogl)**				
							GM	Dense, dark gray, moist, sandy, silty GRAVEL (GM), fine to coarse subround gravel **(Qpogt)**				
215	180											
							ML	Hard, dark gray, moist, slightly clayey SILT (ML), trace sand, low plasticity **(Qpogl)**				
210	185		20		30					M SA		
205	190						CH	Hard, dark gray, moist, silty CLAY (CH), medium to high plasticity **(Qpogl)**				
										M AL	4.6	
200	195		21		78							Dropstones 195.5 to 196 ft bgs, vertical planar fracture
											4.6	
	200											

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

Log of Boring E-109





Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
195	200									
								M AL		
190	205		22		15					
							Grades soft to medium stiff, wet, sandy, clayey silt, medium plasticity			
						GM	Dense, dark gray, moist, silty, sandy GRAVEL (GM) **(Qpogd)** Grades fine to coarse subrounded gravel, occasional cobbles			
185	210									
180	215		23		10					
175	220									
			24		4					
170	225									
			25		50					
165	230									
	235									

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

Log of Boring E-109

Sheet 8 of 8

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
-160	235		26		5							
-155	240											
-150	245		27		35							
							SP-SM	Dense, dark gray, moist to wet, slightly silty SAND (SP-SM), poorly-graded **(Qpogf)**				
												Steel liners in core barrel.
							CL	Hard, dark gray, moist, silty CLAY (CL), trace sand, medium plasticity, homogeneous **(Qpogl)**				
-145	250											Scattered fome gravel dropstones
												253 to 260 ft bgs, high angle fractures 50 to 70 degrees
-140	255		28		100							
-135	260							Terminated boring at 260 feet below ground surface				
-130	265											
	270											

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

Log of Boring E-110

Sheet 1 of 13

Date(s) Drilled	3/28/03 - 4/4/03	Geotechnical Consultant	Camp Dresser & McKee Inc.	Logged By	RW	Checked By	VJP 02-03-04
Drilling Method/Rig Type	Wireline/ T3	Drilling Contractor	Cascade Drilling, Inc.	Total Depth of Borehole	438.0 feet		
Casing Size/Type	PQ (7"O.D.)	Hammer Weight/Drop (lbs/in.)	300# / 30"	Ground Surface Elevation/Datum	444.7 feet / Metro		
Location	603 NE 204th St	Coordinates	N 286964 E 1274158	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											Vacuum out to 5.9 ft bgs, not sampled. Drive 7-inch casing to 8 feet.
440	5											
							SM	Very dense, brown, moist, silty, gravelly SAND (SM), poorly-grade coarse sand, poorly-graded fine to coarse angular gravel **(Qvt)**				Soil description partially inferred from drill action and cuttings
435	10											
430	15											
		■	1	23 - 50/3" (100+)	100							
425	20											
420	25											

Groundwater Observation Data:

OW (FT BGS):	109.4 (Low)	98.4 (High)
VWP1 (FT BGS):	144.8 (Low)	143.4 (High)
VWP2 (FT BGS):	170.1 (Low)	167.6 (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).

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

Log of Boring E-110

Sheet 2 of 13

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											
-415	30											
							GW-GM	Very dense, brown, moist, slightly silty, sandy GRAVEL (GW-GM), well-graded fine to coarse sand, well-graded fine to coarse angular gravel **(Qvtm)**				Soil description partially inferred from drill action and cuttings Drillers note hard drilling
-410	35											
		■	2	28 - 50/2" (100+)	63		SM	Silty, gravelly SAND (SM), fine to coarse sand, fine angular gravel **(Qvtm)**				
-405	40											
												Soil description partially inferred from drill action and cuttings
-400	45											
-395	50											
												Irregular drilling resistance suggest gravel and cobbles
-390	55											
		■	3	48 - 50/5" (100+)	44		SP	Very dense, brown, moist,SAND (SP), trace silt, poorly-graded fine to medium sand **(Qva)**		BG		
-385	60											

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

Log of Boring E-110

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											
380	65											
375	70											
							SP	Very dense, gray green, moist SAND (SP), trace silt, poorly-graded fine to medium sand, occasional organics **(Qpfnf)**				Drillers note interbedded gravel and cobbles
370	75											
		■	4	50/5" (100+)	79					BG		
365	80											
360	85											
355	90											
							CL	Very stiff to hard, gray green, moist, sandy silty CLAY (CL), trace fine gravel, low to medium plasticity, occasional organics **(Qpfnl)**				
350	95											

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

Log of Boring E-110

Sheet 4 of 13

Elevation, feet	Depth, feet	SAMPLES Number	SAMPLES Blows / 6 in. (N)	SAMPLES Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	95								0 to 98' mud-rotary, switch to wire-line at 98', drilling from 95'
		6	26 - 50/5" (100+)	91		Transitions to gravelly, gravel and cobbles in clayey silt matrix, subrounded			
-345	100	5		35					
					SM	Very dense, dark gray, moist, silty to very silty SAND (SM), trace gravel, scattered organics **(Qpfnf)**			
-340	105				ML	Very stiff, dark gray SILT (ML), nonplastic, numerous organics **(Qpfnl)**			
					OL	Hard, brown, moist Organic SILT (OL) **(Qpfnw)**	AD MP		Conventional radiocarbon date >47,930 yrs B.P.
-335	110	7		76	ML	Very stiff, gray olive, moist SILT (ML), trace sand, low plasticity, scattered organics **(Qpfnl)**			
					ML	Very stiff, olive gray, wet SILT (ML), rapid dilatancy, occasional organics, homogeneous **(Qpfnl)**			
-330	115								
						Medium stiff SILT at 118 ft bgs			
-325	120	8		94					
						Transitions to stiff, moist to wet			
-320	125								
-315	130								

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

Log of Boring E-110

Sheet 5 of 13

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
	130		9		77							
							CL	Stiff, gray green, moist, silty CLAY (CL), medium plasticity, slickensides **(Qpogl)**		MP		
310	135											
								Transitions to gray				
305	140		10		100			Transitions to very stiff, gray green to green, silty clay				
300	145							Transitions to gray, sandy, silty clay				
295	150		11		70							
							SM	Very dense, gray green to gray olive, moist, silty, gravelly SAND (SM), fine to coarse sand, fine to coarse subrounded gravel, occasional organics **(Qpogtm)**				
290	155											
								Transitions to slightly silty and gravelly sand				
							GW	Very dense, gray green, moist GRAVEL (GW), well-graded fine to coarse, subrounded gravel, layers of gravelly sand **(Qpogf)**				
285	160		12		30							
							GM	Very dense, gray green, moist, silty, sandy GRAVEL (GM), fine to coarse sand, fine to				
280	165											

CDM

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

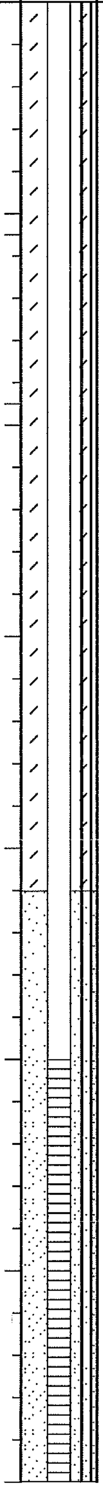
Log of Boring E-110

Sheet 6 of 13

Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	USCS	MATERIAL DESCRIPTION	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	165						coarse gravel, subrounded **(Qpogtm)**			
275	170		13		50					
						SM	Very dense, gray green to olive gray, moist, slightly silty, gravelly SAND (SM), fine to coase sand, fine to coarse subrounded gravel, strong cementation **(Qpogtm)**			
270	175					GW	Dense, gray green, moist GRAVEL (GW),well-graded fine to coarse, subrounded gravel **(Qpogf)**			
265	180		14		33					
							Hard, olive gray, moist, gravelly, sandy SILT (ML), nonplastic stratum			
260	185									
							Stratum of very stiff to hard, gray, moist, slightly clayey, slightly sandy silt, low plasticity, occasional organics, homogeneous, slow to rapid dilitancy			
255	190									
							Transitions to gravel and cobbles, subrounded			
250	195		16		6					
245	200									

Graphic Log

Piezometer Schematic



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

Log of Boring E-110

Sheet 7 of 13

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
	200		17		67		ML	Hard, dark gray, dry to moist, gravelly, sandy SILT (ML), medium plasticity, homogeneous **(Qpogl)**				
								Transitions to very stiff, clayey silt, trace fine sand and fine gravel as dropstones, homogeneous				Sand-filled high angle fractures
240	205											
			18		111			Increasing clay, decreasing sand and gravel				
235	210											209 to 216.5 ft bgs, slickensides
230	215		19		93					M AL		
							SM	Dense, dark gray, wet, silty SAND (SM), rapid dilatancy **(Qpogf)**				
										M SA		
225	220		20		93							
							ML	Hard, dark gray, dry to moist, slightly clayey, sandy SILT (ML), low plasticity, homogeneous **(Qpogl)**				Slickensides at 45 degree angle
							CL	Very stiff, dark gray, moist, slightly silty CLAY (CL), low to medium plasticity, dropstones, slickensided, homogeneous **(Qpogl)**				
220	225											225 to 230 ft bgs, scattered slickensides
			21		100							
							CH	Very stiff, dark gray, moist, slightly sandy CLAY (CH), high plasticity **(Qpogl)**		M AL		
215	230											230 to 240 ft bgs, slickensides, shearing, fracturing
210	235											

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

Log of Boring E-110

Sheet 8 of 13

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	235											
							CL	Very stiff, dark gray, moist slightly sandy CLAY (CL), medium plasticity **(Qpogl)**				
			22		115					M AL		
205	240											240 to 259 ft bgs, scattered slickensides, high angle silt-filled fractures
										M		
								Layer of sand		M AL SA HA M	4.6	
200	245											
			23		100							
195	250							Decrease in clay content				
										M		
190	255									M		
			24		106							
								Transitions to sandy and gravelly				
185	260									M DD UC M SA M SA		Sand-filled fracture at 20 degree angle
							SM	Very dense, gray, dry to moist, very gravelly, silty, clayey SAND (SM), fine to coarse sand, fine subrounded gravel **(Qpogd)**				
			25		83							
180	265											
			26		100							Scattered slickensides, high angle 70 degrees, block structure
							CL	Hard, dark gray, moist, silty CLAY (CL), low to medium plasticity, scattered partings of fine sand				
175	270											

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

Log of Boring E-110

Sheet 9 of 13

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
	270		27		83							
							SM	Very dense, gray, moist, very gravelly, very silty SAND (SM), trace gravel, subrounded to rounded **(Qpogd)**				
-170	275		28		90							
							CL	Hard, dark gray, moist, slightly sandy, silty CLAY (CL), low to medium plasticity, slickensided, homogeneous **(Qpogm)**				
-165	280		15		1							Scattered slickensides 20 to 40 degrees
			29		102							
-160	285											
										M AL		
-155	290											
			30		100							Bedding dip from horizontal approximately 25 degrees
-150	295											
-145	300											
			31		100							
-140	305											

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

Log of Boring E-110

Sheet 10 of 13

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
	305											
												Horizontal breaks along fine sand seam
-135	310											
			32		100							
-130	315									M		
								Interbeds of olive gray and gray green, fine sand from 317 to 320 ft bgs, occasional organics				Paleosol
										M MP		
-125	320											
			33		100			Shell fragments at 322 ft bgs		M PA		Strong HCL reaction at 322 ft bgs
-120	325											
												Organic odor
-115	330											
			34		89			1-foot layer of sandy clay occasionall organics and shell fragments		MP		
-110	335							Dropstones (fine gravel)				Strong HCL reaction
							SP-SM	Very dense, dark gray, wet, slightly silty SAND (SP-SM), poorly-graded, occasional organics **(Qpogf)**				Strong organic odor
												Sheared sand layer; sand injection
-105	340											

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

Log of Boring E-110

Sheet 11 of 13

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
	340											
			35		92			Transitions to moist, silty SAND				
							ML	Hard, dark gray, moist, clayey, sandy SILT (ML), low plasticity,scattered dropstones, slickensided **(Qpogl)**				Blocky structure, numerous slickensides, high angle 50 to 70 degrees (oer consolidated) by movement?
-100	345											
								Layers of fine sand			3	
-95	350											
			36		70						2.5	Sheared sand seam at 50 degrees, sand injection
-90	355						SM	Very dense, dark gray, moist, silty, SAND (SM), fine sand, scattered organics **(Qpogf)**				
							ML	Hard, dark gray, moist to dry, clayey, slightly sandy SILT (ML), low to medium plasticity, dropstones, slickensided **(Qpogl)**				358 to 359 ft bgs, numerous slickensides, high angle 60 to 70 degrees
-85	360											
			37		79							
								Transitions to moist, fine sandy silt, medium plasticity, homogeneous				
-80	365											
							CL	Hard, dark gray, moist, sandy, silty CLAY (CL), trace gravel, medium plasticity, slickensided, homogeneous, occasional organics **(Qpogl)**				
-75	370											
			38		98							
							ML	Hard, dark gray, moist, sandy SILT (ML), fine sand **(Qpogl)**				
										BG		
-70	375											

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

Log of Boring E-110

Sheet 12 of 13

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
	375											
							CL	Hard, dark gray, sandy, silty CLAY (CL), trace gravel, medium plasticity, slickensided, homogeneous, occasional organics **(Qpfnl)**				
-65	380											
								Very fine sand layer				
			39		100							
-60	385											
-55	390											
			40		95							
								Layer of silty fine sand, trace gravel, occasional organics				
-50	395											
-45	400											
			41									
-40	405											
								Sandy gravel layer				
											4	High angle slickensides, near vertical
-35	410											

CDM

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

Log of Boring E-110

Sheet 13 of 13

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	410											
			42		50			Sandy gravel with partings and sand layers				
30	415											
25	420		43		95							
20	425							Transitions to hard sandy silty clay				
15	430		44		100							
								Sand partings				
												Piece of wood, occasional mussel
10	435									MP		Shells and shell fragments
			45		100							
								Terminated boring at 438 feet bgs				
5	440											
0	445											

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

Log of Boring E-211

Sheet 1 of 9

Date(s) Drilled	**6/9/03 - 6/12/03**	Geotechnical Consultant	**Camp Dresser & McKee Inc.**	Logged By	**SHE**	Checked By	**RWS 2/02/04**
Drilling Method/Rig Type	**Wireline/ Porta-drill**	Drilling Contractor	**Gregory Drilling, Inc.**	Total Depth of Borehole	**280.0 feet**		
Casing Size/Type	**PQ (7"O.D.)**	Hammer Weight/Drop (lbs/in.)	**300# / 30"**	Ground Surface Elevation/Datum	**413.4 feet / Metro**		
Location	**20059 Ballinger Way NE**	Coordinates	**N 286325 E 1277100**	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											0 to 6 feet excavated with vacuum truck, not sampled
410	5											
							SM	Medium dense, brown, silty, slightly gravelly to gravelly SAND (SM), fine to medium **(Qvrf)**				Inferred from drill action and cuttings
405	10											
400												Some grinding and bucking while drilling (gravel, possible cobbles)
	15											
395							SM	Very dense, yellow red, moist, silty, gravelly SAND (SM), non-plastic, fine to medium, gravel fine to coarse, subrounded **(Qvt)**				
	20	■	1	2 - 30 - 50/5" (100+)	41							
390	25											

Groundwater Observation Data:

OW (FT BGS):	49.2 (Low)	30.0 (High)
VWP1 (FT BGS)	66.1 (Low)	60.5 (High)
VWP2 (FT BGS):		

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).

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

Log of Boring E-211

Sheet 2 of 9

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											
385												
	30											
380												
	35											
375												
							SP	SAND and GRAVEL **(Qva)**				Heave/slough in hole ~3' Drove sampler through slough - no counts, slough suggests lack of matrix fines, artesian pressure
	40	■	2									
370												
	45											
365												
	50											
360												
	55											
355												
	60											

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

Log of Boring E-211

Sheet 3 of 9

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	18 - 28 - 40 (68)	89		SP	Very dense, gray olive and gray blue, moist SAND (SP), trace silt, gravel, yellow orange laminae, organic material along scattered bedding planes **(Qpfnf)**				2 feet slough, washing hole; slough cleaned, smooth, even sample, bedding inclined 5 to 10 degrees
350												
	65											
							CL-ML	Hard, dark brown, moist, clayey SILT CL-ML), numeroous disseminated organics, trace fine sand in scattered layers, slightly plastic, slow dilatancy, mottled brown and green **(Qpfnl)**				Drilling quiet at 67 ft bgs Driller reports interbedded silty CLAY and SAND, 3-foot beds
345												
	70											
340												
	75											
335												
	80	■	4	9 - 19 - 17 (36)	83							
330												
	85											
325												
	90											
320												
	95											

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

Log of Boring E-211

Sheet 4 of 9

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	95											
315												
	100	■	5	6 - 9 - 13 (22)	100		CH	Very stiff, olive gray, moist, silty CLAY (CL) high plasticity, homogeneous, scattered bedding plane partings **(Qpfnl)**			4.5	Smooth, even drive Sheared zone, top of core
310												
	105											
305												
	110											
300												
	115											
295												
	120	■	6	7 - 13 - 19 (32)	89		ML	Hard, olive gray, wet, clayey SILT (ML), trace fine gravel, medium plasticity, slow dilatancy, occasional fine organic fragments **(Qpfnl)**				Smooth, even drive
290												
	125											
285												
	130											

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

Log of Boring E-211

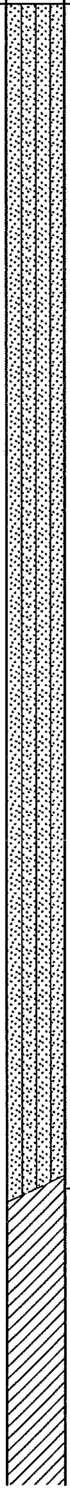
Sheet 5 of 9

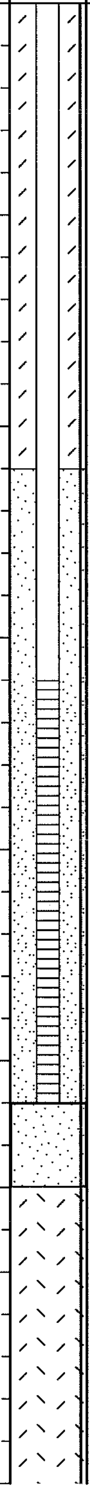
Elevation, feet	Depth, feet	SAMPLES Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log	USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
	130											
280												
	135											
275												
	140		7	10 - 14 - 22 (36)	100							Even drive
270												
	145											
265												
	150						SM	Very dense, olive gray, very silty, gravelly SAND (SM), cobbles, gravel rounded to subangular, sand fine grained, poorly graded, clayey slough **(Qpogt)**				Driller reported change at 150 ft bgs, drill chattering and bucking
260												
	155											
255												
	160		8		13							
250												
	165											Drilled out - button bit, 164 to 170 ft bgs

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

Log of Boring E-211

Sheet 6 of 9





		SAMPLES										
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
	165											
245												
	170		9		17							
240												
	175							Scattered gravel layers, approximately 6 inches to 1 foot thick				Pressure meter test 175 to 180 ft bgs Slow drilling
235								6-inch gravelly beds, with 6-inch sand/silt layers				
	180		10		17							
230								Silt content decreases				
	185									M SA	4	
			11		54							
225												
	190									M SA		Frequent slickensides and fractures, becciated texture
220							CL	Hard, olive gray, moist, silty CLAY (CL), trace gravel and sand dropstones, medium plasticity, no dilatancy, laminae of light gray silt **(Qpogl)**				
	195											
			12		91							
215								6-inch silt layer		M AL	4.6	
	200											

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

Log of Boring E-211

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							High plasticity		SA HA		
210												
	205											
			13		41							
205												
	210							Laminated silt layer from 210 to 211 ft bgs				
										M AL		
200												
	215		14		70							
195												
								Gravelly from 219 to 220 ft bgs				
	220		15		33							
												Rotary 220.5 to 225 ft bgs Drilled out to clean borehole for in situ test, drilling rocky at top, less gravel and cobbles toward 225 ft bgs
190												
												Difficult drilling - formation choking off circulation - mainly clay and silt, few gravel Pressure meter test 225 to 230 ft bgs
	225							Scattered shiny black and small white grains (glass and ash?), volcanics and quartz				
185												
	230											
								Gravelly from 232 to 234 ft bgs				
180												
	235											

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

Log of Boring E-211

Sheet 8 of 9

Elevation, feet	Depth, feet	SAMPLES					USCS	MATERIAL DESCRIPTION	Piezometer Schematic	Lab Tests	Pocket Penetrometer (tsf)	REMARKS AND OTHER TESTS
		Type	Number	Blows / 6 in. (N)	Recovery, %	Graphic Log						
	235		16		63							
175												
								Slightly gravelly				
	240											
170												
			17		62							
	245							Cobbles				
165												
	250							Scattered slickensides, scattered light gray partings				Bedding inclined to 5 degrees
160												
			18		22							
	255											
155												
	260											Sheared and brecciated
150												
			19		72							
	265											
145								Cobbles				
												Pressure meter test 269 to 280 ft bgs
	270											

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

Log of Boring E-211

Sheet 9 of 9

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
	270					▨						
-140						▨						
	275					▨						
-135						▨						
	280							Terminated boring at 280 feet below ground surface				
-130												
	285											
-125												
	290											
-120												
	295											
-115												
	300											
-110												
	305											

Drilled	Start 7/7/2014	End	Total Depth (ft) 80.4	Logged By DTM Checked By CRW	Driller Holocene
Drilling Method	Hollow-Stem Auger				
Surface Elevation (ft)	329	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig
Vertical Datum	Project				
Easting (X)	1375549.288	System Datum	Project	Groundwater	
Northing (Y)	386456.8713			Date Measured / Depth to Water (ft) / Elevation (ft)	

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

Elevation (feet)	Depth (feet)	FIELD DATA Interval / Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							SM	Brown silty fine to medium sand with gravel and occasional cobbles and debris (loose, moist) (fill) (ESU 1A)			Water knife/vactor to 5 feet. Soil description based on visual observation.
325												
	5	12	17		1 MC			SM	Brown silty fine to medium sand (medium dense, moist) (glacial till) (ESU 5A)	12		
								SM	Brownish gray silty fine to medium sand with gravel and occasional cobbles and boulders (very dense, moist) (ESU 5B)			
320												
	10	13	50		2 SA					9	29	
315												
	15	0	50/2"									No recovery
310												Switched to mud rotary
	20	0	50/2"									No recovery
		12	78		3 SA					9	28	
								SM	Gray silty fine to medium sand with gravel (very dense, moist)			
305												
	25	12	66		4 %F					10	25	
300												
	30	10	78		5 SA					10	25	
295												
	35											

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B06

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Figure A-54
Sheet 1 of 3

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	▮	10	59		6 MC					10		
									SM	Gray silty fine to medium sand with gravel (dense, moist)			
290													
	40	▮	13	48		7 SA					10	21	
									SM	Brown silty fine to medium sand with occasional gravel (dense, moist)			
285													
	45	▮	11	35		8 MC					10		
									SP-SM	Brownish gray with oxidation staining fine to medium sand with silt (dense, wet) (advance outwash) (ESU 6B)			
280													
	50	▮	14	37		9 SA					22	12	Groundwater observed at 50 feet during drilling
									SM	Brownish gray silty fine to medium sand (very dense, wet)			
275													
	55	▮	17	61		10 %F					22	13	
									SP-SM	Brownish gray fine to medium sand with silt (very dense, wet)			
270													
	60	▮	18	64		11 %F					22	10	
265													
	65	▮	10	50/6"		12 MC					22		
													Rough drilling at 66 feet
									SM	Brownish gray silty fine sand (very dense, wet)			
260													
	70	▮	16	69		13 SA					24	13	
									SP-SM	Gray fine sand with silt (very dense, wet)			
255													
	75	▮	10	50/6"		14 %F					24	12	

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B06 (continued)

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	FIELD DATA						Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	**Collected Sample**	Sample Name Testing	Water Level						
250									SM	Gray silty fine sand (very dense, wet)			
	80	■	5	50/5"		15 MC					21		

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B06 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Figure A-54
Sheet 3 of 3

Drilled	Start 7/11/2014	End 7/11/2014	Total Depth (ft) 81.5	Logged By ERH Checked By CEW	Driller Holocene
Drilling Method	Hollow-Stem Auger				
Surface Elevation (ft) Vertical Datum	317 Project	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D-120 Truck Rig
Easting (X) Northing (Y)	1375800.355 387658.5549	System Datum	Project	Groundwater	
Notes:	Autohammer efficiency = 70% (measured 9/30/2013)				

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								SOD	3 inches sod			Water knife/vactor to 5 feet. Soil description based on visual observation.
									SM	Brown silty fine to medium sand with gravel, occasional cobbles and boulders (medium dense, moist) (fill) (ESU 1B)			
315													
	5	■	14	28		1 / SA				With decreasing cobbles and boulder content	8	20	
310													
									SP-SM	Gray fine to coarse sand with silt and gravel (dense, moist)			
	10	■	15	35		2 / MC					5		Rough drilling
305													
									SM	Gray silty fine to medium sand with occasional gravel (dense to very dense, moist) (glacial till) (ESU 5B)			
	15	■	18	36		3 / %F					8	26	
300													
	20	■	18	46		4 / SA				Grades to with gravel	8	25	
295													
	25	■	18	57		5 / MC				Grades to brown	8		
290													
									SM	Grayish brown silty fine to medium sand (medium dense, moist)			Rough drilling
	30	■	18	27		6 / SA					7	27	
285													
									SM	Gray silty fine to medium sand with occasional gravel and trace organics (dense, wet)			
	35												

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B08

		FIELD DATA									
Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	18	33	7							
280											Groundwater observed at 36 feet during drilling
							SP	Gray fine to medium sand with occasional gravel and trace silt (very dense, wet) (advance outwash) (ESU 6B)			
	40	18	50	8 SA					15	4	
275											
							SM	Gray silty fine to medium sand (very dense, wet)			
	45	12	56	9 MC					21		
270											
	50	18	60	10 %F					23	15	
265											
							SM	Grayish brown silty fine sand (very dense, wet)			
	55	14	50/5"	11 SA					23	14	
260											
	60	0	50/5"								No recovery
255											
							CL	Gray lean clay (hard, moist) (transitional beds) (ESU 7)			
	65	13	38	12 AL					24		AL (LL = 34%; PI = 11%)
250											
							ML	Gray with oxidation staining silt with sand and trace organics (hard, moist)			
	70	18	63	13 MC					25		
245											
							PEAT	Dark brown peat (hard, moist)			
	75	12	50/6"	14 MC					110		

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B08 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	FIELD DATA						Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level						
240													
									ML	Gray silt with sand (hard, wet)			
	80	█	18	68		15 AL					25		AL (non-plastic)

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B08 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	7/15/2014	7/17/2014	81.5	DTM	CRW	Holocene	Hollow-Stem Auger

Surface Elevation (ft): 331
Vertical Datum: Project
Hammer Data: Autohammer 140 (lbs) / 30 (in) Drop
Drilling Equipment: Mobile B-61 Truck Rig
Easting (X): 1375875.506
Northing (Y): 388349.367
System Datum: Project

Groundwater

Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
330	0							SM	Brown silty fine to medium sand with silt, gravel, occasional cobbles and trace roots (loose, moist) (fill) (ESU 1A)			Water knife/vactor to 5 feet. Soil description based on visual observation.
325	5	2	10		1 MC			SM	Brown silty fine to medium sand with gravel (medium dense, moist) (recessional outwash) (ESU 4)	9		
								SP-SM	Brown fine to medium sand with silt, gravel and occasional cobbles (dense, moist)			
320	10	10	32		2 %F					1	7	
												Rough drilling
								SM	Brown silty fine sand (dense to very dense, moist to wet) (glacial till) (ESU 5B)			
315	15	8	41		3 SA					22	43	Rough drilling Groundwater observed at 15 feet during drilling
310	20	0	50/4"									No recovery
								SP	Brown fine to medium sand with occasional gravel and trace silt (very dense, wet) (advance outwash) (ESU 6B)			
305	25	18	50/4"		4 SA					16	3	
300	30	0	50/2.5"									No recovery
								SP-SM	Brown fine to coarse sand with silt and gravel (very dense, wet)			
	35											

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B09

GeoEngineers

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
295	35	■	4	50/4"		5 SA					14	11	
290	40	■	17	85/11"		6 SA				Grades to with occasional gravel	22	9	
									SP-SM	Brown fine to medium sand with silt (very dense, wet)			
285	45	■	12	50/6"		7 %F					22	9	
									SM	Brown silty fine to medium sand with occasional gravel and silt interbeds (very dense, wet)			
280	50	■	12	50/6"		8 SA					19	17	
275	55	■	12	50/6"		9 %F					20	20	
270	60	■	6	50/6"		10 SA					12	28	
265	65	■	6	50/6"		11 MC					11		
260	70	■	0	50/3"									No recovery
255	75	■	18	40		12 AL					29		AL (LL = 63%; PI = 34%)
									CH	Gray sandy fat clay (hard, moist) (transitional beds) (ESU 7)			

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B09 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Figure A-56
Sheet 2 of 3

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	**Collected Sample**	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
									ML	Gray sandy silt (hard, wet)			
250	80	■	18	83/11"		13 MC					26		

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B09 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Drilled	Start 6/19/2014	End 6/19/2014	Total Depth (ft) 81.5	Logged By DTM Checked By CRW	Driller Holocene
Drilling Method	Mud Rotary				
Surface Elevation (ft)	354	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig
Vertical Datum	Project				
Easting (X)	1376055.124	System Datum	Project	Groundwater	
Northing (Y)	388777.7713				

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: Autohammer efficiency = 87% (measured 11/1/2013)
3 (in) solid well installed at 80 (ft), decommissioned after seismic testing.

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								AC	3 inches asphalt concrete			Water knife/vactor to 5 feet. Soil description based on visual observation.
									SM	Grayish brown silty fine to medium sand with occasional gravel and cobbles (dense to very dense, moist) (glacial till) (ESU 5B)			
350													
	5		8	50/2"		1 SA					13	28	
345													
	10		1	50/3"		2 MC					9		
340													
	15		1	50/3"		3 MC				Grades to moist to wet	8		
335									SM	Grayish brown silty fine to medium sand with occasional gravel (very dense, moist)			
	20		8	50/2"		4 SA					12	43	
330													
	25		3	50/3"		5 MC				Grades to moist to wet	9		
325													
	30		1	50/4"		6							Poor recovery
320									SP-SM	Grayish brown silty fine to medium sand with gravel (very dense, moist to wet) (advance outwash) (ESU 6B)			
	35												

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B10S

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-57
Sheet 1 of 3

Elevation (feet)	Depth (feet)	FIELD DATA						Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level						
	35	■	6	50/4"		7 %F					8	7	
									SM	Grayish brown silty fine to medium sand with gravel (very dense, moist to wet)			
315													
	40	■	2	50/5"		8 MC					11		
310													
	45	■	2	50/3"		9							
305													
	50	■	4	50/4"		10 %F					14	36	
									CL	Grayish brown lean clay with sand (hard, moist)			
300													
	55	■	9	50/3"		11 AL					22		AL (LL = 27%; PI = 8%)
									SM	Brown silty fine to medium sand (very dense, moist)			
295													
	60	■	12	88/9"		12 SA					16	22	
290													
	65	■	0	50/5"									No recovery
									SM	Gray silty fine to medium sand with silt interbeds (very dense, wet)			
285													
	70	■	16	82		13 SA					18	12	Groundwater observed at 70 feet during drilling
280													
	75	■	18	83		14 %F					24	19	

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B10S (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	FIELD DATA						Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level						
275									SM	Gray silty fine sand (very dense, wet)			
	80	█	17	93/11"		15 SA					21	24	

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B10S (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Drilled	Start 6/20/2014	End 6/20/2014	Total Depth (ft) 81.5	Logged By DTM Checked By CRW	Driller Holocene
Drilling Method	Mud Rotary				
Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig		
Surface Elevation (ft) Vertical Datum	362.49 Project	Top of Casing Elevation (ft)	362.26		
Easting (X) Northing (Y)	1376334.3 389321.79	Horizontal Datum	Project		

DOE Well I.D.: BIP344
A 2 (in) well was installed on 6/20/2014 to a depth of 30.25 (ft).

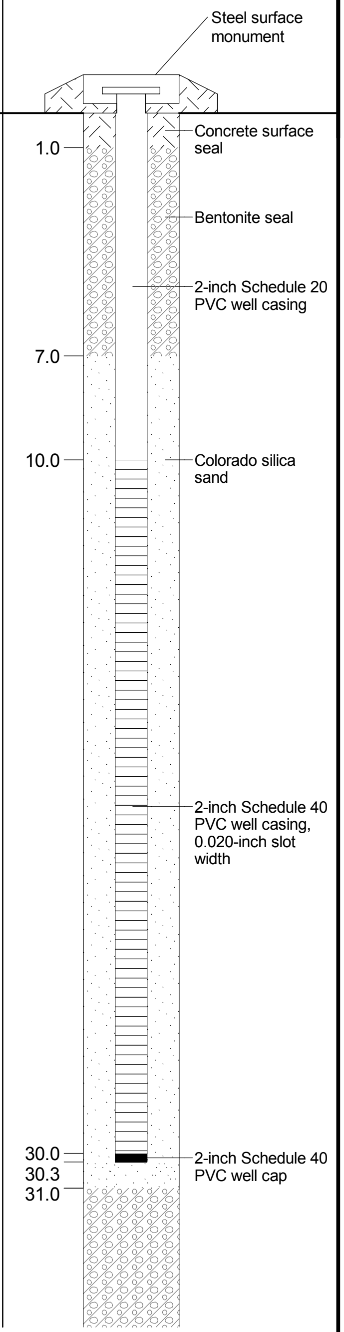
Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
8/12/2014	7.4	354.9

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

FIELD DATA

Elevation (feet)	Depth (feet)	Interval / Recovered (in)	Blows/foot	Collected Sample / Sample Name Testing	Water Level	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0					AC	3 inches asphalt concrete		
						SM	Brown silty fine to medium sand with occasional gravel, cobbles and trace organics (loose, moist) (fill) (ESU 1A)		
360									
	5						(Water knife/vactor to 6 feet. Soil description based on visual observation.)		
		18	19	1 MC		PT	Dark brown/black peat (soft, moist) (wetland deposits) (ESU 2)	18	
355					▼	SP-SM	Gray fine to medium sand with silt (medium dense, wet) (advance outwash) (ESU 6A)		
	10	15	30	2 %F				20	6
350						SP-SM	Grayish brown fine to medium sand with silt and occasional gravel (dense to very dense, wet) (ESU 6B)		
	15	13	60	3 SA				17	9
345									
	20	12	38	4 SA			With decreasing gravel content	22	8
340						SM	Grayish brown silty fine to medium sand (very dense, wet)		
	25	12	58	5 SA				24	14
335									
	30	12	51	6 %F				23	14
330						SP-SM	Grayish brown with oxidation staining fine to medium sand with silt (very dense, wet)		
	35								

WELL LOG



Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B11P

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Figure A-58
Sheet 1 of 3

Depth (feet)	Interval Recovered (in)	Blows/foot	Sample Name / Testing	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
35	18	85	7 / MC			21	
40	18	58	8 / %F			22	10
				SP-SM	Brownish gray silty fine to medium sand with silt (very dense, wet)		
45	18	57	9 / %F			23	10
				SM	Gray silty fine to medium sand with silt interbeds (very dense, wet)		
50	12	50/6"	10 / MC			23	
				ML	Gray sandy silt (hard, wet) (transitional beds) (ESU 7)		
55	11	50/5"	11 / %F			27	70
60	15	88/9"	12 / MC			26	
				CL	Gray lean clay (hard, moist)		
65	18	61	13 / AL		AL (LL = 45%; PI = 20%)	23	
70	18	58	14 / MC			24	
75	18	46	15 / AL		AL (LL = 29%; PI = 10%)	25	

Elevation (feet): 325, 320, 315, 310, 305, 300, 295, 290, 285

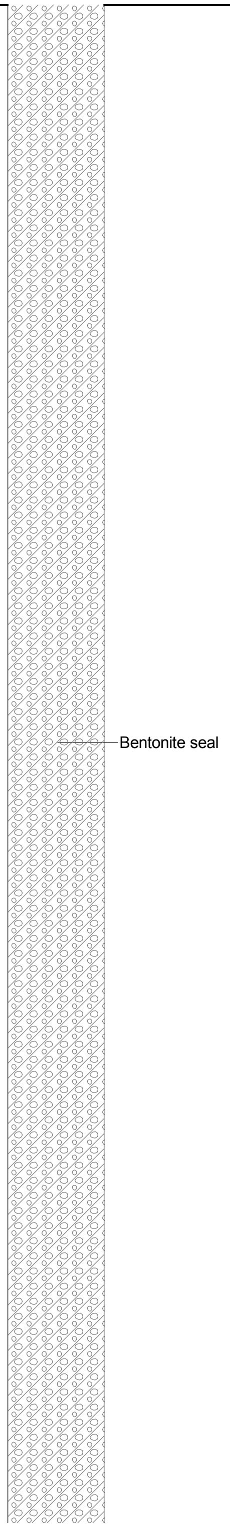
FIELD DATA

Collected Sample

Water Level

Graphic Log

WELL LOG

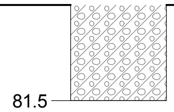


Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B11P (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	FIELD DATA Interval	 Recovered (in)	 Blows/foot	 Collected Sample	 Sample Name Testing	 Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	WELL LOG
	80	▮	15	59		16 MC		▨			27		 81.5

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B11P (continued)

GeoEngineers

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Figure A-58
Sheet 3 of 3

Drilled	Start 7/21/2014	End 7/21/2014	Total Depth (ft) 81	Logged By ERH Checked By CRW	Driller Holocene
Drilling Method	Hollow-Stem Auger				
Surface Elevation (ft) 394 Vertical Datum Project	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig	
Easting (X) 1376263.904 Northing (Y) 389682.3318	System Datum	Project			

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
7/21/2014	38.2	355.85

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								AC	7 inches asphalt concrete			Water knife/vactor to 5.5 feet. Soil description based on visual observation.
									CR	2 inches base course			
									SP-SM	Brown fine sand with silt, gravel and occasional cobbles (medium dense, moist) (fill) (ESU 1B)			
390													
	5	▮	15	10		1 SA			SP-SM	Brown with oxidation staining fine to medium sand with silt (medium dense, moist)	11	12	
385									SP-SM	Brown fine to medium sand with silt and occasional gravel (medium dense, moist)			
	10	▮	13	30		2 %F					6	8	Hard drilling
380													
	15	▮	0	48									No recovery
375									SP-SM	Gray fine to medium sand with silt and occasional gravel (medium dense, moist)			
	20	▮	18	21		3 MC					9		
370									SM	Gray silty fine to medium sand with occasional gravel and lenses of wood/peat and silt (dense, moist) (advance outwash) (ESU 6A)			
	25	▮	13	33		4							
365													
	30	▮	18	31		5 SA					8	13	
360									SM	Brown with oxidation staining silty fine to medium sand with occasional gravel and silt interbeds (dense, moist) (ESU 6B)			
	35												

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B12

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	35		6 %F					17	14	
355							▼		SP	Brown fine to medium sand with trace silt and occasional gravel (dense, wet)			Groundwater observed at 38 feet during drilling
	40		18	42		7 SA					18	4	Driller added mud to control heave
350									SP-SM	Brown fine to medium sand with silt (dense to very dense, wet)			
	45		16	55		8 %F					20	8	
345													
	50		17	47		9 SA					19	10	
340													
	55		14	75		10 %F					21	7	
335									SP-SM	Brown with oxidation staining fine to medium sand with silt and silt interbeds (very dense, wet)			
	60		18	53		11 SA					23	9	
330													
	65		1	64		12							Poor recovery
325													
	70		12	74		13 MC					18		
320									SP-SM	Brown with oxidation staining fine to medium sand with silt (very dense, wet)			
	75		18	67		14 SA					21	10	

Note: See Figure A-0 for explanation of symbols.

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Log of Boring LLE-B12 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-59
Sheet 2 of 3

Elevation (feet)	Depth (feet)	FIELD DATA						Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level						
315								⁙					
	80	■	11	50/5"		15 %F		⁙			22	12	

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B12 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-59
Sheet 3 of 3

Drilled	Start 6/21/2014	End 6/21/2014	Total Depth (ft) 81.5	Logged By CRW Checked By CRW	Driller Holocene
Drilling Method	Hollow-Stem Auger				
Surface Elevation (ft) Vertical Datum	395 Project	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig
Easting (X) Northing (Y)	1376317.541 389984.2055	System Datum	Project	Groundwater	

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								AC	4 inches asphalt concrete			Water knife/vactor to 5 feet. Soil description based on visual observation.
									CR	3 inches base course			
									GP-GM	Gray fine to coarse gravel with silt and sand (medium dense, wet) (fill) (ESU 1A)			
390	5		4	11		1 MC					13		
									SM	Brown silty fine to medium sand with gravel, trace roots and wood fragments (loose to medium dense, moist)			
385	10		14	22		2 %F					10	15	
380	15		18	6		3 SA				With trace wood fragments	13	17	
375	20		12	17		4 MC				With occasional asphalt and debris	11		
									SP	Gray fine to coarse sand (medium dense, moist) (advance outwash) (ESU 6A)			
370	25		18	22		5 SA					7	4	
									SP-SM	Gray fine to medium sand with silt (medium dense, moist)			
365	30		18	23		6 %F					16	8	
													Groundwater observed at 32 feet during drilling
									SP-SM	Gray fine to medium sand with silt and gravel (dense, wet) (ESU 6B)			
360	35												

Note: See Figure A-0 for explanation of symbols.

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Log of Boring LLE-B13

GeoEngineers

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-60
Sheet 1 of 3

		FIELD DATA											
Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		18	48		7 %F					13	6	Driller added mud to auger to prevent heave
355	40		18	44		8 %F					17	5	
									SP-SM	Gray fine to medium sand with silt (dense to very dense, wet)			
350	45		18	40		9 SA					20	8	
345	50		18	55		10 MC					22		
340	55		18	48		11 %F					22	6	
									SM	Gray silty fine to medium sand (very dense, wet)			
335	60		18	64		12 SA					23	12	
330	65		18	72		13 %F					26	15	
									SP-SM	Brown with oxidation staining fine to medium sand with silt (very dense, wet)			
325	70		18	67		14 %F					23	8	
320	75		18	80		15 MC					23		

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B13 (continued)

Elevation (feet)	Depth (feet)	FIELD DATA										
		Interval	Recovered (in)	Blows/foot	**Collected Sample**	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
									SM	Gray silty fine sand with sand interbeds (very dense, wet)			
315	80	■	18	77		16 %F					26	18	

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B13 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Drilled	Start 6/28/2014	End 6/28/2014	Total Depth (ft) 41	Logged By DTM Checked By CRW	Driller Holocene
Drilling Method	Hollow-Stem Auger				
Surface Elevation (ft) 398 Vertical Datum Project	Hammer Data Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment Mobile B-61 Truck Rig			
Easting (X) 1376477.14 Northing (Y) 389951.8931	System Datum Project	Groundwater			

Groundwater

Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

FIELD DATA

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								AC	4 inches asphalt concrete			Water knife/vactor to 5.5 feet. Soil description based on visual observation.
									CR	8 inches base course			
									CC	3 inches concrete			
395									SP-SM	Brown fine to coarse sand with gravel (medium dense, moist) (fill) (ESU 1A)			
	5												
									SP-SM	Brownish gray with oxidation staining fine to medium sand with silt and occasional gravel (medium dense to dense, moist) (advance outwash) (ESU 6A)			
390			12	30		1 MC					9		
	10		12	20		2 %F					9	10	
385									SP-SM	Grayish brown fine to medium sand with silt (dense to very dense, moist) (ESU 6B)			
	15		18	41		3 SA					7	7	
380													
	20		18	54		4 SA					8	12	
375													
	25		18	45		5							
370													
	30		18	47		6 %F					5	7	
365													
	35												

Note: See Figure A-0 for explanation of symbols.

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Log of Boring LLE-B14

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-61

Elevation (feet)	Depth (feet)	FIELD DATA Interval	 Recovered (in)	 Blows/foot	 Collected Sample	 Sample Name Testing	 Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	▮	18	71		7 %F				Grades to wet	21	6	Groundwater observed at 35 feet during drilling
360													
									SP	Brownish gray fine to medium sand with trace silt (very dense, wet)			
	40	▮	12	50/6"		8 SA					30	3	

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B14 (continued)

GeoEngineers

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Drilled	Start 6/28/2014	End 6/28/2014	Total Depth (ft) 41.5	Logged By DTM Checked By CRW	Driller Holocene
Drilling Method	Hollow-Stem Auger				
Surface Elevation (ft) Vertical Datum	400 Project	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig
Easting (X) Northing (Y)	1376476.393 390195.1061	System Datum	Project	Groundwater	

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

Date Measured	Depth to Water (ft)	Elevation (ft)

Elevation (feet)	Depth (feet)	FIELD DATA: Interval	FIELD DATA: Recovered (in)	FIELD DATA: Blows/foot	FIELD DATA: Collected Sample	FIELD DATA: Sample Name Testing	FIELD DATA: Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								AC	8 inches asphalt concrete			Water knife/vactor to 5.5 feet. Soil description based on visual observation.
									CR	9 inches base coarse			
									SP-SM	Grayish brown fine to medium sand with silt and occasional gravel (medium dense, moist) (advance outwash) (ESU 6A)			
395	5												
									SP-SM	Grayish brown fine to medium sand with silt (dense to very dense, moist)			
			18	56		1 MC					7		
390	10		18	29		2 %F					7	8	
										(ESU 6B)			
385	15		18	61		3 SA					4	9	
									SP	Gray fine to medium sand with trace silt (very dense, moist)			
380	20		12	50/6"		4 %F					3	4	
									SW-SM	Brownish gray fine to medium sand with silt (very dense, moist)			
375	25		18	65		5 SA					4	8	
370	30		18	64		6							
									SW-SM	Brownish gray fine to medium sand with silt and occasional gravel (very dense, wet)			
365	35												

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B15

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	FIELD DATA						Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level						
	35		18	76		7 SA					12	7	Groundwater observed at 35 feet during drilling
									SP	Brownish gray fine to medium sand with occasional gravel and trace silt (very dense, wet)			
360	40		14	81/8"		8 %F					16	4	

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B15 (continued)

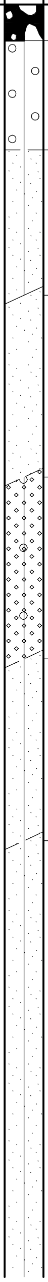
GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-62
Sheet 2 of 2

Drilled	Start 6/18/2014	End 6/18/2014	Total Depth (ft) 101.5	Logged By ERH Checked By CRW	Driller Holocene
Drilling Method	Hollow-Stem Auger				
Surface Elevation (ft) 484 Vertical Datum Project		Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig
Easting (X) 1376462.869 Northing (Y) 390645.5311		System Datum	Project	Groundwater	Date Measured / Depth to Water (ft) / Elevation (ft)

Notes: Autohammer efficiency = 87% (measured 11/1/2013)



Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							CR	Crushed rock			Water knife/vactor to 5 feet. Soil description based on visual observation.
								GP-GM	Gray fine to coarse gravel with silt, sand and cobbles (loose, moist) (fill) (ESU 1A)			
480								SP-SM	Brown fine to medium sand with silt, occasional gravel and trace organics (loose, moist)			
	5		14	4		1 MC				11		
475								SP	Brown fine to medium sand with trace silt (medium dense, moist) (advance outwash) (ESU 6A)			
	10		17	14		2 %F				4	3	
470								SW-SM	Brown fine to medium sand with silt and occasional gravel (medium dense, moist)			
	15		18	25		3 SA				5	9	
465								SP-SM	Brown fine to medium sand with silt (medium dense, moist)			
	20		18	25		4 %F				4	7	
460								SP-SM	Gray fine to medium sand with silt and occasional gravel (dense to very dense, wet) (ESU 6B)			
	25		18	40		5 SA				17	7	Groundwater observed at 26 feet during drilling
455												
	30		14	86/10"		6 SA				13	6	
450												
	35											

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B17

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Figure A-63
Sheet 1 of 3

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	▮	18	47		7 %F					15	8	
									SP	Brown fine to medium sand (very dense, wet)			
445													
	40	▮	15	70/9"		8 SA					16	1	
									SP-SM	Gray fine to medium sand with silt (very dense, wet)			
440													
	45	▮	14	52		9 SA					21	5	
									SP-SM	Brown fine to medium sand with silt (dense to very dense, wet)			
435													
	50	▮	14	53		10 MC					23		
430													
	55	▮	18	48		11 %F					23	11	
									SP-SM	Brown fine sand with silt (dense to very dense, wet)			
425													
	60	▮	14	40		12 SA					23	9	
420													
	65	▮	16	58		13							
									SM	Brown silty fine sand (very dense, wet)			
415													
	70	▮	18	85		14							
									CL	Brown with oxidation staining lean clay (hard, moist to wet)			
									SP-SM	Gray fine sand with silt (very dense, moist)			
410													
	75	▮	11	50/5"		15 %F					24	9	

Note: See Figure A-0 for explanation of symbols.

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Log of Boring LLE-B17 (continued)

GeoEngineers

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
									ML	Gray sandy silt (hard, moist) (transitional beds) (ESU 7)			
405													
	80	■	18	74/11"		16 MC					27		
									ML	Gray silt with sand (hard, moist)			
400													
	85	■	18	45		17 %F					25	89	
									CL	Gray lean clay (hard, moist)			
395													
	90	■	18	60		18 AL					32		AL (LL = 32%; PI = 11%)
390													
	95	■	18	47		19 MC					33		
									CH	Tan fat clay (very stiff, moist)			
385													
	100	■	18	25		20 AL					46		AL (LL = 75%; PI = 45%)

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B17 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Shoreline, Washington
Project Number: 4082-026-02

Figure A-63
Sheet 3 of 3

Drilled Start 4/14/2014 End 4/14/2014	Total Depth (ft) 61	Logged By CRW Checked By CRW	Driller Holocene	Drilling Method Hollow-Stem Auger
Surface Elevation (ft) 390 Vertical Datum Project	Hammer Data Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment Mobile B-61 Truck Rig	
Easting (X) 1376060.17 Northing (Y) 390957.3037	System Datum Project		Groundwater Date Measured / Depth to Water (ft) / Elevation (ft)	

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name / Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								AC	3 inches asphalt			Water knife/vactor to 5.5 feet. Soil description based on visual observation.
									SM	Reddish brown silty sand with gravel and cobbles (medium dense, moist) (fill) (ESU 1A)			
									SP-SM	Brown fine to coarse sand with silt and occasional gravel (medium dense, moist) (advance outwash) (ESU 6A)			
385	5		10	17		1 / MC					7		
380	10		18	25		2 / MC				2 inch silt lens	13		
									SP-SM	Gray fine to medium sand with silt (dense to very dense, moist) (ESU 6B)			
375	15		18	38		3 / SA					9	10	
										With occasional gravel			
370	20		18	70		4 / %F					7	9	
365	25		18	68		5 / %F					8	10	
360	30		12	50/6"		6 / MC					5		
									SP-SM	Grayish brown fine sand with silt (very dense, moist)			
355	35												

Note: See Figure A-0 for explanation of symbols.

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Log of Boring LLE-B18

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	FIELD DATA Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	■	15	85/11"		7 SA					8	10	
										With occasional gravel			
350	40	■	18	85		8 MC					4		
345	45	■	10	50/6"		9 SA					7	9	Gravel zone at 45 feet
340	50	■	16	82		10 %F					4	8	
									SP-SM	Gray fine sand with silt (micaceous) (very dense, moist)			
335	55	■	12	50/6"		11							
330	60	■	10	50/6"		12 SA					6	9	

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B18 (continued)

GeoEngineers

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-64
Sheet 2 of 2

Drilled	Start 7/23/2014	End 7/24/2014	Total Depth (ft) 101.5	Logged By CRW Checked By CRW	Driller Holocene
Drilling Method	Hollow-Stem Auger				
Surface Elevation (ft)	392	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig
Vertical Datum	Project				
Easting (X)	1375821.77	System Datum	Project	Groundwater	
Northing (Y)	391597.49				

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)

Notes: Autohammer efficiency = 87% (measured 11/1/2013)

Elevation (feet)	Depth (feet)	FIELD DATA Interval	FIELD DATA Recovered (in)	FIELD DATA Blows/foot	FIELD DATA Collected Sample	FIELD DATA Sample Name / Testing	FIELD DATA Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0								SOD	4 inches sod			Water knife/vactor to 5 feet. Soil description based on visual observation.
390									SP-SM	Brown fine to medium sand with silt and occasional gravel and cobbles and trace organics (loose, moist) (fill) (ESU 1A)			
									SP-SM	Brown fine to medium sand with silt (medium dense to very dense, moist) (advance outwash) (ESU 6A)			
	5	■	18	22		1 %F					8	7	
385													
	10	■	18	33		2 SA				Grades to with occasional gravel	7	9	
380													
	15	■	18	52		3 %F				With decreasing gravel content, grades to very dense (ESU 6B)	6	9	
375													
	20	■	18	71		4 %F					6	11	
370													
	25	■	18	56		5 %F				Grades to wet	9	7	Groundwater observed at 25 feet during drilling
365									SP-SM	Brown fine to medium sand with silt and occasional gravel (very dense, wet)			
	30	■	16	75/10"		6 SA					15	6	6 inches of heave
360									SW-SM	Brown fine to medium sand with silt and gravel (very dense, wet)			
	35												

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B19

GeoEngineers

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35		15	76		7 SA					13	8	Driller added mud to auger to control heave
355													
									SP-SM	Brown fine to medium sand with silt (dense, wet)			
	40		18	43		8 %F					21	7	
350													
	45		18	43		9 SA					25	11	
345													
	50		18	63		10 MC				Grades to grayish brown	21		
340													
									SM	Grayish brown silty fine to medium sand (very dense, wet)			
	55		18	77		11 %F					20	12	
335													
									SP-SM	Brownish gray fine to medium sand with silt (very dense, wet)			
	60		12	50/6"		12 %F					23	9	
330													
	65		6	50/6"		13 SA					22	8	
325													
									SP-SM	Gray fine to medium sand with silt (very dense, wet)			
	70		17	77/5"		14 %F					21	7	
320													
									CH	Gray fat clay (hard, moist) (transitional beds) (ESU 7)			
	75		18	55		15 AL					26		AL (LL = 53%; PI = 28%)

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B19 (continued)

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-65
Sheet 2 of 3

Elevation (feet)	Depth (feet)	FIELD DATA						Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
		Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level						
315													
	80	■	18	31		16 MC					24		
310													
									CL	Gray with oxidation staining lean clay with sand interbeds (hard, moist)			
	85	■	18	56		17 MC					22		
305													
									MH	Brown with oxidation staining elastic silt (hard, moist)			
	90	■	18	34		18 AL					40		AL (LL = 53%; PI = 23%)
300													
									CH	Brownish gray fat clay (hard, moist)			
	95	■	18	29		19 MC					32		
295													
	100	■	18	37		20 AL					32		AL (LL = 59%; PI = 30%)

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B19 (continued)

GeoEngineers

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	4/18/2014	4/18/2014	41.5	ERH	CRW	Holocene	Hollow-Stem Auger

Surface Elevation (ft) Vertical Datum	432 Project	Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Mobile B-61 Truck Rig
Easting (X) Northing (Y)	1375779.837 392394.9864	System Datum	Project	Groundwater	

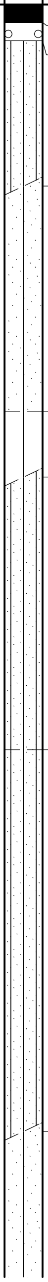
Notes: Autohammer efficiency = 87% (measured 11/1/2013)

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)

FIELD DATA

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	0							AC	6 inches asphalt concrete			Water knife/vactor to 5.5 feet. Soil description based on visual observation.
								GP	3 inches gravel base course			
430								SM	Brown silty sand with gravel and occasional boulders (medium dense, moist) (fill) (ESU 1B)			
	5		15	28		1 MC		SP-SM	Brown fine to medium sand with silt and gravel (medium dense, moist)	6		
425												
	10		18	25		2 MC				9		
								ML	Gray silt with occasional sand and gravel (very stiff, moist)			
420												
								SM	Brown silty fine to medium sand with gravel (medium dense to dense, moist)			
	15		18	30		3 SA				7	19	
415												
	20		14	25		4 %F				8	33	
								SM	Brown silty fine to medium sand with gravel (medium dense to dense, moist)			
410												
	25		18	31		5 SA				10	36	
405												
	30		18	23		6 SA				9	28	
								SP-SM	Gray fine to medium sand with silt and occasional gravel (medium dense, moist)			
400												
	35											

Graphic Log



Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B20

GEOENGINEERS

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Elevation (feet)	Depth (feet)	Interval	Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
	35	■	10	11		7 MC			WOOD	2 to 3 inch wood layer	11		
395									SP-SM	Brown with oxidation staining fine to medium sand with silt and gravel (medium dense, moist) (advance outwash) (ESU 6A)			
									SM	Brown silty fine to medium sand (dense, moist)			
	40	■	18	34		8							

Note: See Figure A-0 for explanation of symbols.

Log of Boring LLE-B20 (continued)

Project: Sound Transit - Lynnwood Link Extension
Project Location: Mountlake Terrace, Washington
Project Number: 4082-026-02

Figure A-66
Sheet 2 of 2

Appendix C

Borehole Data Summary Sheet

Appendix C, Borehole Data Summary Sheet. *Expansions of the abbreviations listed in this table are as follows – Drilling Methods: Hollow Stem Auger (HAS), Mud Rotary (MR), and Becher Hammer (BH); Samplers: Standard Penetration Test (SPT), and Dames and Moore (D&M); Methods of Water Measurement: Vibrating Wire Piezometer (VWP), Observations while Drilling (drilling obs.), and electric tape (e-tape).*

Boring ID	Drilling Method	Sampler	Depth (ft)	Elevation (ft)	N-Value	Density	Water Elevation (ft)	Method and Date of Water Measurements	Percent Moisture	Percent Gravel	Percent Sand	Percent Fines
B06	MR	SPT					279	drilling obs. 7/07/2014				
			50	279	37	dense			22.0	0.0	88.5	11.5
			55	274	61	very dense			22.0			13.0
			60	269	64	very dense			22.0			10.0
			65	264	100	very dense			22.0			
			70	259	69	very dense			24.0	0.0	86.6	13.4
			75	254	100	very dense			24.0			12.0
			80	249	100	very dense			21.0			
B08	HSA	SPT					281	drilling obs. 7/11/2014				
			40	277	50	very dense			15.0	14.8	81.0	4.3
			45	272	56	very dense			21.0			
			50	267	60	very dense			23.0			15.0
			55	262	100	very dense			23.0	3.8	82.0	14.1
B09	HSA	SPT					312	drilling obs. 7/17/2014				
			25	306	100	very dense			16.0	11.7	95.6	2.7
			35	296	100	very dense			14.0	22.4	67.0	10.7
			40	291	100	very dense			22.0	1.1	89.8	9.1
			45	286	100	very dense			22.0			9.0
			50	281	100	very dense			19.0	11.7	71.6	16.7
			55	276	100	very dense			20.0			20.0
			60	271	100	very dense			12.0			28.0
			65	266	100	very dense			11.0			
			70	261	100	very dense						
B10S	MR	SPT					284	drilling obs. 6/19/2014				
			35	319	100	very dense			8.0			7.0
			36	318	100	very dense			11.0			
			37	317	100	very dense						
			40	315	100	very dense			14.0			36.0

Boring ID	Drilling Method	Sampler	Depth (ft)	Elevation (ft)	N-Value	Density	Water Elevation (ft)	Method and Date of Water Measurements	Percent Moisture	Percent Gravel	Percent Sand	Percent Fines
B11P	MR	SPT					354.9	e-tape 8/12/2014				
			10	352.5	30	dense			20.0			6.0
			15	347.5	60	very dense			17.0			9.0
			20	342.5	38	dense			22.0			8.0
			25	337.5	58	very dense			24.0			14.0
			30	332.5	51	very dense			23.0			14.0
			35	327.5	85	very dense			21.0			
			40	322.5	58	very dense			22.0			10.0
			45	317.5	57	very dense			23.0			10.0
			50	312.5	100	very dense			23.0			
B12	HSA	SPT					355.85	e-tape 7/12/2014				
			25	369	33	dense						
			30	364	31	dense			8.0	5.4	81.8	12.9
			35	359	35	dense			17.0			14.0
			40	354	42	dense			18.0	6.4	89.7	3.9
			45	349	55	very dense			20.0			8.0
			50	344	47	dense			19.0	3.6	86.2	10.1
			55	339	75	very dense			21.0			7.0
			60	334	53	very dense			23.0	0.8	90.6	8.6
			65	329	64	very dense						
			70	324	74	very dense			18.0			
			75	319	67	very dense			21.0	0.0	90.1	9.9
			80	314	100	very dense			22.0			12.0
B13	HSA	SPT					363	drilling obs. 6/21/2014				
			25	370	22	med dense			7.0	1.5	94.5	4.0
			30	365	23	med dense			16.0			8.0
			35	360	48	dense			13.0	18.5	75.4	6.1
			40	355	44	dense			17.0			5.0
			45	350	40	dense			20.0	0.2	91.4	8.4
			50	345	55	very dense			22.0			
			55	340	48	dense			22.0			6.0
			60	335	64	very dense			23.0	3.3	84.5	12.2
			65	330	72	very dense			26.0			15.0
			70	325	67	very dense			23.0			8.0
			75	320	80	very dense			23.0			
			80	315	77	very dense			26.0			18.0

Boring ID	Drilling Method	Sampler	Depth (ft)	Elevation (ft)	N-Value	Density	Water Elevation (ft)	Method and Date of Water Measurements	Percent Moisture	Percent Gravel	Percent Sand	Percent Fines
B14	HSA	SPT					363	drilling obs. 6/28/2014				
			12.5	391.5	30	dense			9.0			
			10	388	20	med dense			9.0			10.0
			15	383	41	dense			7.0	0.7	92.0	7.3
			20	378	54	very dense			8.0	1.0	87.3	11.7
			25	373	45	dense						
			30	368	47	dense			5.0			7.0
			35	363	71	very dense			21.0			6.0
			40	358	100	very dense			30.0	4.4	92.3	3.3
B15	HSA	SPT					365	drilling obs. 6/28/2014				
			7.5	392.5	56	very dense			7.0			
			10	390	29	med dense			7.0			8.0
			15	385	61	very dense			4.0	0.1	91.1	8.8
			20	380	100	very dense			3.0			4.0
			25	375	65	very dense			4.0	3.3	89.1	7.6
			30	370	64	very dense						
			35	365	76	very dense			12.0	9.6	83.1	7.3
			40	360	100	very dense			16.0			4.0
B17	HSA	SPT					458	drilling obs. 6/18/2014				
			10	380	14	med dense			4.0			3.0
			15	375	25	med dense			5.0	6.8	83.9	9.3
			20	370	25	med dense			4.0			7.0
			25	365	40	dense			17.0	2.2	90.5	7.3
			30	360	100	very dense			13.0	11.1	82.6	6.3
			35	355	47	dense			15.0			8.0
			40	350	100	very dense			16.0	2.7	96.0	1.3
			45	345	52	very dense			21.0	0.0	94.8	5.2
			50	340	53	very dense			23.0			
			55	335	48	dense			23.0			11.0
			60	330	40	dense			23.0	0.0	91.1	8.9
			65	325	58	very dense						
			70	320	85	very dense						
			75	315	100	very dense			24.0			9.0

Boring ID	Drilling Method	Sampler	Depth (ft)	Elevation (ft)	N-Value	Density	Water Elevation (ft)	Method and Date of Water Measurements	Percent Moisture	Percent Gravel	Percent Sand	Percent Fines
B18	HSA	SPT					N/A	N/A				
			5	385	17	med dense			7.0			
			10	380	25	med dense			13.0			
			15	375	38	dense			9.0	1.3	88.7	10.0
			20	370	70	very dense			7.0			9.0
			25	365	68	very dense			8.0			10.0
			30	360	100	very dense			5.0			
			35	355	100	very dense			8.0	0.0	90.5	9.5
			40	350	85	very dense			4.0			
			45	345	100	very dense			7.0	3.8	87.3	8.9
			50	340	82	very dense			4.0			8.0
			55	335	100	very dense						
			60	330	100	very dense			6.0	0.3	90.8	8.9
B19	HSA	SPT					367	drilling obs. 7/23/2014				
			5	387	22	med dense			8.0		93.0	7.0
			10	382	33	dense			7.0	1.9	88.9	9.2
			15	377	52	very dense			6.0			9.0
			20	372	71	very dense			6.0			11.0
			25	367	56	very dense			9.0			7.0
			30	362	100	very dense			15.0	3.4	91.0	5.6
			35	357	76	very dense			13.0	19.6	72.6	7.8
			40	352	43	dense			21.0			7.0
			45	347	43	dense			25.0	0.0	88.9	11.1
			50	342	63	very dense			21.0			
			55	337	77	very dense			20.0			12.0
			60	332	100	very dense			23.0			9.0
			65	327	100	very dense			22.0	0.0	92.0	8.0
			70	322	100	very dense			21.0			7.0
B20	HSA	SPT					N/A	N/A				
			40	392	34	dense						

Boring ID	Drilling Method	Sampler	Depth (ft)	Elevation (ft)	N-Value	Density	Water Elevation (ft)	Method and Date of Water Measurements	Percent Moisture	Percent Gravel	Percent Sand	Percent Fines
MW-3	BH	D&M					N/A	N/A				
			10	321	26	med dense			10.2			
			20	311	26	med dense			13.3			
			30	301	27	med dense			9.4	1.1	93.7	5.1
			40	291	50	very dense			5.8			
			50	281	11	med dense			4.7			
			60	271	39	dense			3.9	6.3	89.0	4.7
			70	261	48	dense			19.9			
			80	251	N/A	N/A			11.2			
			90	241	N/A	N/A			21.3	8.3	86.7	5.1
			100	231	N/A	N/A			25.8			
			120	211	N/A	N/A			27.8	7.6	89.3	3.1
MW-4	BH	D&M					280.2	VWP 3/27/2002				
			10	377	40	dense			9.1			7.8
			20	367	45	dense			6.0	33.4	59.6	7.0
			30	357	34	dense			10.5			7.1
			40	347	47	dense			5.1	16.4	79.3	4.3
			50	337	72	very dense			5.3			12.4
			60	327	47	dense			13.3	4.3	81.2	14.6
			70	317	63	very dense			4.8			3.6
			80	307	21	med dense			5.2	2.6	91.1	6.3
			90	297	43	dense			4.9			5.3
			100	287	100	very dense			6.6	5.6	88.6	5.9
			110	277	100	very dense			16.8			5.2
			120	267	100	very dense			17.3	2.4	95.2	2.4
			130	257	N/A	N/A			35.4			7.2
			135	252	N/A	N/A			26.1			3.6
			155	232	N/A	N/A			23.6	0.6	95.9	3.6
			175	212	N/A	N/A			22.9	4.8	91.6	3.6
MW-5	BH	D&M					N/A	N/A				
			10	295	16	med dense			8.2			
			20	285	16	med dense			4.8			
			30	275	29	med dense			17.7	2.9	93.9	3.2
			40	265	27	med dense			21.4			
			41	264	27	med dense			22.7			
			50	255	11	med dense			21.1	0.0	97.6	2.4

Boring ID	Drilling Method	Sampler	Depth (ft)	Elevation (ft)	N-Value	Density	Water Elevation (ft)	Method and Date of Water Measurements	Percent Moisture	Percent Gravel	Percent Sand	Percent Fines
MW-6	BH	D&M					N/A	N/A				
			30	284	6	loose			24.0			
			40	274	33	dense			25.5			
			50	264	10	med dense			31.2			
BW-4	MR	D&M					280.63	VWP 2/26/2002				
			10	358	100	very dense						
			20	348	100	very dense			5.7			
			30	338	100	very dense			11.9	16.4	76.7	6.8
			40	328	100	very dense			11.8			
			50	318	100	very dense			9.6	1.7	92.0	6.2
			60	308	100	very dense			18.1			
			70	298	100	very dense						
			80	288	100	very dense			15.1			
			90	278	100	very dense						
			100	268	100	very dense			18.0			
			110	258	100	very dense			23.0			
			120	248	100	very dense			23.1			
			130	238	100	very dense			20.7			
			140	228	100	very dense			23.7			13.7
			150	218	100	very dense			27.1			
			160	208	100	very dense			27.9			
			170	198	100	very dense			23.0			
			180	188	100	very dense			25.6			
BW-5	MR	D&M					364.2	VWP 2/26/2002				
			10	390	60	very dense			13.0			
			20	380	65	very dense			9.0			
			30	370	100	very dense			11.3	0.1	89.6	10.2
			40	360	100	very dense			13.6			
			50	350	100	very dense			18.9			
			60	340	100	very dense			21.4			
BW-6	MR	D&M					N/A	N/A				
			50	400	100	very dense			9.2	48.2	40.9	10.7
			70	380	100	very dense			20.0			
			80	370	100	very dense			21.5			

Boring ID	Drilling Method	Sampler	Depth (ft)	Elevation (ft)	N-Value	Density	Water Elevation (ft)	Method and Date of Water Measurements	Percent Moisture	Percent Gravel	Percent Sand	Percent Fines
E-105	Sonic	D&M					N/A	N/A				
					N/A	N/A						
E-106	Wireline	D&M					N/A	N/A				
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
E-107	Wireline and MR	D&M					231.92	VWP, unknown date				
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						
					100	very dense						

Boring ID	Drilling Method	Sampler	Depth (ft)	Elevation (ft)	N-Value	Density	Water Elevation (ft)	Method and Date of Water Measurements	Percent Moisture	Percent Gravel	Percent Sand	Percent Fines
E-108	Wireline	D&M					N/A	N/A				
					N/A	N/A						
E-109	Wireline	D&M					N/A	N/A				
					N/A	N/A						
E-110	Wireline	D&M					N/A	N/A				
					100	very dense						
E-211	Wireline	D&M					287.12	OW, unknown date				
					N/A	N/A						

Appendix D

Unified Soil Classification Guide (Adapted from Zhou, 2006)

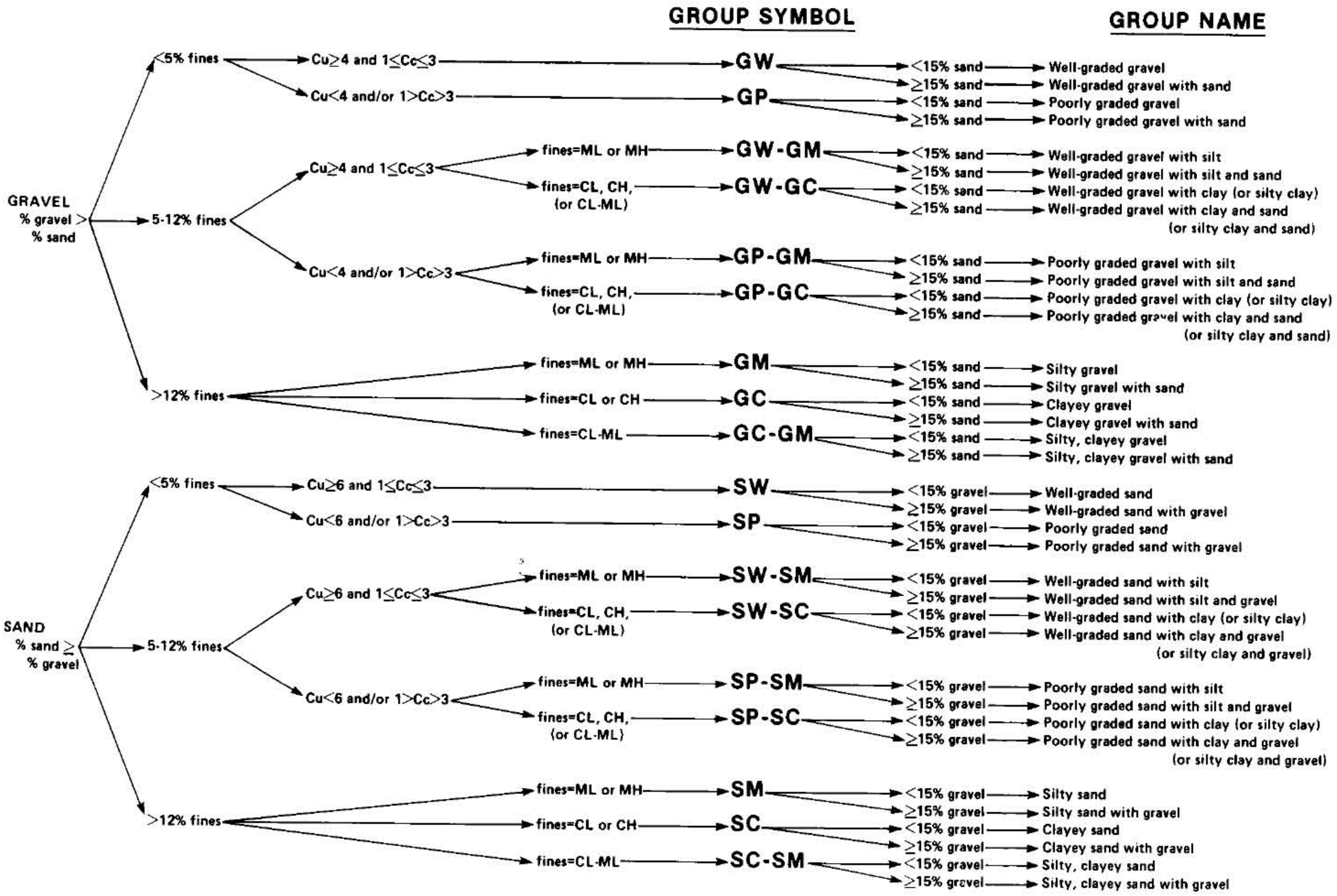


Figure 4-1: Flow chart to determine the group symbol and group name for coarse-grained soils (ASTM D 2487).

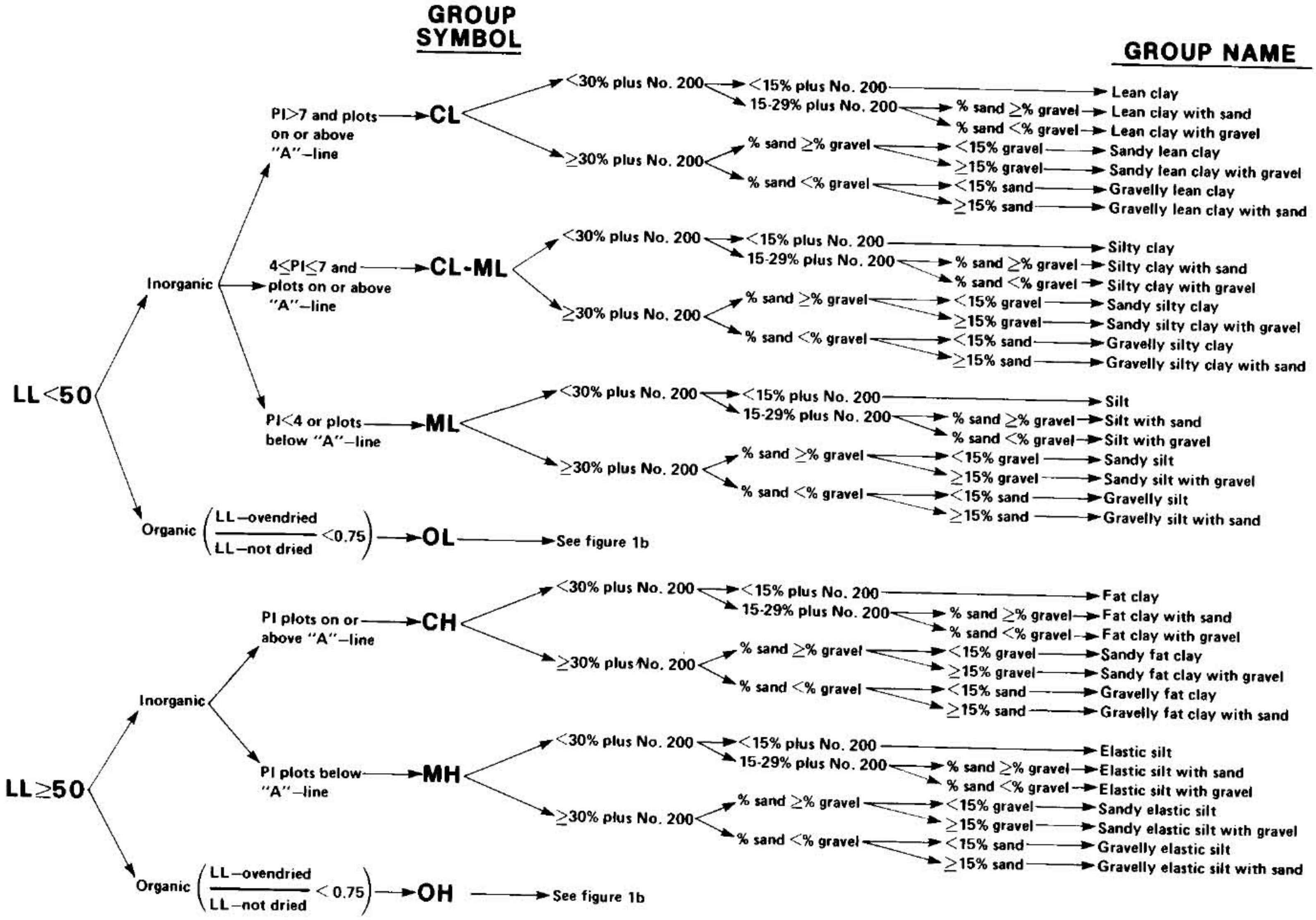


Figure 4-4a. Flow chart to determine the group symbol and group name for fine-grained soils (ASTM D 2487).

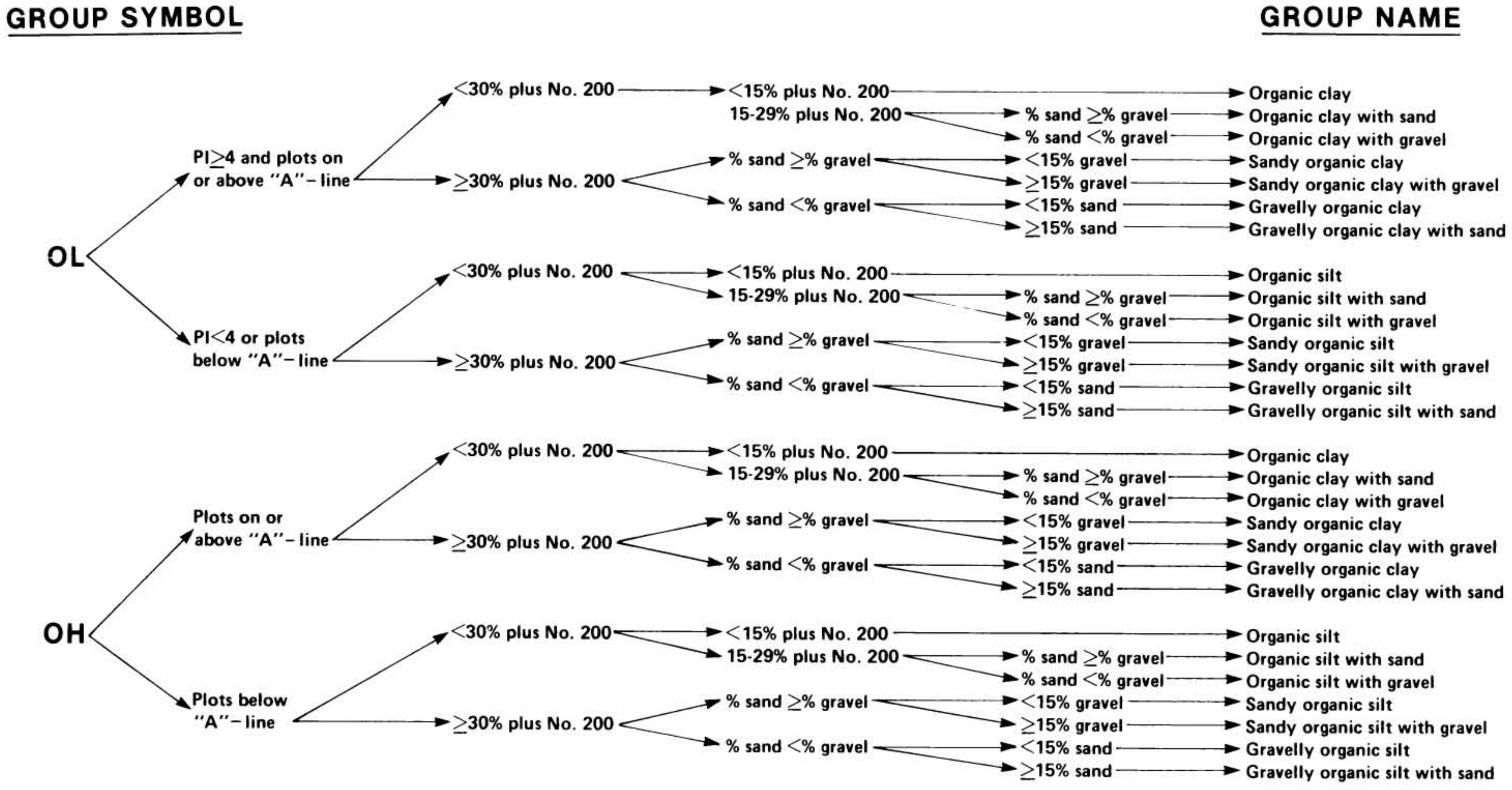


Figure 4-4b. Flow chart to determine the group symbol and group name for organic soils (ASTM D 2487).