Appendix D

Preliminary Grading and Drainage Report

STORMWATER AND GRADING STRATEGIES

Quiemuth Village

Address:

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1.0 PROPOSED PROJECT

1.1 Introduction

Olson Engineering Inc. (OEI) was retained by Acorn Environmental (AE) to complete a conceptual evaluation of the stormwater and grading requirements for the proposed Quiemuth Village development in Lacey, Washington. This study will be used to support the environmental impact analysis being prepared by AE for the mixed-use project. The scope includes a review of background site conditions, an evaluation of on-site facility requirements and a conceptual design of key grading and stormwater facilities as required.

The Nisqually Indian Tribe have traditionally lived off the land and rivers, sustaining their civilization through the respect and protection of the natural ecosystem. The Nisqually Department of Natural Resources maintains the pristine native lands and waterways important to the survival of fish, plants, and wildlife, and in turn their cultural heritage. They have a reputation for environmental stewardship programs that protect and enhance the natural environment.

The method of stormwater runoff treatment is of the utmost importance to the Nisqually Department of Natural Resources. The plan to address runoff is to use the latest Best Management Practices (BMPs) that provide treatment of runoff while also enabling runoff to be infiltrated across the site rather than concentrated in a specific location. The plan also incorporates native vegetation where possible to reduce need for irrigation and further mimic the historic pattern of runoff treating plants and soil as part of the infiltration process. It is the plan of the tribe to create an interactive display of how the onsite stormwater is treated and how this provides the required treatment needed to protect salmon and other stream life. The interactive display will include but not be limited to BMPs descriptions, pollutant types and methods of removal, the cycle of the runoff from the atmosphere to the streams and groundwater, and descriptions of fauna and flora that enhance the natural environment.

1.2 Objectives

The goal of this analysis is to identify and evaluate the stormwater and grading needs and options for the Quiemuth Village on a conceptual level. Specific objectives of the study are to:

- Estimate stormwater flows for the existing and developed conditions and proposed solutions for onsite stormwater treatment and disposal
- Estimate grading quantities and show preliminary finished grade contours

Only once the property is taken into trust will it be subject to federal regulations. These include the Clean Water Act, the National Pollution Discharge Elimination Scheme (NPDES) and the Underground Injection Control (UIC) for Class 5 Injection Wells. Since the project is planning on infiltrating 100% of all runoff on site, the predominant regulation will be the treatment requirements as specified by UIC for class 5 injection wells. The proposed treatment and infiltration system sizing meets these requirements.

Although the project is not subject to the City of Lacey 2022 Stormwater Design Manual (2022 SDM) or the Stormwater Manual for Western Washington (SWMWW) (or any other authority), this analysis seeks to be consistent with both standards.

There are 9 minimum/core requirements as detailed in the Western Washington Stormwater Management Manual and City of Lacey Stormwater Management Manual and these are listed and addressed for this project in section 4.1 of this report. The main focus of this report is how the project will meet the runoff treatment requirements for quality (Core Requirement 6) and quantity (Core Requirement 7) per City of Lacey Stormwater Design Manual.

1.3 Proposed Development

The 174-acre proposed trust property referred to as the “Quiemuth Village” is located adjacent to an existing parcel of land held in trust for the Tribe that is developed with the Nisqually Markets Smoke Shop. The Project Site is bounded by Interstate Highway 5, a parking area for the Cabela’s retail store, and commercially zoned land owned by the Tribe to the south; Marvin Road to the east; Britton Parkway to the north, and a gravel mine and townhome development to the west.

There are two development alternatives: Alternative 1- Proposed Mixed Use Development, and Alternative 2- Reduced Intensity Mixed Use Development. The Tribe proposes to develop a mix of commercial, retail, office, housing, and recreational land uses within the Project Site in addition to ancillary infrastructure and facilities.

Alternative 1: Commercial use consisting of grocers, dining facilities, movie theaters and bowling alley, hotel, artist studios and offices, general and neighborhood retail, a Carvana, a truck stop, and a Top Golf are proposed. The residential portion includes high-density multi-family units and live/work units in the Cultural Village. Throughout the Project Site, there would be parking spaces provided by several surface parking areas

Alternative 2: Similar to Alternative 1 but would have less commercial and retail development and increased recreational space. Commercial uses include a grocer, dining facilities, movie theater and bowling alley, the Cultural Village that include artist studios and offices, regional and neighborhood retail, a Carvana, and a gas station with convenience store. Recreational and open-space development would consist of Top Golf, Open-Space, Indoor Recreation, and an Athletic Complex. In addition, lodging facilities and residential development is proposed, including a hotel, high-density multi-family units and live/work units in the Cultural Village and a school. Throughout the Project Site, there would be parking spaces provided by several surface parking areas.

Below are the areas for the project as a whole for each alternative (1 & 2). These are broken out into their respective individual “sub” developments or catchment areas in section 4.2 to follow. This analysis assumes 85% impervious and 15% impervious area for the commercial sites which will suffice for the conceptual analysis. The impervious area is further divided into roof to paved area ratio of 1:4.

Coverage	Acres
Paved (Pollution Generating Impervious Surface (PGIS))	118.3
Roof	29.6
Landscape (Pollution Generating Pervious Surface (PGPS))	26.1
Total	174.0

Table 1.1: Alternative 1 - Proposed Ground Cover

Coverage	Acres
Paved (PGIS)	86.5
Roof	19.2
Landscape (PGPS)	68.3
Total	174.0

Table 1.2: Alternative 2 – Proposed Ground Cover

See vicinity and site layout maps in **Appendix A** of this report.

2.0 EXISTING CONDITIONS

2.1 Site Description

The 174-acre site is currently undeveloped but has been previously disturbed by logging and grading activities. The southern boundary of the Project Site generally aligns with the planned extension of Main Street from Marvin Road to Gateway Boulevard as shown in the City of Lacey Gateway Specific Plan, and access to the site is provided via partially constructed segments of Main Street that dead end at the western and eastern boundaries of the site. Additionally, southbound off-ramps and on-ramps from Interstate Highway-5 have been partially constructed within the southeastern portion of the Project Site.

The Project Site is situated in the central portion of the Lacy glacial outwash plain that formed as the Vashon glacial ice receded from the area. The ground surface at the site is gently to moderately sloping with localized small hills, ridges, and depressions. The site vegetation consists of scattered young second growth timber, primarily evergreens, with a moderate to dense understory of native and invasive brush and grasses. The site is traversed by a number of gravel roads and trails, including several that reflect the proposed final road configuration.

For calculation purposes to be consistent with the Western Washington Standards, the existing condition is assumed to be forested. However, it should be noted that historically runoff infiltrates onsite and no stormwater leaves the site, therefore the historic ground cover is not relevant since the intent is to also infiltrate all stormwater in the developed condition.

Catchment #	Total Area Forested (AC)
C101	22.59
C102	22.97
C103	18.53
C104	32.50
C105	8.60
C106	28.45
C107	6.50
C108	24.91
C109	8.95
Total:	**174.00**

Table 2: Historic Ground Cover

There is no evidence of on-site stormwater runoff leaving the site that was documented in the geotechnical report by GeoResources LLC dated September 20th, 2013, in **Appendix E**. Furthermore, a site visit was completed by Olson Engineering on April 22, 2022, where the perimeter of the site was walked. From the site visit, it was evident that the site slopes away from Briton Parkway and Marvin Road. There is a drainage way running east west across most of the site with a high point located approximately centrally in the site. The west portion of the site drains to the drainage way which slopes gradually to the west property line. The drainage way east of the high point slopes gradually to the east then curves to the south where it disperses into the southern slope of the east portion of the site. The site is treed with a dense understory from the west end of the Main Street extension to just west of Gateway Boulevard NE. The trees thin out in the area adjacent to the west property line. The eastern portion of the property north and south of the Main Street extension shows signs of grading and other development activity and is currently mostly unvegetated or with sparse grass cover. There were no signs of runoff within the treed areas, the less vegetated area adjacent to the west property line or the disturbed area in the east of the site.

Along the west property line there is a large depression just to the east of the gravel mine located on the adjacent property. Any runoff from the west part of the drainage way would flow to this area prior to discharging from the site. The site visit was during the wet season and no standing water was present in this area with no evidence of any runoff leaving the site due to the pervious nature of the onsite soil. In the east of the site, directly south of the disturbed area there are small depressions adjacent to Interstate 5. The location of the depressions and pervious nature of the surface soils means that no runoff leaves the site along the south property line. Based on the above information, no runoff currently leaves the project sites.

Based on the geotechnical report by Haley Aldridge in **Appendix E**, the tested soils generally have poor to good infiltration properties, exhibiting unfactored drawdown rates of 0.0 to approximately 200 inches per hour. These rates are quite low in some cases and are reflective of the moderate fines content and dense nature of the various soils. Other tests are quite high and are reflective of the gravellier outwash soils found above the till soils. The tests only represent soils at the test locations at the depth that they were obtained, and are unlikely to be representative of the deeper, denser till soils that may underlie the test depths. Haley Aldridge anticipated the deeper soils to generally have lower permeability than the surficial soils. However, the logs from deeper historical borings indicate fines content generally decreasing at greater depths. This suggests that deep infiltration systems may be possible as lower fines content could indicate increased permeability. The adjacent property to the west where the Cabela’s retail store is located has a functioning stormwater facility that consists of a constructed wetland for treatment and an onsite infiltration gallery. There are no stormwater facilities on the Project Site.

3.0 SUBSURFACE CONDITIONS

Soil Description and Classification

The Project Site is situated in the central portion of the Lacy glacial outwash plain that formed as the Vashon glacial ice receded from the area.

According to the Web Soil Survey, the soil on-site is classified as:

(2) Alderwood Gravelly Sand, 8-15% slopes, 29.6%

(33) Everette Very Gravelly Sandy Loam, 8-15% slopes, 7.4%

(46) Indianola Loamy Sand, 0-5% slopes, 5.5%

(110) Spanaway Sandy Gravelly Loam, 0-3% slopes, 57.5%

The hydrologic soil group (HSG) used in WWHM (Western Washington Hydrology Model) calculations based on the City of Lacey SDM are summarized in the table below:

Soil Type	Web Soil Map Unit	HSG
Alderwood	2	A/B
Everette	33	A
Indianola	46	A
Spanaway	110	A/B

Table 3: Hydrologic Soil Groups (HSG)

See Chapter 6 of the City of Lacey Stormwater Design Manual (SDM) Table 6A.6, page 6A-11 and refer to the soils map in the **Appendix A** of this report which shows the soil types and locations within the Project Site.

In accordance with the Geotechnical Report by Haley Aldrich dated September 2022 (See **Appendix E**), subsurface conditions in the site vicinity and therefore expected at the site are typically defined by a layer of organics (topsoil/forest duff) and/or loose to medium dense artificial fill and weathered native soils, overlying native dense to very dense glacial soils. The glacial soils typically consist of sandy gravel or gravelly sand with varying amounts of silt and occasional silt layers. Generally current and historical borings and test pits encountered loose to medium dense fill or native soils to depths of up to about 10 feet below ground surface (bgs) before encountering more dense native materials. However, some historical explorations encountered dense glacial soils at or very near the ground surface.

Below the fill material, native glacial soils consisting of dense to very dense silty sand, sandy gravel and gravelly sand with occasional sandy silt layers typically extended to the bottom of borings, test pits, and wells around the site. Cobbles and boulders were also encountered in the glacial soils.

Based on findings by Haley Aldrich, the nearby historical and on-site field infiltration rates range from 0 to 200 inches per hour, with an average value of approximately 38 inches per hour. When the two highest (200 inches per hour) and two lowest (0 and 0.25 inches per hour) rates are removed, the average rate is approximately 20 inches per hour. Based on this data, for preliminary design purposes, they recommend using an average infiltration rate of 20 inches per hour as an unfactored rate.

3.2 Groundwater

Depth to groundwater appears variable across the site according to the historical explorations. Historical test pits encountered groundwater seepage at depths as shallow as 4 feet. However, as many of the test pits did not encounter seepage, the presence of perched water is interpreted to be variable across the site and may vary with seasonal precipitation and other factors. Historical boring and well logs reported encountering water at various elevations. Terra Associates monitoring wells MW-1 and MW-3 encountered free water at the approximate elevations of 192 and 190(depths of 15 and 10 feet bgs), respectively. WSDOT borings H-4p-17 and H-12-17 encountered free water at elevations of 202 and 186 (depths of 27 and 12 feet bgs), respectively. Hart Crowser borings HC-2 and HC-3 encountered free water at approximate elevations of 188 and 192 (depths of 22 and 30 feet bgs), respectively. As many of the borings did not report free water at or below these elevations, Haley Aldrich concluded that the regional groundwater table varies across the site and may vary according to seasonal precipitation and other factors.

4.0 STORMWATER ANALYSIS

As mentioned previously, the project is not subject to the City of Lacey 2022 Stormwater Design Manual (2022 SDM) or any other jurisdiction, but this analysis seeks to satisfy the city requirements for stormwater. Based on Table 1.0 on page 6 of this report, listing the proposed development ground cover and areas, it shows that the proposed development will create more than 5,000sf of new impervious surface.

Based on the flow diagram, Figure 6 from the 2022 SDM (*Determining requirements for new Development)* shown in **Appendix D**, all core requirements apply to all new and replaced hard surfaces. The reason for this is that the proposed project does not have more than 35% of existing impervious coverage but it does result in greater than 5000sf of new hard surface. Below is a list of the minimum/core requirements based on the City of Lacey 2022 SDM and responses as to how these will be addressed:

4.1 Core Requirements (City of Lacey)

Core Requirement No. 1*: Prepare Stormwater Site Plans and Reports.*

A drainage report and plans will be prepared during the final engineering stage for review and approval.

Core Requirement No. 2*: Construction Stormwater Pollution Prevention.*
An Erosion/Sedimentation Control plan along with a Construction Stormwater Pollution Prevention Plan will be prepared during the final engineering plan approval process consistent with the City of Lacey2022 SDM.

Core Requirement No. 3*: Source Control of Pollution.*
Source control BMPs typically prevent pollution, or other adverse effects of stormwater, from occurring at a developed site. Source control BMPs are classified as operational or structural. All required Source Control BMPs associated with any onsite activity or use, will be implemented once construction has been completed. Examples of these include: correcting illicit discharges to storm drains, formation of a pollution prevention team, preventive maintenance, spill prevention and cleanup, employee training, and record keeping to name a few. More detail about these can be found in 2019 Stormwater Management Manual for Western Washington Volume IV - Chapter 1 - Page 497.

Core Requirement No. 4*: Preserve Natural Drainage Systems and Outfalls.*
There is no evidence of stormwater runoff leaving the site in the existing condition. In the developed condition stormwater runoff will be collected and conveyed to on-site infiltration galleries that will hydrologically mimic the existing condition to the greatest extent practical.

Core Requirement No. 5*: On-Site Stormwater Management.*
Onsite stormwater will be collected and conveyed to water quality treatment facilities prior to being infiltrated onsite. Since no runoff will be leaving the site, the Low Impact Development (LID) performance standard will be met thus meeting the requirements of Core Requirement 5.

Core Requirement No. 6: *Runoff Water Quality Treatment.*
All runoff from pollution generating hard surfaces will be collected and treated in accordance with City of Lacey stormwater manual requirements. See section 6.0 for a more detailed analysis of runoff water quality treatment.

Core Requirement No. 7: *Flow Control.*
All runoff from the site will be collected and routed to infiltration facilities where it will be infiltrated into the ground. No runoff will leave the site. For more detailed analysis of flow control, see section 7.0.

Core Requirement No. 8: *Wetland Protection.*
There are no known wetlands on the project site, therefore this requirement does not apply

Core Requirement No. 9: *Operations and Maintenance.*
Operations and maintenance will be satisfied during final engineering.

4.2 Sizing Flow control and Water Quality Best Management Practices (BMP's)

Each catchment area within the proposed project alternatives contains areas of road, sidewalk, roof, and landscape. Runoff from all these areas will be collected and routed to different water quality and/or flow control BMPs depending on the surface type or use.

The stormwater pollutants of most concern are total suspended solids (TSS), oil and grease, nutrients, pesticides, other organics, pathogens, biochemical oxygen demand (BOD), heavy metals, and salts (chlorides). The excerpt below from the Stormwater Management Manual for Western Washington (SWMWW) gives a brief description for each pollutant:

Total Suspended Solids
This represents particulate solids such as eroded soil, heavy metal precipitates, and biological solids (all considered as conventional pollutants), which can cause sedimentation in streams and turbidity in receiving surface waters. These sediments can destroy the desired habitat for fish and can impact drinking water supplies. The sediment may be carried to streams, lakes, or Puget Sound where they may be toxic to aquatic life and make dredging necessary.

Oil and Grease
Oil and grease can be toxic to aquatic life. Concentrations in stormwater from commercial and industrial areas often exceed Ecology guidelines of:

- *10 mg/L maximum daily average,*
- *15 mg/L maximum at any time, and*
- *no ongoing or frequently recurring visible sheen.*

Nutrients
Phosphorus and nitrogen compounds can cause excessive growth of aquatic vegetation in lakes and marine waters.

Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) is a measure of the oxygen demand from organic, nitrogenous, and other materials that are consumed by bacteria present in receiving waters. BOD in the water may deplete oxygen in the process, threatening higher organisms such as fish.

Toxic Organics

*A study found 19 of the U.S. Environmental Protection Agency's 121 priority pollutants present in the runoff from Seattle streets. The most frequently detected pollutants were pesticides, phenols, phthalates, and polynuclear aromatic hydrocarbons (PAHs).**Heavy***

Metals

Stormwater can contain heavy metals such as lead, zinc, cadmium, and copper at concentrations that often exceed water quality criteria and that can be toxic to fish and other aquatic life. Research in Puget Sound has shown that metals and toxic organics concentrate in sediments and at the water surface (microlayer) where they interfere with the reproductive cycle of many biotic species as well as cause tumors and lesions in fish.

pH

A measure of the alkalinity or acidity that can be toxic to fish if it varies appreciably from neutral pH, which is 7.0.

***Bacteria and Viruses** Stormwater can contain disease-causing bacteria and viruses, although not at concentrations found in sanitary sewage. Shellfish subjected to stormwater discharges near urban areas are usually unsafe for human consumption. Research has shown that the concentrations of pollutants in stormwater from residential, commercial, and industrial areas can exceed Ecology's water quality standards and guidelines.*

The different BMPs proposed to treat runoff for this project have been modelled to determine the runoff and size of each BMP required for treatment and quantity control. Further detail for this modelling is detailed in following sections. For water quality BMP's, the water quality flow was calculated, and the biofiltration cells sized accordingly. For quantity control, shallow infiltration trenches were sized to infiltrate 100% of all the runoff. To size each of the BMP's, the Western Washington Hydrology Model (WWHM2012) was used to determine both the water quality flows and quantity of runoff for each of the design storms.

Biofiltration Cells are discussed in more detail in section 5 which follows, and shallow infiltration trenches are analyzed for the site and discussed in the section 6.

5.0 WATER QUALITY

5.1 Bioretention

The Western Washington Hydrology Model (WWHM2012) was used to model developed flows for water quality facilities. Per both the “Geotechnical Engineering Study” attached in **Appendix E**, and the NRCS Web Soil Survey, on-site soils are gravelly sandy loams, consistent with soil type A and B in WWHM2012. Based on *Figure 8.1 Treatment Facility Selection Flow Chart (***Appendix C**, since infiltration for pollutant removal is practicable due to the suitability of the particle size and cation charge on the particles and the fact that the runoff is to be 100% infiltrated, the following pretreatment BMPs are applicable:

- Pre-settling Basin
- Any Basic Treatment BMP
- Emerging Technologies

The City of Lacey Water Quality flow chart (see **Appendix C**) shows that only basic treatment is required because oil control, phosphorus control and enhanced treatment are not required for this site. The Basic Treatment Facility chosen was Bioretention Cells. This option not only provides the required runoff treatment but also enables some or even all of the treated water to be infiltrated at the location of the biofiltration cell. Bioretention cells also provide the level of enhanced treatment not required but preferred by the Nisqually Indian Tribe.

For the purposes of this analysis all treatment area has been combined thus resulting in a single facility for each catchment or each commercial development that will provide the required treatment. During final design, small individual facilities will be dispersed throughout each site but should have a total treatment capacity similar to the combined facility sizes calculated for this report.

The following Land coverage was used for each facility for their respective catchments. The land uses are limited to paved areas and any landscaping within or directly adjacent to it. No roof areas were included as runoff generated by most roof surfaces do not require treatment. Runoff from roof areas will be routed directly to infiltration facilities for disposal

Catchment #	Treated Area Total (Acre)	Paved Area (SF)	Landscape Area (SF)
C101	18.75	15.36	3.39
C102	19.07	15.62	3.45
C103	15.38	12.60	2.78
C104	26.95	22.09	4.86
C105	7.14	5.85	1.29
C106	23.62	19.35	4.27
C107	5.40	4.42	0.98
C108	20.68	16.94	3.74
C109	7.43	6.09	1.34

Table 4.1: Alternative 1 - Developed Land Cover flowing to Water Quality Facilities

Catchment #	Treated Area Total (Acre)	Paved Area (SF)	Landscape Area (SF)
C201	21.75	4.35	17.40
C202	19.07	15.62	3.45
C203	18.53	3.71	14.82
C204	26.95	22.09	4.86
C205	7.14	5.85	1.29
C206	23.62	19.35	4.27
C207	5.40	4.42	0.98
C208	24.91	4.98	19.93
C209	7.43	6.09	1.34

Table 4.2: Alternative 2 - Developed Land Cover flowing to Water Quality Facilities

5.2 WWHM Model Assumptions and Results

Bioretention facilities provide treatment for the water quality storm (91% of the 24-hour continuous runoff volume) in accordance with City of Lacey Stormwater Design Standards Manual based in Section 5.03 and Volume V of the Stormwater Management Manual for Western Washington (SWMMWW). Each catchment or development area will consist of multiple bioretention cells dispersed throughout the parking area of the site to mimic existing infiltration conditions to the greatest extent practical.

The water quality storm was modeled using Western Washington Hydrology Model (WWHM2012). For bioretention facilities treating less than 5000sf of PGIS and less than 10,000sf total impervious, a saturation safety factor 2 is used to model the facility; otherwise, a saturation safety factor of 4 is applied. A factor of 4 was used in our calculations with the assumption that all the sub-catchments flowing to the bioretention cells will be greater than 5000sf of pollution generating impervious surface (PGIS) and/or greater than 10,000sf total impervious area. Bioretention cell media is required to have an infiltration rate of 12 in/hr for calculation (per SWMMWW). When a saturation safety factor of 4 is applied as required, it results in a media design infiltration rate of 3 in/hr. This would be the most conservative approach for this conceptual design since limiting the catchment area for any bioretention cell could reduce the size by about 50%. At the time of final design, the size of bioretention cells can be reduced by restricting contributing areas to 5,000sf and 10,000sf respectively and thus reducing the saturation factor of safety to 2.

All bioretention treatment facilities are assumed to be 4’ deep, have a native soil infiltration rate of 20 in/hr with a safety factor of 2 applied which results in a design rate of 10 inches per hour. This was determined as previously mentioned, based on findings by Haley Aldrich, the nearby historical and on-site field infiltration rates range from 0 to 200 inches per hour, with an average value of approximately 38 inches per hour. When the two highest (200 inches per hour) and two lowest (0 and 0.25 inches per hour) rates are removed, the average rate is approximately 20 inches per hour. Based on this data, for preliminary design purposes, they recommend using an average infiltration rate of 20 inches per hour as an unfactored rate. To generate a design rate, they recommend applying a factor of safety of 2. This results in a design rate of 10 inches per hour.

Treated runoff infiltrates into the ground through the native soil which aids in reducing the downstream infiltration trenches.

For the WWHM analysis, a 1-acre site was modeled as a baseline or "per/acre" model for each surface type (paving and landscape) to apply to each catchment area to simplify the calculations. The results of this analysis assuming a 4' facility depth are as follows based on the WWHM report in **Appendix B**:

Footprint Area* required per acre of paving = 1580sf
Footprint Area* required per acre of landscape = 400sf
*Area was determined by multiplying the length and width for the facility as defined in the WWHM report

Since there is a linear relationship between the site area and the facility size, simply multiplying the acreage for each catchment by the "per/acre" facility size for each surface type, it allows us to determine the bioretention (BR) facility sizes for each catchment as shown below. For example, C101 is calculated as follows:

BR Facility Area Required for C101(Alt 1) =Paved Area x Area req. per Paved Acre
+ Landscape Area x Area req. per Landscape Acre
= (15.37ac x 1580 sf/ac) + (3.39ac x 400 sf/ac)
= 24,285 sf + 1,356 sf
= 25,641 sf
~ 25,700sf (Rounded up to nearest 100)

The results of the Western Washington Hydrology Model (WWHM12) report for water quality are tabulated on below. The WWHM report can be found in **Appendix B**.

Tabulated sizing results for the bioretention systems WWHM analysis:

Catchment #	Total Treatment Area (Acre)	Paved Area (SF)	Landscape Area (SF)	Bioretention Area Required (SF)
C101	18.75	15.36	3.39	25,700
C102	19.07	15.62	3.45	26,100
C103	15.38	12.60	2.78	21,100
C104	26.95	22.09	4.86	36,900
C105	7.14	5.85	1.29	9,800
C106	23.62	19.35	4.27	32,300
C107	5.40	4.42	0.98	7,400
C108	20.68	16.94	3.74	28,300
C109	7.43	6.09	1.34	10,200

Table 5.1: Alternative 1 - Bioretention Treatment Area Required (total)

Catchment #	Total Treatment Area (Acre)	Paved Area (SF)	Landscape Area (SF)	Bioretention Area Required (SF)
C201	21.75	4.35	17.40	18,500
C202	19.07	15.62	3.45	27,900
C203	18.53	3.71	14.82	15,800
C204	26.95	22.09	4.86	39,400
C205	7.14	5.85	1.29	10,500
C206	23.62	19.35	4.27	34,600
C207	5.40	4.42	0.98	7,900
C208	24.91	4.98	19.93	21,200
C209	7.43	6.09	1.34	10,900

Table 5.2: Alternative 2 - Bioretention Treatment Area Required (total)

The land uses in the table above are limited to paved areas and any landscaping within or directly adjacent to them. No roof areas were included as runoff generated by roof area does not require treatment. Runoff from roof areas will be routed directly to infiltration facilities for disposal.

The proposed locations of these facilities can be seen on the conceptual stormwater plan (C1.0) in **Appendix F**. Supporting data on the design and specifications for biofiltration systems from the Stormwater Manual for Western Washington can be found in **Appendix C** and also include standard plan and cross-sectional details.

5.3 Oil/water Separation Devices

For any site uses subject to oil control, oil/water separation devices will be installed according to City of Lacey and WSDOE requirements. All oil/water separation devices will be sized according to the manufacturer's specifications. The project would not be subject to City of Lacey and WSDOE rules after being taken into trust but would be installed according to these standards.

A truck stop is proposed in the eastern most lot. Development of this use will not only incorporate oil/water separation devices but will also use dead-end sumps within the fuel island, double walled tanks, extensive subsurface monitoring to ensure there are no leaks in any part of the fuel storage or conveyance systems, and implementation of all source control BMPs related to service stations. See “Core Requirement No.3” on page 11 of this report for examples of source control of pollution BMPs.

5.4 Protection for Salmon

The Nisqually Indian Tribe is very active in environment stewardship programs and is partnering with Washington State University (WSU) and the University of Washington (UW) in their research into toxic chemicals that pollute our waterways.

The scientists from WSU and UW have been able to identify a component in runoff that is highly toxic to salmon. Initially a mix of 2,000 chemicals was found in the runoff that was studied. Through extensive studies and testing the scientist were able to narrow it down to one highly toxic chemical named 6PPD-Quinone. 6PPD is a component that is used as an anti-degradant for motor vehicle tires. When 6PPD reacts with ozone, the researchers found that it was transformed into multiple chemicals, including 6PPD-Quinone, the toxic chemical responsible for killing salmon. While 6PPD-Quinone's toxicity to salmon is now well established, the mechanism for toxicity is not yet fully understood and further studies are needed. Since 6PPD is used in the manufacture of all tires around the world, it is assumed that 6PPD-Quinone will be present on every traffic bearing road worldwide.

While additional studies are needed to assess the full effect of 6PPD-Quinone, there have been some positive findings related to its treatment and removal from runoff. There are new studies in which the effectiveness of various methods of filtration have been measured such as sand and biofiltration filters.

Since 6PPD-Quinone is dissolved in water, sand filters were not found to be effective since they only stop contaminants that are 'particulate' in nature, i.e., bound to particles that can be physically filtered out by sand grains. Biofiltration has shown promise since the researchers have found that 6PPD-Quinone is hydrophobic and expect that it will be sequestered by organic matter in the biofiltration media much the same way as other organic pollutants.

Anecdotally based on Dr. Kolodziej's retrospective analysis of water samples from studies on bioretention and bioswales, bioretention (relying on infiltration) removed 6PPD-Quinone to below detection levels whereas bioswales (relying on horizontal flow over vegetation and compost) removed the majority of 6PPD-Quinone, but not all.

Based on the importance of protecting the local waterways and salmon in them, the Nisqually Tribe wants to ensure they are doing everything to treat runoff to achieve this goal. Based on the early studies showing positive removal levels by using bioretention cells followed by infiltration with further treatment in the soils, this is the preferred treatment option proposed for the development of the mixed-use development.

As previously mentioned, the Tribe intends to create an interactive display showing how the onsite stormwater will be treated and how this will provide the required treatment needed to protect salmon and other stream life. This will include but not be limited to; descriptions of the BMPs, pollutant removal methods and how they function, the path of the runoff from the atmosphere to the streams and descriptions of fauna and other flora used to enhance the natural environment.

References:

- A Ubiquitous tire rubber-derived chemical induces acute mortality in Coho Salmon - Science 3rd December 2020 Vol 371, Issue 6525, pg. 185-189 – (Multiple Authors)
- WA Stormwater Center - Technical Q+A On Stormwater and Tire Chemical Toxicity to Aquatic Organisms – Dr's McIntyre and Kolodjiez
- Bioretention reduction of toxicity to Coho salmon from urban stormwater – Effectiveness Study – Stormwater Action Monitoring; September 2017.

6.0 FLOW CONTROL

Please reference sheets CP-1.0: Existing Catchment Plan sheet, CP-2.0 and CP-3.0: Developed Catchment Plans for drainage basins and drainage basin coverage areas in **Appendix F**.

Based on the geotechnical report by Haley Aldrich in **Appendix E**, the tested soils generally have poor to good infiltration properties, exhibiting unfactored drawdown rates of 0.0 to approximately 200 inches per hour. These rates are quite low in some cases and are reflective of the moderate fines content and dense nature of the various soils. Other tests are quite high and are reflective of the gravellier outwash soils found above the till soils. The tests are representative only of the soils at the location and elevation of the tests, and are unlikely to be representative of deeper, denser till soils which may underlie the test depths. Haley Aldrich anticipated deeper soils generally having lower permeability than surficial soils. However, the logs from deeper historical borings indicate fines content generally decreasing at greater depths. This suggests that deep infiltration systems may be possible as lower fines content could indicate increased permeability.

Even though there is variable infiltration across the site, Haley Aldrich still finds the use of stormwater infiltration systems to be feasible. They also recommend and propose the use of small, dispersed, low volume systems, such as bio-swales and infiltration trenches for the project.

Based on findings by Haley Aldrich, the nearby historical and on-site field infiltration rates range from 0 to 200 inches per hour, with an average value of approximately 38 inches per hour. When the two highest (200 inches per hour) and two lowest (0 and 0.25 inches per hour) rates are removed, the average rate is approximately 20 inches per hour. Based on this data, for preliminary design purposes, they recommend using an average infiltration rate of 20 inches per hour as an unfactored rate. A factor a safety of 2 is recommended which results in a design rate of 10 inches per hour.

In the analysis below, The Western Washington Hydrology Model (WWHM2012) was used to model developed and existing flows to size the infiltration galleries. Per both the geotechnical engineering studies, attached in **Appendix E**, and the NRCS Web Soil Survey, onsite soils are gravelly sandy loams, consistent with soil type A/B in WWHM2012 which are generally excellent for infiltration.

Category A Flow Control (as described in the *2020 City of Lacey Stormwater Design Manual on page 2-26 Chapter 2 – Applicability and Core Requirements*) is required for the project which matches developed discharge durations to predeveloped durations for the range of predeveloped discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow.

The existing condition was modeled as forested per the 2022 City of Lacey Stormwater Design Manual, Chapter 2.2.7. The existing condition, however, does not influence the design since no runoff leaves the site but infiltrates and will be fully infiltrated onsite in the developed condition.

As all onsite stormwater will be collected and conveyed to infiltration facilities, in one or various locations which will be determined during final design. For the purposes of this analysis, we will assume one facility per catchment/development area. Because roof drains will bypass the water quality facility, roofs were subtracted from the land coverage when calculating water quality facility flow rates. As a conservative approach for conceptual calculation purposes, catchment areas are divided as follows with the assumption that each sub catchment consists of 85% impervious area and 15% pervious area. The impervious area was further divided into paved and roof area at a 80/20 ratio. Each “sub” development is assumed to be a catchment area in which the stormwater for that area will be individually managed as far as treatment and quantity control or disposal is concerned. The areas for each of the sub-catchments are tabulated as follows:

Catchment #	Total Area (AC)	Impervious Total Area (AC)	Paved Area (PGIS) (AC)	Roof Area (AC)	Landscape Area (AC)
C101	22.59	19.20	15.36	3.84	3.39
C102	22.97	19.52	15.62	3.90	3.45
C103	18.53	15.75	12.60	3.15	2.78
C104	32.50	27.64	22.09	5.55	4.86
C105	8.60	7.31	5.85	1.46	1.29
C106	28.45	24.18	19.35	4.83	4.27
C107	6.50	5.52	4.42	1.10	0.98
C108	24.91	21.17	16.94	4.23	3.74
C109	8.95	7.61	6.09	1.52	1.34
Total:	**174.00**	**147.90**	**118.32**	**29.58**	**26.10**

Table 6.1: Alternative 1 - Developed Land Coverage flowing to Infiltration Facilities

Catchment #	Total Area (AC)	Impervious Total Area (AC)	Paved Area (PGIS) (AC)	Roof Area (AC)	Landscape Area (AC)
C201	22.59	5.19	4.35	0.84	17.40
C202	22.97	19.52	15.62	3.90	3.45
C203	18.53	3.71	3.71	0.00	14.82
C204	32.50	27.64	22.09	5.55	4.86
C205	8.60	7.31	5.85	1.46	1.29
C206	28.45	24.18	19.35	4.83	4.27
C207	6.50	5.52	4.42	1.10	0.98
C208	24.91	4.98	4.98	0.00	19.93
C209	8.95	7.61	6.09	1.52	1.34
Total:	**174.00**	**105.66**	**86.46**	**19.20**	**68.34**

Table 6.2: Alternative 2 - Developed Land Coverage flowing to Infiltration Facilities

Conveyance for on-site surface water will be provided via a catch basin network. Roof drains will be tight lined directly to the infiltration galleries.

The conveyance system will be designed in accordance with the 2022 SDM with sufficient capacity to convey and contain the 25-year peak flow. Calculations will be provided during the final engineering stage of the design.

6.1 Infiltration Facility Design – WWHM Model Results

Each catchment or development area will consist of multiple infiltration trenches (IT) dispersed throughout the parking area of the site to mimic existing infiltration conditions to the greatest extent practical and in accordance with recommendations from Haley Aldrich. Infiltration trenches are relatively shallow and can be affected by perched ground water therefore a conservative infiltration rate was used in the analysis assuming a generic shallow infiltration trench with 35% void space.

For the WWHM analysis, a 1-acre site was modeled as a baseline or "per/acre" model for each surface type (roof, paving and landscape). This is applied to each catchment area to simplify the calculations. The results of this analysis assuming a 3' facility depth, an infiltration rate of 20 in/hr with a safety factor of 2 applied (which results in a design rate of 10 inches per hour) are as follows based on the WWHM report in **Appendix B**:

Footprint Area* required per acre of paving = 1700sf
Footprint Area* required per acre of landscape = 580sf
Footprint Area* required per acre of roof = 2000sf
*Area was determined by multiplying the length and width of the facility as defined in the WWHM report

Since there is a linear relationship between the site area and the facility size, simply multiplying the acreage for each catchment by the "per/acre" facility size for each surface type, it allows us to determine the facility sizes for each catchment as shown below. For example, C1 is calculated as follows:

IT Area Required for C101 = (Paved Area x Area req. per Paved Acre)
+ (Roof Area x Area req. per Landscape Acre)
+ (Landscape Area x Area req. per Roof Acre)
= (15.36ac x 1700sf/ac) + (3.84ac x 2,000sf/ac) + (3.39 x 580sf/ac)
= 26,112sf + 2,227 sf + 6,780sf
= 35,758sf
~ 35,800sf (Rounded up to nearest 100)

Tabulated sizing results for the Infiltration Trench Facilities WWHM analysis:

Catchment #	Total Area (Acre)	Paved Area (SF)	Roof Area (SF)	Landscape Area (SF)	Infiltration Trench Area Required (SF)
C101	22.59	15.36	3.84	3.39	35,800
C102	22.97	15.62	3.90	3.45	36,400
C103	18.53	12.60	3.15	2.78	29,400
C104	32.50	22.09	5.55	4.86	51,500
C105	8.60	5.85	1.46	1.29	13,700
C106	28.45	19.35	4.83	4.27	45,100
C107	6.50	4.42	1.10	0.98	10,300
C108	24.91	16.94	4.23	3.74	39,500
C109	8.95	6.09	1.52	1.34	14,200

Table 7.1: Alternative 1 - Stormwater Infiltration Facility Footprint Area

Catchment #	Total Area (Acre)	Paved Area (SF)	Roof Area (SF)	Landscape Area (SF)	Infiltration Trench Area Required (SF)
C201	22.59	4.35	0.84	17.40	35,900
C202	22.97	15.62	3.90	3.45	42,100
C203	18.53	3.71	0.00	14.82	29,000
C204	32.50	22.09	5.55	4.86	59,600
C205	8.60	5.85	1.46	1.29	15,800
C206	28.45	19.35	4.83	4.27	52,200
C207	6.50	4.42	1.10	0.98	12,000
C208	24.91	4.98	0.00	19.93	38,900
C209	8.95	6.09	1.52	1.34	16,400

Table 7.1: Alternative 2 - Stormwater Infiltration Facility Footprint Area

The proposed location of these facilities can be seen on the conceptual stormwater plans included in **Appendix F**. The facilities have been designed to contain and infiltrate the 24-hour 100-year storm event.

Prior to the final design phase, further geological and infiltration investigation should be completed. This may include PIT tests, trenching, borings and other in situ testing methods as needed to determine the accurate design information for the area of the site being developed. Final facility sizes will be altered accordingly based on these results.

7.0 CONVEYANCE

7.1 Recommendations for Conveyance

Conveyance for on-site surface water will be provided via a catch basin network. Roof drains will be tightlined directly to the infiltration trenches/galleries. The conveyance system will be designed in accordance with the 2022 SDM with sufficient capacity to convey and contain the 25-year peak flow. Calculations will be provided during the final engineering design stage.

8.0 GRADING ANALYSIS AND DESIGN

The site is situated in the central portion of the Lacy glacial outwash plain that formed as the Vashon glacial ice receded from the area. The ground surface at the site is gently to moderately sloping with localized small hills, ridges, and depressions. The site is currently vegetated with scattered young second growth timber, primarily evergreens, with a moderate to dense understory of native and invasive brush and grasses. The site is traversed by a number of gravel roads and trails, including several that reflect the proposed final road configuration.

8.1 Recommendations for construction

- We anticipate that the majority of the excavated native soil along the northern side of the site will be reused as structural fill to raise grades along the southern side of the site. The native soils anticipated to be reused consist of sandy gravel with trace amounts of silt
- Dependent on the time of year this material is reused, moisture conditioning may be necessary, i.e., water added during the dry season and protected from moisture during wet weather.
- When using native material, moisture conditioning will probably be required and will only be possible during extended periods of dry, warm weather.
- Staging areas and haul roads should be constructed to minimize future over excavation of deteriorated sub grade soil.
- If construction occurs during wet periods increased sub grade stabilization will be required.
- Cement treatment may be a suitable alternative wet weather construction technique for sub grade conditions encountered at the site.
- In general fill slopes should not be greater than 2H:IV (horizontal to vertical) and should be benched in if an existing slopes greater than 4H:IV.
- Permanent cut slopes should not be sloped steeper than 3H:IV.

8.2 Grading Assumptions and Quantities

The site has a high point near its center with low areas in the SW NW and SE corners. From the low area in the SE corner, the site gently slopes up to the north and northwest. From the center of the site, a small valley develops to the west just south of the Britton Parkway. This becomes more pronounced as it moves west.

The slopes and low areas associated with the valley in the NW of the site will require extensive grading to enable the proposed uses to be constructed. However, with Gateway Boulevard already constructed, the scope of this grading will be somewhat limited.

The size of the site and flexibility of design elements like road profiles and site layout should enable the site grading to be balanced with no import or export needed.

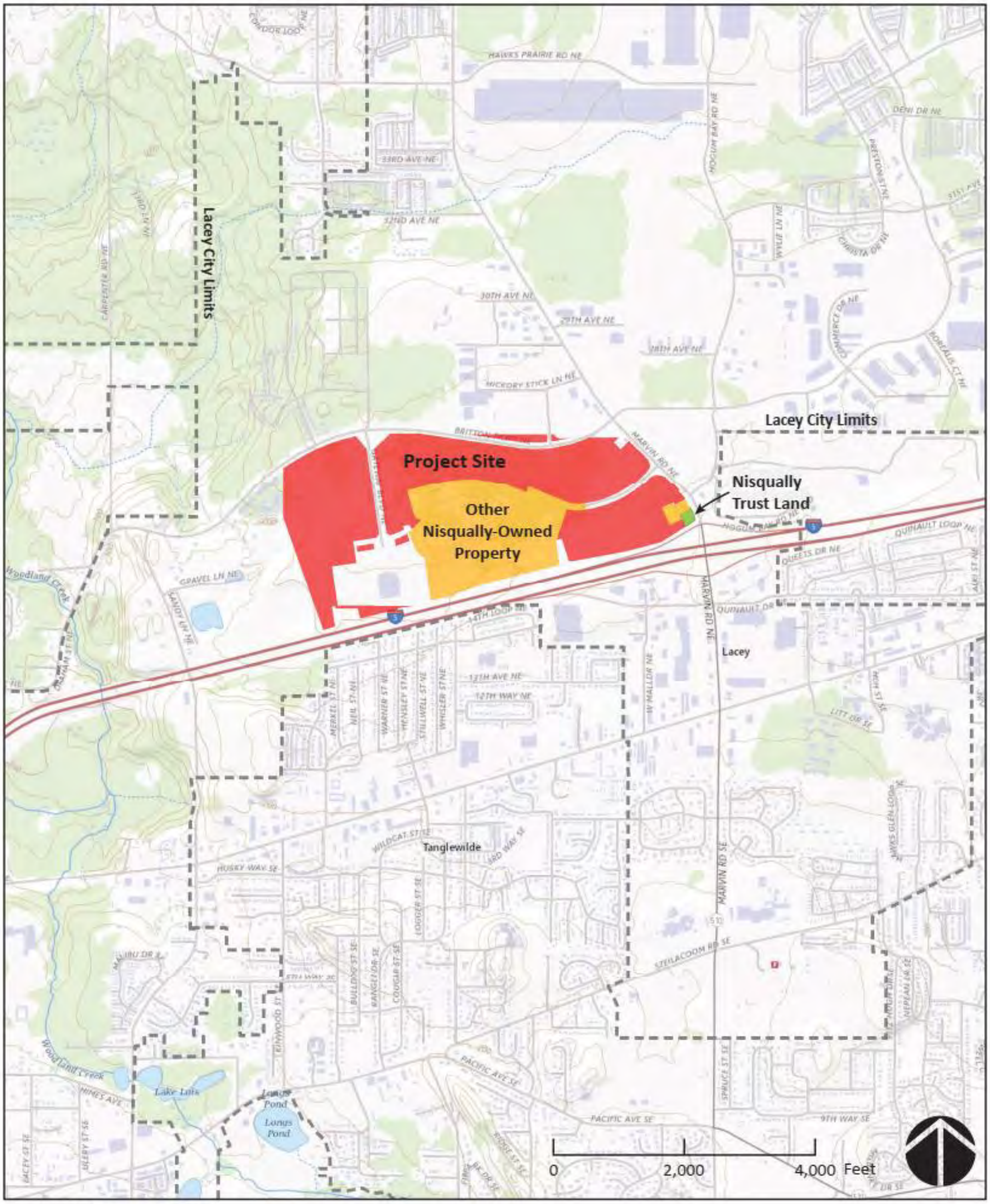
The graded volumes based on the above assumptions are tabulated below:

Alternative	Earthwork Volumes (cy)
Alternative 1	370,000
Alternative 2	362,000

Table 10: Conceptual Grading Volumes

See Conceptual Grading Plan, sheets G-1.0 and G-2.0 in **Appendix F**.

APPENDIX A



Source: USGS National Map (6/2020)

Scale:

Horizontal: *N.T.S.* *Vertical:* *N/A*

For:

Quiemuth Village

Job Number

A10367

OLSON LAND SURVEYORS ENGINEERS ENGINEERING INC. 222 E. EVERGREEN BLVD, VANCOUVER, WA 98660

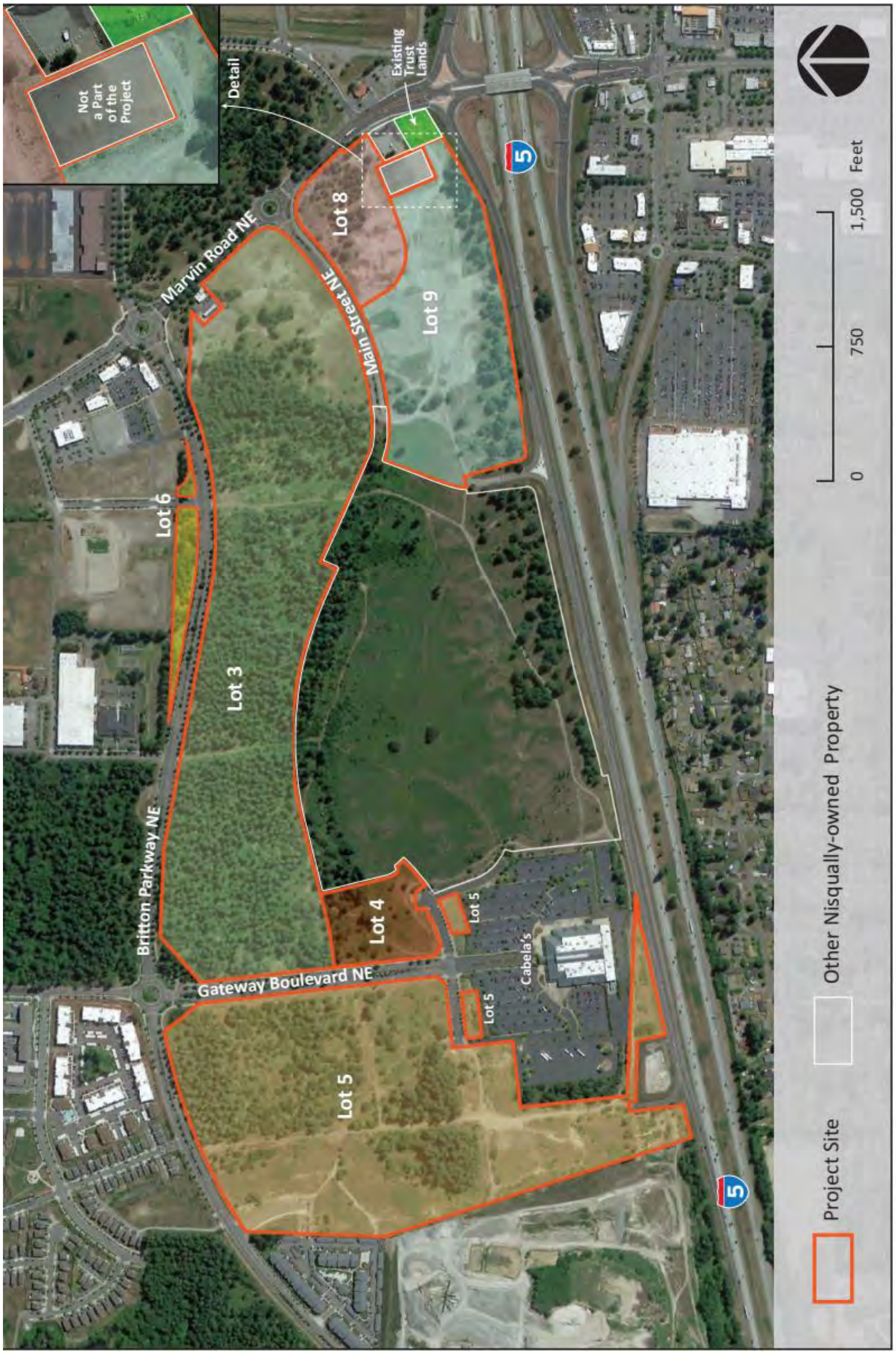
360–695–1385
503–289–9936

Title:

VICINITY MAP

Figure 1

DATE: 8/04/22



Source: WHPacific (3/18/2022), Google imagery (6/26/2021)

Scale:

Horizontal: ***N.T.S.*** ***Vertical:*** ***N/A***

For:

Quiemuth Village

Job Number

A10367

OLSON
LAND SURVEYORS
ENGINEERS
ENGINEERING INC. 222 E. EVERGREEN BLVD, VANCOUVER, WA 98660
360-695-1385
503-289-9936

Title:

PROJECT SITE MAP

Figure 2

DATE: 8/04/22

Figure 3

NISQUALLY INDIAN TRIBE

CONCEPTUAL MASTER PLAN // MIXED-USE PARCELS / OVERALL SITE

0' 200' 400' 800'
SCALE: 1" = 400'-0"

Figure 4

hbg DESIGN

NISQUALLY INDIAN TRIBE

CONCEPTUAL MASTER PLAN // MIXED-USE PARCELS / OVERALL SITE

0' 200' 400' 800'
SCALE: 1" = 400'-0"

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
2	Alderwood gravelly sandy loam, 8 to 15 percent slopes	54.0	29.6%
33	Everett very gravelly sandy loam, 8 to 15 percent slopes	13.5	7.4%
46	Indianola loamy sand, 0 to 5 percent slopes	10.1	5.5%
110	Spanaway gravelly sandy loam, 0 to 3 percent slopes	105.1	57.5%
Totals for Area of Interest		**182.8**	**100.0%**

Scale:
Horizontal: *N.T.S.* *Vertical:* *N/A*

For: Quiemuth Village

Job Number
A10367

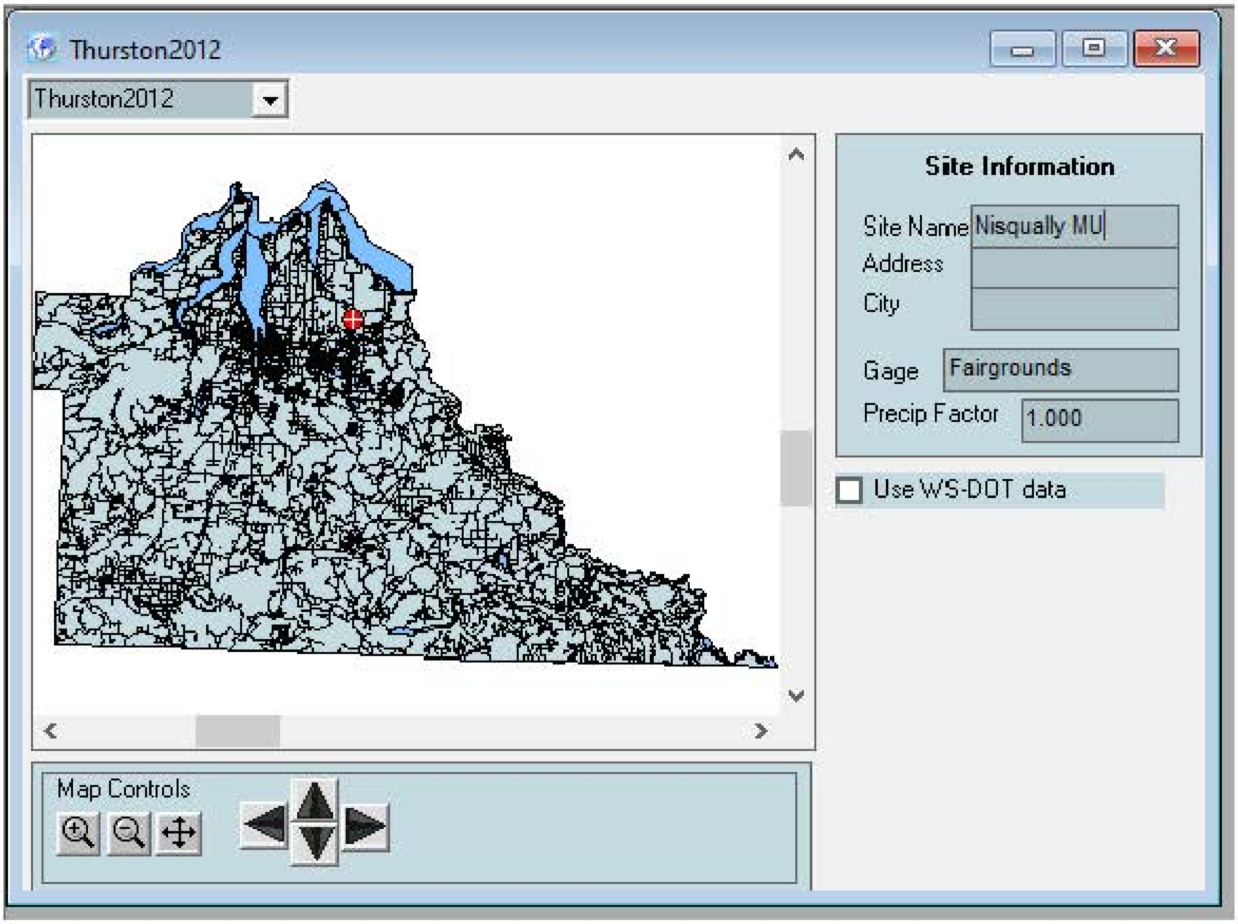
OLSON LAND SURVEYORS ENGINEERS
ENGINEERING INC. 222 E. EVERGREEN BLVD, VANCOUVER, WA 98660
360-695-1385
503-289-9936

Title: SOIL SURVEY MAP

Figure 5

DATE: 8/04/22

APPENDIX B



Thurston2012

Site Name: Nisqually MU

Address:

City:

Gage: Fairgrounds

Precip Factor: 1.000

☐ Use WS-DOT data

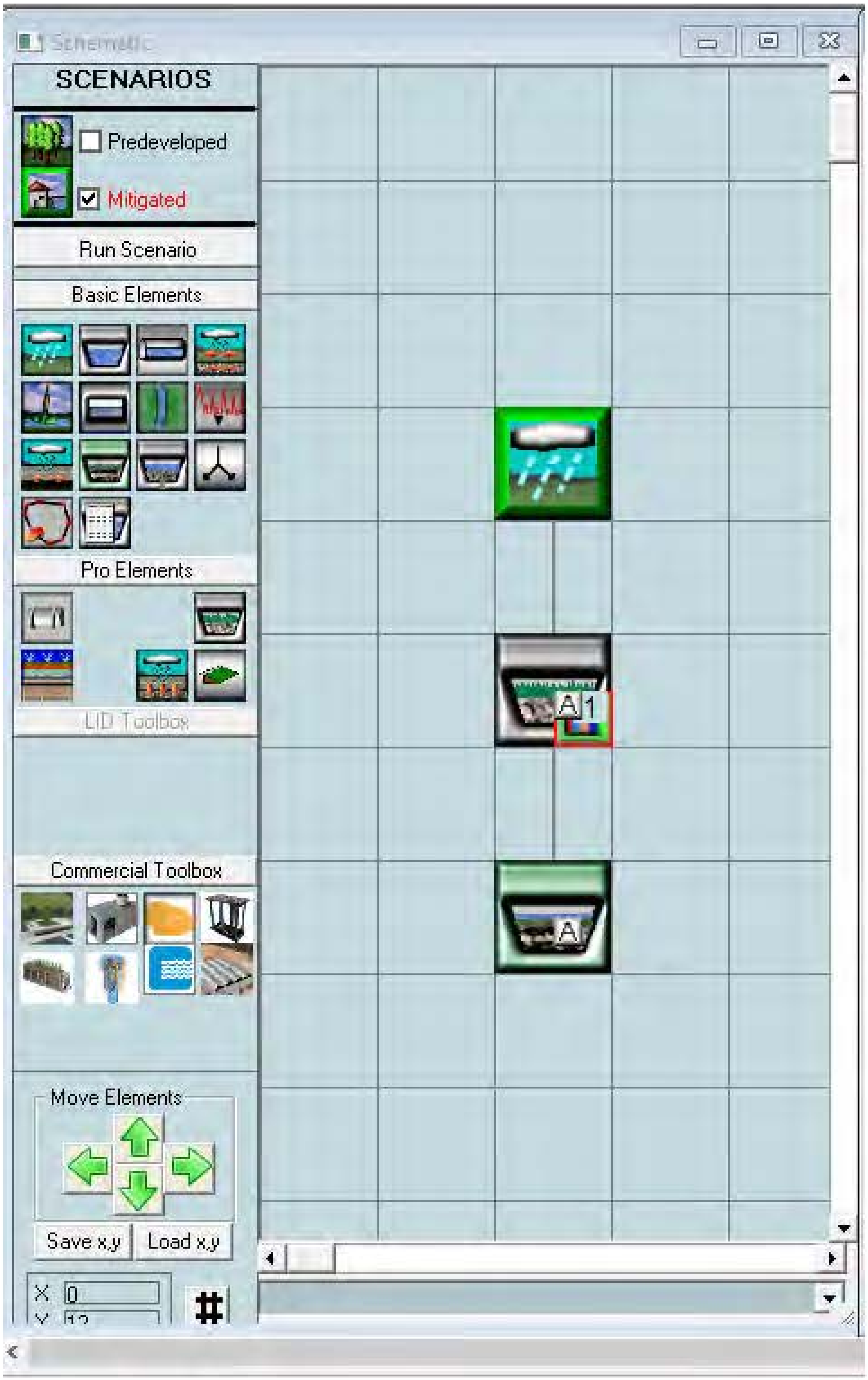
PAVED

AREA CALCULATIONS

WWHM2012

PROJECT REPORT

PAVED AREA CALCULATIONS



☐ Predeveloped

☑ Mitigated

X 0

Subbasin Name: Basin 1

☐ Designate as Bypass for POC:

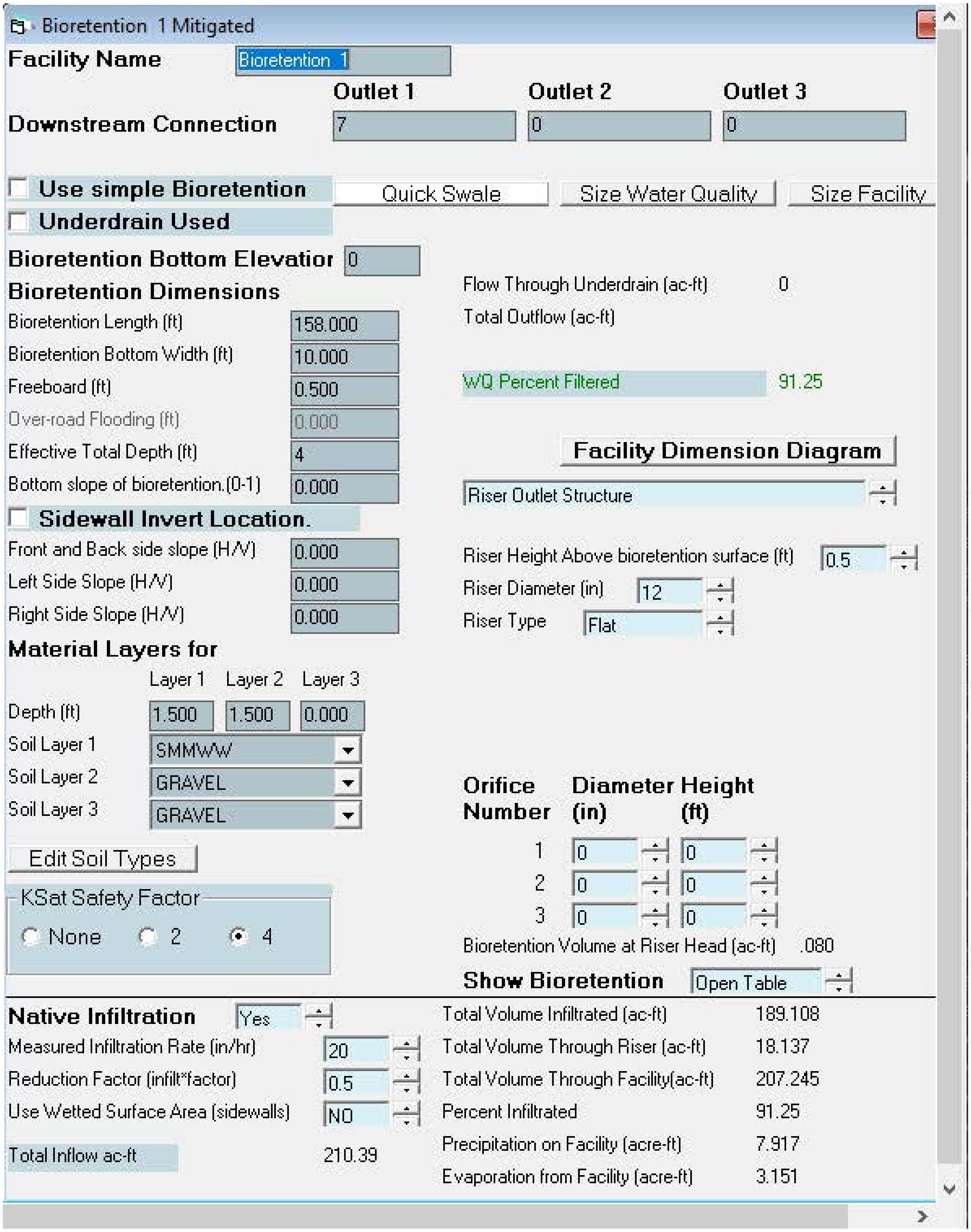
	Surface	Interflow	Groundwater
Flows To :	Surface retention 1	Surface retention 1	

Area in Basin

☑ Show Only Selected

Available Pervious	Acres	Available Impervious	Acres
☑ A/B, Forest, Mod	0	☑ ROADS/FLAT	1

Pervious Total	0	Acres
Impervious Total	1	Acres
Basin Total	1	Acres



Bioretention 1 Mitigated

Facility Name Bioretention 1

	Outlet 1	Outlet 2	Outlet 3
Downstream Connection	7	0	0

☐ **Use simple Bioretention**

☐ **Underdrain Used**

Bioretention Bottom Elevation 0

Bioretention Dimensions

Bioretention Length (ft) 158.000

Bioretention Bottom Width (ft) 10.000

Freeboard (ft) 0.500

Over-road Flooding (ft) 0.000

Effective Total Depth (ft) 4

Bottom slope of bioretention.(0-1) 0.000

☐ **Sidewall Invert Location.**

Front and Back side slope (H/V) 0.000

Left Side Slope (H/V) 0.000

Right Side Slope (H/V) 0.000

Material Layers for

	Layer 1	Layer 2	Layer 3
Depth (ft)	1.500	1.500	0.000

Soil Layer 1 SMMWW

Soil Layer 2 GRAVEL

Soil Layer 3 GRAVEL

KSat Safety Factor

○ None ○ 2 ● 4

Flow Through Underdrain (ac-ft) 0

Total Outflow (ac-ft)

WQ Percent Filtered 91.25

Riser Outlet Structure

Riser Height Above bioretention surface (ft) 0.5

Riser Diameter (in) 12

Riser Type Flat

Orifice Number	Diameter (in)	Height (ft)
1	0	0
2	0	0
3	0	0

Bioretention Volume at Riser Head (ac-ft) .080

Show Bioretention Open Table

Native Infiltration Yes

Measured Infiltration Rate (in/hr) 20

Reduction Factor (infilt*factor) 0.5

Use Wetted Surface Area (sidewalls) NO

Total Inflow ac-ft 210.39

Total Volume Infiltrated (ac-ft) 189.108

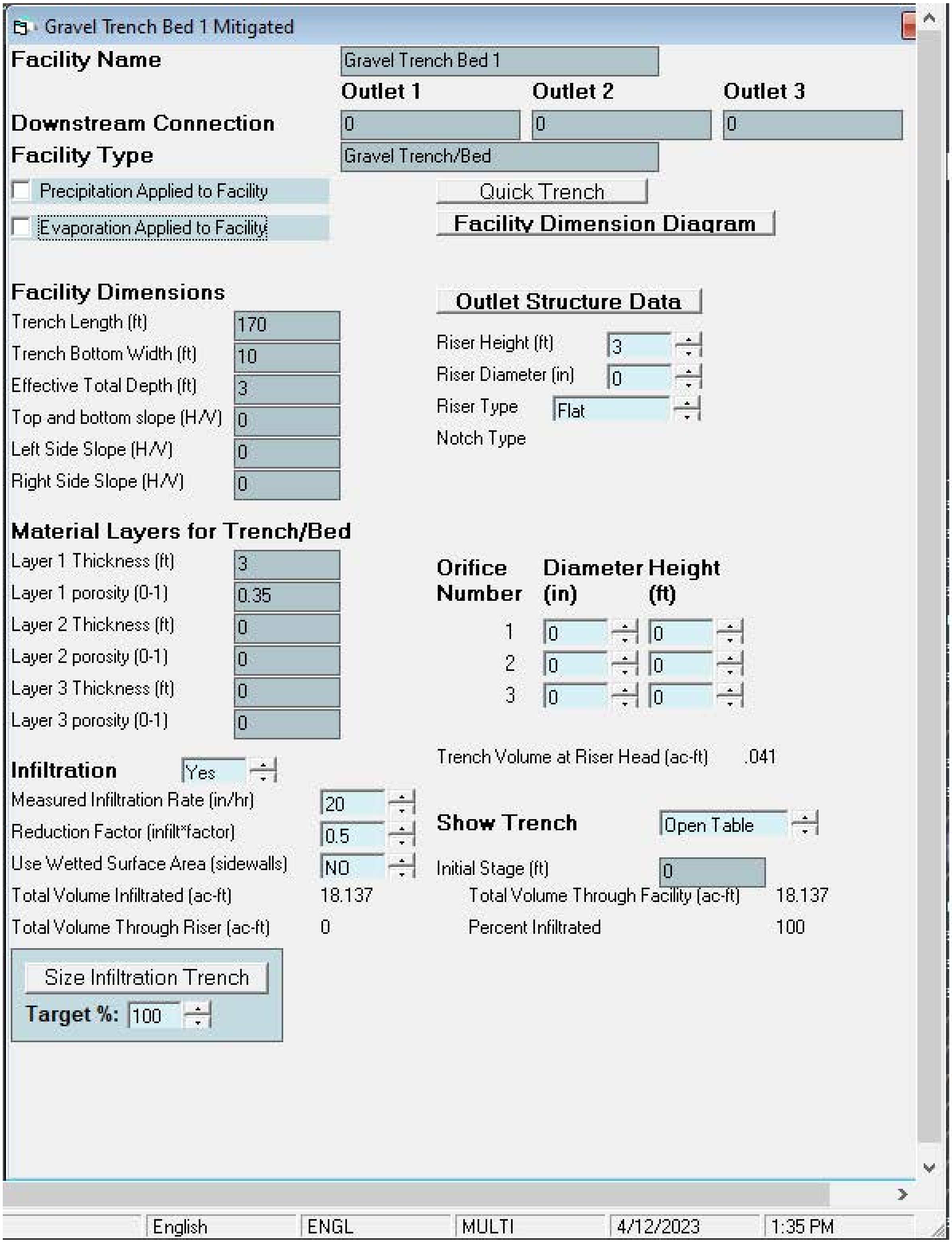
Total Volume Through Riser (ac-ft) 18.137

Total Volume Through Facility(ac-ft) 207.245

Percent Infiltrated 91.25

Precipitation on Facility (acre-ft) 7.917

Evaporation from Facility (acre-ft) 3.151



Gravel Trench Bed 1 Mitigated

Facility Name	Gravel Trench Bed 1		
	Outlet 1	**Outlet 2**	**Outlet 3**
Downstream Connection	0	0	0
Facility Type	Gravel Trench/Bed		

☐ Precipitation Applied to Facility

☐ Evaporation Applied to Facility

Facility Dimensions

Trench Length (ft)	170
Trench Bottom Width (ft)	10
Effective Total Depth (ft)	3
Top and bottom slope (H/V)	0
Left Side Slope (H/V)	0
Right Side Slope (H/V)	0

Material Layers for Trench/Bed

Layer 1 Thickness (ft)	3
Layer 1 porosity (0-1)	0.35
Layer 2 Thickness (ft)	0
Layer 2 porosity (0-1)	0
Layer 3 Thickness (ft)	0
Layer 3 porosity (0-1)	0

Infiltration	Yes
Measured Infiltration Rate (in/hr)	20
Reduction Factor (infilt*factor)	0.5
Use Wetted Surface Area (sidewalls)	NO
Total Volume Infiltrated (ac-ft)	18.137
Total Volume Through Riser (ac-ft)	0

Target %: 100

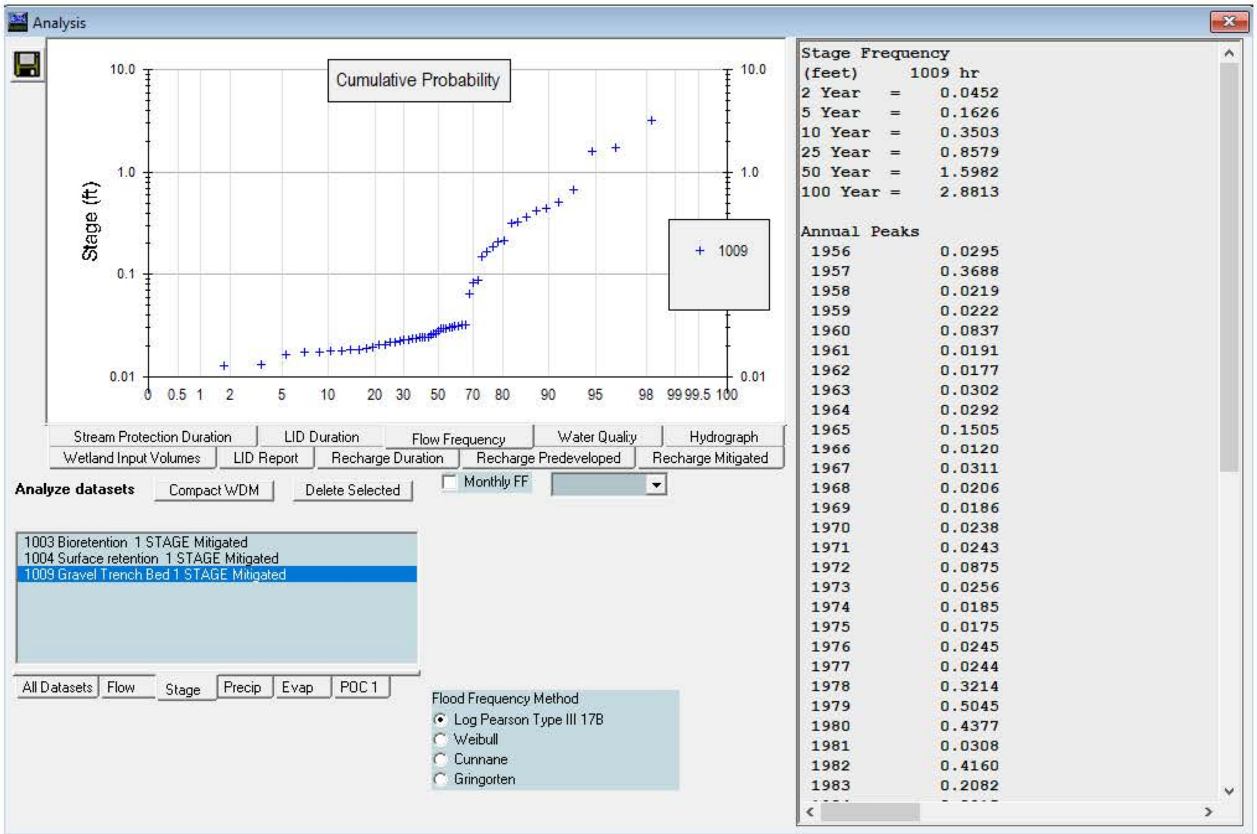
Outlet Structure Data

Riser Height (ft)	3
Riser Diameter (in)	0
Riser Type	Flat
Notch Type	

Orifice Number	Diameter (in)	Height (ft)
1	0	0
2	0	0
3	0	0

Trench Volume at Riser Head (ac-ft)	.041
Show Trench	Open Table
Initial Stage (ft)	0
Total Volume Through Facility (ac-ft)	18.137
Percent Infiltrated	100

English	ENGL	MULTI	4/12/2023	1:35 PM



1003 Bioretention 1 STAGE Mitigated
1004 Surface retention 1 STAGE Mitigated
1009 Gravel Trench Bed 1 STAGE Mitigated

☐ Monthly FF

Flood Frequency Method
● Log Pearson Type III 17B
○ Weibull
○ Cunnane
○ Gringorten

```
Stage Frequency
(feet)      1009 hr
2 Year   =     0.0452
5 Year   =     0.1626
10 Year  =     0.3503
25 Year  =     0.8579
50 Year  =     1.5982
100 Year =     2.8813

Annual Peaks
 1956          0.0295
 1957          0.3688
 1958          0.0219
 1959          0.0222
 1960          0.0837
 1961          0.0191
 1962          0.0177
 1963          0.0302
 1964          0.0292
 1965          0.1505
 1966          0.0120
 1967          0.0311
 1968          0.0206
 1969          0.0186
 1970          0.0238
 1971          0.0243
 1972          0.0875
 1973          0.0256
 1974          0.0185
 1975          0.0175
 1976          0.0245
 1977          0.0244
 1978          0.3214
 1979          0.5045
 1980          0.4377
 1981          0.0308
 1982          0.4160
 1983          0.2082
```

General Model Information

Project Name:	10367.e.Nisqually.MIXED.USE.1ac.paved
Site Name:	Nisqually MU
Site Address:	
City:	
Report Date:	4/12/2023
Gage:	Fairgrounds (Kaiser)
Data Start:	1955/10/01
Data End:	2011/09/30
Timestep:	Hourly
Precip Scale:	1.000
Version Date:	2021/08/18
Version:	4.2.18

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Forest, Mod	3
Pervious Total	3
Impervious Land Use	acre
Impervious Total	0
Basin Total	3

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
ROADS FLAT	1
Impervious Total	1
Basin Total	1

Element Flows To:

Surface	Interflow	Groundwater
Surface retention 1	Surface retention 1	

Routing Elements

Predeveloped Routing

Mitigated Routing

Bioretention 1

Bottom Length:	158.00 ft.
Bottom Width:	10.00 ft.
Material thickness of first layer:	1.5
Material type for first layer:	SMMWW
Material thickness of second layer:	1.5
Material type for second layer:	GRAVEL
Material thickness of third layer:	0
Material type for third layer:	GRAVEL
Infiltration On	
Infiltration rate:	20
Infiltration safety factor:	0.5
Total Volume Infiltrated (ac-ft.):	189.108
Total Volume Through Riser (ac-ft.):	18.137
Total Volume Through Facility (ac-ft.):	207.245
Percent Infiltrated:	91.25
Total Precip Applied to Facility:	7.917
Total Evap From Facility:	3.151

Underdrain not used

Discharge Structure

Riser Height:	0.5 ft.
Riser Diameter:	12 in.

Element Flows To:

Outlet 1	Outlet 2
Gravel Trench Bed 1	

Bioretention Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.0363	0.0000	0.0000	0.0000
0.0440	0.0363	0.0006	0.0000	0.0000
0.0879	0.0363	0.0013	0.0000	0.0000
0.1319	0.0363	0.0019	0.0000	0.0000
0.1758	0.0363	0.0026	0.0000	0.0000
0.2198	0.0363	0.0032	0.0000	0.0002
0.2637	0.0363	0.0038	0.0000	0.0004
0.3077	0.0363	0.0045	0.0000	0.0006
0.3516	0.0363	0.0051	0.0000	0.0009
0.3956	0.0363	0.0058	0.0000	0.0013
0.4396	0.0363	0.0064	0.0000	0.0017
0.4835	0.0363	0.0070	0.0000	0.0023
0.5275	0.0363	0.0077	0.0000	0.0029
0.5714	0.0363	0.0083	0.0000	0.0036
0.6154	0.0363	0.0090	0.0000	0.0044
0.6593	0.0363	0.0096	0.0000	0.0053
0.7033	0.0363	0.0102	0.0000	0.0057
0.7473	0.0363	0.0109	0.0000	0.0064
0.7912	0.0363	0.0115	0.0000	0.0075
0.8352	0.0363	0.0122	0.0000	0.0088
0.8791	0.0363	0.0128	0.0000	0.0101
0.9231	0.0363	0.0134	0.0000	0.0116
0.9670	0.0363	0.0141	0.0000	0.0132
1.0110	0.0363	0.0147	0.0000	0.0138
1.0549	0.0363	0.0154	0.0000	0.0150
1.0989	0.0363	0.0160	0.0000	0.0169

1.1429	0.0363	0.0166	0.0000	0.0189
1.1868	0.0363	0.0173	0.0000	0.0211
1.2308	0.0363	0.0179	0.0000	0.0234
1.2747	0.0363	0.0186	0.0000	0.0258
1.3187	0.0363	0.0192	0.0000	0.0263
1.3626	0.0363	0.0198	0.0000	0.0284
1.4066	0.0363	0.0205	0.0000	0.0312
1.4505	0.0363	0.0211	0.0000	0.0341
1.4945	0.0363	0.0218	0.0000	0.0371
1.5385	0.0363	0.0224	0.0000	0.0403
1.5824	0.0363	0.0231	0.0000	0.0437
1.6264	0.0363	0.0237	0.0000	0.0441
1.6703	0.0363	0.0244	0.0000	0.0472
1.7143	0.0363	0.0251	0.0000	0.0509
1.7582	0.0363	0.0257	0.0000	0.0546
1.8022	0.0363	0.0264	0.0000	0.0731
1.8462	0.0363	0.0271	0.0000	0.0731
1.8901	0.0363	0.0277	0.0000	0.0731
1.9341	0.0363	0.0284	0.0000	0.0731
1.9780	0.0363	0.0290	0.0000	0.0731
2.0220	0.0363	0.0297	0.0000	0.0731
2.0659	0.0363	0.0304	0.0000	0.0731
2.1099	0.0363	0.0310	0.0000	0.0731
2.1538	0.0363	0.0317	0.0000	0.0731
2.1978	0.0363	0.0324	0.0000	0.0731
2.2418	0.0363	0.0330	0.0000	0.0731
2.2857	0.0363	0.0337	0.0000	0.0731
2.3297	0.0363	0.0343	0.0000	0.0731
2.3736	0.0363	0.0350	0.0000	0.0731
2.4176	0.0363	0.0357	0.0000	0.0731
2.4615	0.0363	0.0363	0.0000	0.0731
2.5055	0.0363	0.0370	0.0000	0.0731
2.5495	0.0363	0.0376	0.0000	0.0731
2.5934	0.0363	0.0383	0.0000	0.0731
2.6374	0.0363	0.0390	0.0000	0.0731
2.6813	0.0363	0.0396	0.0000	0.0731
2.7253	0.0363	0.0403	0.0000	0.0731
2.7692	0.0363	0.0410	0.0000	0.0731
2.8132	0.0363	0.0416	0.0000	0.0731
2.8571	0.0363	0.0423	0.0000	0.0731
2.9011	0.0363	0.0429	0.0000	0.0731
2.9451	0.0363	0.0436	0.0000	0.0731
2.9890	0.0363	0.0443	0.0000	0.0731
3.0000	0.0363	0.0444	0.0000	0.0731

Bioretention Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**To Amended(cfs)**	**Infilt(cfs)**
3.0000	0.0363	0.0444	0.0000	0.0549	0.0000
3.0440	0.0363	0.0460	0.0000	0.0549	0.0000
3.0879	0.0363	0.0476	0.0000	0.0581	0.0000
3.1319	0.0363	0.0492	0.0000	0.0597	0.0000
3.1758	0.0363	0.0508	0.0000	0.0613	0.0000
3.2198	0.0363	0.0524	0.0000	0.0629	0.0000
3.2637	0.0363	0.0540	0.0000	0.0645	0.0000
3.3077	0.0363	0.0556	0.0000	0.0661	0.0000
3.3516	0.0363	0.0572	0.0000	0.0677	0.0000
3.3956	0.0363	0.0588	0.0000	0.0693	0.0000
3.4396	0.0363	0.0604	0.0000	0.0709	0.0000

3.4835	0.0363	0.0620	0.0000	0.0725	0.0000
3.5275	0.0363	0.0636	0.0483	0.0742	0.0000
3.5714	0.0363	0.0652	0.2020	0.0758	0.0000
3.6154	0.0363	0.0667	0.4122	0.0774	0.0000
3.6593	0.0363	0.0683	0.6597	0.0790	0.0000
3.7033	0.0363	0.0699	0.9282	0.0806	0.0000
3.7473	0.0363	0.0715	1.2008	0.0822	0.0000
3.7912	0.0363	0.0731	1.4606	0.0838	0.0000
3.8352	0.0363	0.0747	1.6924	0.0854	0.0000
3.8791	0.0363	0.0763	1.8845	0.0870	0.0000
3.9231	0.0363	0.0779	2.0318	0.0886	0.0000
3.9670	0.0363	0.0795	2.1391	0.0902	0.0000
4.0000	0.0363	0.0807	2.2515	0.0914	0.0000

Surface retention 1

Element Flows To:

Outlet 1	Outlet 2
Gravel Trench Bed 1	Bioretention 1

Gravel Trench Bed 1

Bottom Length:	170.00 ft.
Bottom Width:	10.00 ft.
Trench bottom slope 1:	0 To 1
Trench Left side slope 0:	0 To 1
Trench right side slope 2:	0 To 1
Material thickness of first layer:	3
Pour Space of material for first layer:	0.35
Material thickness of second layer:	0
Pour Space of material for second layer:	0
Material thickness of third layer:	0
Pour Space of material for third layer:	0
Infiltration On	
Infiltration rate:	20
Infiltration safety factor:	0.5
Total Volume Infiltrated (ac-ft.):	18.137
Total Volume Through Riser (ac-ft.):	0
Total Volume Through Facility (ac-ft.):	18.137
Percent Infiltrated:	100
Total Precip Applied to Facility:	0
Total Evap From Facility:	0

Discharge Structure

Riser Height:	3 ft.
Riser Diameter:	0 in.

Element Flows To:

Outlet 1 Outlet 2

Gravel Trench Bed Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.039	0.000	0.000	0.000
0.0333	0.039	0.000	0.000	0.393
0.0667	0.039	0.000	0.000	0.393
0.1000	0.039	0.001	0.000	0.393
0.1333	0.039	0.001	0.000	0.393
0.1667	0.039	0.002	0.000	0.393
0.2000	0.039	0.002	0.000	0.393
0.2333	0.039	0.003	0.000	0.393
0.2667	0.039	0.003	0.000	0.393
0.3000	0.039	0.004	0.000	0.393
0.3333	0.039	0.004	0.000	0.393
0.3667	0.039	0.005	0.000	0.393
0.4000	0.039	0.005	0.000	0.393
0.4333	0.039	0.005	0.000	0.393
0.4667	0.039	0.006	0.000	0.393
0.5000	0.039	0.006	0.000	0.393
0.5333	0.039	0.007	0.000	0.393
0.5667	0.039	0.007	0.000	0.393
0.6000	0.039	0.008	0.000	0.393
0.6333	0.039	0.008	0.000	0.393
0.6667	0.039	0.009	0.000	0.393
0.7000	0.039	0.009	0.000	0.393
0.7333	0.039	0.010	0.000	0.393
0.7667	0.039	0.010	0.000	0.393
0.8000	0.039	0.010	0.000	0.393
0.8333	0.039	0.011	0.000	0.393

0.8667	0.039	0.011	0.000	0.393
0.9000	0.039	0.012	0.000	0.393
0.9333	0.039	0.012	0.000	0.393
0.9667	0.039	0.013	0.000	0.393
1.0000	0.039	0.013	0.000	0.393
1.0333	0.039	0.014	0.000	0.393
1.0667	0.039	0.014	0.000	0.393
1.1000	0.039	0.015	0.000	0.393
1.1333	0.039	0.015	0.000	0.393
1.1667	0.039	0.015	0.000	0.393
1.2000	0.039	0.016	0.000	0.393
1.2333	0.039	0.016	0.000	0.393
1.2667	0.039	0.017	0.000	0.393
1.3000	0.039	0.017	0.000	0.393
1.3333	0.039	0.018	0.000	0.393
1.3667	0.039	0.018	0.000	0.393
1.4000	0.039	0.019	0.000	0.393
1.4333	0.039	0.019	0.000	0.393
1.4667	0.039	0.020	0.000	0.393
1.5000	0.039	0.020	0.000	0.393
1.5333	0.039	0.020	0.000	0.393
1.5667	0.039	0.021	0.000	0.393
1.6000	0.039	0.021	0.000	0.393
1.6333	0.039	0.022	0.000	0.393
1.6667	0.039	0.022	0.000	0.393
1.7000	0.039	0.023	0.000	0.393
1.7333	0.039	0.023	0.000	0.393
1.7667	0.039	0.024	0.000	0.393
1.8000	0.039	0.024	0.000	0.393
1.8333	0.039	0.025	0.000	0.393
1.8667	0.039	0.025	0.000	0.393
1.9000	0.039	0.026	0.000	0.393
1.9333	0.039	0.026	0.000	0.393
1.9667	0.039	0.026	0.000	0.393
2.0000	0.039	0.027	0.000	0.393
2.0333	0.039	0.027	0.000	0.393
2.0667	0.039	0.028	0.000	0.393
2.1000	0.039	0.028	0.000	0.393
2.1333	0.039	0.029	0.000	0.393
2.1667	0.039	0.029	0.000	0.393
2.2000	0.039	0.030	0.000	0.393
2.2333	0.039	0.030	0.000	0.393
2.2667	0.039	0.031	0.000	0.393
2.3000	0.039	0.031	0.000	0.393
2.3333	0.039	0.031	0.000	0.393
2.3667	0.039	0.032	0.000	0.393
2.4000	0.039	0.032	0.000	0.393
2.4333	0.039	0.033	0.000	0.393
2.4667	0.039	0.033	0.000	0.393
2.5000	0.039	0.034	0.000	0.393
2.5333	0.039	0.034	0.000	0.393
2.5667	0.039	0.035	0.000	0.393
2.6000	0.039	0.035	0.000	0.393
2.6333	0.039	0.036	0.000	0.393
2.6667	0.039	0.036	0.000	0.393
2.7000	0.039	0.036	0.000	0.393
2.7333	0.039	0.037	0.000	0.393
2.7667	0.039	0.037	0.000	0.393

2.8000	0.039	0.038	0.000	0.393
2.8333	0.039	0.038	0.000	0.393
2.8667	0.039	0.039	0.000	0.393
2.9000	0.039	0.039	0.000	0.393
2.9333	0.039	0.040	0.000	0.393
2.9667	0.039	0.040	0.000	0.393
3.0000	0.039	0.041	0.000	0.393

Analysis Results

POC 1

POC #1 was not reported because POC must exist in both scenarios and both scenarios must have been run.

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

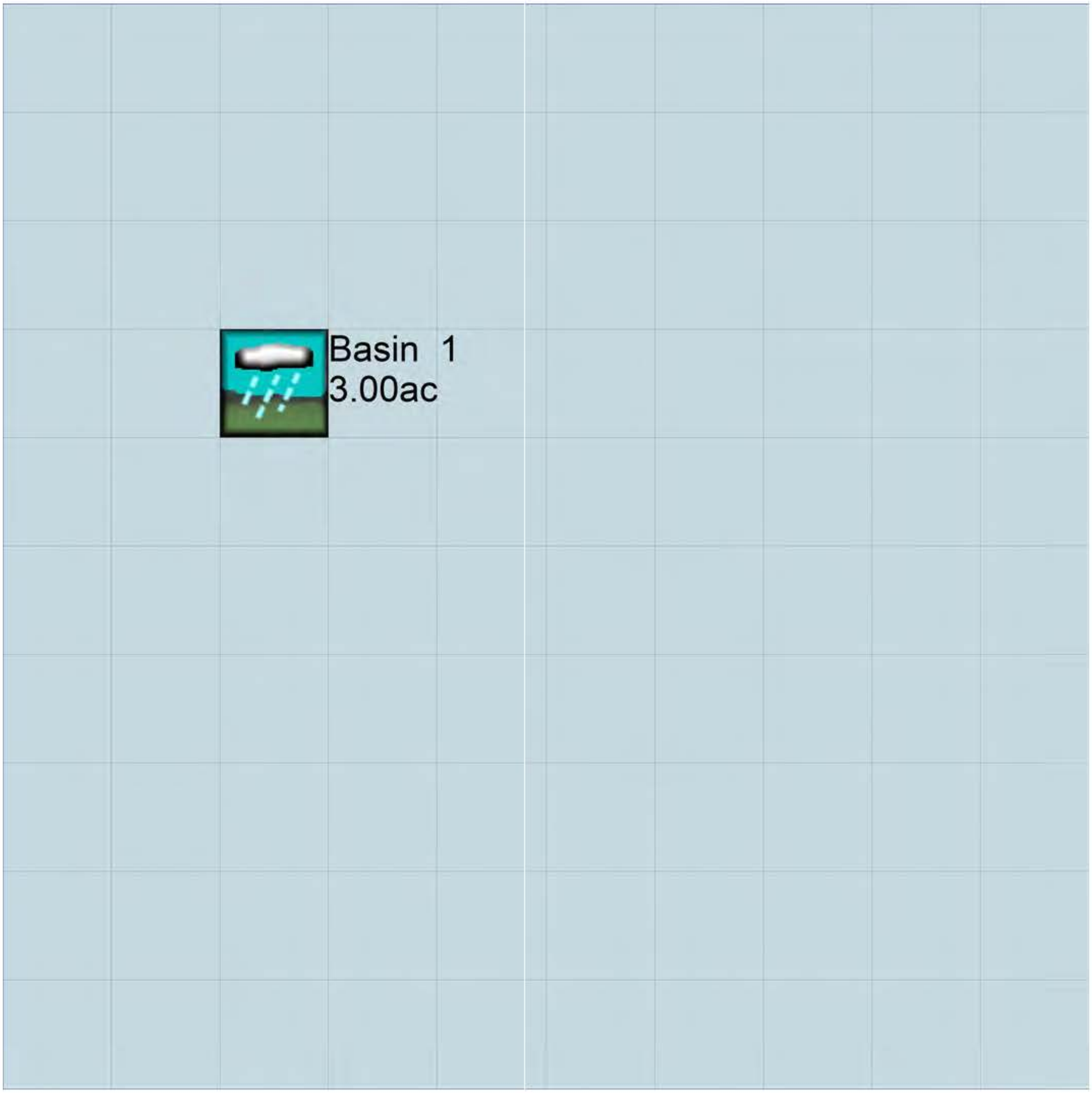
No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix

Predeveloped Schematic



Mitigated Schematic

Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1955 10 01        END    2011 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                             ***
WDM        26   10367.e.Nisqually.MIXED.USE.1ac.paved.wdm
MESSU      25   Pre10367.e.Nisqually.MIXED.USE.1ac.paved.MES
           27   Pre10367.e.Nisqually.MIXED.USE.1ac.paved.L61
           28   Pre10367.e.Nisqually.MIXED.USE.1ac.paved.L62
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:60
      PERLND       2
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out           ***
    2     A/B, Forest, Mod        1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
    2         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
    2         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
    2         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1
```

```
  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
    2              0         5         2       400       0.1       0.3     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
    2              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
    2            0.2       0.5      0.35         0       0.7       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
    2              0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                        in  out           ***
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                 <--Area-->     <-Target->   MBLK   ***
<Name>   #                 <-factor->     <Name>   #   Tbl#   ***
```

```
******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                   ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG              ***
                                           in  out                             ***
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                        ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                           ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1         SUM  PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1         SUM  IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
END EXT TARGETS
```

```
MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***

END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1955 10 01        END    2011 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   10367.e.Nisqually.MIXED.USE.1ac.paved.wdm
MESSU      25   Mit10367.e.Nisqually.MIXED.USE.1ac.paved.MES
           27   Mit10367.e.Nisqually.MIXED.USE.1ac.paved.L61
           28   Mit10367.e.Nisqually.MIXED.USE.1ac.paved.L62
           30   POC10367.e.Nisqually.MIXED.USE.1ac.paved1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:60
      IMPLND       1
      GENER        2
      RCHRES       1
      RCHRES       2
      RCHRES       3
      COPY         1
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Surface retention  1        MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
    2        24
  END OPCODE
  PARM
    #    #         K ***
    2              0.
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                           in  out           ***
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
  END ACTIVITY

  PRINT-INFO
```

```
    <PLS > **************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                     in  out            ***
    1      ROADS/FLAT            1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    1         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    1         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    1         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    1            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    1              0         0
  END IWAT-PARM3
```

```
  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    1              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
IMPLND   1                           1     RCHRES   1      5

******Routing******
RCHRES   1                           1     RCHRES   3      7
RCHRES   1                           1     RCHRES   2      8
IMPLND   1                           1     COPY     1     15
RCHRES   2                           1     COPY   501     17
RCHRES   1                           1     COPY   501     17
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   12.1        DISPLY   1     INPUT  TIMSER 1
GENER    2 OUTPUT TIMSER      .0002778     RCHRES   1     EXTNL  OUTDGT 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                          in  out                            ***
    1     Surface retentio-006    2    1    1    1   28    0    1
    2     Bioretention  1         2    1    1    1   28    0    1
    3     Gravel Trench Be-007    2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
    2         1    0    0    0    0    0    0    0    0    0
    3         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
    2         4    0    0    0    0    0    0    0    0    0    1    9
    3         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
    1        0  1  0  0    4  5  0  0  0       0  1  0  0  0       2  1  2  2  2
    2        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
    3        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1
```

```
  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1             1      0.01       0.0       0.0       0.0       0.0
    2             2      0.03       0.0       0.0       0.0       0.0
    3             3      0.03       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND    Initial  value  of OUTDGT
          *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    2           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    3           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
*** User-Defined Variable Quantity Lines
***                          addr
***                        <------>
*** kwd  varnam optyp  opn  vari  s1 s2 s3 tp multiply  lc ls ac as agfn ***
  <****> <----> <----> <-> <----><-><-><-><-><--------> <><-> <><-> <--> ***
  UVQUAN vol2   RCHRES   2 VOL              4
  UVQUAN v2m2   GLOBAL     WORKSP  1        3
  UVQUAN vpo2   GLOBAL     WORKSP  2        3
  UVQUAN v2d2   GENER    2 K       1        3
*** User-Defined Target Variable Names
***                addr or                       addr or
***               <------>                      <------>
*** kwd   varnam ct  vari  s1 s2 s3  frac oper     vari  s1 s2 s3  frac oper
  <****>  <----><-> <----><-><-><-> <---> <-->    <----><-><-><-> <---> <-->
  UVNAME  v2m2    1 WORKSP  1         1.0 QUAN
  UVNAME  vpo2    1 WORKSP  2         1.0 QUAN
  UVNAME  v2d2    1 K       1         1.0 QUAN
*** opt foplop dcdts  yr mo dy hr mn d t   vnam  s1 s2 s3 ac quantity  tc  ts rp
  <****><-><--><><-><--> <> <> <> <><><>  <----><-><-><-><-><--------> <> <-><->
  GENER   2                               v2m2             =  2198.56
*** Compute remaining available pore space
  GENER   2                               vpo2             =  v2m2
  GENER   2                               vpo2            -=  vol2
*** Check to see if VPORA goes negative; if so set VPORA = 0.0
IF (vpo2 < 0.0) THEN
  GENER   2                               vpo2             =  0.0
END IF
*** Infiltration volume
  GENER   2                               v2d2             =  vpo2
END SPEC-ACTIONS
FTABLES
  FTABLE      2
   70    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)     (cfs)     (cfs)  (ft/sec)    (Minutes)***
  0.000000  0.036272  0.000000  0.000000  0.000000
  0.043956  0.036272  0.000640  0.000000  0.000000
  0.087912  0.036272  0.001280  0.000000  0.000000
  0.131868  0.036272  0.001920  0.000000  0.000000
  0.175824  0.036272  0.002561  0.000000  0.000000
  0.219780  0.036272  0.003201  0.000000  0.000230
  0.263736  0.036272  0.003841  0.000000  0.000397
  0.307692  0.036272  0.004481  0.000000  0.000623
  0.351648  0.036272  0.005121  0.000000  0.000917
  0.395604  0.036272  0.005761  0.000000  0.001284
  0.439560  0.036272  0.006401  0.000000  0.001730
  0.483516  0.036272  0.007042  0.000000  0.002261
  0.527473  0.036272  0.007682  0.000000  0.002882
  0.571429  0.036272  0.008322  0.000000  0.003598
  0.615385  0.036272  0.008962  0.000000  0.004413
```

```
0.659341  0.036272  0.009602  0.000000  0.005332
0.703297  0.036272  0.010242  0.000000  0.005693
0.747253  0.036272  0.010882  0.000000  0.006359
0.791209  0.036272  0.011522  0.000000  0.007498
0.835165  0.036272  0.012163  0.000000  0.008753
0.879121  0.036272  0.012803  0.000000  0.010127
0.923077  0.036272  0.013443  0.000000  0.011625
0.967033  0.036272  0.014083  0.000000  0.013249
1.010989  0.036272  0.014723  0.000000  0.013758
1.054945  0.036272  0.015363  0.000000  0.015003
1.098901  0.036272  0.016003  0.000000  0.016891
1.142857  0.036272  0.016644  0.000000  0.018915
1.186813  0.036272  0.017284  0.000000  0.021078
1.230769  0.036272  0.017924  0.000000  0.023384
1.274725  0.036272  0.018564  0.000000  0.025835
1.318681  0.036272  0.019204  0.000000  0.026340
1.362637  0.036272  0.019844  0.000000  0.028433
1.406593  0.036272  0.020484  0.000000  0.031182
1.450549  0.036272  0.021125  0.000000  0.034082
1.494505  0.036272  0.021765  0.000000  0.037136
1.538462  0.036272  0.022426  0.000000  0.040345
1.582418  0.036272  0.023088  0.000000  0.043709
1.626374  0.036272  0.023750  0.000000  0.044074
1.670330  0.036272  0.024411  0.000000  0.047223
1.714286  0.036272  0.025073  0.000000  0.050876
1.758242  0.036272  0.025735  0.000000  0.054571
1.802198  0.036272  0.026396  0.000000  0.073148
1.846154  0.036272  0.027058  0.000000  0.073148
1.890110  0.036272  0.027720  0.000000  0.073148
1.934066  0.036272  0.028381  0.000000  0.073148
1.978022  0.036272  0.029043  0.000000  0.073148
2.021978  0.036272  0.029705  0.000000  0.073148
2.065934  0.036272  0.030366  0.000000  0.073148
2.109890  0.036272  0.031028  0.000000  0.073148
2.153846  0.036272  0.031690  0.000000  0.073148
2.197802  0.036272  0.032351  0.000000  0.073148
2.241758  0.036272  0.033013  0.000000  0.073148
2.285714  0.036272  0.033675  0.000000  0.073148
2.329670  0.036272  0.034336  0.000000  0.073148
2.373626  0.036272  0.034998  0.000000  0.073148
2.417582  0.036272  0.035660  0.000000  0.073148
2.461538  0.036272  0.036321  0.000000  0.073148
2.505495  0.036272  0.036983  0.000000  0.073148
2.549451  0.036272  0.037645  0.000000  0.073148
2.593407  0.036272  0.038306  0.000000  0.073148
2.637363  0.036272  0.038968  0.000000  0.073148
2.681319  0.036272  0.039630  0.000000  0.073148
2.725275  0.036272  0.040291  0.000000  0.073148
2.769231  0.036272  0.040953  0.000000  0.073148
2.813187  0.036272  0.041615  0.000000  0.073148
2.857143  0.036272  0.042276  0.000000  0.073148
2.901099  0.036272  0.042938  0.000000  0.073148
2.945055  0.036272  0.043600  0.000000  0.073148
2.989011  0.036272  0.044261  0.000000  0.073148
3.000000  0.036272  0.050472  0.000000  0.073148
END FTABLE  2
FTABLE      1
 24    5
   Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
    (ft)   (acres) (acre-ft)   (cfs)      (cfs)   (ft/sec)    (Minutes)***
0.000000  0.036272  0.000000  0.000000  0.000000
0.043956  0.036272  0.001594  0.000000  0.054861
0.087912  0.036272  0.003189  0.000000  0.058076
0.131868  0.036272  0.004783  0.000000  0.059684
0.175824  0.036272  0.006377  0.000000  0.061292
0.219780  0.036272  0.007972  0.000000  0.062899
0.263736  0.036272  0.009566  0.000000  0.064507
0.307692  0.036272  0.011161  0.000000  0.066115
0.351648  0.036272  0.012755  0.000000  0.067722
0.395604  0.036272  0.014349  0.000000  0.069330
```

```
  0.439560  0.036272  0.015944  0.000000  0.070938
  0.483516  0.036272  0.017538  0.000000  0.072545
  0.527473  0.036272  0.019132  0.048301  0.074153
  0.571429  0.036272  0.020727  0.202028  0.075761
  0.615385  0.036272  0.022321  0.412175  0.077368
  0.659341  0.036272  0.023915  0.659695  0.078976
  0.703297  0.036272  0.025510  0.928167  0.080584
  0.747253  0.036272  0.027104  1.200769  0.082191
  0.791209  0.036272  0.028699  1.460630  0.083799
  0.835165  0.036272  0.030293  1.692395  0.085407
  0.879121  0.036272  0.031887  1.884482  0.087014
  0.923077  0.036272  0.033482  2.031838  0.088622
  0.967033  0.036272  0.035076  2.139092  0.090230
  1.000000  0.036272  0.036272  2.251466  0.091435
  END FTABLE  1
  FTABLE      3
   92    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.039027  0.000000  0.000000  0.000000
  0.033333  0.039027  0.000455  0.000000  0.393519
  0.066667  0.039027  0.000911  0.000000  0.393519
  0.100000  0.039027  0.001366  0.000000  0.393519
  0.133333  0.039027  0.001821  0.000000  0.393519
  0.166667  0.039027  0.002277  0.000000  0.393519
  0.200000  0.039027  0.002732  0.000000  0.393519
  0.233333  0.039027  0.003187  0.000000  0.393519
  0.266667  0.039027  0.003642  0.000000  0.393519
  0.300000  0.039027  0.004098  0.000000  0.393519
  0.333333  0.039027  0.004553  0.000000  0.393519
  0.366667  0.039027  0.005008  0.000000  0.393519
  0.400000  0.039027  0.005464  0.000000  0.393519
  0.433333  0.039027  0.005919  0.000000  0.393519
  0.466667  0.039027  0.006374  0.000000  0.393519
  0.500000  0.039027  0.006830  0.000000  0.393519
  0.533333  0.039027  0.007285  0.000000  0.393519
  0.566667  0.039027  0.007740  0.000000  0.393519
  0.600000  0.039027  0.008196  0.000000  0.393519
  0.633333  0.039027  0.008651  0.000000  0.393519
  0.666667  0.039027  0.009106  0.000000  0.393519
  0.700000  0.039027  0.009562  0.000000  0.393519
  0.733333  0.039027  0.010017  0.000000  0.393519
  0.766667  0.039027  0.010472  0.000000  0.393519
  0.800000  0.039027  0.010927  0.000000  0.393519
  0.833333  0.039027  0.011383  0.000000  0.393519
  0.866667  0.039027  0.011838  0.000000  0.393519
  0.900000  0.039027  0.012293  0.000000  0.393519
  0.933333  0.039027  0.012749  0.000000  0.393519
  0.966667  0.039027  0.013204  0.000000  0.393519
  1.000000  0.039027  0.013659  0.000000  0.393519
  1.033333  0.039027  0.014115  0.000000  0.393519
  1.066667  0.039027  0.014570  0.000000  0.393519
  1.100000  0.039027  0.015025  0.000000  0.393519
  1.133333  0.039027  0.015481  0.000000  0.393519
  1.166667  0.039027  0.015936  0.000000  0.393519
  1.200000  0.039027  0.016391  0.000000  0.393519
  1.233333  0.039027  0.016846  0.000000  0.393519
  1.266667  0.039027  0.017302  0.000000  0.393519
  1.300000  0.039027  0.017757  0.000000  0.393519
  1.333333  0.039027  0.018212  0.000000  0.393519
  1.366667  0.039027  0.018668  0.000000  0.393519
  1.400000  0.039027  0.019123  0.000000  0.393519
  1.433333  0.039027  0.019578  0.000000  0.393519
  1.466667  0.039027  0.020034  0.000000  0.393519
  1.500000  0.039027  0.020489  0.000000  0.393519
  1.533333  0.039027  0.020944  0.000000  0.393519
  1.566667  0.039027  0.021400  0.000000  0.393519
  1.600000  0.039027  0.021855  0.000000  0.393519
  1.633333  0.039027  0.022310  0.000000  0.393519
  1.666667  0.039027  0.022766  0.000000  0.393519
```

```
  1.700000  0.039027  0.023221  0.000000  0.393519
  1.733333  0.039027  0.023676  0.000000  0.393519
  1.766667  0.039027  0.024131  0.000000  0.393519
  1.800000  0.039027  0.024587  0.000000  0.393519
  1.833333  0.039027  0.025042  0.000000  0.393519
  1.866667  0.039027  0.025497  0.000000  0.393519
  1.900000  0.039027  0.025953  0.000000  0.393519
  1.933333  0.039027  0.026408  0.000000  0.393519
  1.966667  0.039027  0.026863  0.000000  0.393519
  2.000000  0.039027  0.027319  0.000000  0.393519
  2.033333  0.039027  0.027774  0.000000  0.393519
  2.066667  0.039027  0.028229  0.000000  0.393519
  2.100000  0.039027  0.028685  0.000000  0.393519
  2.133333  0.039027  0.029140  0.000000  0.393519
  2.166667  0.039027  0.029595  0.000000  0.393519
  2.200000  0.039027  0.030051  0.000000  0.393519
  2.233333  0.039027  0.030506  0.000000  0.393519
  2.266667  0.039027  0.030961  0.000000  0.393519
  2.300000  0.039027  0.031416  0.000000  0.393519
  2.333333  0.039027  0.031872  0.000000  0.393519
  2.366667  0.039027  0.032327  0.000000  0.393519
  2.400000  0.039027  0.032782  0.000000  0.393519
  2.433333  0.039027  0.033238  0.000000  0.393519
  2.466667  0.039027  0.033693  0.000000  0.393519
  2.500000  0.039027  0.034148  0.000000  0.393519
  2.533333  0.039027  0.034604  0.000000  0.393519
  2.566667  0.039027  0.035059  0.000000  0.393519
  2.600000  0.039027  0.035514  0.000000  0.393519
  2.633333  0.039027  0.035970  0.000000  0.393519
  2.666667  0.039027  0.036425  0.000000  0.393519
  2.700000  0.039027  0.036880  0.000000  0.393519
  2.733333  0.039027  0.037335  0.000000  0.393519
  2.766667  0.039027  0.037791  0.000000  0.393519
  2.800000  0.039027  0.038246  0.000000  0.393519
  2.833333  0.039027  0.038701  0.000000  0.393519
  2.866667  0.039027  0.039157  0.000000  0.393519
  2.900000  0.039027  0.039612  0.000000  0.393519
  2.933333  0.039027  0.040067  0.000000  0.393519
  2.966667  0.039027  0.040523  0.000000  0.393519
  3.000000  0.039027  0.040978  0.000000  0.393519
  3.033333  0.039027  0.042279  0.064540  0.393519
  END FTABLE  3
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1         SUM  PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1         SUM  IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1         SUM  RCHRES   1     EXTNL  PREC
WDM      1 EVAP     ENGL    0.5            RCHRES   1     EXTNL  POTEV
WDM      1 EVAP     ENGL    0.76           RCHRES   2     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   2 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   2 HYDR   O      1 1        1      WDM   1001 FLOW     ENGL      REPL
RCHRES   2 HYDR   O      2 1        1      WDM   1002 FLOW     ENGL      REPL
RCHRES   2 HYDR   STAGE  1 1        1      WDM   1003 STAG     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1004 STAG     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1      WDM   1005 FLOW     ENGL      REPL
COPY     1 OUTPUT MEAN   1 1     12.1      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     12.1      WDM    801 FLOW     ENGL      REPL
RCHRES   3 HYDR   RO     1 1        1      WDM   1006 FLOW     ENGL      REPL
RCHRES   3 HYDR   O      1 1        1      WDM   1007 FLOW     ENGL      REPL
```

```
RCHRES   3 HYDR   O      2 1        1      WDM   1008 FLOW     ENGL      REPL
RCHRES   3 HYDR   STAGE  1 1        1      WDM   1009 STAG     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5

  MASS-LINK        7
RCHRES     OFLOW  OVOL   1                 RCHRES         INFLOW IVOL
  END MASS-LINK    7

  MASS-LINK        8
RCHRES     OFLOW  OVOL   2                 RCHRES         INFLOW IVOL
  END MASS-LINK    8

  MASS-LINK       15
IMPLND     IWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   15

  MASS-LINK       17
RCHRES     OFLOW  OVOL   1                 COPY           INPUT  MEAN
  END MASS-LINK   17


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1992/ 4/16 22: 0

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1          V2         VOL
92 1.7850E+03 1841.7      2176.2
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1992/ 4/16 22: 0

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 3400.0     -2.347E+04    6.9021  6.9021E+00      2
```

Disclaimer

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ROOF

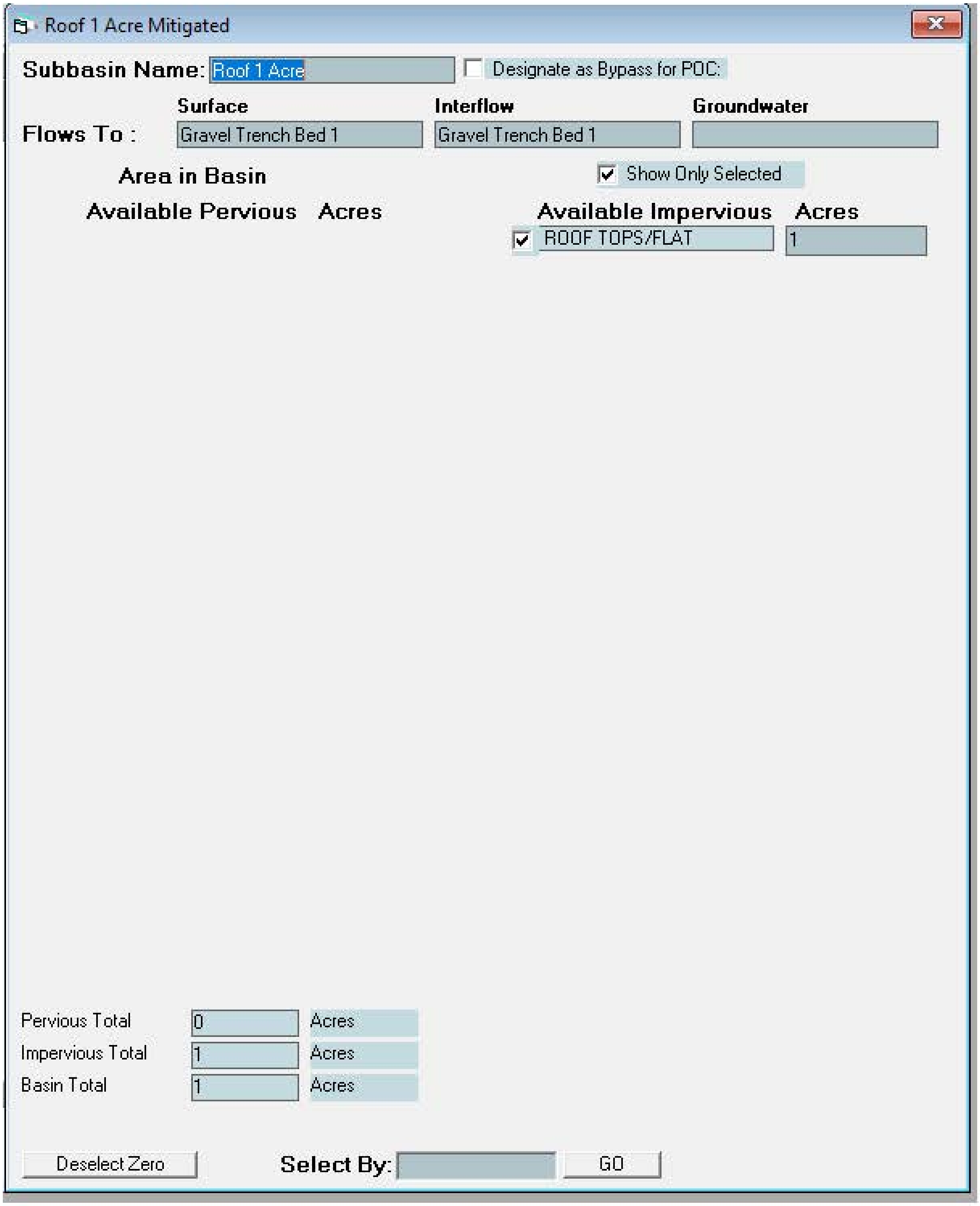
AREA CALCULATIONS

WWHM2012

PROJECT REPORT

ROOF AREA CALCULATIONS


Schematic
SCENARIOS
☐ Predeveloped
☑ Mitigated
Run Scenario
Basic Elements
Pro Elements
LID Toolbox
Commercial Toolbox
Move Elements
Save x,y
Load x,y
X 40



Roof 1 Acre Mitigated

Subbasin Name: Roof 1 Acre

☐ Designate as Bypass for POC:

Flows To :

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

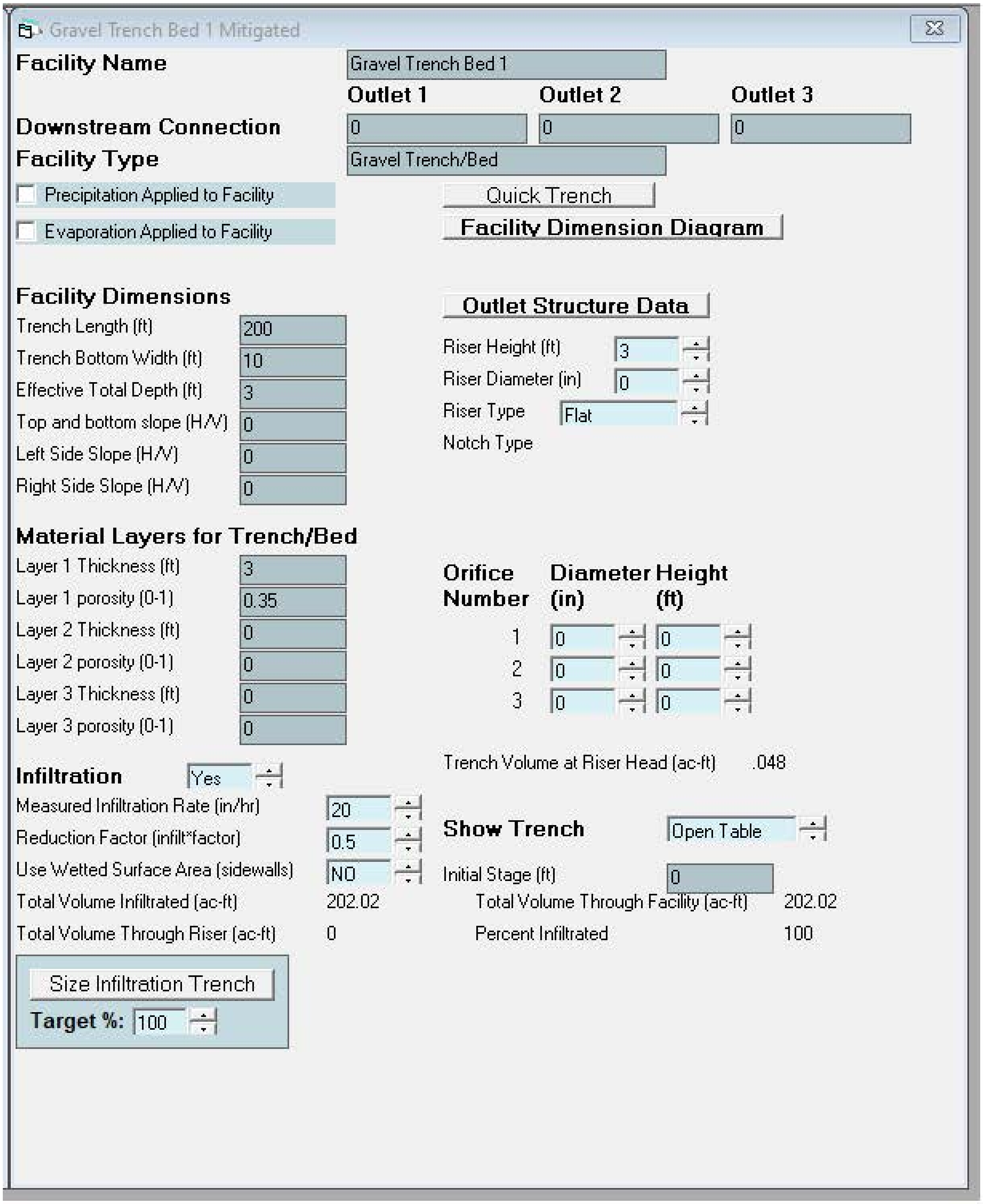
Area in Basin

☑ Show Only Selected

Available Pervious	Acres	Available Impervious	Acres
		☑ ROOF TOPS/FLAT	1

Pervious Total	0	Acres
Impervious Total	1	Acres
Basin Total	1	Acres

Select By:



Gravel Trench Bed 1 Mitigated

Facility Name Gravel Trench Bed 1

	Outlet 1	**Outlet 2**	**Outlet 3**
Downstream Connection	0	0	0

Facility Type Gravel Trench/Bed

☐ Precipitation Applied to Facility

☐ Evaporation Applied to Facility

Facility Dimensions

Trench Length (ft) 200
Trench Bottom Width (ft) 10
Effective Total Depth (ft) 3
Top and bottom slope (H/V) 0
Left Side Slope (H/V) 0
Right Side Slope (H/V) 0

Material Layers for Trench/Bed

Layer 1 Thickness (ft) 3
Layer 1 porosity (0-1) 0.35
Layer 2 Thickness (ft) 0
Layer 2 porosity (0-1) 0
Layer 3 Thickness (ft) 0
Layer 3 porosity (0-1) 0

Infiltration Yes

Measured Infiltration Rate (in/hr) 20
Reduction Factor (infilt*factor) 0.5
Use Wetted Surface Area (sidewalls) NO
Total Volume Infiltrated (ac-ft) 202.02
Total Volume Through Riser (ac-ft) 0

Target %: 100

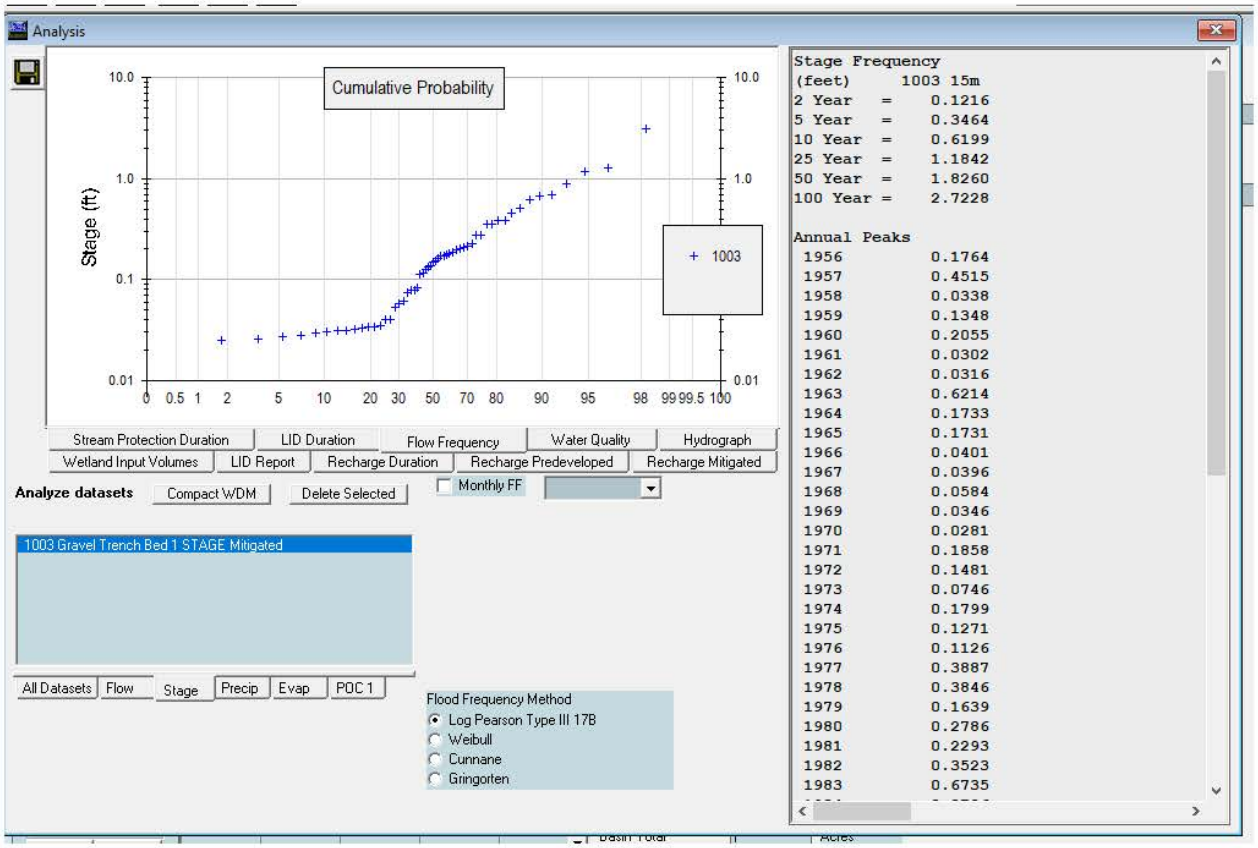
Riser Height (ft) 3
Riser Diameter (in) 0
Riser Type Flat
Notch Type

Orifice Number	**Diameter (in)**	**Height (ft)**
1	0	0
2	0	0
3	0	0

Trench Volume at Riser Head (ac-ft) .048

Show Trench Open Table

Initial Stage (ft) 0
Total Volume Through Facility (ac-ft) 202.02
Percent Infiltrated 100



1003 Gravel Trench Bed 1 STAGE Mitigated

Flood Frequency Method
● Log Pearson Type III 17B
○ Weibull
○ Cunnane
○ Gringorten

```
Stage Frequency
(feet)      1003 15m
2 Year   =     0.1216
5 Year   =     0.3464
10 Year  =     0.6199
25 Year  =     1.1842
50 Year  =     1.8260
100 Year =     2.7228

Annual Peaks
 1956          0.1764
 1957          0.4515
 1958          0.0338
 1959          0.1348
 1960          0.2055
 1961          0.0302
 1962          0.0316
 1963          0.6214
 1964          0.1733
 1965          0.1731
 1966          0.0401
 1967          0.0396
 1968          0.0584
 1969          0.0346
 1970          0.0281
 1971          0.1858
 1972          0.1481
 1973          0.0746
 1974          0.1799
 1975          0.1271
 1976          0.1126
 1977          0.3887
 1978          0.3846
 1979          0.1639
 1980          0.2786
 1981          0.2293
 1982          0.3523
 1983          0.6735
```

General Model Information

Project Name:	10367.e.Nisqually.MIXED.USE.1ac.roof
Site Name:	Nisqually MU
Site Address:	
City:	
Report Date:	4/12/2023
Gage:	Fairgrounds (Kaiser)
Data Start:	1955/10/01
Data End:	2011/09/30
Timestep:	15 Minute
Precip Scale:	1.000
Version Date:	2021/08/18
Version:	4.2.18

POC Thresholds

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Forest, Mod	1
Pervious Total	1
Impervious Land Use	acre
Impervious Total	0
Basin Total	1

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Roof 1 Acre

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
ROOF TOPS FLAT	1
Impervious Total	1
Basin Total	1

Element Flows To:

Surface	Interflow	Groundwater
Gravel Trench Bed 1	Gravel Trench Bed 1	

Routing Elements

Predeveloped Routing

Mitigated Routing

Gravel Trench Bed 1

Bottom Length:	200.00 ft.
Bottom Width:	10.00 ft.
Trench bottom slope 1:	0 To 1
Trench Left side slope 0:	0 To 1
Trench right side slope 2:	0 To 1
Material thickness of first layer:	3
Pour Space of material for first layer:	0.35
Material thickness of second layer:	0
Pour Space of material for second layer:	0
Material thickness of third layer:	0
Pour Space of material for third layer:	0
Infiltration On	
Infiltration rate:	20
Infiltration safety factor:	0.5
Total Volume Infiltrated (ac-ft.):	202.02
Total Volume Through Riser (ac-ft.):	0
Total Volume Through Facility (ac-ft.):	202.02
Percent Infiltrated:	100
Total Precip Applied to Facility:	0
Total Evap From Facility:	0

Discharge Structure

Riser Height:	3 ft.
Riser Diameter:	0 in.

Element Flows To:

Outlet 1	Outlet 2

Gravel Trench Bed Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.045	0.000	0.000	0.000
0.0333	0.045	0.000	0.000	0.463
0.0667	0.045	0.001	0.000	0.463
0.1000	0.045	0.001	0.000	0.463
0.1333	0.045	0.002	0.000	0.463
0.1667	0.045	0.002	0.000	0.463
0.2000	0.045	0.003	0.000	0.463
0.2333	0.045	0.003	0.000	0.463
0.2667	0.045	0.004	0.000	0.463
0.3000	0.045	0.004	0.000	0.463
0.3333	0.045	0.005	0.000	0.463
0.3667	0.045	0.005	0.000	0.463
0.4000	0.045	0.006	0.000	0.463
0.4333	0.045	0.007	0.000	0.463
0.4667	0.045	0.007	0.000	0.463
0.5000	0.045	0.008	0.000	0.463
0.5333	0.045	0.008	0.000	0.463
0.5667	0.045	0.009	0.000	0.463
0.6000	0.045	0.009	0.000	0.463
0.6333	0.045	0.010	0.000	0.463
0.6667	0.045	0.010	0.000	0.463
0.7000	0.045	0.011	0.000	0.463
0.7333	0.045	0.011	0.000	0.463
0.7667	0.045	0.012	0.000	0.463

0.8000	0.045	0.012	0.000	0.463
0.8333	0.045	0.013	0.000	0.463
0.8667	0.045	0.013	0.000	0.463
0.9000	0.045	0.014	0.000	0.463
0.9333	0.045	0.015	0.000	0.463
0.9667	0.045	0.015	0.000	0.463
1.0000	0.045	0.016	0.000	0.463
1.0333	0.045	0.016	0.000	0.463
1.0667	0.045	0.017	0.000	0.463
1.1000	0.045	0.017	0.000	0.463
1.1333	0.045	0.018	0.000	0.463
1.1667	0.045	0.018	0.000	0.463
1.2000	0.045	0.019	0.000	0.463
1.2333	0.045	0.019	0.000	0.463
1.2667	0.045	0.020	0.000	0.463
1.3000	0.045	0.020	0.000	0.463
1.3333	0.045	0.021	0.000	0.463
1.3667	0.045	0.022	0.000	0.463
1.4000	0.045	0.022	0.000	0.463
1.4333	0.045	0.023	0.000	0.463
1.4667	0.045	0.023	0.000	0.463
1.5000	0.045	0.024	0.000	0.463
1.5333	0.045	0.024	0.000	0.463
1.5667	0.045	0.025	0.000	0.463
1.6000	0.045	0.025	0.000	0.463
1.6333	0.045	0.026	0.000	0.463
1.6667	0.045	0.026	0.000	0.463
1.7000	0.045	0.027	0.000	0.463
1.7333	0.045	0.027	0.000	0.463
1.7667	0.045	0.028	0.000	0.463
1.8000	0.045	0.028	0.000	0.463
1.8333	0.045	0.029	0.000	0.463
1.8667	0.045	0.030	0.000	0.463
1.9000	0.045	0.030	0.000	0.463
1.9333	0.045	0.031	0.000	0.463
1.9667	0.045	0.031	0.000	0.463
2.0000	0.045	0.032	0.000	0.463
2.0333	0.045	0.032	0.000	0.463
2.0667	0.045	0.033	0.000	0.463
2.1000	0.045	0.033	0.000	0.463
2.1333	0.045	0.034	0.000	0.463
2.1667	0.045	0.034	0.000	0.463
2.2000	0.045	0.035	0.000	0.463
2.2333	0.045	0.035	0.000	0.463
2.2667	0.045	0.036	0.000	0.463
2.3000	0.045	0.037	0.000	0.463
2.3333	0.045	0.037	0.000	0.463
2.3667	0.045	0.038	0.000	0.463
2.4000	0.045	0.038	0.000	0.463
2.4333	0.045	0.039	0.000	0.463
2.4667	0.045	0.039	0.000	0.463
2.5000	0.045	0.040	0.000	0.463
2.5333	0.045	0.040	0.000	0.463
2.5667	0.045	0.041	0.000	0.463
2.6000	0.045	0.041	0.000	0.463
2.6333	0.045	0.042	0.000	0.463
2.6667	0.045	0.042	0.000	0.463
2.7000	0.045	0.043	0.000	0.463

2.7333	0.045	0.043	0.000	0.463
2.7667	0.045	0.044	0.000	0.463
2.8000	0.045	0.045	0.000	0.463
2.8333	0.045	0.045	0.000	0.463
2.8667	0.045	0.046	0.000	0.463
2.9000	0.045	0.046	0.000	0.463
2.9333	0.045	0.047	0.000	0.463
2.9667	0.045	0.047	0.000	0.463
3.0000	0.045	0.048	0.000	0.463

Analysis Results

POC 1

POC #1 was not reported because POC must exist in both scenarios and both scenarios must have been run.

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

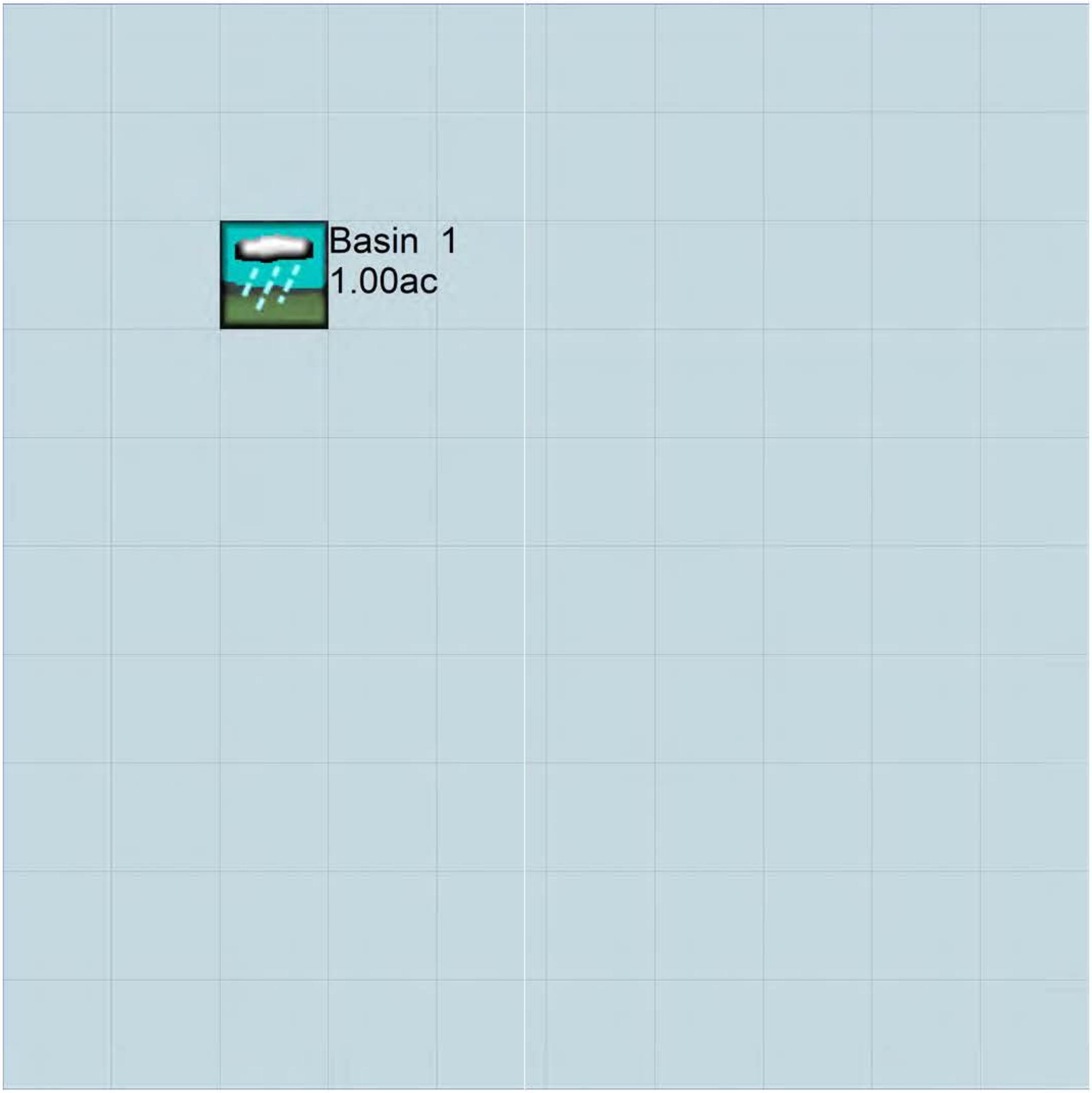
No PERLND changes have been made.

IMPLND Changes

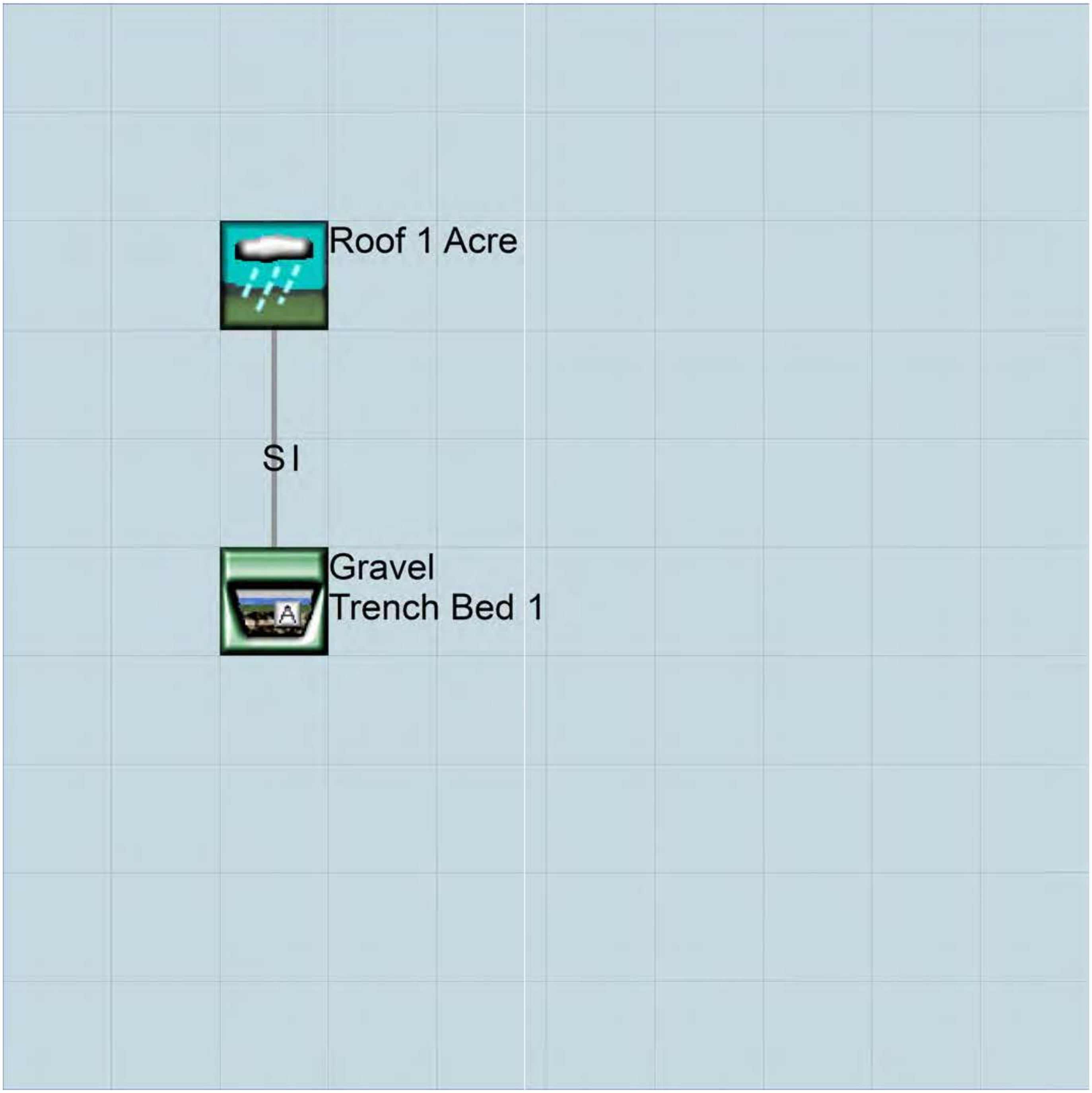
No IMPLND changes have been made.

Appendix

Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1955 10 01        END    2011 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   10367.e.Nisqually.MIXED.USE.1ac.roof.wdm
MESSU      25   Mit10367.e.Nisqually.MIXED.USE.1ac.roof.MES
           27   Mit10367.e.Nisqually.MIXED.USE.1ac.roof.L61
           28   Mit10367.e.Nisqually.MIXED.USE.1ac.roof.L62
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      IMPLND       4
      RCHRES       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                            User  t-series Engl Metr ***
                                             in  out             ***
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
```

```
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                     in  out           ***
    4      ROOF TOPS/FLAT         1    1    1   27    0
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    4         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    4         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    4         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    4            400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    4              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    4              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
```

```
Roof 1 Acre***
IMPLND   4                           1     RCHRES   1      5

******Routing******
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                          in  out                            ***
    1     Gravel Trench Be-005    2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *        ***
    1        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1             1      0.04       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
   92    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)      (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.045914  0.000000  0.000000  0.000000
  0.033333  0.045914  0.000536  0.000000  0.462963
  0.066667  0.045914  0.001071  0.000000  0.462963
  0.100000  0.045914  0.001607  0.000000  0.462963
```

```
  0.133333  0.045914  0.002143  0.000000  0.462963
  0.166667  0.045914  0.002678  0.000000  0.462963
  0.200000  0.045914  0.003214  0.000000  0.462963
  0.233333  0.045914  0.003750  0.000000  0.462963
  0.266667  0.045914  0.004285  0.000000  0.462963
  0.300000  0.045914  0.004821  0.000000  0.462963
  0.333333  0.045914  0.005357  0.000000  0.462963
  0.366667  0.045914  0.005892  0.000000  0.462963
  0.400000  0.045914  0.006428  0.000000  0.462963
  0.433333  0.045914  0.006964  0.000000  0.462963
  0.466667  0.045914  0.007499  0.000000  0.462963
  0.500000  0.045914  0.008035  0.000000  0.462963
  0.533333  0.045914  0.008571  0.000000  0.462963
  0.566667  0.045914  0.009106  0.000000  0.462963
  0.600000  0.045914  0.009642  0.000000  0.462963
  0.633333  0.045914  0.010178  0.000000  0.462963
  0.666667  0.045914  0.010713  0.000000  0.462963
  0.700000  0.045914  0.011249  0.000000  0.462963
  0.733333  0.045914  0.011785  0.000000  0.462963
  0.766667  0.045914  0.012320  0.000000  0.462963
  0.800000  0.045914  0.012856  0.000000  0.462963
  0.833333  0.045914  0.013391  0.000000  0.462963
  0.866667  0.045914  0.013927  0.000000  0.462963
  0.900000  0.045914  0.014463  0.000000  0.462963
  0.933333  0.045914  0.014998  0.000000  0.462963
  0.966667  0.045914  0.015534  0.000000  0.462963
  1.000000  0.045914  0.016070  0.000000  0.462963
  1.033333  0.045914  0.016605  0.000000  0.462963
  1.066667  0.045914  0.017141  0.000000  0.462963
  1.100000  0.045914  0.017677  0.000000  0.462963
  1.133333  0.045914  0.018212  0.000000  0.462963
  1.166667  0.045914  0.018748  0.000000  0.462963
  1.200000  0.045914  0.019284  0.000000  0.462963
  1.233333  0.045914  0.019819  0.000000  0.462963
  1.266667  0.045914  0.020355  0.000000  0.462963
  1.300000  0.045914  0.020891  0.000000  0.462963
  1.333333  0.045914  0.021426  0.000000  0.462963
  1.366667  0.045914  0.021962  0.000000  0.462963
  1.400000  0.045914  0.022498  0.000000  0.462963
  1.433333  0.045914  0.023033  0.000000  0.462963
  1.466667  0.045914  0.023569  0.000000  0.462963
  1.500000  0.045914  0.024105  0.000000  0.462963
  1.533333  0.045914  0.024640  0.000000  0.462963
  1.566667  0.045914  0.025176  0.000000  0.462963
  1.600000  0.045914  0.025712  0.000000  0.462963
  1.633333  0.045914  0.026247  0.000000  0.462963
  1.666667  0.045914  0.026783  0.000000  0.462963
  1.700000  0.045914  0.027319  0.000000  0.462963
  1.733333  0.045914  0.027854  0.000000  0.462963
  1.766667  0.045914  0.028390  0.000000  0.462963
  1.800000  0.045914  0.028926  0.000000  0.462963
  1.833333  0.045914  0.029461  0.000000  0.462963
  1.866667  0.045914  0.029997  0.000000  0.462963
  1.900000  0.045914  0.030533  0.000000  0.462963
  1.933333  0.045914  0.031068  0.000000  0.462963
  1.966667  0.045914  0.031604  0.000000  0.462963
  2.000000  0.045914  0.032140  0.000000  0.462963
  2.033333  0.045914  0.032675  0.000000  0.462963
  2.066667  0.045914  0.033211  0.000000  0.462963
  2.100000  0.045914  0.033747  0.000000  0.462963
  2.133333  0.045914  0.034282  0.000000  0.462963
  2.166667  0.045914  0.034818  0.000000  0.462963
  2.200000  0.045914  0.035354  0.000000  0.462963
  2.233333  0.045914  0.035889  0.000000  0.462963
  2.266667  0.045914  0.036425  0.000000  0.462963
  2.300000  0.045914  0.036961  0.000000  0.462963
  2.333333  0.045914  0.037496  0.000000  0.462963
  2.366667  0.045914  0.038032  0.000000  0.462963
  2.400000  0.045914  0.038567  0.000000  0.462963
  2.433333  0.045914  0.039103  0.000000  0.462963
```

```
  2.466667  0.045914  0.039639  0.000000  0.462963
  2.500000  0.045914  0.040174  0.000000  0.462963
  2.533333  0.045914  0.040710  0.000000  0.462963
  2.566667  0.045914  0.041246  0.000000  0.462963
  2.600000  0.045914  0.041781  0.000000  0.462963
  2.633333  0.045914  0.042317  0.000000  0.462963
  2.666667  0.045914  0.042853  0.000000  0.462963
  2.700000  0.045914  0.043388  0.000000  0.462963
  2.733333  0.045914  0.043924  0.000000  0.462963
  2.766667  0.045914  0.044460  0.000000  0.462963
  2.800000  0.045914  0.044995  0.000000  0.462963
  2.833333  0.045914  0.045531  0.000000  0.462963
  2.866667  0.045914  0.046067  0.000000  0.462963
  2.900000  0.045914  0.046602  0.000000  0.462963
  2.933333  0.045914  0.047138  0.000000  0.462963
  2.966667  0.045914  0.047674  0.000000  0.462963
  3.000000  0.045914  0.048209  0.000000  0.462963
  3.033333  0.045914  0.049740  0.064540  0.462963
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1              PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1              IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   1 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1      WDM   1001 FLOW     ENGL      REPL
RCHRES   1 HYDR   O      2 1        1      WDM   1002 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1003 STAG     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1992/ 4/16 21:30

RCHRES:     1

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2         VOL
92 2100.0     2166.7     2292.3
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1992/ 4/16 21:30

RCHRES:     1

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2   COUNT
0.0000E+00 4000.0     -1.154E+04    2.8840  2.8840E+00      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1992/ 4/16 21:45

RCHRES:     1

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2         VOL
92 2.1000E+03 2166.7     2345.8
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1992/ 4/16 21:45

RCHRES:     1

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2   COUNT
0.0000E+00 4000.0     -1.474E+04    3.6857     3.6857       2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1992/ 4/16 22: 0

RCHRES:     1
```

```
The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92 2100.0     2166.7     2428.7
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1992/ 4/16 22: 0

RCHRES:     1

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 4000.0     -1.971E+04    4.9283  4.9283E+00      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1992/ 4/16 22:15

RCHRES:     1

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92 2.1000E+03 2166.7     2262.9
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1992/ 4/16 22:15

RCHRES:     1

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 4000.0     -9.770E+03    2.4426  2.4426E+00      2
```

Disclaimer

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LANDSCAPE

AREA CALCULATIONS

WWHM2012

PROJECT REPORT

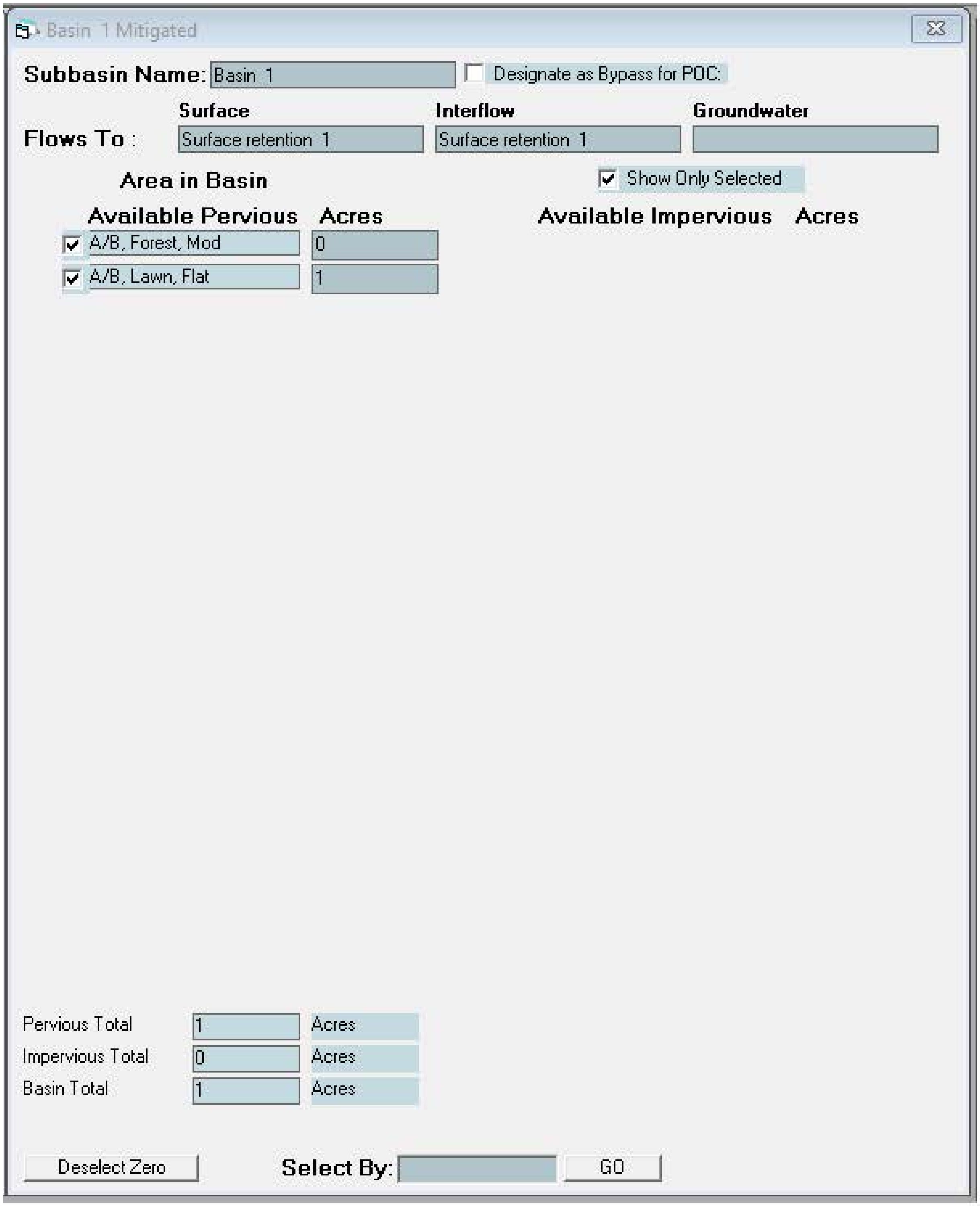
LANDSCAPE AREA CALCULATIONS

☐ Predeveloped

☑ Mitigated

X 30

Y



Subbasin Name: Basin 1 ☐ Designate as Bypass for POC:

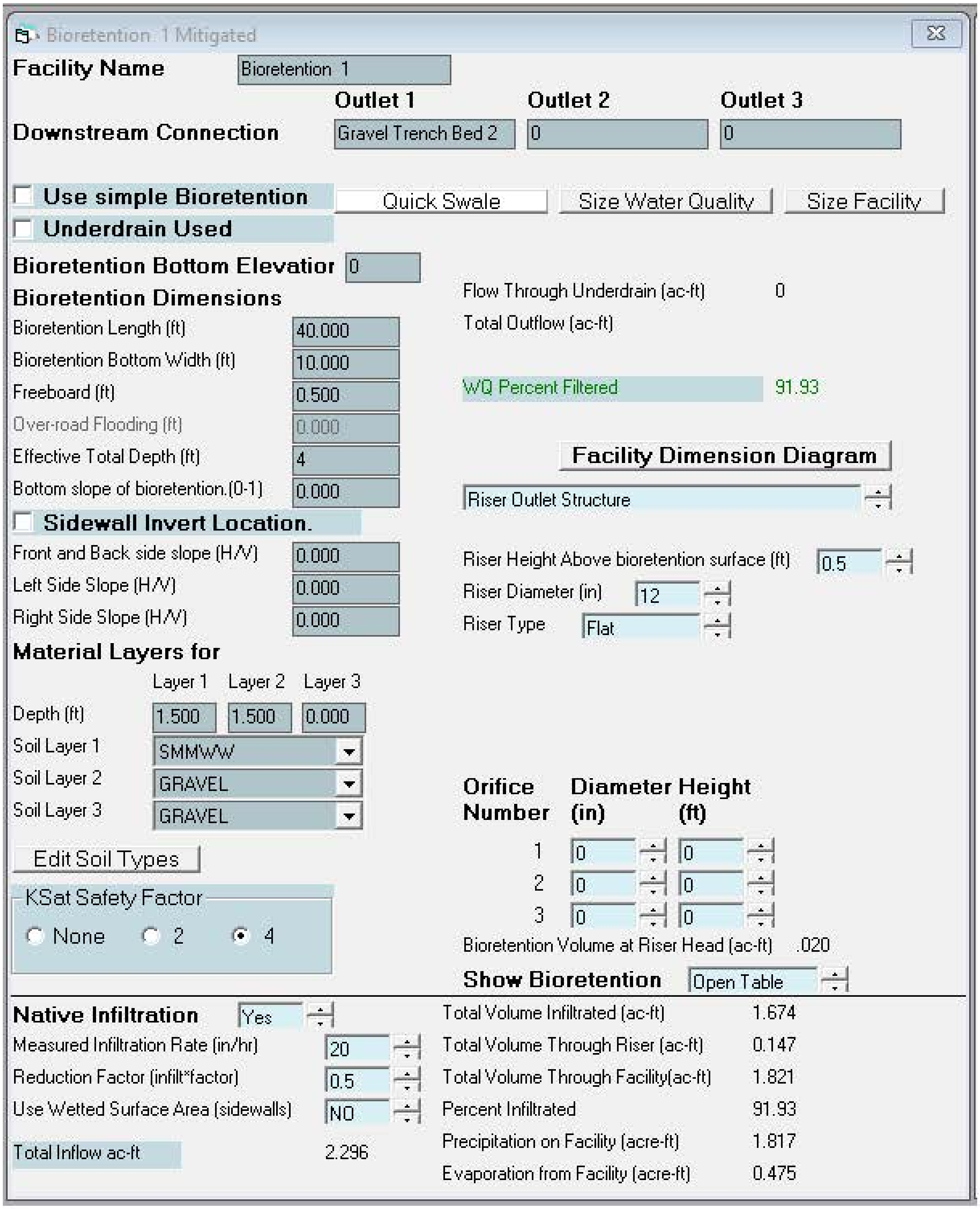
	Surface	Interflow	Groundwater
Flows To :	Surface retention 1	Surface retention 1	

Area in Basin ☑ Show Only Selected

Available Pervious	Acres
☑ A/B, Forest, Mod	0
☑ A/B, Lawn, Flat	1

Available Impervious **Acres**

Pervious Total	1	Acres
Impervious Total	0	Acres
Basin Total	1	Acres



Facility Name Bioretention 1

	Outlet 1	Outlet 2	Outlet 3
Downstream Connection	Gravel Trench Bed 2	0	0

☐ Use simple Bioretention
☐ Underdrain Used

Bioretention Bottom Elevatior 0

Bioretention Dimensions

Bioretention Length (ft) 40.000
Bioretention Bottom Width (ft) 10.000
Freeboard (ft) 0.500
Over-road Flooding (ft) 0.000
Effective Total Depth (ft) 4
Bottom slope of bioretention.(0-1) 0.000

☐ Sidewall Invert Location.

Front and Back side slope (H/V) 0.000
Left Side Slope (H/V) 0.000
Right Side Slope (H/V) 0.000

Material Layers for

	Layer 1	Layer 2	Layer 3
Depth (ft)	1.500	1.500	0.000

Soil Layer 1 SMMWW
Soil Layer 2 GRAVEL
Soil Layer 3 GRAVEL

KSat Safety Factor
○ None ○ 2 ● 4

Flow Through Underdrain (ac-ft) 0
Total Outflow (ac-ft)

WQ Percent Filtered 91.93

Riser Outlet Structure

Riser Height Above bioretention surface (ft) 0.5
Riser Diameter (in) 12
Riser Type Flat

Orifice Number	Diameter (in)	Height (ft)
1	0	0
2	0	0
3	0	0

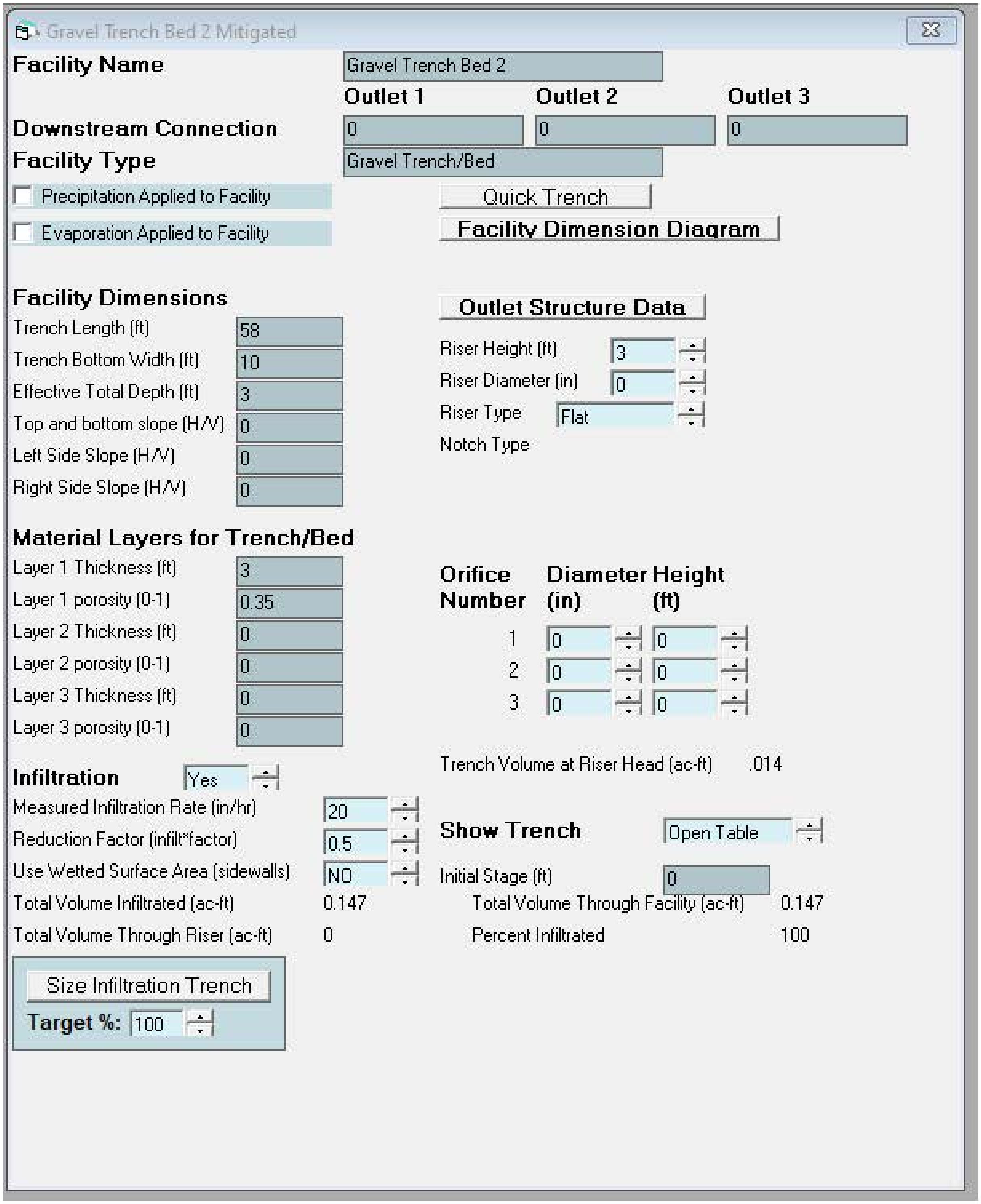
Bioretention Volume at Riser Head (ac-ft) .020

Show Bioretention Open Table

Native Infiltration Yes
Measured Infiltration Rate (in/hr) 20
Reduction Factor (infilt*factor) 0.5
Use Wetted Surface Area (sidewalls) NO

Total Inflow ac-ft 2.296

Total Volume Infiltrated (ac-ft) 1.674
Total Volume Through Riser (ac-ft) 0.147
Total Volume Through Facility(ac-ft) 1.821
Percent Infiltrated 91.93
Precipitation on Facility (acre-ft) 1.817
Evaporation from Facility (acre-ft) 0.475



Gravel Trench Bed 2 Mitigated

Facility Name Gravel Trench Bed 2

	Outlet 1	Outlet 2	Outlet 3
Downstream Connection	0	0	0

Facility Type Gravel Trench/Bed

☐ Precipitation Applied to Facility

☐ Evaporation Applied to Facility

Facility Dimensions

Trench Length (ft) 58
Trench Bottom Width (ft) 10
Effective Total Depth (ft) 3
Top and bottom slope (H/V) 0
Left Side Slope (H/V) 0
Right Side Slope (H/V) 0

Material Layers for Trench/Bed

Layer 1 Thickness (ft) 3
Layer 1 porosity (0-1) 0.35
Layer 2 Thickness (ft) 0
Layer 2 porosity (0-1) 0
Layer 3 Thickness (ft) 0
Layer 3 porosity (0-1) 0

Infiltration Yes

Measured Infiltration Rate (in/hr) 20
Reduction Factor (infilt*factor) 0.5
Use Wetted Surface Area (sidewalls) NO
Total Volume Infiltrated (ac-ft) 0.147
Total Volume Through Riser (ac-ft) 0

Target %: 100

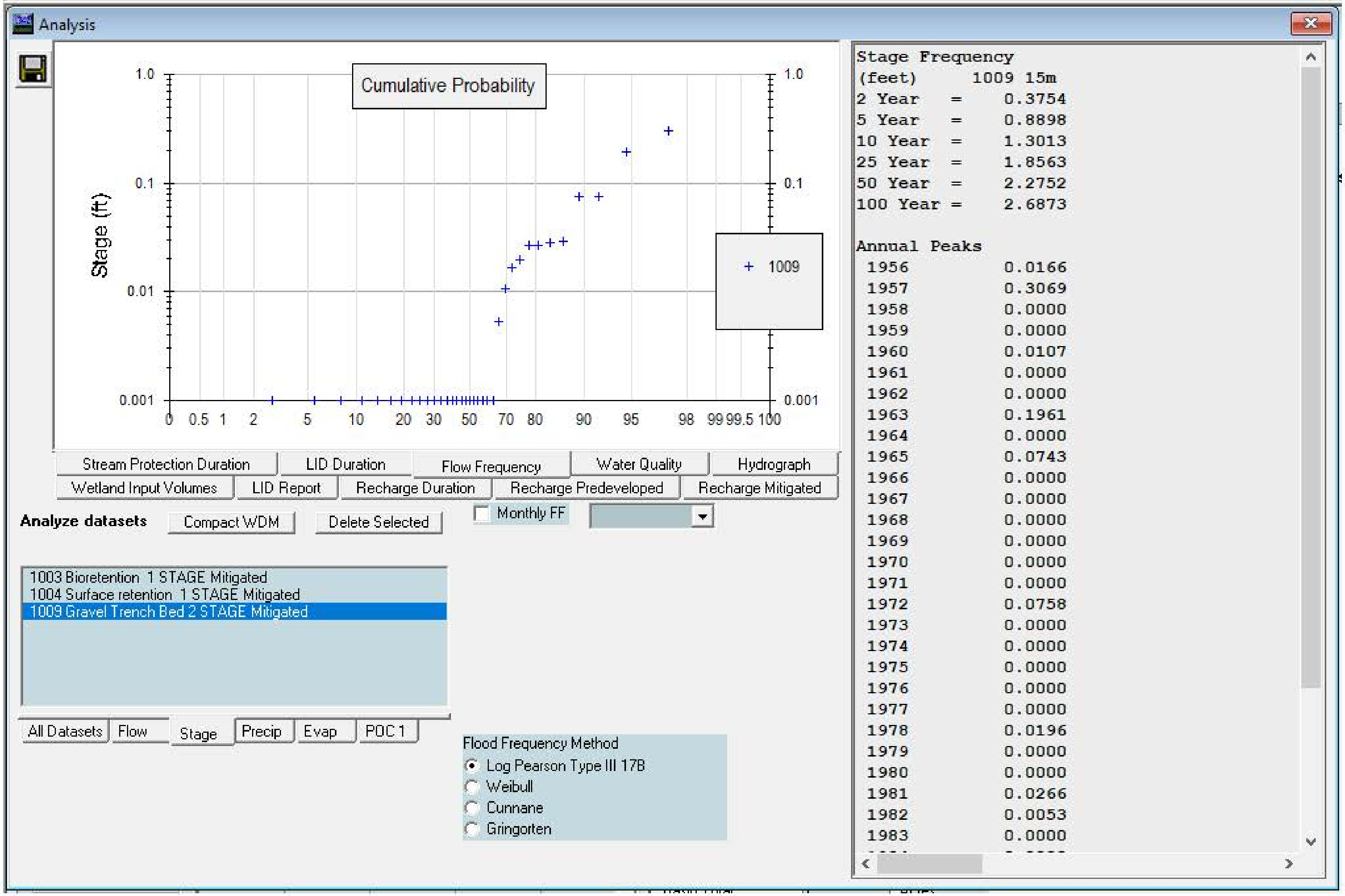
Riser Height (ft) 3
Riser Diameter (in) 0
Riser Type Flat
Notch Type

Orifice Number	Diameter (in)	Height (ft)
1	0	0
2	0	0
3	0	0

Trench Volume at Riser Head (ac-ft) .014

Show Trench Open Table

Initial Stage (ft) 0
Total Volume Through Facility (ac-ft) 0.147
Percent Infiltrated 100



☐ Monthly FF

1003 Bioretention 1 STAGE Mitigated
1004 Surface retention 1 STAGE Mitigated
1009 Gravel Trench Bed 2 STAGE Mitigated

Flood Frequency Method
● Log Pearson Type III 17B
○ Weibull
○ Cunnane
○ Gringorten

```
Stage Frequency
(feet)      1009 15m
2 Year   =    0.3754
5 Year   =    0.8898
10 Year  =    1.3013
25 Year  =    1.8563
50 Year  =    2.2752
100 Year =    2.6873

Annual Peaks
 1956         0.0166
 1957         0.3069
 1958         0.0000
 1959         0.0000
 1960         0.0107
 1961         0.0000
 1962         0.0000
 1963         0.1961
 1964         0.0000
 1965         0.0743
 1966         0.0000
 1967         0.0000
 1968         0.0000
 1969         0.0000
 1970         0.0000
 1971         0.0000
 1972         0.0758
 1973         0.0000
 1974         0.0000
 1975         0.0000
 1976         0.0000
 1977         0.0000
 1978         0.0196
 1979         0.0000
 1980         0.0000
 1981         0.0266
 1982         0.0053
 1983         0.0000
```

General Model Information

Project Name:	10367.e.Nisqually.MIXED.USE.1ac.landscape
Site Name:	Nisqually MU
Site Address:	
City:	
Report Date:	4/12/2023
Gage:	Fairgrounds (Kaiser)
Data Start:	1955/10/01
Data End:	2011/09/30
Timestep:	15 Minute
Precip Scale:	1.000
Version Date:	2021/08/18
Version:	4.2.18

POC Thresholds

Low Flow Threshold for POC1:	50 Percent of the 2 Year
High Flow Threshold for POC1:	50 Year

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Forest, Mod	1
Pervious Total	1
Impervious Land Use	acre
Impervious Total	0
Basin Total	1

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
A B, Lawn, Flat	1
Pervious Total	1
Impervious Land Use	acre
Impervious Total	0
Basin Total	1

Element Flows To:

Surface	Interflow	Groundwater
Surface retention 1	Surface retention 1	

Routing Elements

Predeveloped Routing

Mitigated Routing

Bioretention 1

Bottom Length:	40.00 ft.
Bottom Width:	10.00 ft.
Material thickness of first layer:	1.5
Material type for first layer:	SMMWW
Material thickness of second layer:	1.5
Material type for second layer:	GRAVEL
Material thickness of third layer:	0
Material type for third layer:	GRAVEL
Infiltration On	
Infiltration rate:	20
Infiltration safety factor:	0.5
Total Volume Infiltrated (ac-ft.):	1.674
Total Volume Through Riser (ac-ft.):	0.147
Total Volume Through Facility (ac-ft.):	1.821
Percent Infiltrated:	91.93
Total Precip Applied to Facility:	1.817
Total Evap From Facility:	0.475

Underdrain not used
Discharge Structure
Riser Height: 0.5 ft.
Riser Diameter: 12 in.
Element Flows To:
Outlet 1 Outlet 2
Gravel Trench Bed 2

Bioretention Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.0092	0.0000	0.0000	0.0000
0.0440	0.0092	0.0002	0.0000	0.0000
0.0879	0.0092	0.0003	0.0000	0.0000
0.1319	0.0092	0.0005	0.0000	0.0000
0.1758	0.0092	0.0006	0.0000	0.0000
0.2198	0.0092	0.0008	0.0000	0.0001
0.2637	0.0092	0.0010	0.0000	0.0001
0.3077	0.0092	0.0011	0.0000	0.0002
0.3516	0.0092	0.0013	0.0000	0.0002
0.3956	0.0092	0.0015	0.0000	0.0003
0.4396	0.0092	0.0016	0.0000	0.0004
0.4835	0.0092	0.0018	0.0000	0.0006
0.5275	0.0092	0.0019	0.0000	0.0007
0.5714	0.0092	0.0021	0.0000	0.0009
0.6154	0.0092	0.0023	0.0000	0.0011
0.6593	0.0092	0.0024	0.0000	0.0013
0.7033	0.0092	0.0026	0.0000	0.0014
0.7473	0.0092	0.0028	0.0000	0.0016
0.7912	0.0092	0.0029	0.0000	0.0019
0.8352	0.0092	0.0031	0.0000	0.0022
0.8791	0.0092	0.0032	0.0000	0.0026
0.9231	0.0092	0.0034	0.0000	0.0029
0.9670	0.0092	0.0036	0.0000	0.0034
1.0110	0.0092	0.0037	0.0000	0.0035
1.0549	0.0092	0.0039	0.0000	0.0038
1.0989	0.0092	0.0041	0.0000	0.0043

1.1429	0.0092	0.0042	0.0000	0.0048
1.1868	0.0092	0.0044	0.0000	0.0053
1.2308	0.0092	0.0045	0.0000	0.0059
1.2747	0.0092	0.0047	0.0000	0.0065
1.3187	0.0092	0.0049	0.0000	0.0067
1.3626	0.0092	0.0050	0.0000	0.0072
1.4066	0.0092	0.0052	0.0000	0.0079
1.4505	0.0092	0.0053	0.0000	0.0086
1.4945	0.0092	0.0055	0.0000	0.0094
1.5385	0.0092	0.0057	0.0000	0.0102
1.5824	0.0092	0.0058	0.0000	0.0111
1.6264	0.0092	0.0060	0.0000	0.0112
1.6703	0.0092	0.0062	0.0000	0.0120
1.7143	0.0092	0.0063	0.0000	0.0129
1.7582	0.0092	0.0065	0.0000	0.0138
1.8022	0.0092	0.0067	0.0000	0.0185
1.8462	0.0092	0.0069	0.0000	0.0185
1.8901	0.0092	0.0070	0.0000	0.0185
1.9341	0.0092	0.0072	0.0000	0.0185
1.9780	0.0092	0.0074	0.0000	0.0185
2.0220	0.0092	0.0075	0.0000	0.0185
2.0659	0.0092	0.0077	0.0000	0.0185
2.1099	0.0092	0.0079	0.0000	0.0185
2.1538	0.0092	0.0080	0.0000	0.0185
2.1978	0.0092	0.0082	0.0000	0.0185
2.2418	0.0092	0.0084	0.0000	0.0185
2.2857	0.0092	0.0085	0.0000	0.0185
2.3297	0.0092	0.0087	0.0000	0.0185
2.3736	0.0092	0.0089	0.0000	0.0185
2.4176	0.0092	0.0090	0.0000	0.0185
2.4615	0.0092	0.0092	0.0000	0.0185
2.5055	0.0092	0.0094	0.0000	0.0185
2.5495	0.0092	0.0095	0.0000	0.0185
2.5934	0.0092	0.0097	0.0000	0.0185
2.6374	0.0092	0.0099	0.0000	0.0185
2.6813	0.0092	0.0100	0.0000	0.0185
2.7253	0.0092	0.0102	0.0000	0.0185
2.7692	0.0092	0.0104	0.0000	0.0185
2.8132	0.0092	0.0105	0.0000	0.0185
2.8571	0.0092	0.0107	0.0000	0.0185
2.9011	0.0092	0.0109	0.0000	0.0185
2.9451	0.0092	0.0110	0.0000	0.0185
2.9890	0.0092	0.0112	0.0000	0.0185
3.0000	0.0092	0.0112	0.0000	0.0185

Bioretention Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**To Amended(cfs)**	**Infilt(cfs)**
3.0000	0.0092	0.0112	0.0000	0.0139	0.0000
3.0440	0.0092	0.0117	0.0000	0.0139	0.0000
3.0879	0.0092	0.0121	0.0000	0.0147	0.0000
3.1319	0.0092	0.0125	0.0000	0.0151	0.0000
3.1758	0.0092	0.0129	0.0000	0.0155	0.0000
3.2198	0.0092	0.0133	0.0000	0.0159	0.0000
3.2637	0.0092	0.0137	0.0000	0.0163	0.0000
3.3077	0.0092	0.0141	0.0000	0.0167	0.0000
3.3516	0.0092	0.0145	0.0000	0.0171	0.0000
3.3956	0.0092	0.0149	0.0000	0.0176	0.0000
3.4396	0.0092	0.0153	0.0000	0.0180	0.0000

3.4835	0.0092	0.0157	0.0000	0.0184	0.0000
3.5275	0.0092	0.0161	0.0483	0.0188	0.0000
3.5714	0.0092	0.0165	0.2020	0.0192	0.0000
3.6154	0.0092	0.0169	0.4122	0.0196	0.0000
3.6593	0.0092	0.0173	0.6597	0.0200	0.0000
3.7033	0.0092	0.0177	0.9282	0.0204	0.0000
3.7473	0.0092	0.0181	1.2008	0.0208	0.0000
3.7912	0.0092	0.0185	1.4606	0.0212	0.0000
3.8352	0.0092	0.0189	1.6924	0.0216	0.0000
3.8791	0.0092	0.0193	1.8845	0.0220	0.0000
3.9231	0.0092	0.0197	2.0318	0.0224	0.0000
3.9670	0.0092	0.0201	2.1391	0.0228	0.0000
4.0000	0.0092	0.0204	2.2515	0.0231	0.0000

Surface retention 1

Element Flows To:

Outlet 1	Outlet 2
Gravel Trench Bed 2	Bioretention 1

Gravel Trench Bed 2

Bottom Length:	58.00 ft.
Bottom Width:	10.00 ft.
Trench bottom slope 1:	0 To 1
Trench Left side slope 0:	0 To 1
Trench right side slope 2:	0 To 1
Material thickness of first layer:	3
Pour Space of material for first layer:	0.35
Material thickness of second layer:	0
Pour Space of material for second layer:	0
Material thickness of third layer:	0
Pour Space of material for third layer:	0
Infiltration On	
Infiltration rate:	20
Infiltration safety factor:	0.5
Total Volume Infiltrated (ac-ft.):	0.147
Total Volume Through Riser (ac-ft.):	0
Total Volume Through Facility (ac-ft.):	0.147
Percent Infiltrated:	100
Total Precip Applied to Facility:	0
Total Evap From Facility:	0

Discharge Structure

Riser Height:	3 ft.
Riser Diameter:	0 in.

Element Flows To:

Outlet 1	Outlet 2

Gravel Trench Bed Hydraulic Table

Stage(feet)	**Area(ac.)**	**Volume(ac-ft.)**	**Discharge(cfs)**	**Infilt(cfs)**
0.0000	0.013	0.000	0.000	0.000
0.0333	0.013	0.000	0.000	0.134
0.0667	0.013	0.000	0.000	0.134
0.1000	0.013	0.000	0.000	0.134
0.1333	0.013	0.000	0.000	0.134
0.1667	0.013	0.000	0.000	0.134
0.2000	0.013	0.000	0.000	0.134
0.2333	0.013	0.001	0.000	0.134
0.2667	0.013	0.001	0.000	0.134
0.3000	0.013	0.001	0.000	0.134
0.3333	0.013	0.001	0.000	0.134
0.3667	0.013	0.001	0.000	0.134
0.4000	0.013	0.001	0.000	0.134
0.4333	0.013	0.002	0.000	0.134
0.4667	0.013	0.002	0.000	0.134
0.5000	0.013	0.002	0.000	0.134
0.5333	0.013	0.002	0.000	0.134
0.5667	0.013	0.002	0.000	0.134
0.6000	0.013	0.002	0.000	0.134
0.6333	0.013	0.003	0.000	0.134
0.6667	0.013	0.003	0.000	0.134
0.7000	0.013	0.003	0.000	0.134
0.7333	0.013	0.003	0.000	0.134
0.7667	0.013	0.003	0.000	0.134
0.8000	0.013	0.003	0.000	0.134
0.8333	0.013	0.003	0.000	0.134

0.8667	0.013	0.004	0.000	0.134
0.9000	0.013	0.004	0.000	0.134
0.9333	0.013	0.004	0.000	0.134
0.9667	0.013	0.004	0.000	0.134
1.0000	0.013	0.004	0.000	0.134
1.0333	0.013	0.004	0.000	0.134
1.0667	0.013	0.005	0.000	0.134
1.1000	0.013	0.005	0.000	0.134
1.1333	0.013	0.005	0.000	0.134
1.1667	0.013	0.005	0.000	0.134
1.2000	0.013	0.005	0.000	0.134
1.2333	0.013	0.005	0.000	0.134
1.2667	0.013	0.005	0.000	0.134
1.3000	0.013	0.006	0.000	0.134
1.3333	0.013	0.006	0.000	0.134
1.3667	0.013	0.006	0.000	0.134
1.4000	0.013	0.006	0.000	0.134
1.4333	0.013	0.006	0.000	0.134
1.4667	0.013	0.006	0.000	0.134
1.5000	0.013	0.007	0.000	0.134
1.5333	0.013	0.007	0.000	0.134
1.5667	0.013	0.007	0.000	0.134
1.6000	0.013	0.007	0.000	0.134
1.6333	0.013	0.007	0.000	0.134
1.6667	0.013	0.007	0.000	0.134
1.7000	0.013	0.007	0.000	0.134
1.7333	0.013	0.008	0.000	0.134
1.7667	0.013	0.008	0.000	0.134
1.8000	0.013	0.008	0.000	0.134
1.8333	0.013	0.008	0.000	0.134
1.8667	0.013	0.008	0.000	0.134
1.9000	0.013	0.008	0.000	0.134
1.9333	0.013	0.009	0.000	0.134
1.9667	0.013	0.009	0.000	0.134
2.0000	0.013	0.009	0.000	0.134
2.0333	0.013	0.009	0.000	0.134
2.0667	0.013	0.009	0.000	0.134
2.1000	0.013	0.009	0.000	0.134
2.1333	0.013	0.009	0.000	0.134
2.1667	0.013	0.010	0.000	0.134
2.2000	0.013	0.010	0.000	0.134
2.2333	0.013	0.010	0.000	0.134
2.2667	0.013	0.010	0.000	0.134
2.3000	0.013	0.010	0.000	0.134
2.3333	0.013	0.010	0.000	0.134
2.3667	0.013	0.011	0.000	0.134
2.4000	0.013	0.011	0.000	0.134
2.4333	0.013	0.011	0.000	0.134
2.4667	0.013	0.011	0.000	0.134
2.5000	0.013	0.011	0.000	0.134
2.5333	0.013	0.011	0.000	0.134
2.5667	0.013	0.012	0.000	0.134
2.6000	0.013	0.012	0.000	0.134
2.6333	0.013	0.012	0.000	0.134
2.6667	0.013	0.012	0.000	0.134
2.7000	0.013	0.012	0.000	0.134
2.7333	0.013	0.012	0.000	0.134
2.7667	0.013	0.012	0.000	0.134

2.8000	0.013	0.013	0.000	0.134
2.8333	0.013	0.013	0.000	0.134
2.8667	0.013	0.013	0.000	0.134
2.9000	0.013	0.013	0.000	0.134
2.9333	0.013	0.013	0.000	0.134
2.9667	0.013	0.013	0.000	0.134
3.0000	0.013	0.014	0.000	0.134

Analysis Results

POC 1

POC #1 was not reported because POC must exist in both scenarios and both scenarios must have been run.

Model Default Modifications

Total of 0 changes have been made.

PERLND Changes

No PERLND changes have been made.

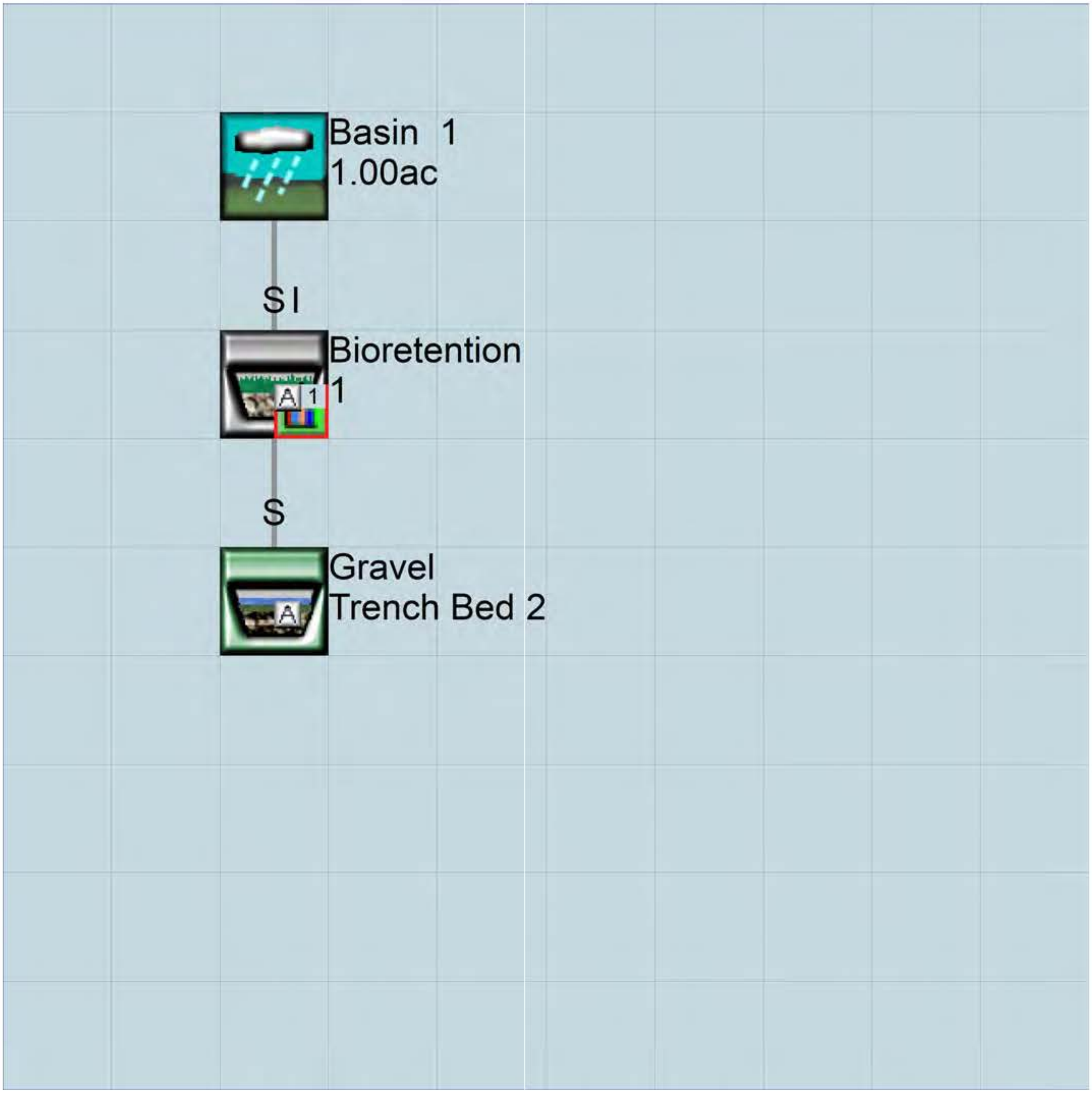
IMPLND Changes

No IMPLND changes have been made.

Appendix

Predeveloped Schematic

Mitigated Schematic



Predeveloped UCI File

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1955 10 01        END    2011 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM        26   10367.e.Nisqually.MIXED.USE.1ac.landscape.wdm
MESSU      25   Mit10367.e.Nisqually.MIXED.USE.1ac.landscape.MES
           27   Mit10367.e.Nisqually.MIXED.USE.1ac.landscape.L61
           28   Mit10367.e.Nisqually.MIXED.USE.1ac.landscape.L62
           30   POC10367.e.Nisqually.MIXED.USE.1ac.landscape1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND       7
      GENER        2
      RCHRES       1
      RCHRES       2
      RCHRES       3
      COPY         1
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Surface retention  1        MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
    2        24
  END OPCODE
  PARM
    #    #         K ***
    2             0.
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                        User  t-series Engl Metr ***
                                         in  out           ***
    7     A/B, Lawn, Flat         1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
    7         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
```

```
  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
    7         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
    7         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
    7             0         5       0.8       400      0.05       0.3     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
    7             0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                               ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
    7           0.1       0.5      0.25         0       0.7      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
              ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS      AGWS      GWVS
    7             0         0         0         0         3         1         0
  END PWAT-STATE1

END PERLND

IMPLND
  GEN-INFO
    <PLS ><-------Name------->   Unit-systems   Printer ***
    # -  #                     User  t-series Engl Metr ***
                                      in  out           ***
  END GEN-INFO
  *** Section IWATER***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
```

```
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND   7                          1      RCHRES   1      2
PERLND   7                          1      RCHRES   1      3

******Routing******
PERLND   7                          1      COPY     1     12
PERLND   7                          1      COPY     1     13
RCHRES   2                          1      RCHRES   3      7
RCHRES   1                          1      RCHRES   3      7
RCHRES   1                          1      RCHRES   2      8
RCHRES   2                          1      COPY   501     17
RCHRES   1                          1      COPY   501     17
END SCHEMATIC

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1
GENER    2 OUTPUT TIMSER      .0011111     RCHRES   1     EXTNL  OUTDGT 1



<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
END NETWORK

RCHRES
  GEN-INFO
    RCHRES       Name        Nexits   Unit Systems   Printer                 ***
    # -  #<------------------><---> User T-series  Engl Metr LKFG            ***
                                            in  out                          ***
    1     Surface retentio-006    2    1    1    1   28    0    1
    2     Bioretention  1         2    1    1    1   28    0    1
    3     Gravel Trench Be-007    2    1    1    1   28    0    1
  END GEN-INFO
  *** Section RCHRES***

  ACTIVITY
    <PLS > ************* Active Sections *****************************
    # -  # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFG PKFG PHFG ***
    1         1    0    0    0    0    0    0    0    0    0
    2         1    0    0    0    0    0    0    0    0    0
    3         1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ******************* PIVL  PYR
    # -  # HYDR ADCA CONS HEAT  SED  GQL OXRX NUTR PLNK PHCB PIVL  PYR  *********
    1         4    0    0    0    0    0    0    0    0    0    1    9
    2         4    0    0    0    0    0    0    0    0    0    1    9
    3         4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  HYDR-PARM1
    RCHRES  Flags for each HYDR Section                                      ***
    # -  #  VC A1 A2 A3  ODFVFG for each *** ODGTFG for each     FUNCT  for each
            FG FG FG FG  possible  exit  *** possible  exit      possible  exit
             *  *  *  *    *  *  *  *  *       *  *  *  *  *         ***
```

```
    1        0  1  0  0    4  5  0  0  0       0  1  0  0  0       2  1  2  2  2
    2        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
    3        0  1  0  0    4  5  0  0  0       0  0  0  0  0       2  2  2  2  2
  END HYDR-PARM1

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1             1      0.01       0.0       0.0       0.0       0.0
    2             2      0.01       0.0       0.0       0.0       0.0
    3             3      0.01       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                         ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
          *** ac-ft     for each possible exit       for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    2           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
    3           0         4.0  5.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
*** User-Defined Variable Quantity Lines
***                          addr
***                        <------>
*** kwd  varnam optyp  opn  vari  s1 s2 s3 tp multiply  lc ls ac as agfn ***
  <****> <----> <----> <-> <----><-><-><-><-><--------> <><-> <><-> <--> ***
  UVQUAN vol2   RCHRES   2 VOL              4
  UVQUAN v2m2   GLOBAL     WORKSP  1        3
  UVQUAN vpo2   GLOBAL     WORKSP  2        3
  UVQUAN v2d2   GENER    2 K       1        3
*** User-Defined Target Variable Names
***                    addr or                        addr or
***                   <------>                       <------>
*** kwd   varnam ct  vari  s1 s2 s3  frac oper     vari  s1 s2 s3  frac oper
  <****>  <----><-> <----><-><-><-> <---> <-->    <----><-><-><-> <---> <-->
  UVNAME  v2m2    1 WORKSP  1         1.0 QUAN
  UVNAME  vpo2    1 WORKSP  2         1.0 QUAN
  UVNAME  v2d2    1 K       1         1.0 QUAN
*** opt foplop dcdts  yr mo dy hr mn d t   vnam  s1 s2 s3 ac quantity  tc  ts rp
  <****><-><--><><-><--> <> <> <> <><><>  <----><-><-><-><-><--------> <> <-><->
  GENER   2                               v2m2            =  506.6
*** Compute remaining available pore space
  GENER   2                               vpo2            =  v2m2
  GENER   2                               vpo2           -=  vol2
*** Check to see if VPORA goes negative; if so set VPORA = 0.0
IF (vpo2 < 0.0) THEN
  GENER   2                               vpo2            =  0.0
END IF
*** Infiltration volume
  GENER   2                               v2d2            =  vpo2
END SPEC-ACTIONS
FTABLES
  FTABLE      2
   70    5
     Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
      (ft)   (acres) (acre-ft)    (cfs)     (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.009183  0.000000  0.000000  0.000000
  0.043956  0.009183  0.000162  0.000000  0.000000
  0.087912  0.009183  0.000324  0.000000  0.000000
  0.131868  0.009183  0.000486  0.000000  0.000000
  0.175824  0.009183  0.000648  0.000000  0.000000
  0.219780  0.009183  0.000810  0.000000  0.000058
  0.263736  0.009183  0.000972  0.000000  0.000100
  0.307692  0.009183  0.001134  0.000000  0.000158
  0.351648  0.009183  0.001296  0.000000  0.000232
  0.395604  0.009183  0.001459  0.000000  0.000325
  0.439560  0.009183  0.001621  0.000000  0.000438
```

```
0.483516  0.009183  0.001783  0.000000  0.000572
0.527473  0.009183  0.001945  0.000000  0.000730
0.571429  0.009183  0.002107  0.000000  0.000911
0.615385  0.009183  0.002269  0.000000  0.001117
0.659341  0.009183  0.002431  0.000000  0.001350
0.703297  0.009183  0.002593  0.000000  0.001441
0.747253  0.009183  0.002755  0.000000  0.001610
0.791209  0.009183  0.002917  0.000000  0.001898
0.835165  0.009183  0.003079  0.000000  0.002216
0.879121  0.009183  0.003241  0.000000  0.002564
0.923077  0.009183  0.003403  0.000000  0.002943
0.967033  0.009183  0.003565  0.000000  0.003354
1.010989  0.009183  0.003727  0.000000  0.003483
1.054945  0.009183  0.003889  0.000000  0.003798
1.098901  0.009183  0.004052  0.000000  0.004276
1.142857  0.009183  0.004214  0.000000  0.004789
1.186813  0.009183  0.004376  0.000000  0.005336
1.230769  0.009183  0.004538  0.000000  0.005920
1.274725  0.009183  0.004700  0.000000  0.006540
1.318681  0.009183  0.004862  0.000000  0.006668
1.362637  0.009183  0.005024  0.000000  0.007198
1.406593  0.009183  0.005186  0.000000  0.007894
1.450549  0.009183  0.005348  0.000000  0.008628
1.494505  0.009183  0.005510  0.000000  0.009402
1.538462  0.009183  0.005678  0.000000  0.010214
1.582418  0.009183  0.005845  0.000000  0.011065
1.626374  0.009183  0.006013  0.000000  0.011158
1.670330  0.009183  0.006180  0.000000  0.011955
1.714286  0.009183  0.006348  0.000000  0.012880
1.758242  0.009183  0.006515  0.000000  0.013815
1.802198  0.009183  0.006683  0.000000  0.018519
1.846154  0.009183  0.006850  0.000000  0.018519
1.890110  0.009183  0.007018  0.000000  0.018519
1.934066  0.009183  0.007185  0.000000  0.018519
1.978022  0.009183  0.007353  0.000000  0.018519
2.021978  0.009183  0.007520  0.000000  0.018519
2.065934  0.009183  0.007688  0.000000  0.018519
2.109890  0.009183  0.007855  0.000000  0.018519
2.153846  0.009183  0.008023  0.000000  0.018519
2.197802  0.009183  0.008190  0.000000  0.018519
2.241758  0.009183  0.008358  0.000000  0.018519
2.285714  0.009183  0.008525  0.000000  0.018519
2.329670  0.009183  0.008693  0.000000  0.018519
2.373626  0.009183  0.008860  0.000000  0.018519
2.417582  0.009183  0.009028  0.000000  0.018519
2.461538  0.009183  0.009195  0.000000  0.018519
2.505495  0.009183  0.009363  0.000000  0.018519
2.549451  0.009183  0.009530  0.000000  0.018519
2.593407  0.009183  0.009698  0.000000  0.018519
2.637363  0.009183  0.009865  0.000000  0.018519
2.681319  0.009183  0.010033  0.000000  0.018519
2.725275  0.009183  0.010200  0.000000  0.018519
2.769231  0.009183  0.010368  0.000000  0.018519
2.813187  0.009183  0.010535  0.000000  0.018519
2.857143  0.009183  0.010703  0.000000  0.018519
2.901099  0.009183  0.010870  0.000000  0.018519
2.945055  0.009183  0.011038  0.000000  0.018519
2.989011  0.009183  0.011205  0.000000  0.018519
3.000000  0.009183  0.011630  0.000000  0.018519
END FTABLE  2
FTABLE      1
 24    5
   Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
    (ft)   (acres) (acre-ft)   (cfs)      (cfs)   (ft/sec)    (Minutes)***
0.000000  0.009183  0.000000  0.000000  0.000000
0.043956  0.009183  0.000404  0.000000  0.013889
0.087912  0.009183  0.000807  0.000000  0.014703
0.131868  0.009183  0.001211  0.000000  0.015110
0.175824  0.009183  0.001615  0.000000  0.015517
0.219780  0.009183  0.002018  0.000000  0.015924
```

```
0.263736  0.009183  0.002422  0.000000  0.016331
0.307692  0.009183  0.002825  0.000000  0.016738
0.351648  0.009183  0.003229  0.000000  0.017145
0.395604  0.009183  0.003633  0.000000  0.017552
0.439560  0.009183  0.004036  0.000000  0.017959
0.483516  0.009183  0.004440  0.000000  0.018366
0.527473  0.009183  0.004844  0.048301  0.018773
0.571429  0.009183  0.005247  0.202028  0.019180
0.615385  0.009183  0.005651  0.412175  0.019587
0.659341  0.009183  0.006055  0.659695  0.019994
0.703297  0.009183  0.006458  0.928167  0.020401
0.747253  0.009183  0.006862  1.200769  0.020808
0.791209  0.009183  0.007265  1.460630  0.021215
0.835165  0.009183  0.007669  1.692395  0.021622
0.879121  0.009183  0.008073  1.884482  0.022029
0.923077  0.009183  0.008476  2.031838  0.022436
0.967033  0.009183  0.008880  2.139092  0.022843
1.000000  0.009183  0.009183  2.251466  0.023148
END FTABLE  1
FTABLE      3
 92    5
   Depth      Area    Volume  Outflow1  Outflow2  Velocity  Travel Time***
    (ft)   (acres) (acre-ft)   (cfs)      (cfs)   (ft/sec)    (Minutes)***
0.000000  0.013315  0.000000  0.000000  0.000000
0.033333  0.013315  0.000155  0.000000  0.134259
0.066667  0.013315  0.000311  0.000000  0.134259
0.100000  0.013315  0.000466  0.000000  0.134259
0.133333  0.013315  0.000621  0.000000  0.134259
0.166667  0.013315  0.000777  0.000000  0.134259
0.200000  0.013315  0.000932  0.000000  0.134259
0.233333  0.013315  0.001087  0.000000  0.134259
0.266667  0.013315  0.001243  0.000000  0.134259
0.300000  0.013315  0.001398  0.000000  0.134259
0.333333  0.013315  0.001553  0.000000  0.134259
0.366667  0.013315  0.001709  0.000000  0.134259
0.400000  0.013315  0.001864  0.000000  0.134259
0.433333  0.013315  0.002019  0.000000  0.134259
0.466667  0.013315  0.002175  0.000000  0.134259
0.500000  0.013315  0.002330  0.000000  0.134259
0.533333  0.013315  0.002485  0.000000  0.134259
0.566667  0.013315  0.002641  0.000000  0.134259
0.600000  0.013315  0.002796  0.000000  0.134259
0.633333  0.013315  0.002951  0.000000  0.134259
0.666667  0.013315  0.003107  0.000000  0.134259
0.700000  0.013315  0.003262  0.000000  0.134259
0.733333  0.013315  0.003418  0.000000  0.134259
0.766667  0.013315  0.003573  0.000000  0.134259
0.800000  0.013315  0.003728  0.000000  0.134259
0.833333  0.013315  0.003884  0.000000  0.134259
0.866667  0.013315  0.004039  0.000000  0.134259
0.900000  0.013315  0.004194  0.000000  0.134259
0.933333  0.013315  0.004350  0.000000  0.134259
0.966667  0.013315  0.004505  0.000000  0.134259
1.000000  0.013315  0.004660  0.000000  0.134259
1.033333  0.013315  0.004816  0.000000  0.134259
1.066667  0.013315  0.004971  0.000000  0.134259
1.100000  0.013315  0.005126  0.000000  0.134259
1.133333  0.013315  0.005282  0.000000  0.134259
1.166667  0.013315  0.005437  0.000000  0.134259
1.200000  0.013315  0.005592  0.000000  0.134259
1.233333  0.013315  0.005748  0.000000  0.134259
1.266667  0.013315  0.005903  0.000000  0.134259
1.300000  0.013315  0.006058  0.000000  0.134259
1.333333  0.013315  0.006214  0.000000  0.134259
1.366667  0.013315  0.006369  0.000000  0.134259
1.400000  0.013315  0.006524  0.000000  0.134259
1.433333  0.013315  0.006680  0.000000  0.134259
1.466667  0.013315  0.006835  0.000000  0.134259
1.500000  0.013315  0.006990  0.000000  0.134259
1.533333  0.013315  0.007146  0.000000  0.134259
```

```
  1.566667  0.013315  0.007301  0.000000  0.134259
  1.600000  0.013315  0.007456  0.000000  0.134259
  1.633333  0.013315  0.007612  0.000000  0.134259
  1.666667  0.013315  0.007767  0.000000  0.134259
  1.700000  0.013315  0.007922  0.000000  0.134259
  1.733333  0.013315  0.008078  0.000000  0.134259
  1.766667  0.013315  0.008233  0.000000  0.134259
  1.800000  0.013315  0.008388  0.000000  0.134259
  1.833333  0.013315  0.008544  0.000000  0.134259
  1.866667  0.013315  0.008699  0.000000  0.134259
  1.900000  0.013315  0.008854  0.000000  0.134259
  1.933333  0.013315  0.009010  0.000000  0.134259
  1.966667  0.013315  0.009165  0.000000  0.134259
  2.000000  0.013315  0.009320  0.000000  0.134259
  2.033333  0.013315  0.009476  0.000000  0.134259
  2.066667  0.013315  0.009631  0.000000  0.134259
  2.100000  0.013315  0.009787  0.000000  0.134259
  2.133333  0.013315  0.009942  0.000000  0.134259
  2.166667  0.013315  0.010097  0.000000  0.134259
  2.200000  0.013315  0.010253  0.000000  0.134259
  2.233333  0.013315  0.010408  0.000000  0.134259
  2.266667  0.013315  0.010563  0.000000  0.134259
  2.300000  0.013315  0.010719  0.000000  0.134259
  2.333333  0.013315  0.010874  0.000000  0.134259
  2.366667  0.013315  0.011029  0.000000  0.134259
  2.400000  0.013315  0.011185  0.000000  0.134259
  2.433333  0.013315  0.011340  0.000000  0.134259
  2.466667  0.013315  0.011495  0.000000  0.134259
  2.500000  0.013315  0.011651  0.000000  0.134259
  2.533333  0.013315  0.011806  0.000000  0.134259
  2.566667  0.013315  0.011961  0.000000  0.134259
  2.600000  0.013315  0.012117  0.000000  0.134259
  2.633333  0.013315  0.012272  0.000000  0.134259
  2.666667  0.013315  0.012427  0.000000  0.134259
  2.700000  0.013315  0.012583  0.000000  0.134259
  2.733333  0.013315  0.012738  0.000000  0.134259
  2.766667  0.013315  0.012893  0.000000  0.134259
  2.800000  0.013315  0.013049  0.000000  0.134259
  2.833333  0.013315  0.013204  0.000000  0.134259
  2.866667  0.013315  0.013359  0.000000  0.134259
  2.900000  0.013315  0.013515  0.000000  0.134259
  2.933333  0.013315  0.013670  0.000000  0.134259
  2.966667  0.013315  0.013825  0.000000  0.134259
  3.000000  0.013315  0.013981  0.000000  0.134259
  3.033333  0.013315  0.014425  0.000000  0.134259
  END FTABLE  3
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    1               PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    1               IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76            PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76            IMPLND   1 999 EXTNL  PETINP
WDM      2 PREC     ENGL    1               RCHRES   1     EXTNL  PREC
WDM      1 EVAP     ENGL    0.5             RCHRES   1     EXTNL  POTEV
WDM      1 EVAP     ENGL    0.76            RCHRES   2     EXTNL  POTEV

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
RCHRES   2 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   2 HYDR   O      1 1        1      WDM   1001 FLOW     ENGL      REPL
RCHRES   2 HYDR   O      2 1        1      WDM   1002 FLOW     ENGL      REPL
RCHRES   2 HYDR   STAGE  1 1        1      WDM   1003 STAG     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1004 STAG     ENGL      REPL
RCHRES   1 HYDR   O      1 1        1      WDM   1005 FLOW     ENGL      REPL
```

```
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
RCHRES   3 HYDR   RO     1 1        1      WDM   1006 FLOW     ENGL      REPL
RCHRES   3 HYDR   O      1 1        1      WDM   1007 FLOW     ENGL      REPL
RCHRES   3 HYDR   O      2 1        1      WDM   1008 FLOW     ENGL      REPL
RCHRES   3 HYDR   STAGE  1 1        1      WDM   1009 STAG     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK        2
PERLND     PWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    2

  MASS-LINK        3
PERLND     PWATER IFWO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    3

  MASS-LINK        7
RCHRES     OFLOW  OVOL   1                 RCHRES         INFLOW IVOL
  END MASS-LINK    7

  MASS-LINK        8
RCHRES     OFLOW  OVOL   2                 RCHRES         INFLOW IVOL
  END MASS-LINK    8

  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

  MASS-LINK       13
PERLND     PWATER IFWO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   13

  MASS-LINK       17
RCHRES     OFLOW  OVOL   1                 COPY           INPUT  MEAN
  END MASS-LINK   17


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 16:15

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS        V1         V2        VOL
92 6.0901E+02  628.35     715.06
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 16:15

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -6.360E+03    5.4831  5.4831E+00      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 16:30

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS        V1         V2        VOL
92 6.0901E+02  628.35     832.37
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 16:30

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -1.340E+04   11.548     11.548        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 16:45

RCHRES:     3
```

```
The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1          V2        VOL
92  609.01     628.35     982.86
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 16:45

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -2.242E+04   19.330     19.330        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 17: 0

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1          V2        VOL
92  609.01     628.35    1180.2
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 17: 0

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -3.426E+04   29.535   2.9535E+01      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 17:15

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1          V2        VOL
92 6.0901E+02  628.35    1395.3
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 17:15

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -4.716E+04   40.657     40.657         2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 17:30

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92  609.01     628.35    1631.0
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 17:30

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -6.129E+04   52.840   5.2840E+01       2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 17:45

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92 6.0901E+02  628.35    1876.0
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 17:45

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
```

```
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -7.599E+04   65.508     65.508        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 18: 0

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92  609.01     628.35    2068.0
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 18: 0

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -8.751E+04   75.436     75.436        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 18:15

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92  609.01     628.35    2132.1
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 18:15

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -9.135E+04   78.748     78.748        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 18:30
```

```
RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92  609.01     628.35    2156.4
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 18:30

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -9.281E+04   80.006     80.006        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 18:45

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92  609.01     628.35    2176.9
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 18:45

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -9.404E+04   81.066   8.1066E+01      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 19: 0

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:
```

```
NROWS         V1         V2        VOL
92 6.0901E+02  628.35    2159.9
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 19: 0

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -9.302E+04   80.189     80.189        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 19:15

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92  609.01     628.35    2094.4
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 19:15

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -8.909E+04   76.799     76.799        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 19:30

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92  609.01     628.35    1995.5
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 19:30

RCHRES:     3
```

```
Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -8.316E+04   71.687     71.687        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 19:45

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1          V2         VOL
92  609.01     628.35    1874.6
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 19:45

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -7.591E+04   65.439   6.5439E+01      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 20: 0

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1          V2         VOL
92 6.0901E+02  628.35    1753.8
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 20: 0

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -6.866E+04   59.191   5.9191E+01      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 20:15

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1          V2        VOL
92 6.0901E+02  628.35    1633.0
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 20:15

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -6.141E+04   52.944   5.2944E+01      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 20:30

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1          V2        VOL
92 6.0901E+02  628.35    1512.1
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 20:30

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -5.417E+04   46.696   4.6696E+01      2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 20:45

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
```

```
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92 6.0901E+02  628.35    1391.3
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 20:45

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -4.692E+04   40.449     40.449        2
```

```
ERROR/WARNING ID:   341   6

DATE/TIME: 1991/ 4/ 4 21: 0

RCHRES:     3

The volume of water in this reach/mixed reservoir is greater than the value
in the "volume" column of the last row of RCHTAB().  To continue the
simulation the table has been extrapolated, based on information contained
in the last two rows.  This will usually result in some loss of accuracy.
If depth is being calculated it will also cause an error condition.
Relevant data are:

NROWS         V1         V2        VOL
92  609.01     628.35    1270.5
```

```
The count for the WARNING printed above has reached its maximum.

If the condition is encountered again the message will not be repeated.
```

```
ERROR/WARNING ID:   341   5

DATE/TIME: 1991/ 4/ 4 21: 0

RCHRES:     3

Calculation of relative depth, using Newton's method of successive
approximations, converged to an invalid value (not in range 0.0 to 1.0).
Probably ftable was extrapolated.  If extrapolation was small, no problem.
Remedy; extend ftable.  Relevant data are:

A          B          C      RDEP1      RDEP2  COUNT
0.0000E+00 1160.0     -3.967E+04   34.201   3.4201E+01      2
```

Disclaimer

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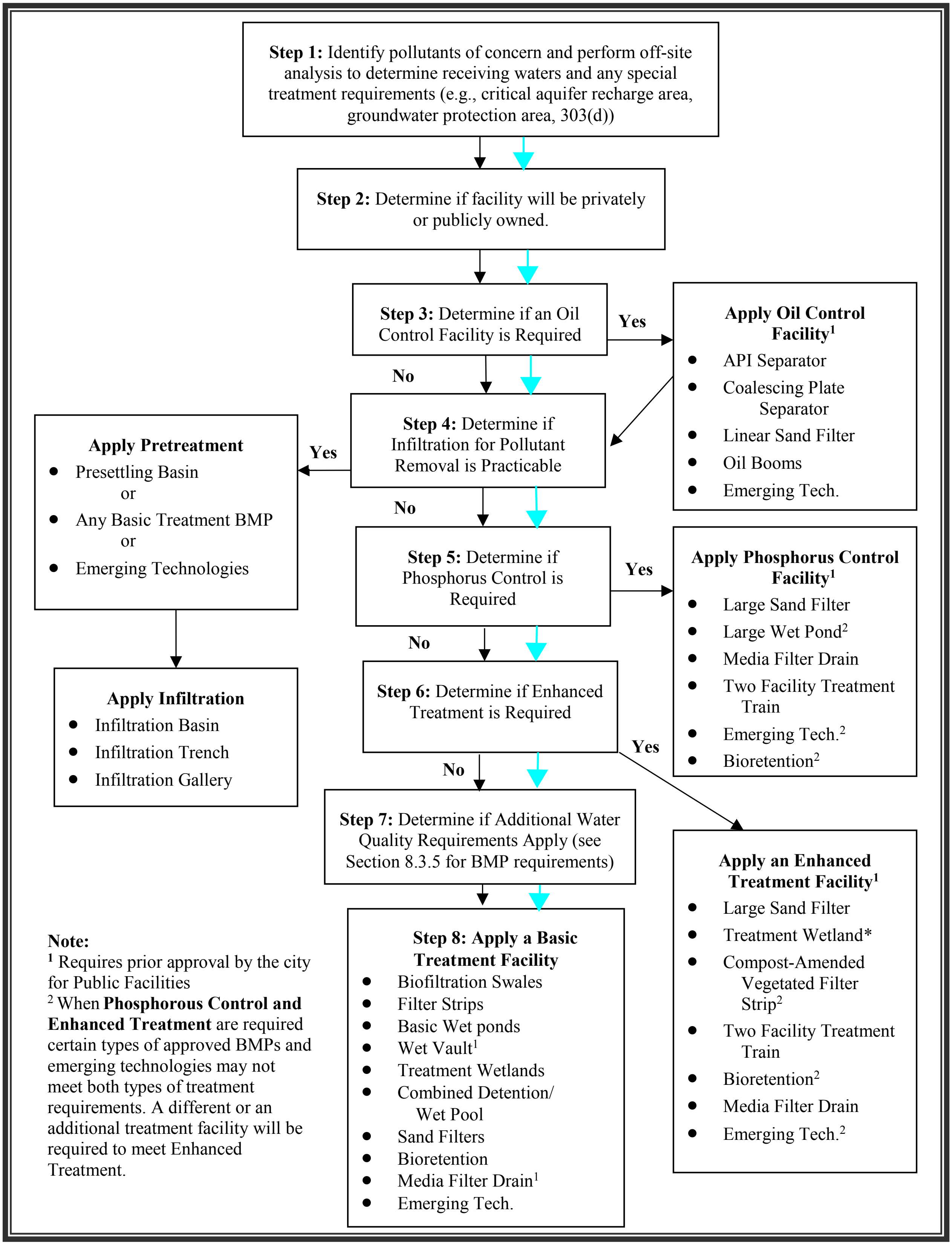
APPENDIX C



Note:
[1] Requires prior approval by the city for Public Facilities
[2] When **Phosphorous Control and Enhanced Treatment** are required certain types of approved BMPs and emerging technologies may not meet both types of treatment requirements. A different or an additional treatment facility will be required to meet Enhanced Treatment.

Figure 8.1. Treatment Facility Selection Flow Chart.

7.4.4 Bioretention Cells, Swales, and Planter Boxes (Ecology BMPs T5.14B and T7.30)

Description

Bioretention BMPs are shallow stormwater systems with a designed soil mix and plants adapted to the local climate and soil moisture conditions. Bioretention BMPs are designed to mimic a forested condition by controlling stormwater through detention, infiltration, and evapotranspiration. Bioretention BMPs also provide runoff treatment through sedimentation, filtration, adsorption, and phytoremediation.

Bioretention BMPs function by storing stormwater as surface ponding before it filters through the underlying amended soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is infiltrated into the underlying soil.

The terms “bioretention” and “rain garden” are sometimes used interchangeably. Bioretention BMPs and rain gardens are applications of the same LID concept and can be highly effective for reducing surface runoff and removing pollutants. However, in the City (in accordance with Ecology’s distinction), the term “bioretention” is used to describe an engineered BMP that includes designed soil mixes and perhaps underdrains and control structures. The term “rain garden” is used to describe a shallow landscaped depression on small project sites that only trigger Core Requirements #1 through #5. Rain gardens have less restrictive design criteria for the soil mix and do not include underdrains or other control structures. See Section 7.4.5 for more information on rain garden design.

The term bioretention is used to describe various designs using soil and plant complexes to manage stormwater. The following bioretention-related terminology is used in this manual:

- **Bioretention cells** are shallow depressions with a designed planting soil mix and a variety of plant material, including trees, shrubs, grasses, and/or other herbaceous plants. Bioretention cells may or may not have an underdrain and are not designed as a conveyance system. Bioretention cells can be configured as depressed landscape islands, larger basins, planters, or vegetated curb extensions.

- **Bioretention swales** incorporate the same design features as bioretention cells; however, bioretention swales are designed as part of a system that can convey stormwater when maximum ponding depth is exceeded. Bioretention swales have relatively gentle side slopes and ponding depths that are typically 6 to 12 inches.

- **Bioretention planters and planter boxes** incorporate designed soil mix and a variety of plant material including trees, shrubs, grasses, and/or other herbaceous plants within a vertical walled container usually constructed from formed concrete, but could include other materials. Planter boxes are completely impervious and include a bottom (must include an underdrain). Planters have an open bottom and allow infiltration to the subgrade. These designs are often used in ultra-urban settings.

Note: Ecology has approved use of certain patented treatment systems that use specific, high flow rate media for treatment. These systems may be similar to bioretention BMPs, but unless specifically approved by Ecology are not considered on-site stormwater management BMPs and are not options for meeting the requirements of Core Requirement #5. The Ecology approval (General Use Level Designations only) is meant to be used to meet Core Requirement #6, where appropriate.

Figure 7.6 provides an example illustration of a bioretention BMP. See Figure 7.7 for an example of a bioretention planter. Refer to the DG&PWS for standard detail drawings.

Applications and Limitations

Bioretention provides effective removal of many stormwater pollutants by passing stormwater through a soil profile that meets specified characteristics. Bioretention BMPs that infiltrate stormwater into the ground can also serve a significant flow reduction function.

- Bioretention BMPs are an on-site stormwater management BMP option for:

  1) Projects that only have to comply with Core Requirements #1 through #5, and

  2) Projects that trigger Core Requirements #1 through #9.

- Bioretention can achieve the LID Performance Standard option or can be applied from the List #1 or List #2 option of Core Requirement #5.

- Bioretention BMPs may meet the Core Requirement #6 requirements for basic and enhanced treatment (see Chapter 2 and Chapter 8) when the bioretention soil meets the requirements described under the Bioretention Soil Mix subsection below.

- Bioretention can be designed to fully meet the flow control duration standard of Core Requirement #7. However, because they typically do not have an orifice restricting overflow or underflow discharge rates, most designs typically don’t fully meet Core Requirement #7. Nonetheless, their performance contributes to meeting the standard, and that can result in much smaller flow control BMPs on the project site.

- Bioretention BMPs are particularly effective at flow control in locations where the underlying soil has a high infiltration rate. Where the native soils have low infiltration rates, underdrain systems can be installed and the BMP used to filter pollutants and detain flows that exceed infiltration capacity of the surrounding soil. However, designs utilizing underdrains provide less flow control benefits.

- Bioretention constructed with imported composted material should not be used within one-quarter mile of phosphorus-sensitive waterbodies if the underlying native soil does not meet the requirements for treatment soil provided in Chapter 8, Section 8.6.3.

- Bioretention constructed with imported composted material and underdrains are not allowed when the underdrain is upstream of a phosphorus-sensitive receiving water because preliminary monitoring indicates that bioretention BMPs constructed with imported composted material can add phosphorus to stormwater.

    - Phosphorus-sensitive waterbodies include:

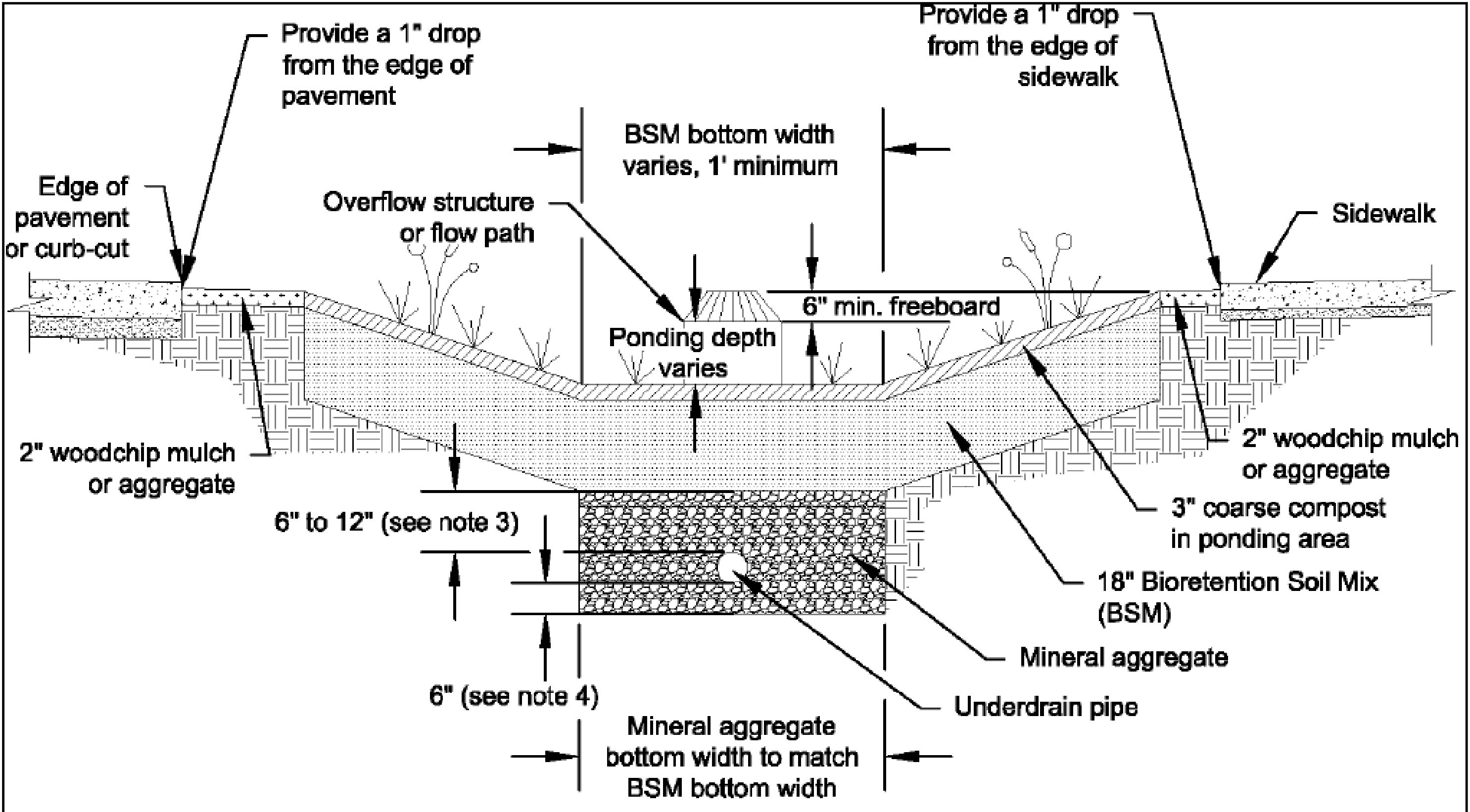
        - All lakes and ponds

        - Waterbodies listed in lake management plans, water quality improvement plans, or salmon recovery plans that recommend reducing sources of phosphorus in order to control aquatic plant growth

        - Surface waters listed on the state (303)d list for dissolved oxygen or pH due partly, or entirely, to elevated nutrient concentrations

    - High-performance bioretention soil mixes may be used in locations near phosphorus-sensitive waterbodies. Refer to the latest guidance on using high-performance mixes, available on Ecology's website at: <https://fortress.wa.gov/ecy/publications/SummaryPages/2110023.html>

- Because bioretention BMPs use an imported soil mix that has a moderate design infiltration rate, they are best applied for small drainage areas, and near the source of the stormwater. Cells may be scattered throughout a subdivision, a swale may run alongside the access road, or a series of planter boxes may serve the road.



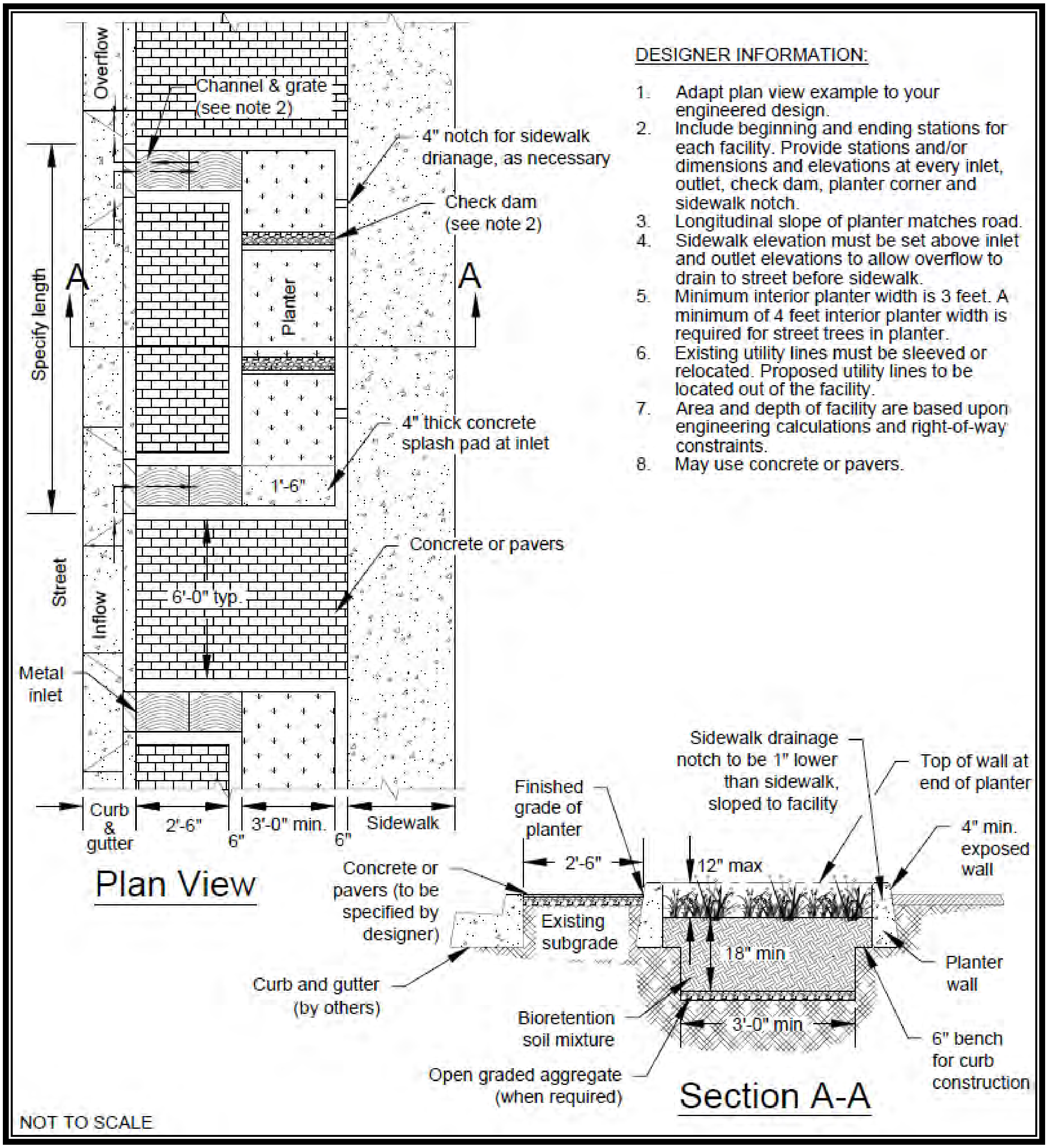
Notes:

1. Scarify subgrade 3" min. before BSM installation
2. Compact BSM to 85% per ASTM 1577
3. Minimum 6" to discourage fines from entering the underdrain from the BSM. Maximum 12" to prevent unnecessary BMP depth from encroaching into the seasonal high ground water.
4. If depth to the seasonal high ground water allows, this distance may be larger.
5. When an underdrain is used, the design must ensure that the seasonal high ground water does not encroach into the BMP (including the mineral aggregate layer surrounding the underdrain pipe).

NOT TO SCALE

Source: Ecology

Figure 7.6. Bioretention (shown with optional underdrain).



DESIGNER INFORMATION:

1. Adapt plan view example to your engineered design.
2. Include beginning and ending stations for each facility. Provide stations and/or dimensions and elevations at every inlet, outlet, check dam, planter corner and sidewalk notch.
3. Longitudinal slope of planter matches road.
4. Sidewalk elevation must be set above inlet and outlet elevations to allow overflow to drain to street before sidewalk.
5. Minimum interior planter width is 3 feet. A minimum of 4 feet interior planter width is required for street trees in planter.
6. Existing utility lines must be sleeved or relocated. Proposed utility lines to be located out of the facility.
7. Area and depth of facility are based upon engineering calculations and right-of-way constraints.
8. May use concrete or pavers.

Source: Ecology

Figure 7.7. Example of a Bioretention Planter.

- Bioretention BMPs are applicable to new development, redevelopment and retrofit projects. Typical applications with or without underdrains include:
    - Individual lots for managing rooftop, driveway, and other on-lot impervious surfaces.
    - Shared BMPs located in common areas for individual lots.
    - Areas within loop roads or cul-de-sacs.
    - Landscaped parking lot islands, where bioretention can be situated lower than the height of the parking lot surface so that stormwater runoff is directed as sheet flow into the bioretention BMP. This application, in concert with permeable surfaces in the parking lot, can greatly attenuate stormwater runoff.
    - Within rights-of-ways along roads (often linear bioretention swales and cells).
    - Common landscaped areas in apartment complexes or other multifamily housing designs.
    - Planters on building roofs, patios, and as part of streetscapes.

Infeasibility Criteria

See Appendix 7B for infeasibility criteria for bioretention. If one or more infeasibility criteria apply, bioretention is not required for consideration in the List #1 or List #2 option of Core Requirement #5. In addition, other bioretention design criteria and site limitations that make bioretention BMPs infeasible (e.g., setback requirements) may also be used to demonstrate infeasibility, subject to approval by the City. If a project proponent wishes to use a bioretention BMP, though is not required to because of these infeasibility criteria, they may propose a functional design to the City.

Other Site Suitability Factors

- **Utility conflicts:** Consult City requirements for horizontal and vertical separation required for publicly-owned utilities, such as sewer lines. Consult the appropriate franchise utility owners for separation requirements from their utilities, which may include communications, water, power, and gas. When separation requirements cannot be met, designs should include appropriate mitigation measures, such as impermeable liners over the utility, sleeving utilities, fixing known leaky joints or cracked conduits, and/or adding an underdrain to the bioretention.

- **Transportation safety:** The design configuration and selected plant types should provide adequate sight distances, clear zones, and appropriate setbacks for roadway applications in accordance with the City's requirements.

- **Ponding depth and surface water draw-down:** Flow control needs, as well as location in the development, and mosquito breeding cycles will determine draw-down timing. For example, front yards and entrances to residential or commercial developments may require rapid surface dewatering for aesthetics.

- **Impacts of surrounding activities:** Human activity influences the location of the BMP in the development. For example, locate bioretention BMPs away from traveled areas on individual lots to prevent soil compaction and damage to vegetation or provide elevated or bermed pathways in areas where foot traffic is inevitable and provide barriers, such as wheel stops, to restrict vehicle access in roadside applications.

- **Visual buffering:** Bioretention BMPs can be used to buffer structures from roads, enhance privacy among residences, and as an aesthetic site feature.

- **Site growing characteristics and plant selection:** Appropriate plants should be selected for sun exposure, soil moisture, and adjacent plant communities. Native species or hardy cultivars are recommended and can flourish in the properly designed and placed bioretention soil mix with no nutrient or pesticide inputs and 2 to 3 years of irrigation for establishment. Invasive species control will be required as typical with all planted landscape areas.

Modeling and Sizing

Bioretention BMPs receiving runoff from roads or a combination of roads and other impervious/pervious surfaces will be larger than rain gardens. For bioretention BMPs designed to meet Core Requirement #5, the bioretention BMP shall have a horizontally projected surface area below the overflow which is at least 5 percent of the total impervious surface area draining to it. If pervious areas will also be draining to the bioretention BMP, the horizontally projected surface area below the overflow shall be increased by 2 percent of the pervious area. For bioretention BMPs designed to meet Core Requirement #6 or #7, the bioretention BMP must be sized using an approved continuous simulation model.

Ecology’s approval status for continuous simulation models is provided in the “Additional Resources” section of the 2019 Ecology Manual: <https://fortress.wa.gov/ecy/ezshare/wq/Permits/Flare/2019SWMMWW/2019SWMMWW.htm>

When using continuous modeling to size bioretention BMPs, the assumptions listed in Table 7.3 shall be applied. It is recommended that bioretention cells be modeled as a layer of soil (with specified infiltration rate) with infiltration to underlying soil, ponding, and overflow. The bioretention soil is designed in accordance with the treatment soil requirements outlined in the design criteria below.

To meet Core Requirement #6, at least 91 percent of the influent runoff file produced using a continuous simulation model must be infiltrated. Applicable water quality design storm volume drawdown requirements must also be met (see Chapter 8).

If 91 percent of the influent runoff file cannot be infiltrated, the percent infiltrated may be subtracted from the 91 percent volume that must be treated, and downstream treatment BMPs may be significantly smaller as a result.

Table 7.3. Continuous Modeling Assumptions for Bioretention Cells.

Variable	Assumption
Computational Time Step	15 minutes
Inflows to BMP	Surface flow and interflow from drainage area routed to BMP
Precipitation and Evaporation Applied to BMP	Yes. If model does not apply precipitation and evaporation to BMP, include the BMP area in the basin area (note that this will underestimate the evaporation of ponded water).
Bioretention Soil Mix Measured Infiltration Rate	For imported soil, rate is 12 inch per hour before applying the correction factor.
Bioretention Soil Porosity	30 percent
Bioretention Soil Depth	Minimum of 18 inches
Native Soil Infiltration Rate	Measured infiltration rate, including applicable safety factors (see Appendix 7A)
Infiltration Across Wetted Surface Area	Only if side slopes are 3:1 or flatter
Underdrain (optional)	If an underdrain is placed at bottom extent of the bioretention soil layer, all water that filters through the bioretention soil must be routed through the underdrain (i.e., no losses to infiltration). If there is no liner or impermeable layer and the underdrain is elevated above the bottom extent of the bioretention soil or aggregate layer, water stored in the bioretention soil or aggregate below the underdrain invert may be allowed to infiltrate.
Overflow	Overflow elevation set at maximum ponding elevation (excluding freeboard). May be modeled as weir flow over riser edge or riser notch. Note that the total BMP depth (including freeboard) must be sufficient to allow water surface elevation to rise above the overflow elevation to provide head for discharge.

To meet Core Requirement #7, the tributary areas, cell bottom area, and ponding depth must be iteratively sized until the duration curves and/or peak values meet the applicable flow control requirements (see Chapter 2).

Infiltration rates of the native soil (i.e., the undisturbed soil below the imported and/or amended BMP soil) and bioretention soil mix infiltration rate must be used when sizing and modeling bioretention BMPs. The native infiltration rate shall be determined using the methods outlined above. The method for determining infiltration rate of bioretention soil mix is described in the Bioretention Soil Mix subsection below.

Field and Design Procedures

Geotechnical analysis is an important first step to develop an initial assessment of the variability of site soils, infiltration characteristics, and the necessary frequency and depth of infiltration tests. This section includes infiltration testing requirements and application of appropriate safety factors specific to bioretention BMPs.

Refer to Appendix 7A for detailed descriptions of methods for infiltration rate testing procedures; however, note that the subgrade safety factors in Appendix 7A may not apply to bioretention (additional details provided below).

If the bioretention BMP includes a liner and does not infiltrate into the underlying soils, they are not considered infiltration BMPs and are not subject to the infiltration procedures or the setbacks provided in this section. Adhere to setbacks and site constraints for detention vaults included in Section 7.5.3 for these BMPs.

Determining Design Infiltration Rate

Determining the infiltration rate of the site soils is necessary to determine feasibility of designs that intend to infiltrate stormwater on site. Infiltration rates are also necessary to estimate bioretention performance using an approved continuous simulation model.

Determining Initial Soil Infiltration Rate

Initial (measured) infiltration rates are determined through soil infiltration tests. Infiltration tests must be run at the anticipated elevation of the top of the native soil beneath the bioretention BMP. Test hole or test pit explorations shall be conducted during mid to late in the “wet season” (December 1 through April 30) to provide accurate soil saturation and groundwater-level information. The following provides required test procedures for analysis of the soils underlying bioretention BMPs:

- Projects subject to Core Requirements #1 through #5:
    - One small-scale PIT or soil grain size analysis (for sites underlain by Type A soils) outlined in Appendix 7A shall be performed at each potential bioretention site. Tests at more than one site could reveal the advantages of one location over another.

      Note that to demonstrate infeasibility of bioretention BMPs for Core Requirement #5, a small-scale PIT in accordance with Appendix 7A must be used (i.e., measured infiltration rate of less than 0.3 inches per hour).
    - Confirm that the site has the required 1-foot minimum clearance to the seasonal high groundwater or other impermeable layer (refer to Setbacks and Site Constraints below).

- Projects subject to Core Requirements #1 through #9:
    - For small bioretention cells (bioretention BMPs receiving water from one or two individual lots or <0.25 acre of pavement or other impervious surface), a small-scale PIT or soil grain size analysis (for sites underlain by Type A soils) outlined in Appendix 7A shall be performed at each potential bioretention site. Tests at more than one site could reveal the advantages of one location over another.
    - For large bioretention cells (bioretention BMPs receiving water from several lots or 0.25 acre or more of pavement or other impervious surface), a small-scale PIT or soil grain size analysis (for sites underlain by Type A soils) outlined in Appendix 7A, shall be performed every 5,000 square feet. The more test pits/borings used, and the more evidence of consistency in the soils, the less of a safety factor may be used. If soil characteristics across the site are consistent, a geotechnical professional may recommend a reduction in the number of tests.

      If using the PIT method, multiple small-scale or one large-scale PIT can be used. If using the small-scale test, measurements shall be taken at several locations within the area of interest.
    - For bioretention swales or long, narrow bioretention BMPs (i.e., one following the road right-of-way), a small-scale PIT or soil grain size analysis (for sites underlain by Type A soils) outlined in Appendix 7A shall be performed every 200 linear feet and within each length of road with varying subsurface characteristics (i.e., groundwater elevation, soils type, infiltration rates). However, if the site subsurface characterization, including soil borings across the development site, indicate consistent soil characteristics and depths to seasonal high groundwater conditions, the number of test locations may be reduced to a frequency recommended by a geotechnical professional.

      Note that to demonstrate infeasibility of bioretention BMPs for Core Requirement #5, a small-scale PIT or large-scale PIT in accordance with Appendix 7A must be used (i.e., measured infiltration rate of less than 0.3 inches per hour).
    - Confirm that the site has the required 1- or 3-foot minimum clearance to the seasonal high groundwater or other impermeable layer (refer to Setbacks and Site Constraints below).
    - If a single bioretention BMP serves a drainage area exceeding 1 acre, infiltration receptor analysis and performance testing may be necessary. See Section 7.2.2, Step 5, for specific requirements for infiltration receptor characterization.

- If the general site assessment cannot confirm that the seasonal high groundwater or hydraulic restricting layer will be greater than 1 or 3 feet below the bottom of the bioretention, monitoring wells or excavated pits should be placed strategically to assess depth to groundwater.

Assignment of Appropriate Safety Factor

- If deemed necessary by a qualified professional engineer, a safety factor may be applied to the measured K_{sat} of the subgrade soils to estimate its design (long-term) infiltration rate. Depending on the size of the BMP, the variability of the underlying soils, and the number of infiltration tests performed, a safety factor may be advisable. (Note: This is a separate design issue from the assignment of a safety factor to the overlying, designed bioretention soil mix. See the Bioretention Soil Mix subsection below).

- The overlying bioretention soil mix provides excellent protection for the underlying native soil from sedimentation. Accordingly, a safety factor for the native soil (i.e., $F_{plugging}$ used in Appendix 7A) does not have to take into consideration the extent of influent control and clogging over time.

Prepare Soils Report

For projects subject to Core Requirements #1 through #5, a Soils Report must be prepared by a professional soil scientist certified by the Soil Science Society of America (or an equivalent national program), a locally licensed on-site sewage designer, or by other suitably trained persons working under the supervision of a professional engineer, geologist, hydrogeologist, or engineering geologist registered in the State of Washington. Refer to Chapter 3, Section 3.3.2, for Abbreviated Drainage Plan Soils Report requirements.

For projects subject to Core Requirements #1 through #9, a Soils Report must be prepared that is stamped by a professional engineer with geotechnical expertise, a licensed geologist, a hydrogeologist, or an engineering geologist registered in the State of Washington. Refer to Chapter 3, Section 3.3.3, for Drainage Control Plan Soils Report requirements.

Estimate Volume of Stormwater

If required, use an approved continuous simulation model to generate an influent file that will be used to size the bioretention BMP. The BMP must infiltrate either all of the flow volume as specified by the influent file, or a sufficient amount of the flow volume such that any overflow/bypass meets the flow duration standard in Core Requirement #7. In addition, the overflow/bypass must meet the LID Performance Standard if it is the option chosen to meet Core Requirement #5, or if it is required of the project.

Bioretention Design Criteria

The following provides descriptions, recommendations, and requirements related to the components of bioretention. Some or all of the components may be used for a given application depending on the site characteristics and restrictions, pollutant loading, and design objectives. Submittal for BMP review must include documentation of the following elements, discussed in detail below:

- Setbacks and site constraints
- Flow entrance/presettling
- Ponding area
- Bottom area and side slopes
- Overflow
- Bioretention soil mix
- Underdrain (if included)
- Check dams and weirs
- Planting
- Mulch layer
- Hydraulic restriction layer.

Setbacks and Site Constraints

For setbacks and site constraints for non-infiltrating bioretention (i.e., lined bioretention cells or planter boxes), refer to the setbacks for detention vaults in Section 7.5.3. Infeasibility criteria documented in Appendix 7B include setbacks and site constraints used to evaluate the bioretention option of List #1 and List #2 (Core Requirement #5). The following minimum setbacks and site constraints apply to all infiltrating bioretention BMPs (i.e., bioretention without a liner or planter box):

- All bioretention BMPs shall have a minimum of 1-foot positive vertical clearance from any open water maximum surface elevation to structures within 25 feet.

- All bioretention BMPs shall be a minimum of 10 feet away from any structure or property line. This setback may be reduced by the City for BMPs within or adjacent to the right-of-way.

- All bioretention BMPs shall be set back at least 50 feet from top of slopes steeper than 15 percent and greater than 10 feet high. A reduced setback may be allowed if a geotechnical assessment and Soils Report is prepared that addresses the potential impact of the BMP on the slope and recommends a reduced setback. In no case shall the setback be less than the vertical height of the slope.

- All bioretention BMPs shall be a minimum of 5 feet from septic tanks and distribution boxes.

- For sites with on-site or adjacent septic systems, the edge of the design water surface must be at least 30 feet upgradient, or 10 feet downgradient, of the septic drainfield primary and reserve areas (per WAC 246-272A-0210). Additional site-specific considerations may be required for septic systems serving commercial or light industrial land use to protect environmentally sensitive areas. This requirement may be modified by the Thurston County Public Health and Social Services Department if site topography clearly prohibits flows from intersecting the septic drainfield or where site conditions (soil permeability, distance between systems, etc.) indicate that this is unnecessary.

- Bioretention is prohibited within 300 feet of an erosion hazard or landslide hazard area (as defined by Section 14.37.030 LMC) unless the slope stability impacts of such systems have been analyzed and mitigation proposed by a geotechnical professional, and appropriate analysis indicates that the impacts are negligible.

- In no case shall bioretention BMPs be placed closer than 100 feet from drinking water wells and springs used for drinking water supplies.

    - Where water supply wells exist nearby, it is the responsibility of the applicant’s engineer to locate such wells, meet any applicable protection standards, and assess possible impacts of the proposed infiltration BMP on groundwater quality. If negative impacts on an individual or community water supply are possible, additional runoff treatment must be included in the BMP design, or relocation of the BMP should be considered.

    - Bioretention BMPs upgradient of drinking water supplies and within 1-, 5-, and 10-year time of travel zones must comply with the DG&PWS, Chapter 6.025 Wellhead Protection Areas, which includes the following:

        - Requires directing all stormwater away from source wells

        - Prohibits introducing stormwater directly into the same aquifer of a drinking water supply well within the well’s 1-year WHPA

        - May require more stringent requirements, if needed to protect drinking water sources with higher susceptibility to contamination.

    - Infiltration systems that qualify as Underground Injection Control Wells must comply with Chapter 173-218 WAC. Refer to Appendix 7C for additional requirements and guidance related to UIC wells.

    - The Soils Report must be updated to demonstrate and document that the above criteria are met and to address potential impacts to water supply wells or springs.

- All bioretention BMPs shall be a minimum of 3 feet from the lowest elevation of the bioretention soil, or any underlying gravel layer, and the seasonal high groundwater elevation or other impermeable layer if the area tributary to the BMP meets or exceeds any of the following thresholds:

  - 5,000 square feet of PGIS
  - 10,000 square feet of impervious area
  - 0.75 acres of lawn and landscape.

- For bioretention systems with a contributing area less than the above thresholds, a minimum of 1 foot of clearance from seasonal high groundwater or other impermeable layer is acceptable.

- In the event that the downstream pathway of infiltration, interflow, and/or the infiltration capacity is insufficient to handle the contributing area flows (e.g., a BMP enclosed in a loop roadway system or a landscape island within a parking lot), an underdrain system can be incorporated into the bioretention BMP. The underdrain system can then be conveyed to a nearby vegetated channel, another stormwater BMP or dispersed into a natural protection area. See the underdrain section below for additional information.

Flow Entrance/Presettling

The design of flow entrance to a bioretention BMP will depend upon topography, flow velocities, flow volume, and site constraints. Flows entering a BMP should have a velocity of less than 1 foot per second to minimize erosion potential. Vegetated buffer strips are the preferred entrance type because they slow incoming flows and provide initial settling of particulates.

Minimum requirements associated with the flow entrance/presettling design include the following:

- If concentrated flows are entering the BMP, engineered flow dissipation (e.g., rock pad or flow dispersion weir) must be incorporated. Avoid the use of angular rock or quarry spalls at the flow entrance and instead use round (river) rock if needed. Removing sediment from angular rock is difficult.

- A minimum 2-inch grade change between the edge of a contributing impervious surface and the vegetated flow entrance, or 5 percent slope from the outer curb face extending to a minimum of 12 inches beyond the back of curb, is required.

- If the catchment area contains unvegetated exposed soils or steep slopes, a presettling system (e.g., a filter strip, presettling basin, or vault) is required.

Four primary types of flow entrances can be used for bioretention:

1. Dispersed, low velocity flow across a grass or landscape area—this is the preferred method of delivering flows to the BMP and can provide initial settling

of particulates. Dispersed flow may not be possible given space limitations or if the BMP is controlling roadway or parking lot flows where curbs are mandatory.

2. Dispersed flow across pavement or gravel and past wheel stops for parking areas.

   - Parking lots that incorporate bioretention into landscaped areas should use concrete curb blocks as wheel stops to protect the bioretention BMP from traffic intrusion while also allowing the parking lot runoff to flow somewhat unobstructed to the bioretention BMP.

   - A 1-inch drop should be provided from the edge of pavement to the top of the bioretention BMP.

3. Drainage curb cuts for roadside, driveway, or parking lot areas—curb cuts shall include rock or other erosion protection material in the channel entrance to dissipate energy.

   - The minimum 12-inch drainage curb cut results in a 12-inch opening measured at the curb flow line and will require a 3-foot cut in an existing curb. An 18-inch curb cut is recommended for most applications.

   - Provide an area for settling and periodic removal of sediment and coarse material before flow dissipates to the remainder of the cell.

   - Curb cuts used for bioretention BMPs in high-use parking lots or roadways require increased level of maintenance due to high coarse particulates and trash accumulation in the flow entrance and associated bypass of flows. The following are methods recommended for areas where heavy trash and coarse particulates are anticipated:

     - Curb cut width: 18 inches.

     - At a minimum the flow entrance should drop 2 inches from gutter line into the bioretention BMP and provide an area for settling and periodic removal of debris.

     - Plan for more frequent inspection and maintenance for areas with large impervious areas, high traffic loads and larger debris loads.

     - Catch basins or forebays may be necessary at the flow entrance to adequately capture debris and sediment load from large contributing areas and high-use areas. Piped flow entrance in this setting can easily clog and catch basins with regular maintenance are necessary to capture coarse and fine debris and sediment.

   - A 1-inch drop should be provided from the edge of the curb-cut to the top of the bioretention BMP.

- Refer to the Bioretention Curb Cut Standard Detail (Drawing 5-12) in the DG&PWS.

4. Pipe flow entrance—piped entrances shall include rock or other erosion protection material in the BMP entrance to dissipate energy and/or provide flow dispersion.

   - Catch basin: In some locations where road sanding or higher than usual sediment inputs are anticipated, catch basins can be used to settle sediment and release water to the bioretention BMP through a grate for filtering coarse material.

   - Trench drains: can be used to cross sidewalks or driveways where a deeper pipe conveyance creates elevation problems. Trench drains tend to clog and may require additional maintenance.

Woody plants should not be placed directly in the entrance flow path as they can restrict or concentrate flows and can be damaged by erosion around the root ball.

Ponding Area

Bioretention ponding area may be an earthen depression (for bioretention cells and swales), or a planter box (for bioretention planters or planter boxes). The ponding area provides surface storage for storm flows, particulate settling, and the first stages of pollutant treatment within the BMP. Ponding depth and draw-down rate requirements are to provide surface storage, adequate infiltration capability, and soil moisture conditions that allow for a range of appropriate plant species. Soils must be allowed to dry out periodically in order to 1) restore hydraulic capacity of system, 2) maintain infiltration rates, 3) maintain adequate soil oxygen levels for healthy soil biota and vegetation, 4) provide proper soil conditions for biodegradation and retention of pollutants, and 5) prevent conditions supportive of mosquito breeding.

Minimum requirements associated with the bioretention ponding area design include the following:

- The ponding depth shall be a maximum of 12 inches.

- The surface pool drawdown time (surface ponding volume) shall be a maximum of 24 hours (drain time is calculated as a function of ponding depth and native soil design infiltration rate or bioretention soil mix infiltration rate, whichever is less).

The minimum freeboard measured from the invert of the overflow pipe or earthen channel to BMP overtopping elevation shall be 2 inches for drainage areas less than 1,000 square feet and 6 inches for drainage areas 1,000 square feet or greater. There should be a 1-inch drop from the edge of pavement or curb cut to the maximum freeboard elevation.

If berming is used to achieve the minimum top elevation needed to meet ponding depth and freeboard needs, the maximum slope on the berm shall be 3H:1V, and minimum top width of the design berm shall be 1 foot. Soil used for berming shall be imported bioretention soil or amended native soil and compacted to a minimum of 90 percent dry density.

Bottom Area and Side Slopes

Bioretention BMPs are highly adaptable and can fit various settings such as rural and urban roadsides, ultra-urban streetscapes, and parking lots by adjusting bottom area and side slope configuration. Recommended maximum and minimum dimensions include:

- The maximum planted side slope should be 3H:1V. If steeper side slopes are necessary rockeries, concrete walls, or soil wraps may be effective design options.
- The bottom width should be no less than 2 feet.

Bioretention BMPs should have a minimum shoulder of 12 inches between the road edge and beginning of the bioretention side slope where flush curbs are used. Compaction effort for the shoulder should be 90 percent proctor.

Overflow

An overflow route must be identified for stormwater flows that overtop the bioretention BMP when infiltration capacity is exceeded or the BMP becomes plugged and fails. The overflow route must be able to convey the 100-year recurrence interval developed peak flow to the downstream conveyance system or other acceptable discharge point without posing a health or safety risk or causing property damage.

Overflow designs shall be tailored to site conditions. Options include, but are not limited to: an emergency overflow spillway (minimum length of 3 feet), a vertical drain pipe installed at the designed maximum ponding elevation (12 inches) and connected to a downstream BMP or an approved discharge point, or a curb cut at the downgradient end of the bioretention BMP to direct overflows back to the street.

Bioretention Soil Mix

Unlike infiltration basins and trenches, the native soil underlying bioretention BMPs is not subject to the soil infiltration treatment requirements discussed in Chapter 8 (i.e., soil suitability criteria #1 and soil suitability criteria #2). Bioretention BMPs meet the requirements for basic and enhanced treatment, when the bioretention soil mix meets the requirements of the bioretention soil mix design criteria (see bioretention soil mix criteria below).

Do not use filter fabrics between the subgrade and the bioretention soil mix. The gradation between existing soils and bioretention soil mix is not great enough to allow significant migration of fines into the bioretention soil mix. Additionally, filter fabrics may clog with downward migration of fines from the bioretention soil mix.

The minimum requirements associated with the bioretention soil mix include the following:

- Minimum depth of treatment soil must be 18 inches
- Projects can either use a default bioretention soil mix or can create a custom bioretention soil mix.
    - Projects which use the default bioretention soil mix do not have to test bioretention soil mix infiltration rate. They may assume the rates specified in the next subsection.
    - Projects which create a custom bioretention soil mix rather than using the default requirements must demonstrate compliance with the specific design criteria and must test the bioretention soil mix infiltration rate as described in the Custom Bioretention Soil Mix subsection below.

Default Bioretention Soil Mix

Bioretention soil shall be a well-blended mixture of mineral aggregate and composted material measured on a volume basis. Bioretention soil shall consist of two parts fine compost (approximately 35 to 40 percent) by volume and three parts mineral aggregate (approximately 60 to 65 percent), by volume. The mixture shall be well blended to produce a homogeneous mix.

Mineral Aggregate

- Percent Fines: A range of 2 to 4 percent passing the U.S. #200 sieve is ideal and fines should not be above 5 percent for a proper functioning specification according to American Society for Testing and Materials (ASTM) D422.

Mineral Aggregate Gradation

- Mineral Aggregate shall be free of wood, waste, coating, or any other deleterious material. The aggregate portion of the bioretention soil mix shall be well graded. According to ASTM D2487-98 (Classification of Soils for Engineering Purposes [Unified Soil Classification System]), well-graded sand should have the following gradation coefficients:
    - Coefficient of Uniformity (Cu = D60/D10) equal to or greater than 4, and
    - Coefficient of Curve (Cc = (D30)2/D60 x D10) greater than or equal to 1 and less than or equal to 3.

Aggregate shall be analyzed by an accredited lab using the U.S. sieve numbers and gradation noted in Table 7.4.

Table 7.4. Aggregate for Bioretention Soil.

U.S. Sieve Number	Percent Passing
0.375 inch	100
4	95–100
10	75–90
40	24–40
100	4–10
200	2–5

Where existing soils meet the above aggregate gradation, those soils may be amended rather than importing mineral aggregate.

Compost to Aggregate Ratio, Organic Matter Content, Cation Exchange Capacity

- Compost to aggregate ratio: 60 to 65 percent mineral aggregate, 35 to 40 percent compost.
- Organic matter content: 5 to 8 percent by weight.
- Cation Exchange Capacity (CEC) must be greater than 5 milliequivalents (meq) per 100 grams of dry soil. Note: Soil mixes meeting the above specifications do not have to be tested for CEC. They will readily meet the minimum CEC.

Composted Material

To ensure that the bioretention soil mix will support healthy plant growth and root development, contribute to biofiltration of pollutants, and not restrict infiltration when used in the proportions cited herein, the following compost standards are required:

- Material must meet the definition of “composted material” in WAC 173-350-100 and complies with testing parameters and other standards in WAC 173-350-220.
- Material must be produced at a composting facility that is permitted by a jurisdictional health authority. Permitted compost facilities in Washington are included on a list available at <https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Organic-materials/Managing-organics-compost>.
- The compost product must originate a minimum of 65 percent by volume from recycled plant waste comprising “yard debris,” “crop residues,” and “bulking agents” as those terms are defined in WAC 173-350-100. A maximum of 35 percent by volume of “postconsumer food waste” as defined in WAC 173-350-100, but not including biosolids, may be substituted for recycled plant waste.
- Moisture content must be such that there is no visible free water or dust produced when handling the material.

- The material shall be tested in accordance with the U.S. Composting Council "Test Method for the Examination of Compost and Composting" (TMECC), as established in the Composting Council's "Seal of Testing Assurance" (STA) program. Most Washington compost BMPs now use these tests.

- Composted material shall meet the size gradations established in the U.S. Composting Council's Seal of Testing Assurance (STA) program, as follows: Fine Compost shall meet the following gradation by dry weight:

	Min.	**Max.**
Percent passing 2″	100	
Percent passing 1″	99	100
Percent passing 0.625″	90	100
Percent passing 0.25″	75	100

- The pH shall be between 6.0 and 8.5 (TMECC 04.11-A).

- "Physical contaminants" (as defined in WAC 173-350-100) content shall be less than 1 percent by weight (TMECC 03.08-A) total, not to exceed 0.25 percent film plastic by dry weight.

- Minimum organic matter content shall be 40 percent by dry weight basis as determined by TMECC 05.07-A, "Loss-On-Ignition Organic Matter Method."

- Soluble salt contents shall be less than 4.0 dS/mm (mmhos/cm) tested in accordance with TMECC 04.10-A, "1:5 Slurry Method, Mass Basis."

- Maturity indicators from a cucumber bioassay shall be greater than 80 percent for both emergence and vigor, in accordance with TMECC 05.05-A, "Germination and Vigor".

- The material must be stable (low oxygen use and CO2 generation) and mature (capable of supporting plant growth). This is critical to plant success in a bioretention soil mixes. Stability shall be 7 mg CO_2-C/g OM/day or below in accordance with TMECC 05.08-B, "Carbon Dioxide Evolution Rate."

- Fine Compost shall have a carbon to nitrogen ratio of less than 25:1 as determined using TMECC 05.02A "Carbon to Nitrogen Ratio" which uses the TMECC 04.01 "Organic Carbon" and TMECC 04.02-D "Total Nitrogen by Oxidation." The Engineer may specify a Carbon:Nitrogen ratio up to 35:1 for projects where the plants selected are entirely Puget Sound lowland native species, and up to 40:1 for coarse compost to be used as a surface mulch (not in a soil mix).

Compost not conforming to the above requirements or taken from a source other than those tested and accepted shall be immediately removed from the project and replaced.

If using the bioretention soil mix included herein, a default infiltration rate of 12 inches per hour shall be used. Refer to the Determining Design Bioretention Soil Mix Infiltration Rate section below.

High Performance Bioretention Soil Mix

High-performance bioretention soil mixes may be used in locations near phosphorus-sensitive waterbodies. Refer to the latest guidance on using high-performance soil mixes, available on Ecology’s website at: <https://fortress.wa.gov/ecy/publications/SummaryPages/2110023.html>.

Custom Bioretention Soil Mixes

Projects which prefer to create a custom bioretention soil mix rather than using the default requirements above must demonstrate compliance with the following criteria using the specified test method:

- CEC ≥ 5 milliequivalents/100 grams of dry soil; U.S. EPA 9081.
- pH between 5.5 and 7.0.
- 5 to 8 percent organic matter content before and after the saturated hydraulic conductivity test; ASTM D2974 (Standard Test Method for Moisture, Ash, and Organic Matter of Peat and Other Organic Soils).
- 2 to 5 percent fines passing the U.S. #200 sieve; TMECC 04.11-A.
- If compost is used in creating the custom mix, it must meet all of the specifications listed above for compost, except for the gradation specification. An alternative gradation specification must indicate the minimum percent passing for a range of similar particle sizes.
- Measured (initial) saturated hydraulic conductivity of less than 12 inches per hour; ASTM D2434 (Standard Test Method for Permeability of Granular Soils [Constant Head]) at 85 percent compaction per ASTM D1557 (Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort). Also, use Appendix 7A, Recommended Modifications to ASTM D2434 When Measuring Hydraulic Conductivity for Bioretention Soil Mixes.
- Design (long-term) saturated hydraulic conductivity greater than 1 inch per hour. Refer to the Determining Design Bioretention Soil Mix Infiltration Rate section below.

Determining Design Bioretention Soil Mix Infiltration Rate

A long-term infiltration rate correction factor of 4 shall be used for the bioretention soil if the area tributary to the BMP meets or exceeds any of the below thresholds:

- 10,000 square feet of impervious area
- 5,000 square feet of PGIS
- 0.75 acres of lawn and landscape.

For bioretention BMPs with a contributing area less than the above thresholds, a long-term infiltration rate correction factor of 2 for the bioretention soil mix is acceptable.

Underdrain (Optional)

Where the underlying native soils have an estimated initial infiltration rate between 0.3 and 0.6 inches per hour, bioretention BMPs without an underdrain, or with an elevated underdrain directed to a surface outlet, may be used to satisfy List #2 of Core Requirement #5. Underdrained bioretention BMPs must meet the following criteria if they are used to satisfy List #2 of Core Requirement #5:

- The invert of the underdrain must be at least 6 inches above the bottom of the aggregate bedding layer. A larger distance between the underdrain and bottom of the bedding layer is desirable, but cannot be used to trigger infeasibility due to inadequate vertical separation to the seasonal high water table, bedrock, or other impermeable layer.
- The distance between the bottom of the bioretention soil mix and the crown of the underdrain pipe must be not less than 6 or more than 12 inches.
- The aggregate bedding layer must run the full length and the full width of the bottom of the bioretention BMP.
- The BMP must not be underlain by a low permeability liner that prevents infiltration into the native soil.

Underdrain systems should be installed only if the bioretention BMP is located where infiltration is not permitted and a liner is used, or where subgrade soils have infiltration rates that do not meet the maximum pool drawdown time. In these cases, underdrain systems can be installed and the BMP can be used to filter pollutants and detain flows. However, designs utilizing underdrains provide less infiltration and flow control benefits.

The volume above an underdrain pipe in a bioretention BMP provides pollutant filtering and some flow attenuation; however, only the void volume of the aggregate below the underdrain invert and above the bottom of the bioretention BMP (subgrade) can be used in an approved continuous simulation model for dead storage volume that provides flow control benefit. Assume a 40 percent void volume for the filter material aggregate specified below.

The minimum requirements associated with the underdrain design include:

- Slotted, thick-walled plastic pipe must be used:

  - Minimum pipe diameter: 6 inches (pipe diameter will depend on hydraulic capacity required). Changes in pipe diameter shall be made using a junction box or other approved structure. Within the public right-of-way any underdrain shall have a minimum diameter of 8 inches (pipe diameter will depend on hydraulic capacity required).
  - Slotted subsurface drain PVC per DG&PWS and WSDOT Standard Specifications.

- Slots should be cut perpendicular to the long axis of the pipe and be 0.04 to 0.069 inches by 1-inch long and be spaced 0.25 inches apart (spaced longitudinally). Slots should be arranged in four rows spaced on 45-degree centers and cover one-half of the circumference of the pipe. Underdrain pipe slope must be no less than 0.5 percent.

- Pipe must be placed in filter material and have a minimum cover depth of 4 inches.

- Filter material shall meet the requirements of WSDOT Standard Specifications Section 9-03.12(4) (gravel backfill for drains).

- A 6-inch non-perforated cleanout must be connected to the underdrain every 300 feet minimum.

- The underdrain can be connected to a downstream BMP such as another bioretention/rain garden BMP as part of a connected system, or to an approved discharge point. A geotextile fabric (specifications in Chapter 8, Appendix 8A) must be used between the soil layer and underdrain.

Check Dams and Weirs

For sloped bioretention BMPs, check dams are necessary to provide ponding, reduce flow velocities, and reduce the potential for erosion. Typical check dam materials include concrete, wood, rock, compacted dense soil covered with vegetation, and vegetated hedge rows. Design depends on flow control goals, local regulations for structures within road rights-of-way, and aesthetics. Optimum spacing is determined by flow control benefit (modeling) in relation to cost considerations. See the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for typical designs.

UIC Discharge

Where bioretention facilities discharge to UICs, Underground Injection Control (UIC) regulations are applicable and must be followed (Chapter 173-218 WAC). See Appendix 7C.

Planting

In general, the predominant plant material utilized in bioretention BMPs are species adapted to stresses associated with wet and dry conditions. Soil moisture conditions will vary within the BMP from saturated (bottom of cell) to relatively dry (rim of cell). Accordingly, wetland plants may be used in the lower areas, if saturated soil conditions exist for appropriate periods, and drought-tolerant species planted on the perimeter of the BMP or on mounded areas.

The minimum requirements associated with the vegetation design include the following:

- The design plans must specify that vegetation coverage of selected plants will achieve 90 percent coverage within 2 years or additional plantings will be provided until this coverage requirement is met
- For BMPs receiving runoff from 5,000 square feet or more impervious surface, plant spacing and plant size must be designed to achieve specified coverage by a certified landscape architect
- The plants must be sited according to sun, soil, wind, and moisture requirements
- The side slopes for the bioretention BMP (vertical or sloped) can affect the plant selection and must be considered.
- At a minimum, provisions must be made for supplemental irrigation during the first 2 growing seasons following installation and in subsequent periods of drought.
- If a bioretention BMP will be located in a full shade area (i.e., receiving less than 3 hours of direct sunlight per day), then a licensed landscape architect shall provide input on the plant selection and layout. If a licensed landscape architect determines that plants will not survive in the fully shaded location, 3 inches of washed sandy gravel backfill (see DG&PWS) or mulch may be used as a top dressing in lieu of plants.

Additionally, trees can be planted along the side slopes or bottom of bioretention cells that are unlined.

Refer to the *Low Impact Development Technical Guidance Manual for Puget Sound* (Hinman and Wulkan 2012) for additional planting guidance, including:

- Guidance and recommendations for plant selection and increasing survival rates
- Planting zone descriptions
- Optimum planting times
- Plant selection for planting zones based on sun exposure

Mulch Layer

Bioretention BMPs shall be designed with a mulch layer or a dense groundcover. Properly selected mulch material also reduces weed establishment, regulates soil temperatures and moisture, and adds organic matter to soil. Mulch shall be:

- Medium compost in the bottom of the BMP (compost is less likely to float during cell inundation). Compost shall not include biosolids of manures.
- Wood chip mulch composed of shredded or chipped hardwood or softwood on cell slopes above ponding elevation and rim area. Arborist mulch is mostly woody trimmings from trees and shrubs and is a good source of mulch material. Wood chip operations are a good source for mulch material that has more control of size distribution and consistency. Do not use shredded construction wood debris or any shredded wood to which preservatives have been added.
- Free of weed seeds, soil, roots, and other material that is not trunk or branch wood and bark.
- A minimum of 2 and a maximum of 3 inches thick (thicker applications can inhibit proper oxygen and carbon dioxide cycling between the soil and atmosphere).

Mulch shall not include weed seeds, soil, roots, and other material that are not from the above ground components of a tree, grass clippings (decomposing grass clippings are a source of nitrogen and are not recommended for mulch in bioretention BMPs), or pure bark (bark is essentially sterile and inhibits plant establishment).

In bioretention BMPs where higher flow velocities are anticipated, an aggregate mulch may be used to dissipate flow energy and protect underlying bioretention soil mix. Aggregate mulch varies in size and type, but 1- to 1.5-inch gravel (rounded) decorative rock is typical. The area covered with aggregate mulch must not exceed one-third of the BMP bottom area.

As an alternative to mulch, a dense groundcover may be used. Mulch is required in conjunction with the groundcover until groundcover is established.

Hydraulic Restriction Layer

For infiltrating bioretention BMPs adjacent to roads, foundations, or other sensitive infrastructure, it may be necessary to restrict lateral infiltration pathways to prevent excessive hydrologic loading using a restricting layer (for the sides of the bioretention BMP only). Geomembrane liners are a type of restricting layer that can be incorporated into bioretention designs. Geomembrane liners completely block infiltration. The liner shall have a minimum thickness of 30 mils and be ultraviolet (UV) resistant.

Note: only the infiltrating bottom area (i.e., unlined) shall be used in sizing calculations or hydrologic modeling.

If it is necessary to prevent infiltration to underlying soils (e.g., contaminated soils or steep slope areas), the BMP must include a hydraulic restriction layer across the entire BMP. The BMP may be composed of a low permeability (e.g., concrete) container with a closed bottom, or may be lined with a low permeability material (e.g., geomembrane liner) to prevent infiltration. In these cases, underdrains are required.

Signage

The City recommends that bioretention installations used to meet Core Requirement #5, #6, and/or #7 include informational signage upon completion of the installation to help identify the vegetated area as a stormwater BMP and to inform maintenance crews and the general public about protecting the BMP's function.

Construction Criteria

See Chapter 5, Section 5.3, for infiltration BMP construction requirements. The minimum requirements associated with bioretention BMP construction include the following:

- Bioretention BMPs that infiltrate into the underlying soil (i.e., do not include a liner) rely on water movement through the surface soils as infiltration and interflow to underlying soils. Therefore, it is important to always consider the pathway of interflow and ensure that the pathway is maintained in an unobstructed and uncompacted state. This is true during the construction phase as well as postconstruction.

- During construction, it is critical to prevent clogging and over-compaction of the subgrade and bioretention soils.

- Place bioretention soil per the requirements of bioretention soil mix requirements specified in this section.

Acceptance Testing

The project engineer or designee shall inspect bioretention BMPS before, during, and after construction to ensure BMPs are built to design specifications, that proper procedures are employed in construction, that the infiltration surface is not compacted, and that protection from sedimentation is in place. Prior to placement of the bioretention soil mix, the project engineer shall verify that the finished subgrade is scarified and meets the designed infiltration rate.

Before release of the maintenance bond, the project engineer shall perform a minimum of two acceptance tests after construction to determine if the BMP will operate as designed. The type of test will depend on specific BMP and site constraints, and therefore shall be determined by the project engineer on a case-by-case basis, and must be submitted for approval by the City prior to testing. The City must be notified of the scheduled infiltration testing at least 2 working days in advance of the test. See Appendix 7A for infiltration testing requirements. If the tests indicate the BMP will not function as designed, this information must be brought to the immediate attention of the City along with any reasons as to why not and how it can be remedied.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

APPENDIX D

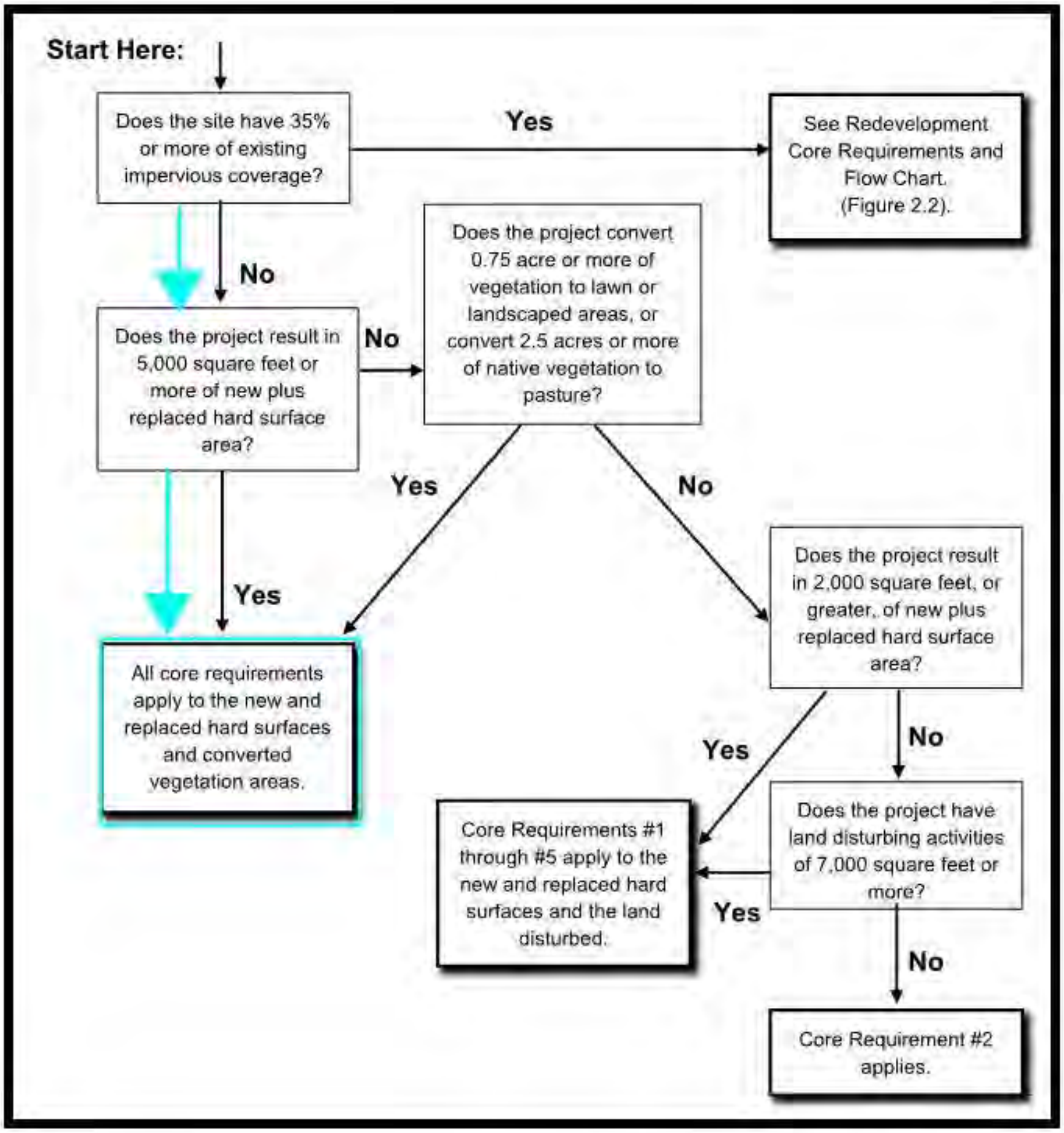
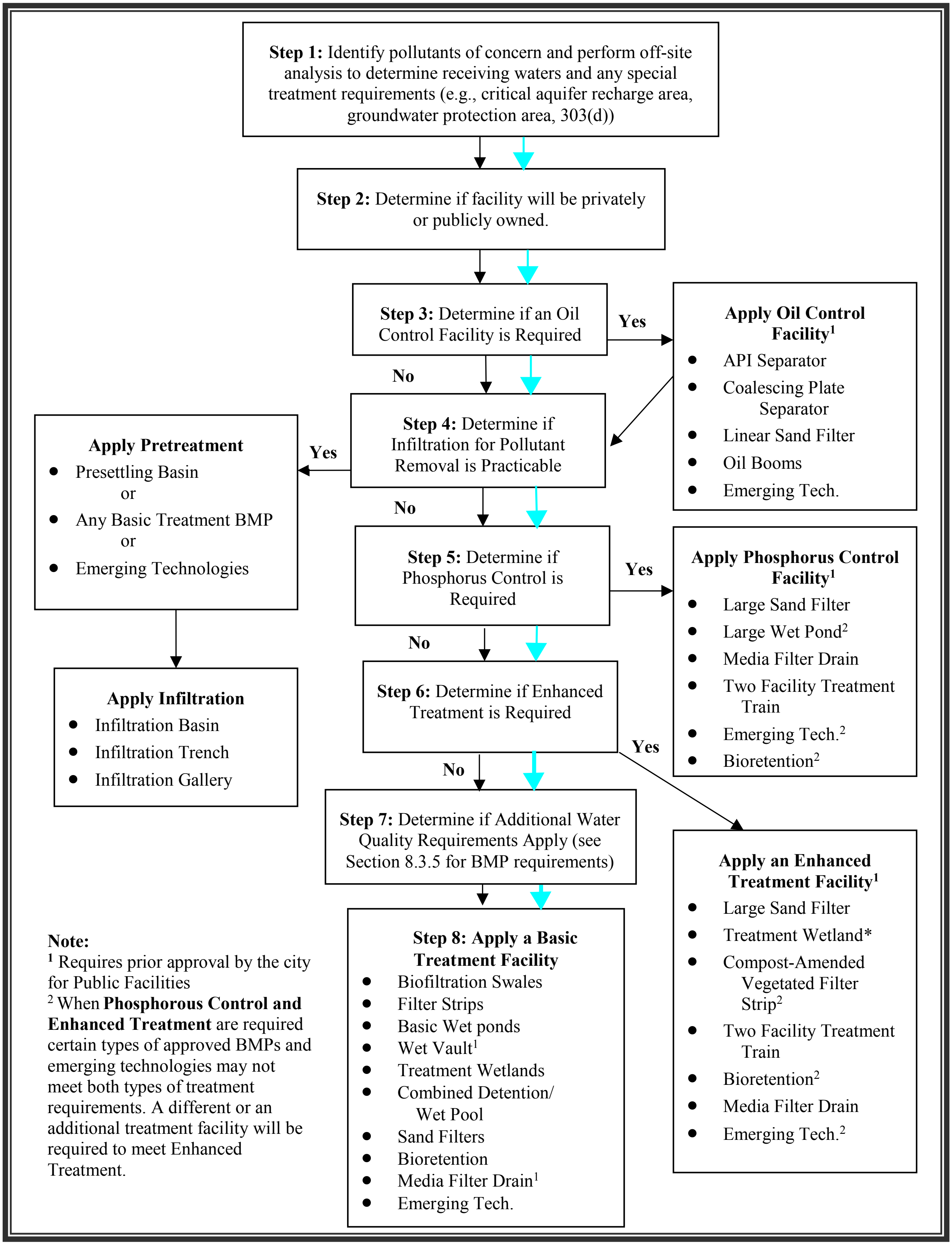


Figure 6: Determining Requirements for New Development



Note:
[1] Requires prior approval by the city for Public Facilities
[2] When **Phosphorous Control and Enhanced Treatment** are required certain types of approved BMPs and emerging technologies may not meet both types of treatment requirements. A different or an additional treatment facility will be required to meet Enhanced Treatment.

Figure 8.1. Treatment Facility Selection Flow Chart.

- **Voids behind geotextile:** Voids between the geotextile and excavation sides must be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Place natural soils in these voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. This remedial process helps to avoid soil piping, geotextile clogging, and possible surface subsidence.

- **Unstable excavation sites:** Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trench boxes or trapezoidal, rather than rectangular, cross-sections may be needed.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

Acceptance Testing

To demonstrate that the BMP performs as designed, it may be required that the constructed BMP is tested and monitored per the Acceptance Testing requirements in Section 7.2.2.

7.4.8 Infiltration Galleries

Description

The term “infiltration galleries” refers to manufactured detention structures, commonly referred to as “infiltration chambers,” within a broad gravel trench. Infiltration chambers are buried structures, typically arch-shaped, within which collected stormwater is temporarily stored and then infiltrated into the underlying soil. Infiltration chambers create an underground cavity that can provide a greater void volume than infiltration trenches and often require a smaller footprint. Infiltration galleries may be allowed on a case-by-case basis and must be sized per the manufacturer’s guidance.

Applications and Limitations

- Infiltration galleries can be used to meet the flow control standards of Core Requirement #7.

- When used in combination with other on-site stormwater management BMPs, they can also help achieve compliance with the LID Performance Standard option of Core Requirement #5.

- Infiltration galleries can be used to help meet the runoff treatment requirements of Core Requirement #6 if the underlying soil meets the requirements provided in Chapter 8, Section 8.6.

- Infiltration galleries require adequate separation from seasonally-high groundwater and adequate setback distances, per Section 7.2

  In order to find adequate infiltration rates, an engineer may propose to excavate through a till layer or low permeability layer when designing a stormwater BMP. This results in a deep UIC, which is described in Appendix 7C, Section 7C.15. Since excavating through this low permeability layer creates a new condition, more extensive geotechnical assessments, runoff treatment BMPs, and monitoring are required by the City.

Modeling and Sizing

See Section 7.2.3 for guidance on modeling and sizing of infiltration BMPs.

Infiltration Gallery Design Criteria

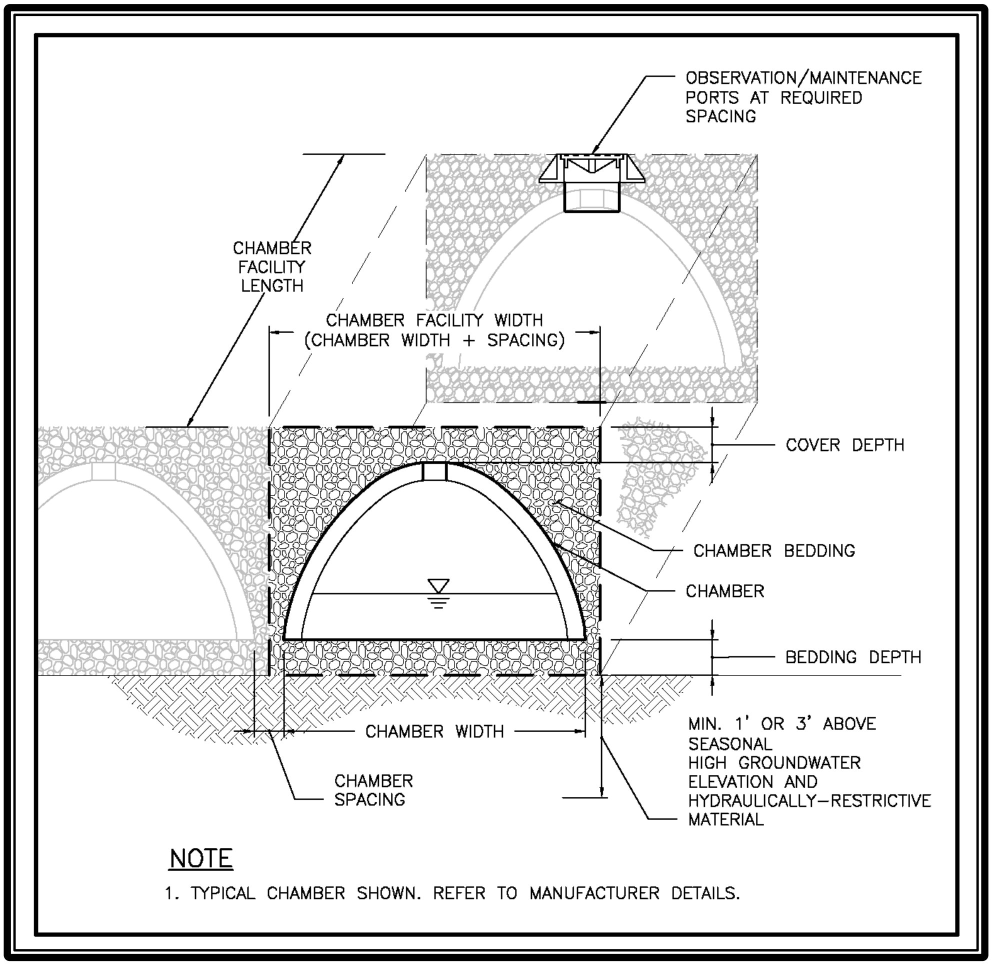
Refer to Section 7.2 for general procedures and design criteria applicable to infiltration basins, trenches, and galleries. Refer to Figure 7.14 for a schematic of a typical infiltration chamber. This section provides additional design criteria specific to infiltration trenches:

- Gallery layout
- Access
- Gallery bedding
- Subgrade
- Overflow

Gallery Layout

- Infiltration chambers can be constructed of a variety of different materials (e.g., plastic, concrete, aluminum, steel) and shapes (i.e., arch, box).
- Chamber spacing and depth of cover shall be per the manufacturer’s requirements, unless otherwise directed by the City.
- **Surface cover:** An infiltration chamber may be placed under a porous or impervious surface cover to conserve space. If located under pavement, the following are required:
  - Observation wells must be placed no further than 100 feet apart.
  - The plans, details, and the Maintenance and Source Control Manual must all clearly state that the pavement may have to be removed and/or other site improvements impacted due to maintenance, repair, or replacement of the stormwater infiltration system(s).

- o No infiltration galleries shall be allowed under any private or public streets.



Source: City of Seattle

Figure 7.14. Typical Infiltration Chamber.

Access

- A catch basin or manhole is required at the inlet of each chamber of the infiltration gallery, for inspection and maintenance access to the entire gallery.

- An access port, cleanout, or catch basin is required at the distal end for accessibility to conduct inspections and maintenance.

- **Observation well:** Install an observation well near the center of the gallery (if level) or near the lower end of each chamber, to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. See Figure 7.13 for an example observation well detail. It should consist of a perforated PVC pipe which is a minimum of 6 inches in diameter and it should be constructed flush with the ground elevation. For larger galleries a 12- to 36-inch diameter well can be installed to facilitate maintenance operations such as pumping out the sediment. The top of the well must be equipped with a secure well cap to discourage vandalism and tampering.

Gallery Bedding

- Minimum bedding shall be from 6 inches below the infiltration chamber to an elevation one-half the outside height of the chamber.
- Infiltration gallery bedding is specified by the manufacturer. The aggregate material for the infiltration gallery must consist of a clean aggregate and meet WSDOT Standard Specification 9-03.12(5) that nominally ranges from 0.75-inch to 1.5-inch diameter. A maximum diameter of 3 inches and a minimum diameter of 1.5 inches may be approved if void space is maintained. Void space for these aggregates must be in the range of 30 to 40 percent.

Subgrade

The minimum underlying native soil initial infiltration rate for infiltration galleries is 0.6 inches per hour.

During construction the subgrade soil surface can become smeared and sealed by excavation equipment. The design shall require scarification or raking of the side walls and bottom of the BMP excavation to a minimum depth of 4 inches after excavation to restore infiltration rate.

Freeboard

A minimum of 1 foot of freeboard is required when establishing the design chamber depth. Freeboard is measured from the rim of the chamber to the maximum ponding level or from the rim down to the overflow point if overflow or a spillway is included.

Construction Criteria

During construction, it is critical to prevent clogging and over-compaction of the subgrade. Refer to the minimum construction requirements for infiltration trenches in Section 7.4.7.

Operations and Maintenance Requirements

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements. Manufacturers of specific infiltration chambers may have additional operation and maintenance recommendations, which shall be included in the Maintenance and Source Control Manual for the finished project site.

Acceptance Testing

To demonstrate that the BMP performs as designed, it may be required that the constructed BMP is tested and monitored per the Acceptance Testing requirements in Section 7.2.2.

  - For grid systems, refer to manufacturer's testing recommendations.

The City must be notified of the scheduled infiltration testing at least two working days in advance of the test. If the tests indicate the BMP will not function as designed, this information must be brought to the immediate attention of the City along with any reasons as to why not and how it can be remedied.

Operations and Maintenance Criteria

- See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.
- Where run-on flows onto permeable pavement, these areas shall be identified in the Maintenance and Source Control Manual as requiring more frequent cleaning and inspection to ensure that the overall BMP is performing.
- Clogging is the primary mechanism that degrades infiltration rates. However, as discussed above, the surface design can have a significant influence on clogging of void space.
- Studies have indicated that infiltration rates on moderately degraded porous asphalts and pervious concrete can be partially restored by suctioning and sweeping of the surface. Highly degraded porous asphalts and concrete require high pressure washing with suction.
- For large scale cleaning use vacuum surface cleaning machines (such as Cyclone, Elgin, etc.) for cleaning pervious concrete and porous asphalt.
- Maintenance frequencies of suctioning and sweeping shall be specified in the Maintenance and Source Control Manual, or as specified in Chapter 10, whichever is more stringent.
- Permeable pavement systems designed with pavers have advantages of ease of disassembly when repairs or utility work is necessary. However, it is important to note that the paver removal area should be no greater than the area that can be replaced at the end of the day. If an area of pavers is removed, leaving remaining edges unconfined, it is likely that loading in nearby areas will create movement of the remaining pavers thereby unraveling significantly more area than intended.

7.4.7 Infiltration Trenches (Ecology BMP T7.20)

Description

Infiltration trenches are most appropriate for small contributing areas and retrofit situations where space is limited. Infiltration trenches are generally at least 24 inches wide, and are backfilled with a coarse stone aggregate, allowing for temporary storage of stormwater runoff in the voids of the aggregate material. Stored runoff then gradually infiltrates into the surrounding soil. The surface of the trench can consist of stone, gabion, sand, or a grassed covered area with a surface inlet. Perforated rigid pipe of at least 8-inch diameter can also be used to distribute the stormwater in a stone trench.

Note that an infiltration trench with a perforated pipe is considered a UIC well and is required to be registered with Ecology unless the infiltration trench is located at a single-family home (or duplex) and only receives residential roof runoff or is used to control basement flooding (per WAC 173-218-070 (1)(e). See also Section 7.3 for more information on UIC well registration.

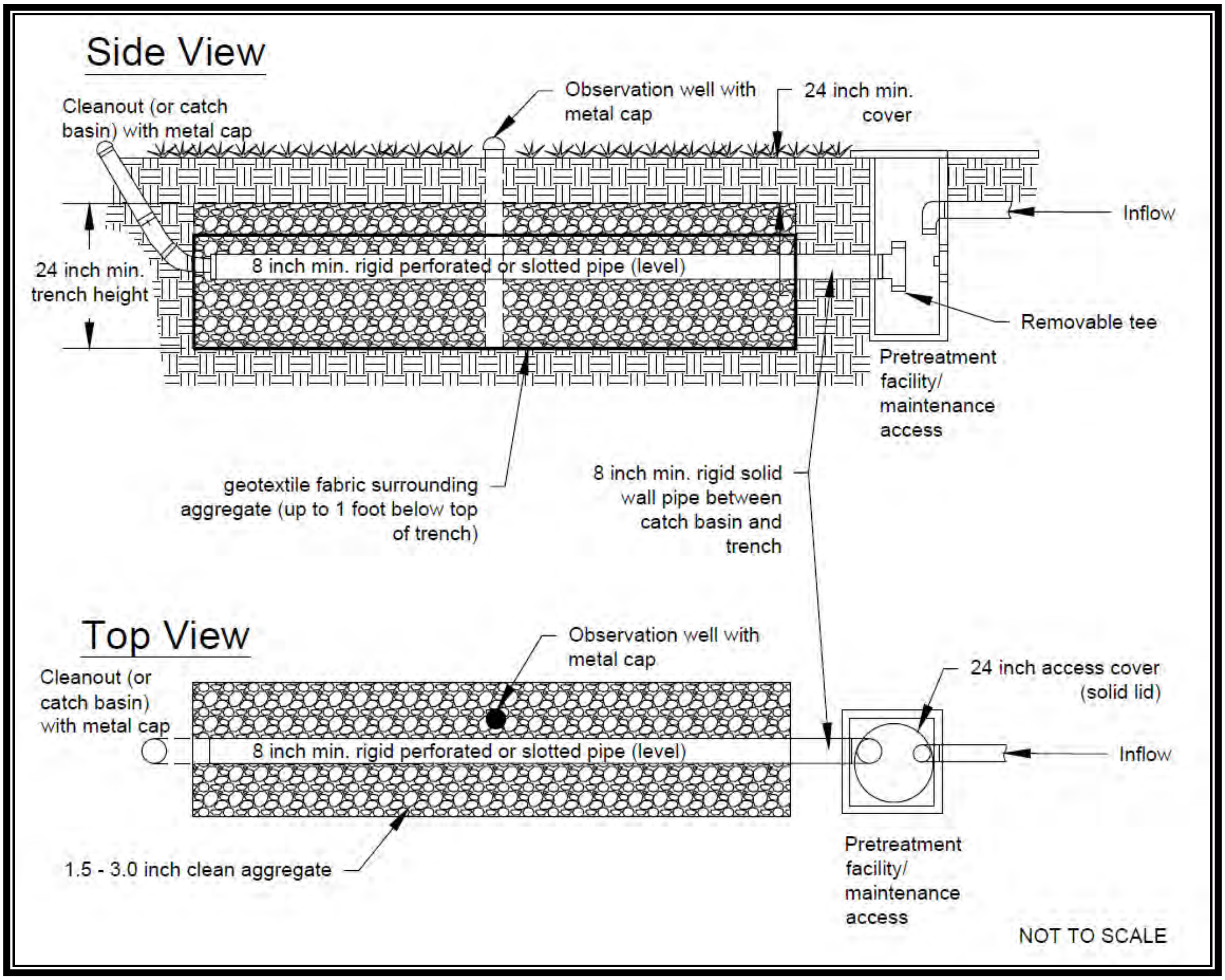
See Figures 7.11a, 7.11b, and 7.12 for examples of infiltration trench BMPs in various configurations and site settings. Included in the details are infiltration trenches with a grass buffer, as well as an example of a parking lot perimeter infiltration trench design. For trenches associated specifically with roof downspout infiltration, see Section 7.4.10.

Applications and Limitations

- Infiltration trenches can be used to meet the flow control standards of Core Requirement #7.
- When used in combination with other on-site stormwater management BMPs, they can also help achieve compliance with the LID Performance Standard option of Core Requirement #5.
- Infiltration trenches can be used to meet some of the runoff treatment requirements of Core Requirement #6 if the underlying soil meets the requirements provided in Chapter 8, Section 8.6.
- Infiltration trenches require adequate separation from seasonally-high groundwater and adequate setback distances, per Section 7.2
- In order to find adequate infiltration rates, an engineer may propose to excavate through a till layer or low permeability layer when designing a stormwater BMP. This results in a deep UIC, which is described in Appendix 7C, Section 7C.15. Since excavating through this low permeability layer creates a new condition, more extensive geotechnical assessments, runoff treatment BMPs, and monitoring are required by the City.

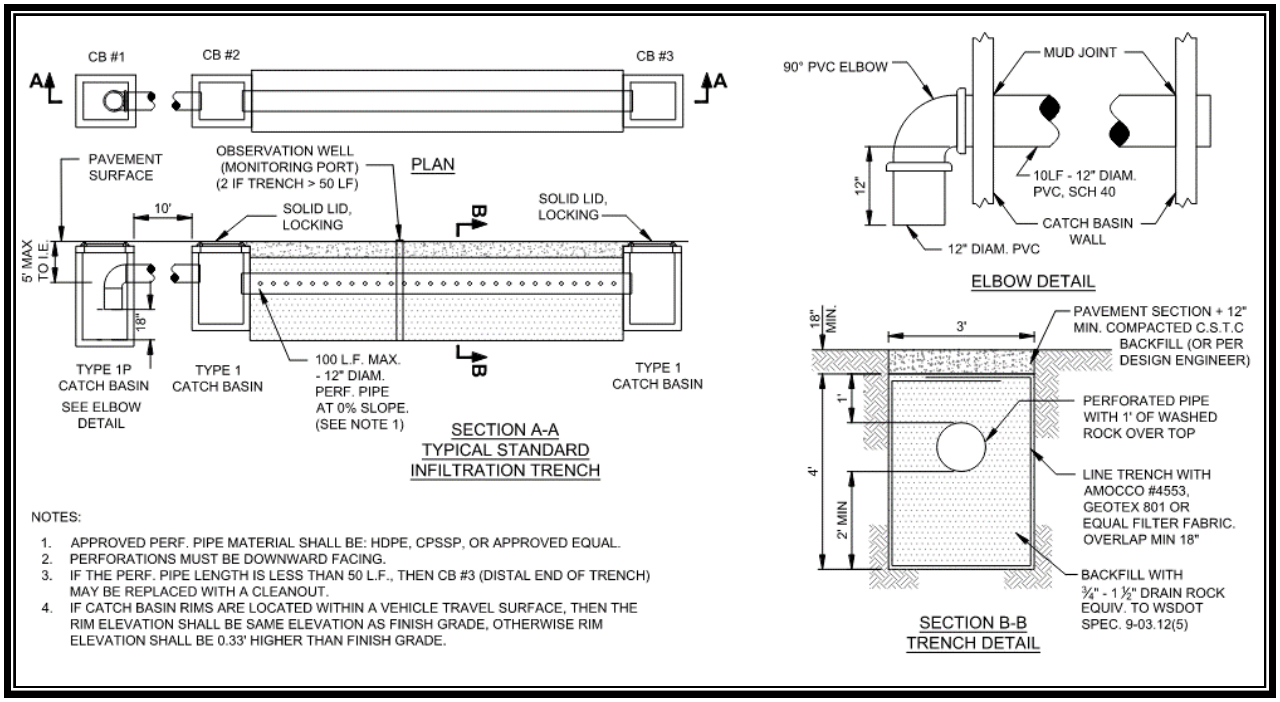
Modeling and Sizing

See Section 7.2.3 for guidance on modeling and sizing of infiltration BMPs.



Source: Ecology

Figure 7.11a. Infiltration Trench Design.

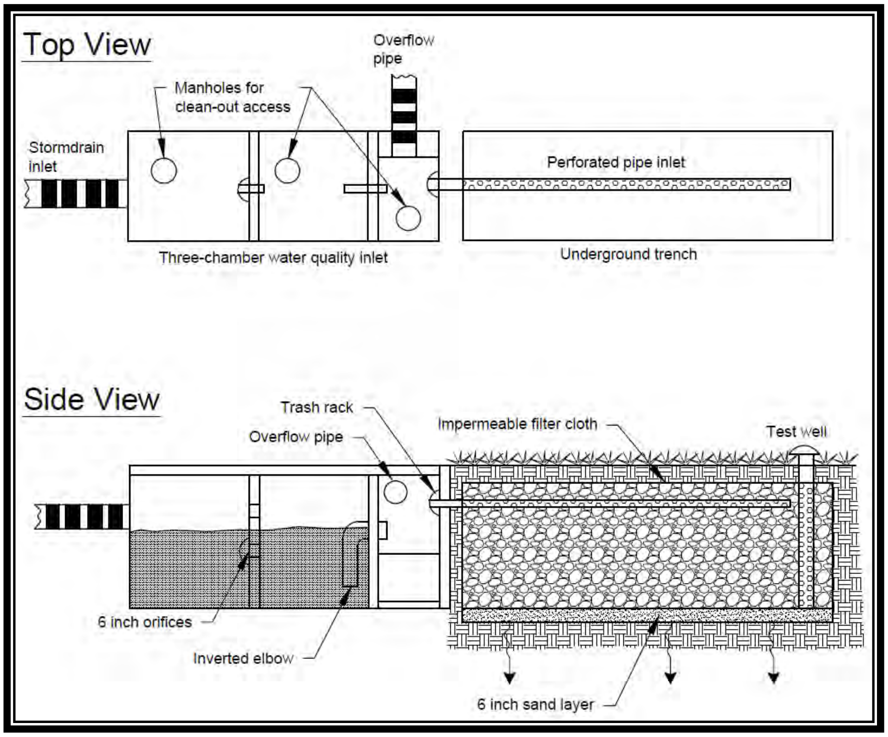


NOTES:

1. APPROVED PERF. PIPE MATERIAL SHALL BE: HDPE, CPSSP, OR APPROVED EQUAL.
2. PERFORATIONS MUST BE DOWNWARD FACING.
3. IF THE PERF. PIPE LENGTH IS LESS THAN 50 L.F., THEN CB #3 (DISTAL END OF TRENCH) MAY BE REPLACED WITH A CLEANOUT.
4. IF CATCH BASIN RIMS ARE LOCATED WITHIN A VEHICLE TRAVEL SURFACE, THEN THE RIM ELEVATION SHALL BE SAME ELEVATION AS FINISH GRADE, OTHERWISE RIM ELEVATION SHALL BE 0.33' HIGHER THAN FINISH GRADE.

Source: Pierce County

Figure 7.11b. Alternative Infiltration Trench Design.



Source: Ecology

Figure 7.12. Underground Trench with Oil/Grit Chamber.

Infiltration Trench Design Criteria

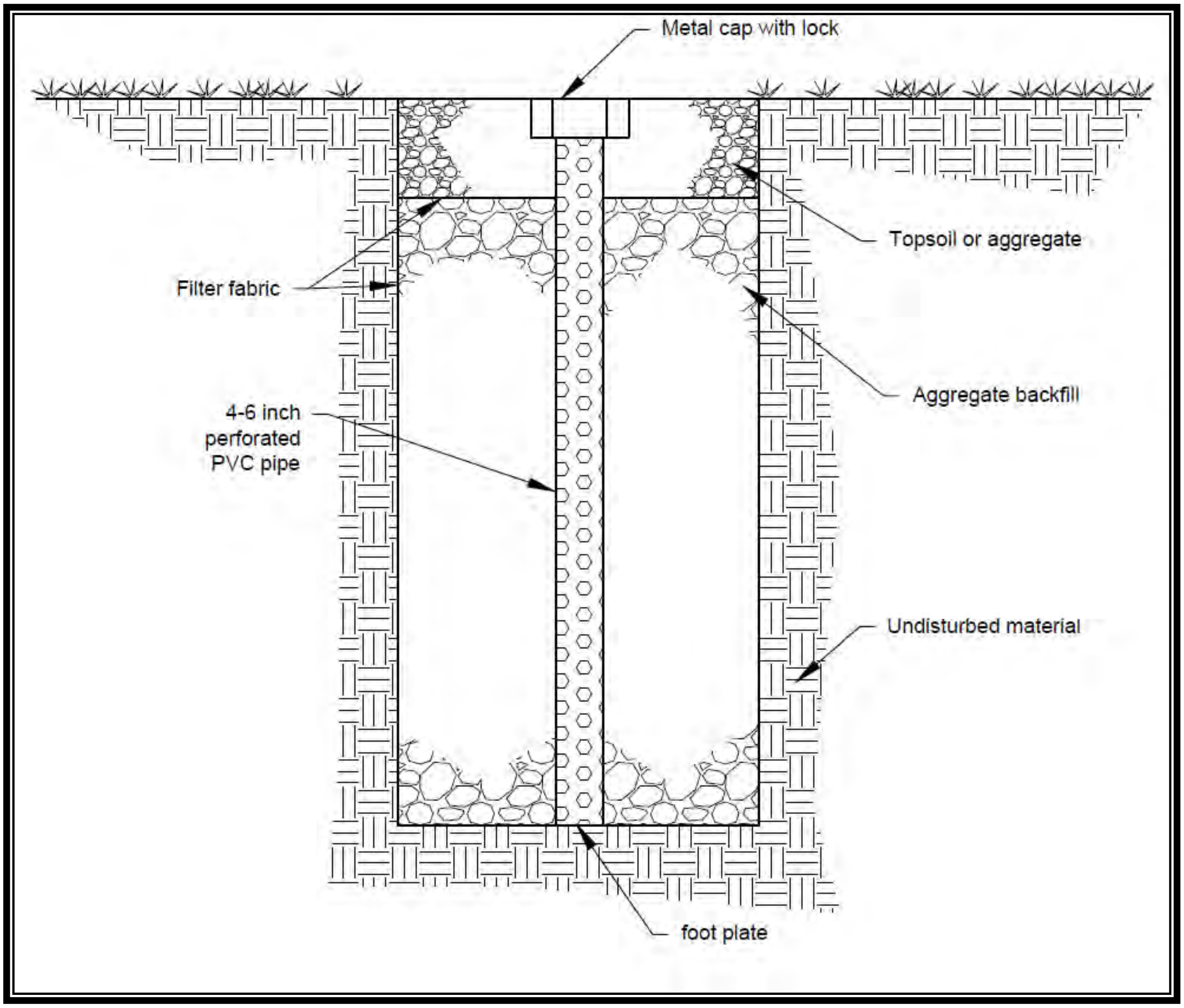
Refer to Section 7.2.3 for general procedures and design criteria applicable to infiltration basins, trenches, and galleries. This section provides additional design criteria specific to infiltration trench layout, access, bedding and geotextile, and overflow.

Trench Layout

- Surface cover: A stone filled trench can be placed under a porous or impervious surface cover to conserve space. If located under pavement, the following are required:
    - Observation wells must be placed no further than 100 feet apart.
    - The plans, details, and Maintenance and Source Control Manual must all clearly state that the pavement may have to be removed and/or other site improvements impacted due to maintenance, repair, or replacement of the stormwater infiltration system(s).
    - No infiltration trenches shall be allowed under any private or public streets.
- Flows must be evenly distributed across the trench to ensure that the trench will function as designed. Include appropriate measures to distribute flows (e.g., manifold system, level spreader).

Access

- A catch basin is required at the inlet of the infiltration trench for access.
- Provide a structure or cleanout at the end of each infiltration pipe for accessibility to conduct inspections and maintenance.
- Observation well: Install an observation well at the lower end of the infiltration trench to check water levels, drawdown time, sediment accumulation, and conduct water quality monitoring. See Figure 7.13 for an example observation well detail. It should consist of a perforated PVC pipe which is 4 to 6 inches in diameter, and it should be constructed flush with the ground elevation. For larger trenches a 12- to 36-inch-diameter well can be installed to facilitate maintenance operations such as pumping out the sediment. The top of the well must be equipped with a secure well cap to discourage vandalism and tampering.



Source: Ecology

Figure 7.13. Observation Well Details.

Trench Bedding and Geotextile

- Backfill material: The aggregate material for the infiltration trench must consist of a clean aggregate and meet WSDOT Standard Specification 9-03.12(5) that nominally ranges from 0.75-inch to 1.5-inch diameter. A maximum diameter of 3 inches and a minimum diameter of 1.5 inches may be approved if void space is maintained. Void space for these aggregates must be in the range of 30 to 40 percent.

- Geotextile fabric liner: Completely encase the aggregate fill material in an engineering geotextile material. Geotextile must surround all of the aggregate fill material except for the top 1 foot, which is placed over the geotextile. Carefully select geotextile fabric with acceptable properties to avoid plugging (see Chapter 8, Appendix 8A).

- A 6-inch minimum layer of sand may be used as a filter media at the bottom of the trench instead of geotextile.

- The bottom sand or geotextile fabric as shown in Figures 7.11 and 7.12.

  Refer to the *Geosynthetic Design and Construction Guidelines* (FHWA 1995) for design guidance on geotextiles in drainage applications. Refer *Long-Term Performance of Geosynthetics in Drainage Applications* (NCHRP 1994, for long-term performance data and background on the potential for geotextiles to clog, blind, or to allow piping to occur and how to design for these issues.

Overflow

- Because an infiltration trench is generally used for small drainage areas, an emergency spillway is not necessary. However, provide a nonerosive overflow channel leading to a stabilized watercourse.

Construction Criteria for Trenches

- Most of the construction requirements for small-scale infiltration BMPs included in Chapter 5, Section 5.3, apply to all infiltration BMPs. Additional specific construction criteria for infiltration trenches are provided below. Criteria for residential roof downspout infiltration trenches are provided in Section 7.4.10.

- **Trench preparation:** Excavated materials must be placed away from the trench sides to enhance trench wall stability. Take care to keep this material away from slopes, neighboring property, sidewalks, and streets. It is recommended that this material be covered with plastic (see erosion and sediment control criteria in Chapter 5, BMP C123 – Plastic Covering).

- **Stone aggregate placement and compaction:** Place the stone aggregate in lifts and compact using plate compactors. In general, a maximum loose lift thickness of 12 inches is recommended. The compaction process ensures geotextile conformity to the excavation sides, thereby reducing potential piping and geotextile clogging, and settlement problems.

- **Potential contamination:** Prevent natural or fill soils from intermixing with the stone aggregate. Remove all contaminated stone aggregate and replace with uncontaminated stone aggregate.

- **Overlapping and covering:** Following the stone aggregate placement, the geotextile must be folded over the stone aggregate to form a 12-inch minimum longitudinal overlap. When overlaps are required between rolls, the upstream roll must overlap a minimum of 2 feet over the downstream roll in order to provide a shingled effect.

- **Voids behind geotextile:** Voids between the geotextile and excavation sides must be avoided. Removing boulders or other obstacles from the trench walls is one source of such voids. Place natural soils in these voids at the most convenient time during construction to ensure geotextile conformity to the excavation sides. This remedial process helps to avoid soil piping, geotextile clogging, and possible surface subsidence.

- **Unstable excavation sites:** Vertically excavated walls may be difficult to maintain in areas where the soil moisture is high or where soft or cohesionless soils predominate. Trench boxes or trapezoidal, rather than rectangular, cross-sections may be needed.

Operations and Maintenance Criteria

See Core Requirement #9 in Chapter 2, Section 2.2.9 and Chapter 10 for information on maintenance requirements.

Acceptance Testing

To demonstrate that the BMP performs as designed, it may be required that the constructed BMP is tested and monitored per the Acceptance Testing requirements in Section 7.2.2.

7.4.8 Infiltration Galleries

Description

The term "infiltration galleries" refers to manufactured detention structures, commonly referred to as "infiltration chambers," within a broad gravel trench. Infiltration chambers are buried structures, typically arch-shaped, within which collected stormwater is temporarily stored and then infiltrated into the underlying soil. Infiltration chambers create an underground cavity that can provide a greater void volume than infiltration trenches and often require a smaller footprint. Infiltration galleries may be allowed on a case-by-case basis and must be sized per the manufacturer's guidance.

Applications and Limitations

- Infiltration galleries can be used to meet the flow control standards of Core Requirement #7.

- When used in combination with other on-site stormwater management BMPs, they can also help achieve compliance with the LID Performance Standard option of Core Requirement #5.

- Infiltration galleries can be used to help meet the runoff treatment requirements of Core Requirement #6 if the underlying soil meets the requirements provided in Chapter 8, Section 8.6.

APPENDIX E

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September 20, 2013

Wig Properties, LLC
4811-134th PL SE
Bellevue, WA 98006

Attn: Leshya Wig

Geotechnical Engineering Services
Earthwork Recommendations
Parcels L, N & O
Lacey Gateway Project
Marvin Rd & Main St. NE
Lacey, Washington
Prop:.WigProp.Gateway.RG

INTRODUCTION & SCOPE

This report presents the results of our data review, site observations and monitoring of the recently completed borings/monitoring wells (by others) for the Lacey Gateway project. The purpose of our report is to provide geotechnical engineering recommendations and design criteria for the proposed earthwork activity at the site in preparation for commercial development. The proposed initial development will occur in the northeast portion of the site on the parcels listed above. The general location of the subject parcels is illustrated on the attached Site Vicinity Map, Figure 1.

We previously completed geotechnical reports for projects in the vicinity of the site. We also reviewed the existing geotechnical and environmental reports for the project site. This report provides site specific information for proposed earthwork/grading activities at the site, generally the filling of a localized depression which will create a more uniform or flatter ground surface.

Based on the information provided, we understand that the proposed commercial development will likely include the construction of a number of commercial buildings with associated asphalt parking, asphalt/concrete driveways, and typical underground utilities. Stormwater considerations are being addressed by others. The project will be constructed in phases, Phase 1 being the northeast portion of the site. The specific project area is included as Figure 2.

As indicated, the purpose of our report is to provide geotechnical engineering recommendations and design criteria for the proposed earthwork activity at the site in preparation for commercial development. Specifically, the scope of services for this project will include the following:

1. Reviewing the available geotechnical data for the site area.
2. Monitoring at least one of the planned environmental borings at the site.
3. Providing geotechnical earthwork recommendations for the expected site grading activities; including site preparation, subgrade preparation, fill placement criteria, suitability of on-site soils for use as structural fill, temporary and permanent cut and fill slopes, and drainage/erosion control measures.
4. Summarizing our observations, data review and exploration data in a written geotechnical earthwork report.

SITE CONDITIONS

Surface Conditions

The site is situated in the central portion of the Lacy glacial outwash plain that formed as the Vashon glacial ice receeded from the area. The site is bounded by other commercial development on the north, east and west, and by Interstate Highway 5 on the south. The ground surface at the site is gently to moderately sloping with localized small hills, ridges and depressions. The proposed earthwork activity for the site is to regrade the east portion of the site to a flatter overall configuration by moving the native soil materials from the hills/ridges into a depression.

The site is currently vegetated with scattered young second growth timber, primarily evergreens, with a moderate to dense understory of native and invasive brush and grasses. The site is traversed by a number of gravel roads and trails, including several that reflect the proposed final road configuration. The general condition of the site is illustrated on the Site Aerial Photograph, Figure 3.

Subsurface Conditions

To provide the necessary geotechnical engineering information for the project, we reviewed the available surface and subsurface data for the site, which included a numerous previous test pit excavations. We also monitored and reviewed the data from three new borings with monitoring wells completed in the east portion of the three subject parcels.

Based on our data review, our site observations and experience in the area, subsurface conditions in this area generally consist of outwash sand and gravel with intermittent layers of fine sand and silty sand, which is the mapped stratigraphy for the area. The soils encountered in the borings generally consisted of very dense sandy gravel over sandy gravel with variable silt content. No groundwater seepage was encountered in Boring MW-2 completed at a depth of approximately 75 feet below the adjacent ground surface. Groundwater was measured at depths of 15 feet and 10 feet below the adjacent ground surfaces in MW-1 and MW-2, respectively. The approximate locations of the explorations at the site are illustrated on the Site Plan, Figure 2. Soil logs of the three recent borings are included in Appendix "A".

We expect that there will be localized areas of the site that are mantled by a thin, intermittent veneer of recessional outwash overlying a discontinuous thin layer of glacial till. The till, where present, or the recessional outwash where the till is absent, are underlain by advance outwash sand and gravel that was encountered to the full depth explored in the deeper explorations.

Groundwater Conditions

Groundwater conditions in site area are similar to those in the surrounding areas of Hawks Prairie. In general, there are two groundwater zones in this area; a shallow seasonal perched water table and a deeper glacial advance outwash aquifer. The shallow seasonal perched water table is related to rainfall that infiltrates through the surficial permeable soils and perches on the underlying very dense soils. The shallow perched seepage at the site was encountered at or just above the surface of the dense advance outwash in borings MW-1 and MW-3, where present, and locally on silt lenses near the outwash channel. The shallow perched water also resulted in slight to moderate seepage in several of the test pits at the time of excavation, and in the borings. No groundwater seepage was observed in MW-2, indicating that the perched water is intermittent across the site. MW-2 extended to a depth of 75 feet without encountering groundwater seepage, indicating that the regional water table is greater than this depth. We expect that once the site is developed, the amount of seasonal perched water at the site will be significantly reduced.

Relative to the deeper regional groundwater aquifer, we reviewed the available water well logs from the Washington State Department of Ecology website. The wells were grouped in areas near the intersection of Britton Parkway and Carpenter Road (west of the site), near the Hawks Prairie Landfill (southeast of the site), and on some of the nearby parcels. In general, most of the well logs did not encountered static water within the upper 15 to 30 feet. Instead, water was generally encountered at depths of 90 to 230 feet.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of our data review, site reconnaissance, subsurface exploration monitoring, and our experience in the area, it is our opinion that the site may be graded using conventional earthwork equipment and methodology. The site soils generally consist of sand and gravel with variable silt, cobble and boulder content. These soils are comparable to commercial aggregate materials and may be utilized for structural fill during virtually any type of weather. Where silty lenses of soil material (till) are encountered, these soils may require blending during wet weather conditions. Pertinent conclusions and geotechnical recommendations regarding earthwork are presented below.

Structural Fill

All material placed as fill associated with mass grading, as utility trench backfill, under building areas, or under roadways should be placed as structural fill. The structural fill should be placed in horizontal lifts of appropriate thickness to allow adequate and uniform compaction of each lift. Fill should be compacted to at least 95 percent of MDD (maximum dry density as determined in accordance with ASTM D-1557).

The appropriate lift thickness will depend on the fill characteristics and compaction equipment used. We recommend that the appropriate lift thickness be evaluated by our field representative during construction. We recommend that our representative be present during site grading activities to observe the work and perform field density tests.

The suitability of material for use as structural fill will depend on the gradation and moisture content of the soil. As the amount of fines (material passing US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult to achieve. During wet weather, we recommend use of well-graded sand and gravel with less than 5 percent (by weight) passing the US No. 200 sieve based on that fraction passing the 3/4-inch sieve, such as Gravel Backfill for Walls (9-03.12(2)). If prolonged dry weather prevails during the earthwork and foundation installation phase of construction, higher fines content (up to 10 to 12 percent) will be acceptable.

Material placed for structural fill should be free of debris, organic matter, trash and cobbles greater than 6-inches in diameter. The moisture content of the fill material should be adjusted as necessary for proper compaction.

Suitability of On-Site Materials as Fill

During dry weather construction, any non-organic on-site soil may be considered for use as structural fill; provided it meets the criteria described above in the structural fill section and can be compacted as recommended. If the soil material is over-optimum in moisture content when excavated, it will likely be necessary to blend, aerate or dry the soil prior to placement as structural fill. We did not observe the shallow site soils to be excessively moist while monitoring the subsurface exploration program. No significant seepage was reported in the test pits previously excavated at the site.

The near surface recessional outwash do not appear to contain significant amount of silts, and as such would likely be suitable for reuse as structural fill during extended periods of wet weather. The localized areas of native glacial till soils at the site generally consisted of silty gravel with fine sand. These soils are generally comparable to "common borrow" material and will be suitable for use as structural fill provided the moisture content is maintained within 4 percent of the optimum moisture level. However, due to the high fines content, the till soils encountered across the site will likely be unsuitable during extended periods of wet weather.

We recommend that completed graded-areas be restricted from traffic or protected prior to wet weather conditions. The graded areas may be protected by paving, placing asphalt-treated base, a layer of free-draining material such as pit run sand and gravel or clean crushed rock material containing less than 5 percent fines, or some combination of the above.

Temporary Excavations

All excavations at the site associated with confined spaces, such as utility trenches and retaining walls, must be completed in accordance with local, state, or federal requirements. Based on current Washington State Safety and Health Administration (WSHA 296-155-66401) regulations, the shallow upper soils on the site would be classified as Type B soils while the deeper sandy glacial till soils would be classified as Type A soils.

According to WSHA, for temporary excavations of less than 20 feet in depth, the side slopes in Type A soils should be laid back at a slope inclination of ¾H:1V (Horizontal: Vertical) while Type B soils should be laid back at a slope inclination of 1H:1V. It should be recognized that slopes of this nature do ravel and require occasional maintenance. All exposed slope faces should be covered with a durable reinforced plastic membrane, jute matting, or other erosion control mats during construction to prevent slope raveling and rutting during periods of precipitation. These guidelines assume that all surface loads are kept at a minimum distance of at least one half the depth of the cut away from the top of the slope and that significant seepage is not present on the slope face. Flatter cut slopes will be necessary where significant raveling or seepage occurs, or if construction materials will be stockpiled along the slope crest.

All job site safety issues and precautions are the responsibility of the contractor providing services/work. The following cut/fill slope guidelines are provided for planning purposes only. Temporary cut slopes will likely be necessary during grading operations or utility installation.

This information is provided solely for the benefit of the owner and other design consultants, and should not be construed to imply that GeoResources assumes responsibility for job site safety. It is understood that job site safety is the sole responsibility of the project contractor.

Pavement Subgrade

Based on the granular nature of the site soils, we expect that the native soils can be utilized for the roadway subbase material. Where the native soils are "clean" or have limited fines content, it may be necessary to mix sand into the coarser material for binder. Without binder material, the soils may be difficult to drive on.

All pavement subgrades should be proof-rolled with a loaded dump truck or heavy compactor to verify the density. Any areas where this proof-rolling operation reveals soft, organic, or pumping soils at or closely beneath the pavement subgrade should be overexcavated to a maximum depth of 8 inches and replaced with a suitable structural fill material. All structural fill should be compacted according to our recommendations given in the "**Structural Fill"** section above. Specifically, the upper 2 feet of soils underlying pavement section should be compacted to at least 95 percent of ASTM: D-1557, and all soils below 2 feet should be compacted to at least 90 percent.

For the top course, we recommend using imported, clean, crushed rock, such as "Crushed Surfacing Top Course" per WSDOT Standard Specification 9-03.9(3). For the base course, we recommend using imported, clean, well-graded sand and gravel, such as "Ballast" or "Gravel Borrow" per WSDOT Standard Specifications 9-03.9(1) and 9-03.14, respectively.

All top course and base course material should be compacted to at least 95 percent of the modified Proctor maximum dry density (based on ASTM:D-1557), and all asphalt concrete should be compacted to at least 92 percent of the Rice value (ASTM:D-2041). We recommend that a GeoResources representative be retained to verify the compaction of each course before the successive course is placed. For the subbase course and pavement course, this is best accomplished by means of frequent density testing. For the base course, methodology observations and hand probing are more appropriate than density testing.

LIMITATIONS

We have prepared this report for Wig Properties, and project team members for use in design and construction of the various components of this project. The data and report can be utilized for bidding or estimating purposes, but our report, conclusions and recommendations should not be construed as a warranty of the subsurface conditions, as they may vary both vertically and laterally.

If there are changes in the locations or assumptions stated for this project, the conclusions and recommendations presented may not be fully applicable. If design changes are made, we should review the proposed changes to verify the applicability of our conclusions and recommendations.

Within the limitations of scope, schedule and budget, our services were executed in accordance with generally accepted practices in this area at the time this report was prepared. No warranty, express or implied, should be understood.

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We appreciate the opportunity to be of service to you on this project. Please call if you have any questions regarding this submittal, or if we can provide additional services.

Yours very truly,
GeoResources, LLC

Dana C. Biggerstaff, PE
Senior Engineer

DANA CHRISTOPHER BIGGERSTAFF
50040

10/14/13

Bradley P. Biggerstaff, LEG, LHG
Principal

2228
BRADLEY P. BIGGERSTAFF

10/6

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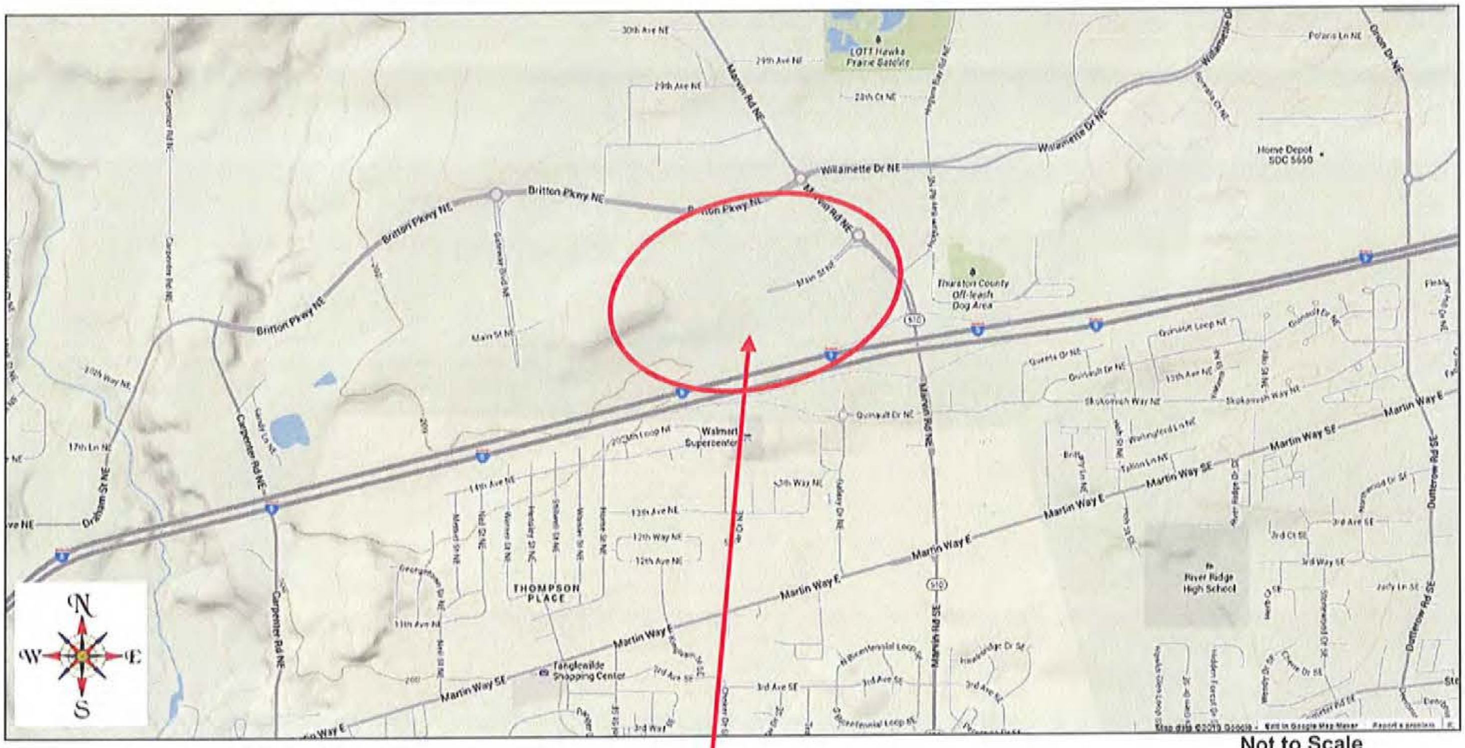

Not to Scale

Approximate Site Location

GeoResources, LLC
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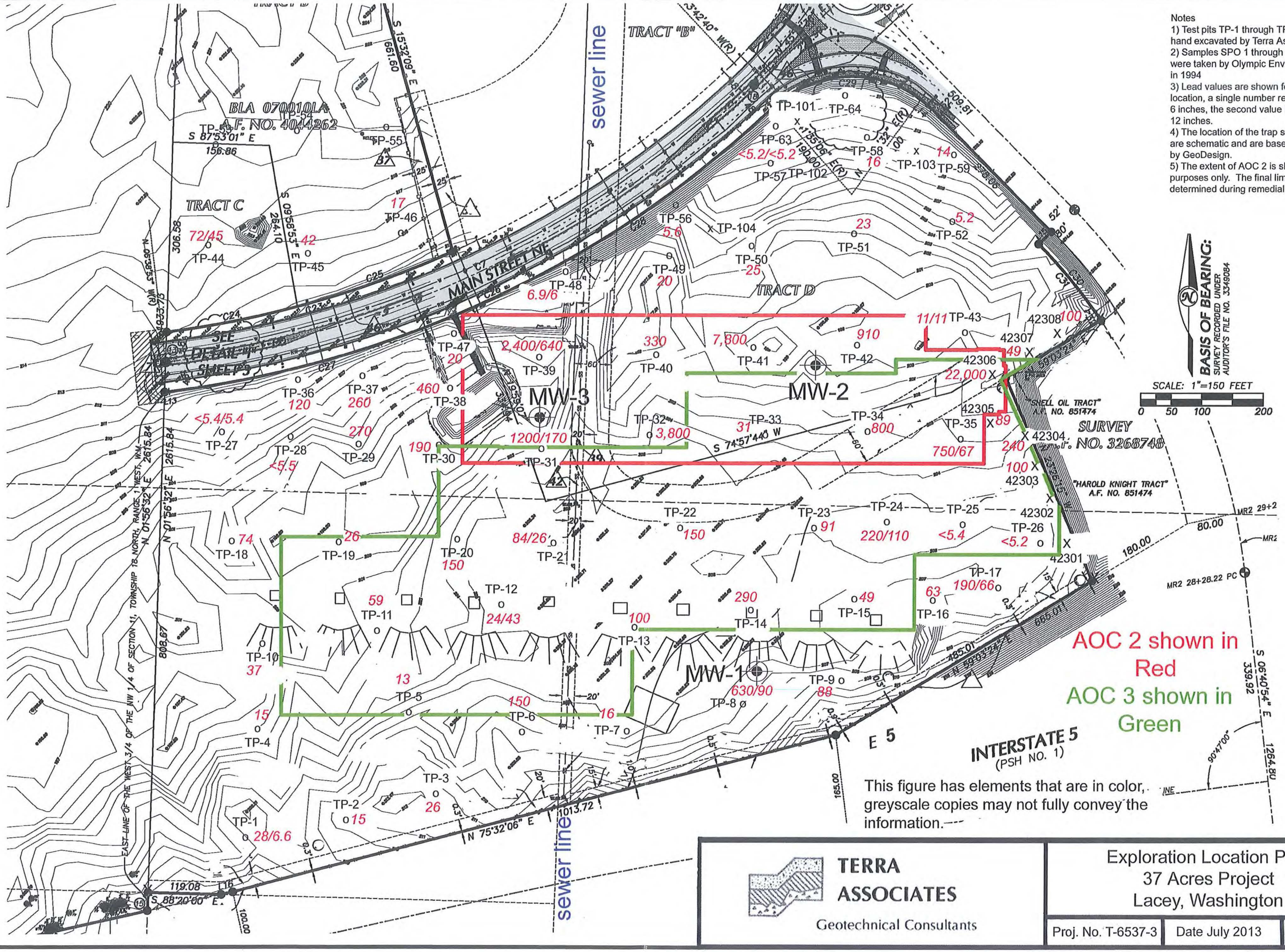
Site Vicinity Map
Proposed Lacey Gateway Commercial Project
Parcels k, L, M, N, & O
Marvin Road NE & Britton Parkway NE
Lacey, Washington

DocID: WigProp.Gateway.F	July 2013	Figure 1

Notes
1) Test pits TP-1 through TP-62 were hand excavated by Terra Assoc. in 2012
2) Samples SPO 1 through SPO 4 were taken by Olympic Environmental in 1994
3) Lead values are shown for each sample location, a single number reflects the upper 6 inches, the second value is the sample at 12 inches.
4) The location of the trap stands and houses are schematic and are based on a sketch by GeoDesign.
5) The extent of AOC 2 is shown for planning purposes only. The final limits will be determined during remedial action



AOC 2 shown in Red

AOC 3 shown in Green

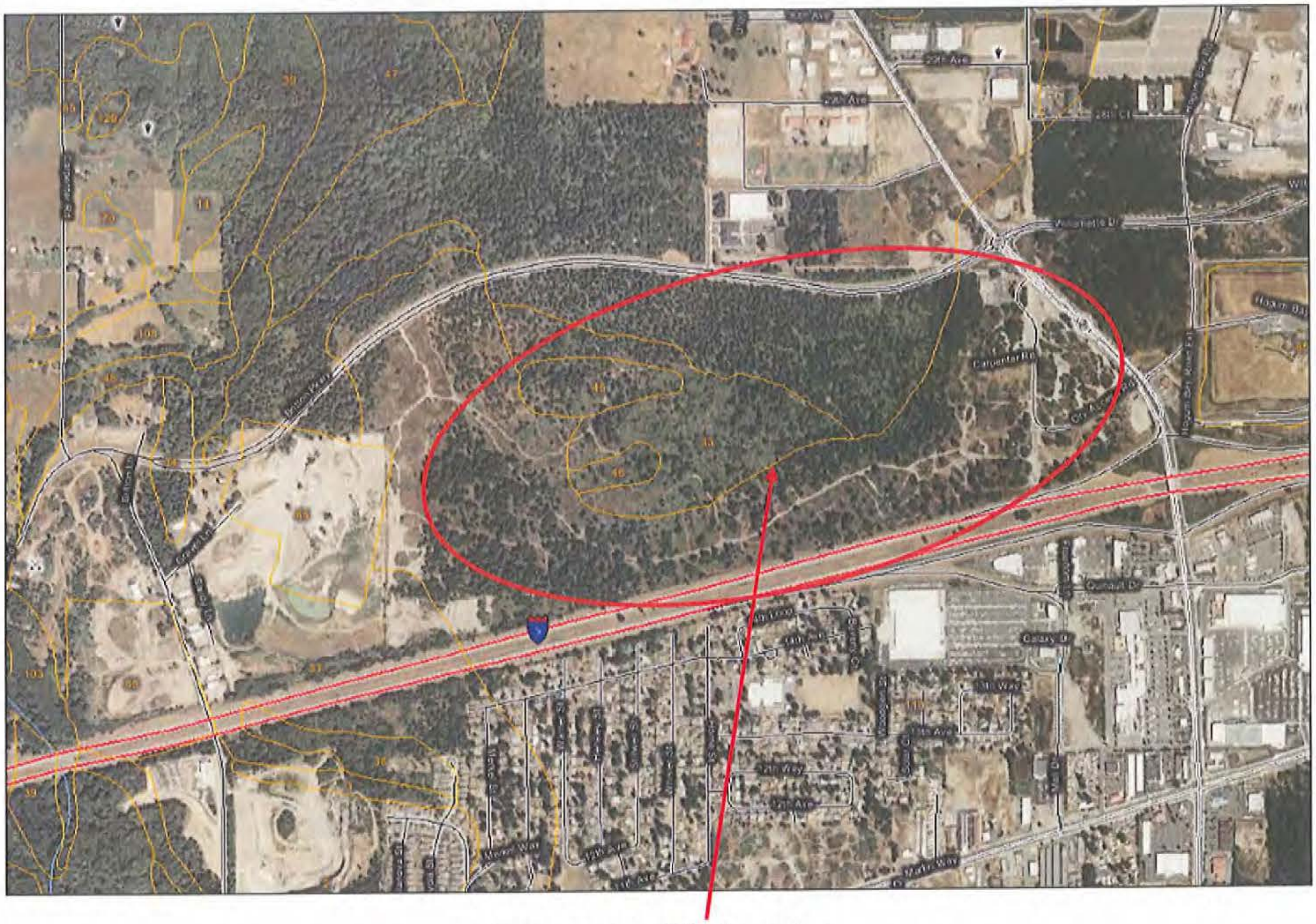
This figure has elements that are in color, greyscale copies may not fully convey the information.

TERRA ASSOCIATES

Geotechnical Consultants

Exploration Location Plan
37 Acres Project
Lacey, Washington

Proj. No. T-6537-3	Date July 2013	Figure 1



Approximate Site Location

(map created from the USDA Natural Resource Conservation Service Web Soil Survey)

Soil Type	Soil Name	Parent Material	Slopes	Erosion Hazard	Hydrologic Soils Group
2	Alderwood gravelly sandy loam	Glacial Till	3 to 15	Moderate	B (D at depth)
33	Everett gravelly sandy loam	Glacial Till	3 to 15	Moderate	B (D at depth)
46	Indianola loamy sand	Sandy glacial outwash	0 to 3	Slight	A
85	Pits, Gravel	-	-	-	-
110	Spanaway gravelly sandy loam	Volcanic ash over gravelly glacial outwash	0 to 3	Slight	A

Not to Scale

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NRCS SCS Soils Map

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Parcels k, L, M, N, & O
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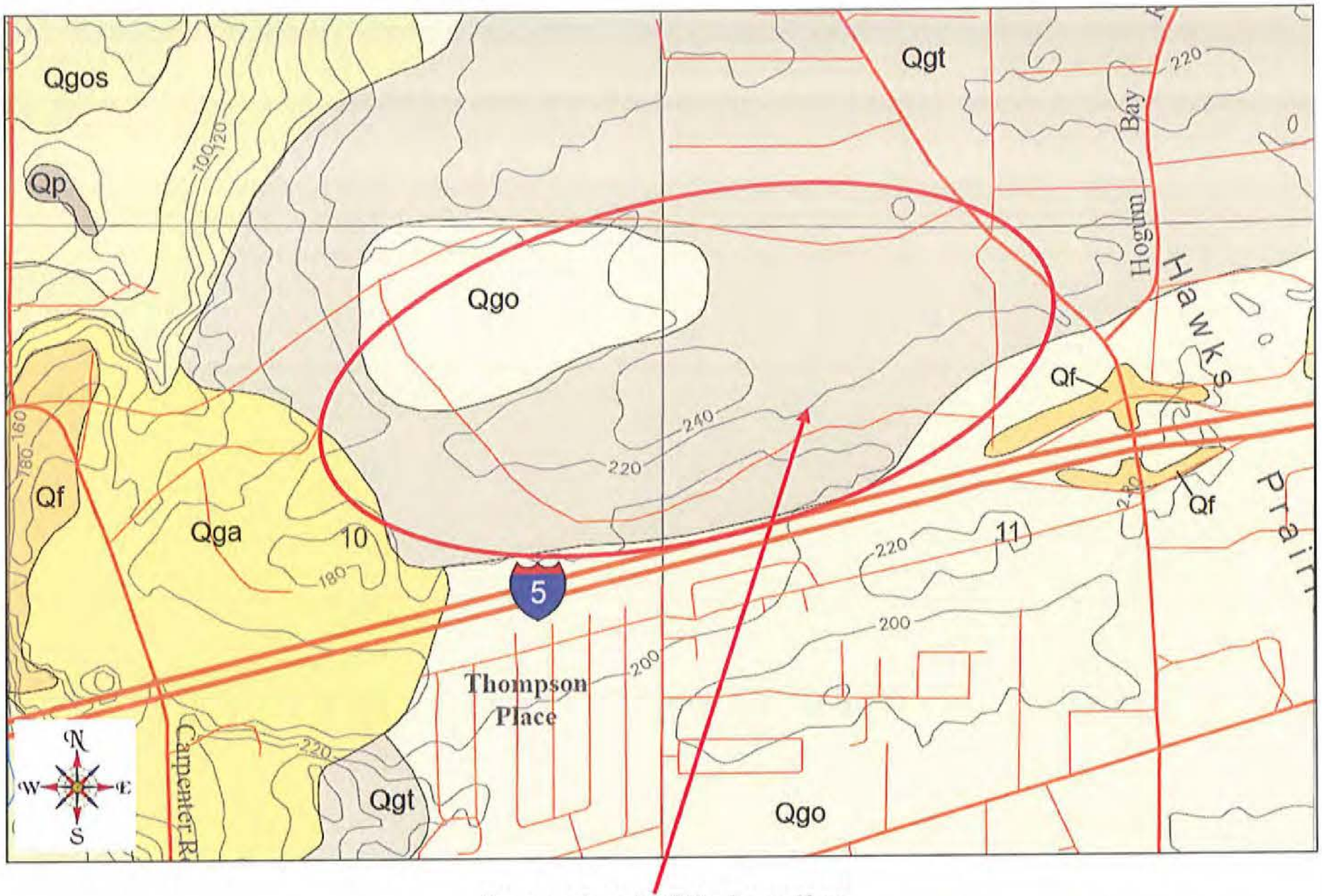
Lacey, Washington

DocID: WigProp.Gateway.F	July 2013	Figure 3



Approximate Site Location

An excerpt from the *Geologic Map of the Lacey 7.5-minute Quadrangle, Thurston County, Washington* by Robert L. Logan, Timothy J. Walsh, Henry W. Schasse, and Michael Polenz (2003)

Qf	**Fill**—Clay, silt, sand, gravel, organic matter, rip-rap, and debris; includes engineered and non-engineered fills; shown only where fill placement is extensive, sufficiently thick to be of geotechnical significance, and readily verifiable.
Qgo	**Vashon recessional outwash**—Recessional and proglacial stratified, moderately to well-rounded, poorly to moderately sorted outwash sand and gravel of northern or mixed northern and Cascade source, locally containing silt and clay; also contains lacustrine deposits and ice-contact stratified drift. Some areas mapped as unit Qgo may instead be advance outwash (unit Qga), as it is difficult to tell the difference between the two without the presence of an intervening till
Qgt	**Vashon till**—Unstratified and, in most exposures, highly compacted mixture of clay, silt, sand, and gravel deposited directly by glacier ice; gray where fresh and light yellowish brown where stained; unsorted and, in most exposures, of very low permeability; most

Not to Scale

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USGS Geologic Map
Proposed Lacey Gateway Commercial Project
Parcels k, L, M, N, & O
Marvin Road NE & Britton Parkway NE
Lacey, Washington

DocID: WigProp.Gateway.F	July 2013	Figure 4

APPENDIX “A”

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More than 50% Retained on No. 200 Sieve	GRAVEL More than 50% Of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More than 50% Of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or more	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is based on ASTM D2487-90.
3. Description of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and or test data.

SOIL MOISTURE MODIFIERS:

Dry-	Absence of moisture, dry to the touch
Moist-	Damp, but no visible water
Wet-	Visible free water or saturated, usually soil is obtained from below water table

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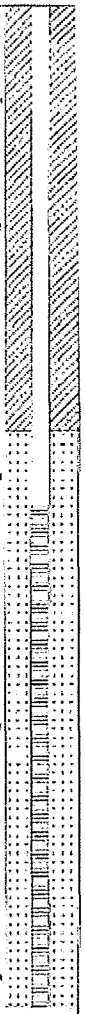
Soil Classification System
Proposed Lacey Gateway Commercial Project
Parcels k, L, M, N, & O
Marvin Road NE & Britton Parkway NE
Lacey, Washington

DocID: WigProp.Gateway.F | **July 2013** | **Figure 5**

Client: Wig Properties LLC-Nisqually **Driller:** Cascade Drilling **Logged By:** CRL

Location: Lacey, Washington **Approx. Elev:** 307 +/- Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	Moisture Content % Wp |-----x-----| Wl 10 30 50 70 90	Pocket Penetrometer TSF 1 2 3 4 SPT (N) Blows/ft 10 20 30 40	Observ. Well
		(12 inches SOD and TOPSOIL.)				
1		Gray sandy GRAVEL, dry.				
2				2.9	50/6"	
3			Very Dense			
4						
5				6.0	50/6"	
6						
7		Gray sandy GRAVEL with silt, moist becoming wet below 10 feet.	Very Dense			
8						
9						
10				8.5	50/2"	
11						
12						
13						
14		Seepage observed at 15 feet.				
▽ 15				11.6	50/6"	
16						
17						
18						
19						
20				8.5	50/6"	
21		Monitoring well terminated at 20 feet. Groundater observed at 15 feet during drilling. 2-inch PVC monitoring well constructed as shown. (WDOE Well Tag BIC 548)				
22						
23						
24						
25						



Note: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site.

Terra Associates, Inc.

Consultants in Geotechnical Engineering, Geology and Environmental Earth Sciences

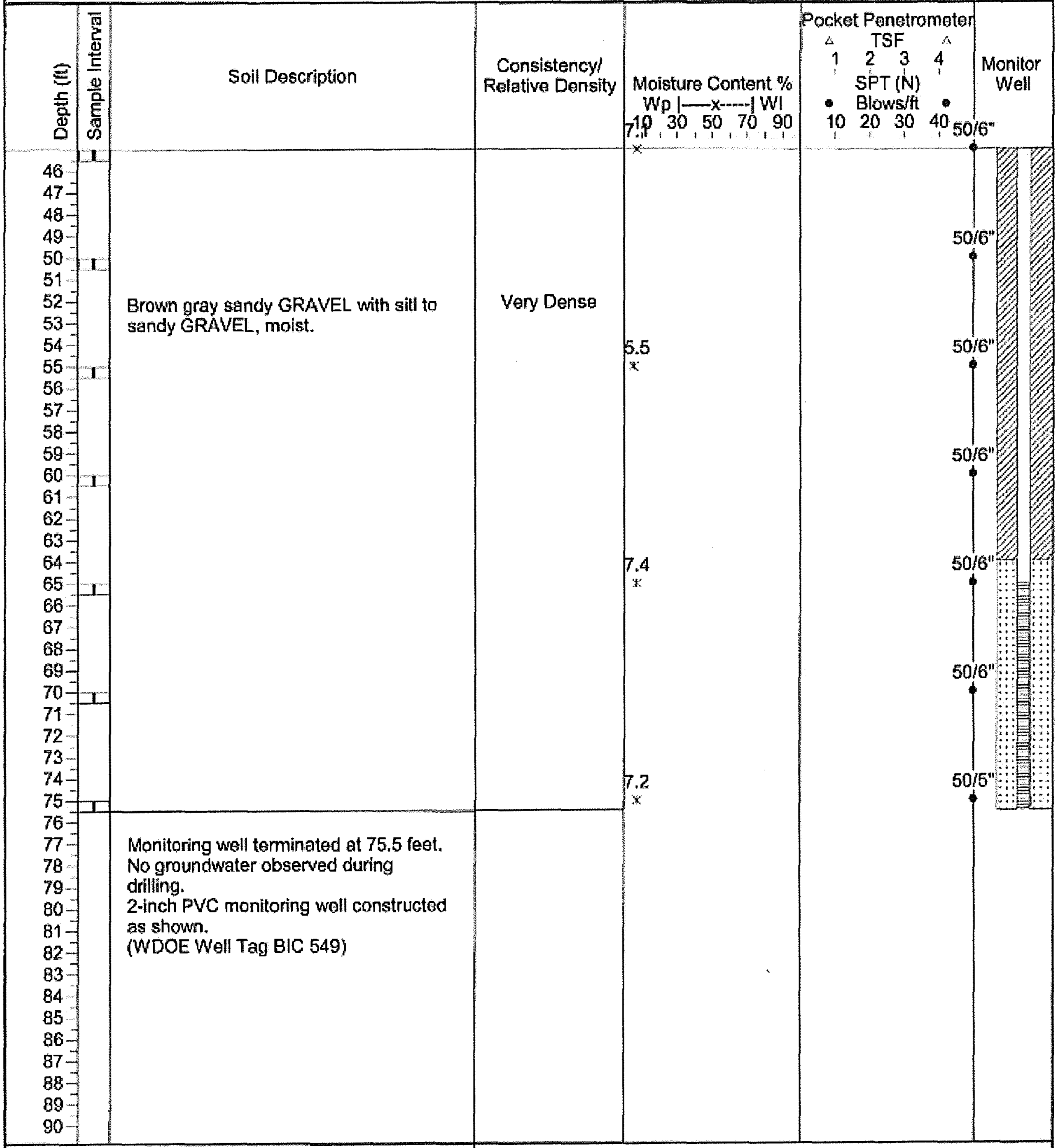
LOG OF MONITORING WELL MW-2

Figure No. A-2

Project: 37 Acre Site **Project No:** T-6537-3 **Date Drilled:** 6/23/13

Client: Wig Properties LLC-Nisqually **Driller:** Cascade Drilling **Logged By:** CRL

Location: Lacey, Washington **Approx. Elev:** 200 +/- Feet



Soil Description	Consistency/ Relative Density
Brown gray sandy GRAVEL with sitl to sandy GRAVEL, moist.	Very Dense

Monitoring well terminated at 75.5 feet.
No groundwater observed during drilling.
2-inch PVC monitoring well constructed as shown.
(WDOE Well Tag BIC 549)

LOG OF MONITORING WELL MW-3

Figure No. A-3

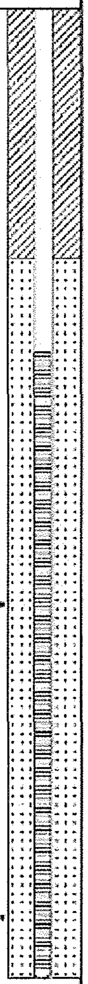
Project: 37 Acre Site **Project No:** T-6537-3 **Date Drilled:** 6/24/13

Client: Wig Properties LLC-Nisqually **Driller:** Cascade Drilling **Logged By:** CRL

Location: Lacey, Washington **Approx. Elev:** 200 +/- Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	Moisture Content % Wp |-----x-----| Wl 10 30 50 70 90	Pocket Penetrometer TSF 1 2 3 4 SPT (N) Blows/ft 10 20 30 40
0		(Upper 18 inches removed prior to drilling)			
2		Brown-gray sandy GRAVEL with silt, dry.			
5	5–6.5		Dense to Very Dense	5.6	36
▼ 10	10–11			10.3	50/6"
11		Brown gravelly SAND with silt, wet.	Very Dense		
15	15–15.5			8.3	50/6"
15.5		Monitoring well terminated at 15.5 feet. Groundwater observed below 10 feet. 2-inch PVC monitoring well constructed as shown. (WDOE Well Tag BIC 550)			

Observ. Well



Note: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site.

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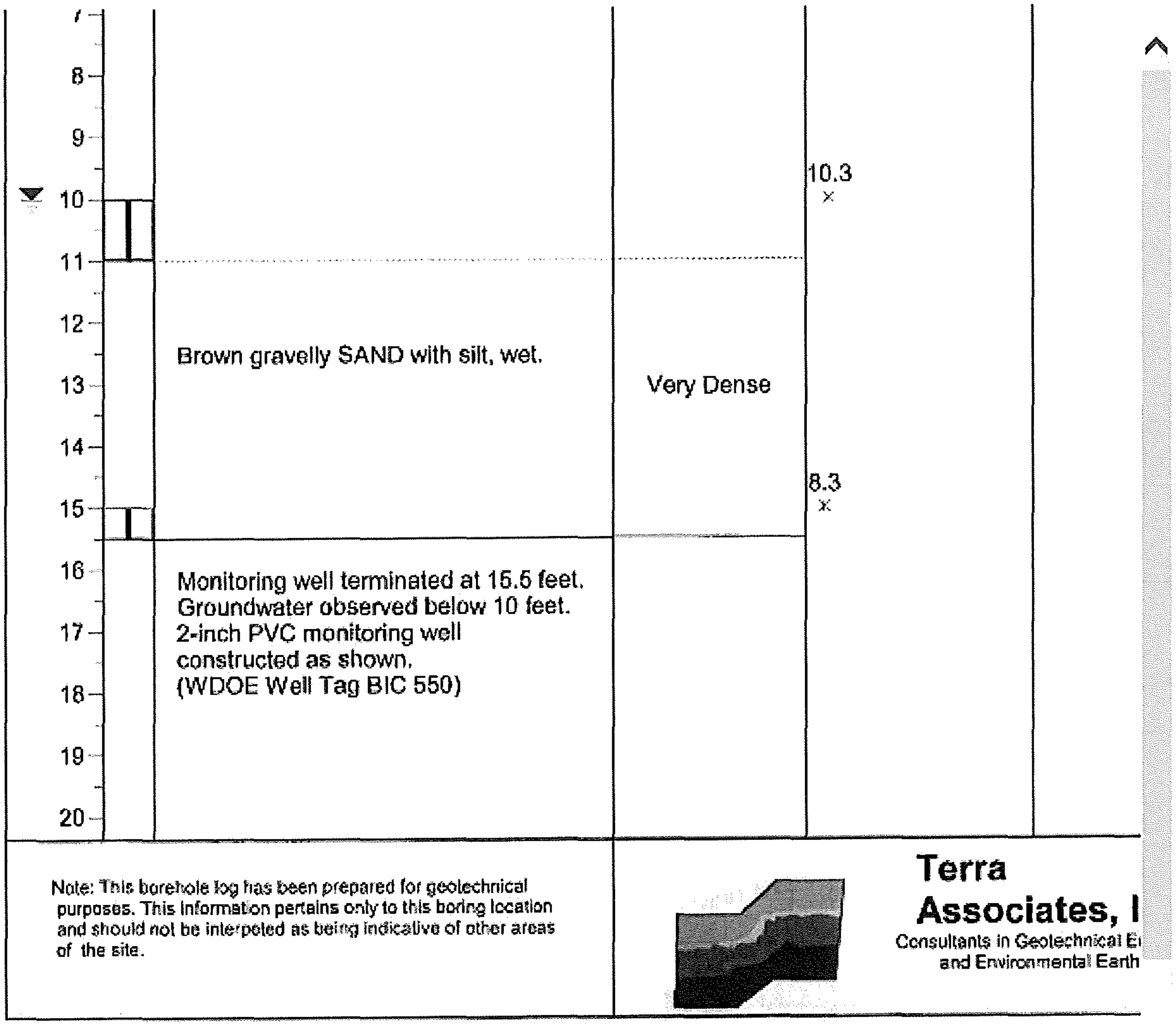
Consultants in Geotechnical Engineering, Geology and Environmental Earth Sciences



Brown gravelly SAND with silt, wet.

Very Dense

Monitoring well terminated at 15.5 feet.
Groundwater observed below 10 feet.
2-inch PVC monitoring well
constructed as shown.
(WDOE Well Tag BIC 550)

Note: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site.

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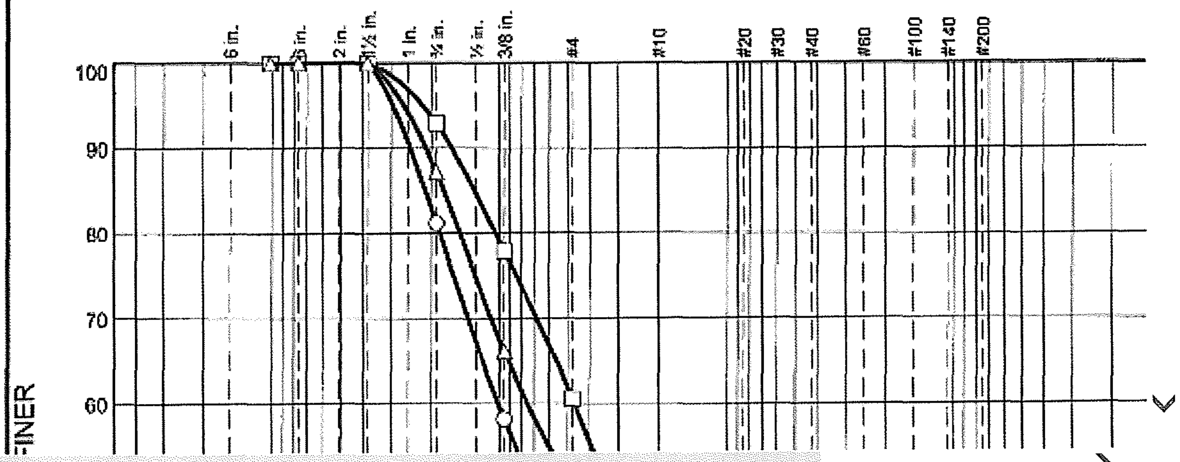
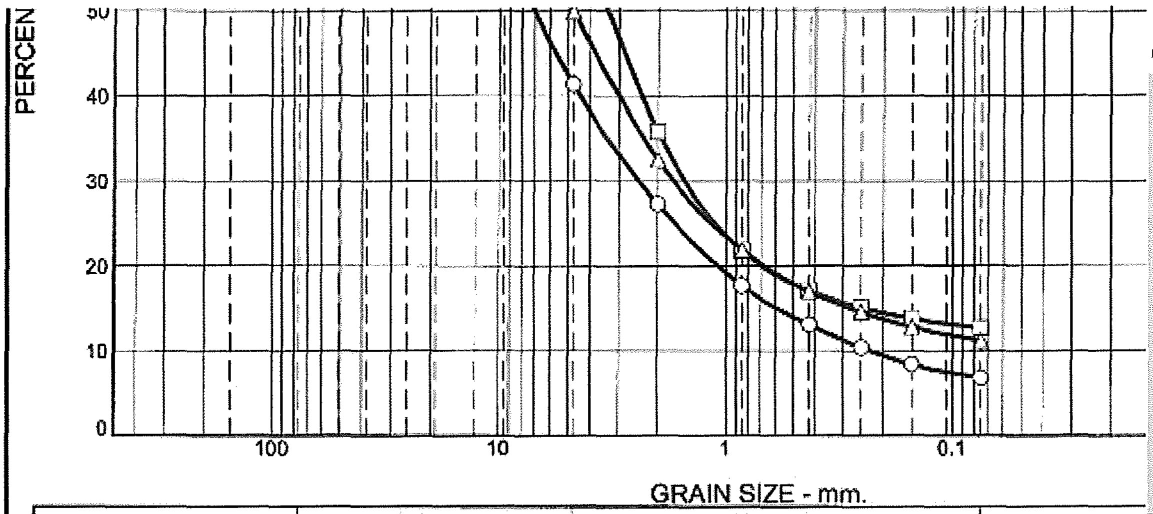
and Environmental Earth

Particle Size Distribution Report





	% +3"	% Gravel		% Sand			Silt
		Coarse	Fine	Coarse	Medium	Fine	
○	0.0	18.8	39.8	14.1	14.2	6.3	
□	0.0	7.1	32.4	24.7	18.7	4.4	
△	0.0	12.8	37.3	17.4	15.5	5.8	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}
○			21.2620	10.1172	7.0177	2.4243	0.5879	0.2287
□			12.8972	4.6660	3.3229	1.5256	0.2419	
△			17.6422	7.5184	4.7724	1.7081	0.2762	

Material Description

○ Gravelly sand with silt
□ Silty gravel with sand
△ Sandy gravel with silt

Project No. 6537-3 **Client:** Wig Properties
Project: 37-acre Parcel

Remar

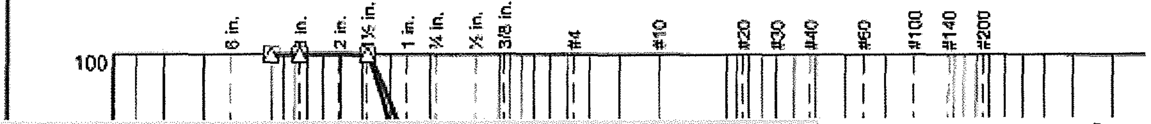
○ **Location:** MW-1 **Depth:** 2.5/4.0'
□ **Location:** MW-1 **Depth:** 5/6.0'
△ **Location:** MW-1 **Depth:** 10/11'

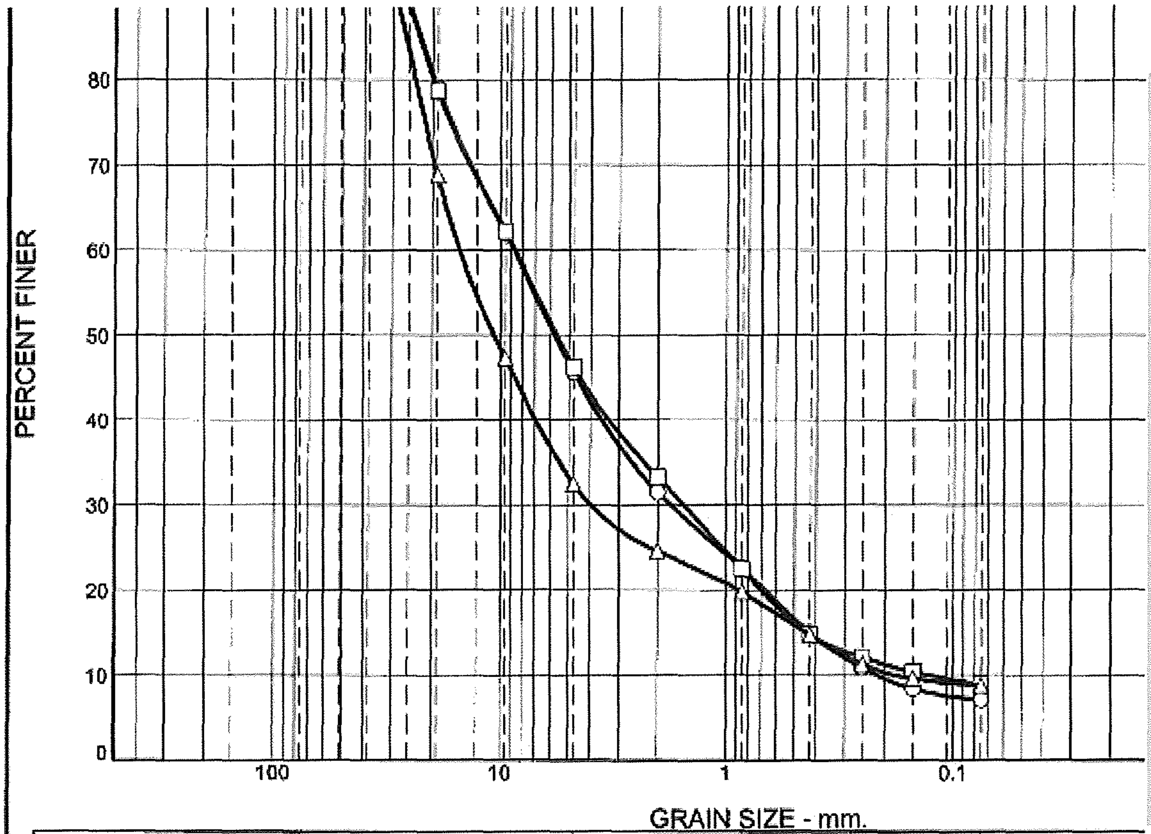
Terra Associates, Inc.

Kirkland, WA

Tested By: FQ

Particle Size Distribution Report





	% +3"	% Gravel		% Sand			Silt
		Coarse	Fine	Coarse	Medium	Fine	
○	0.0	20.9	33.5	14.1	16.5	7.9	
□	0.0	21.3	32.5	12.9	18.5	5.9	
△	0.0	31.2	36.3	7.9	9.9	5.9	

☒	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}
○			22.6945	8.7416	5.7703	1.7550	0.4250	0.2143
□			22.9311	8.6472	5.6652	1.5358	0.4359	0.1287
△			26.2718	15.2024	10.6529	3.9752	0.4425	0.1773

Material Description

○ Sandy gravel with silt
□ Sandy gravel with silt
△ sandy gravel with silt

Project No. 6537-3 **Client:** Wig Properties
Project: 37-acre Parcel

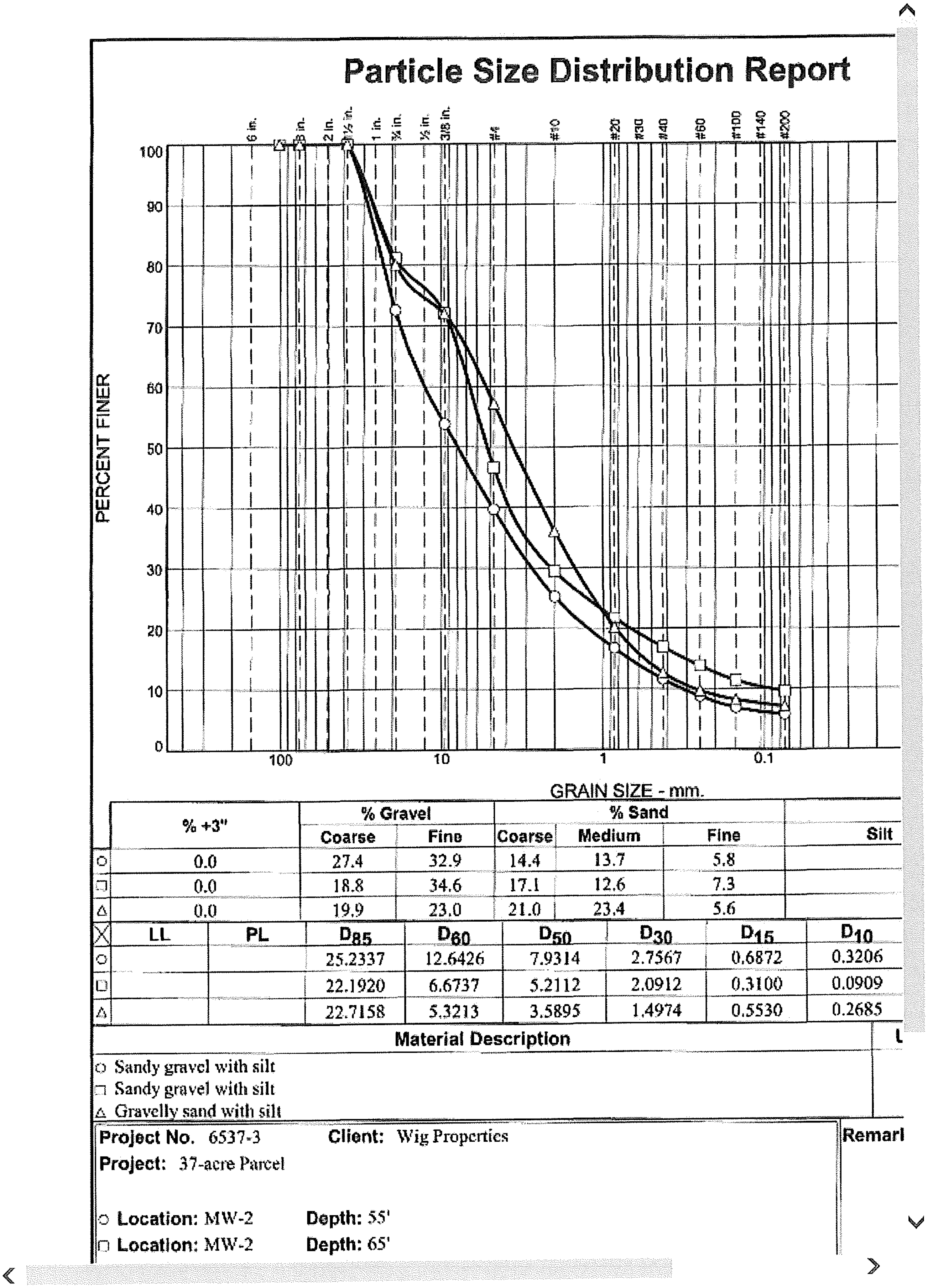
○ **Location:** MW-1 **Depth:** 20'
□ **Location:** MW-2 **Depth:** 15'
△ **Location:** MW-2 **Depth:** 45'

Remar

Terra Associates, Inc.

Kirkland, WA

Tested By: FQ



Particle Size Distribution Report

	% +3"	% Gravel		% Sand			Silt
		Coarse	Fine	Coarse	Medium	Fine	
○	0.0	27.4	32.9	14.4	13.7	5.8	
□	0.0	18.8	34.6	17.1	12.6	7.3	
△	0.0	19.9	23.0	21.0	23.4	5.6	

X	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}
○			25.2337	12.6426	7.9314	2.7567	0.6872	0.3206
□			22.1920	6.6737	5.2112	2.0912	0.3100	0.0909
△			22.7158	5.3213	3.5895	1.4974	0.5530	0.2685

Material Description

○ Sandy gravel with silt
□ Sandy gravel with silt
△ Gravelly sand with silt

Project No. 6537-3 **Client:** Wig Properties
Project: 37-acre Parcel

Remarl

○ **Location:** MW-2 **Depth:** 55'
□ **Location:** MW-2 **Depth:** 65'

PRELIMINARY GEOTECHNICAL REPORT ON
NISQUALLY QUIEMUTH VILLAGE
BRITTON PARKWAY NE AND MARVIN ROAD NE
LACEY, WASHINGTON

by
Haley & Aldrich, Inc.
Seattle, Washington

for
Olson Engineering, a division of MacKay & Sposito, Inc.
Vancouver, Washington

File No. 020509-000
January 2023

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SEATTLE, WA 98121
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SIGNATURE PAGE FOR

REPORT ON
NISQUALLY QUIEMUTH VILLAGE
BRITTON PARKWAY NE AND MARVIN ROAD NE
LACEY, WASHINGTON

PREPARED FOR
OLSON ENGINEERING, A DIVISION OF MACKAY & SPOSITO, INC.
VANCOUVER, WASHINGTON

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Haley & Aldrich, Inc.

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1. Introduction

Haley & Aldrich, Inc. (Haley & Aldrich) is pleased to submit this report on our preliminary geotechnical assessment for the proposed Nisqually Quiemuth Village mixed-use development. The approximately 200-acre site is located west of Marvin Road NE, north of Interstate 5 (I-5), and south of Britton Parkway NE in Lacey, Washington. Our work was completed in general accordance with our agreement with Olson Engineering, a division of MacKay & Sposito, Inc. (Olson), dated 20 March 2022, and our supplemental infiltration testing agreement, dated 22 July 2022.

This report presents our preliminary geotechnical engineering findings and recommendations to aid with planning and design of the project. Figures are presented at the end of the text. The location of the site is shown on Figure 1, and the existing site layout and topography with the location of historical explorations is shown on Figures 2 and 3. Supporting information is provided in the appendices. Appendix A contains historical subsurface exploration logs completed by others, and Appendix B contains the results of historical laboratory testing completed by others.

1.1 PROJECT UNDERSTANDING

The proposed Lacey project area is approximately 200 acres, located northwest of the I-5 and Marvin Road interchange. The site is bound to the north by Britton Parkway NE, to the south by I-5, to the east by Marvin Road NE, and to the west by the Britton Place apartment complex, and a sand and gravel pit. A short segment of Main Street NE bisects the northeast site boundary and Gateway Boulevard NE crosses through the western portion of the property.

Several parcels adjacent to the site include the following: a Cabela's store in the southwest corner of the project site, a 7-Eleven in the northeast corner, and a retail store, former (demolished) gas station, and former storage yard in the southeast corner. The Cabela's, 7-Eleven, and retail store are not part of the study area shown on Figure 2. The remainder of the property generally consists of undeveloped level to gently rolling ground that is lightly to heavily wooded with grasses and low ground cover.

2. Scope of Services

This geotechnical site evaluation was performed to obtain preliminary geotechnical information on subsurface conditions at the site and to develop preliminary geotechnical design recommendations for the subject project. Specifically, our scope of services included the following tasks:

- Reviewed relevant, readily available geologic maps and geotechnical reports that cover the site vicinity and nearby to evaluate geologic hazards, regional soil mapping, and local soil and groundwater conditions.
- Conducted a reconnaissance of the site to observe relevant surface features (e.g., signs of past grading).
- Conducted a limited site exploration program consisting of:
    - Six test pits advanced to depths between 8 and 12.5 feet below ground surface (bgs) using a mini-excavator; and
    - Six falling head infiltration tests.
- Conducted a limited laboratory testing program on select soil samples consisting of moisture content, grain size, and fines content tests.
- Presented historical and current infiltration testing results at and near the site.
- Evaluated seismic design criteria and preliminarily identifying seismic hazards, including ground shaking, ground shaking amplification, and liquefaction.
- Identified appropriate conceptual foundation, retaining wall, and infiltration system types for use at the site, including discussing key constraints to design and construction for such improvements.
- Prepared this report summarizing our preliminary findings, conclusions, and recommendations.

3. Soil Conditions

3.1 GEOLOGY AND SOIL MAPPING

3.1.1 Geologic Mapping

Geology in the vicinity of the project site is mapped in the Washington Geologic Information Portal at the 1:24,000 scale, as shown on Figure 4. The geology of the site has been mapped as Quaternary glacial till, Quaternary glacial advance outwash, and Quaternary glacial outwash. The glacial till deposits are described as Vashon Stade till consisting of a “highly compacted mixture of clay, silt, sand, and gravel deposited directly by glacier ice.” The glacial advance outwash deposits are described as Vashon Stade Advance Outwash consisting of “sand and gravel and lacustrine clay, silt, and sand of northern or mixed northern and Cascadian source, deposited during glacial advance.” The glacial outwash deposits are described as Vashon Stade recessional outwash consisting of “recessional and proglacial, sand and gravel of northern or mixed northern and Cascade source, locally containing silt and clay.” Mapping indicates that locally the surficial geology may include modified land and artificial fill (Washington State Department of Natural Resources 2022).

Based on our review of the United States Geological Survey’s (USGS’) Quaternary Fault and Fold Database of the United States, mapped faults near the site include the Olympia Structure faults located 4 miles west of the site, the Tacoma faults located 20.5 miles north of the site, and the Lucky Dog fault located 24 miles northwest of the site. The Cascadia Subduction Zone (CSZ; referred to in the database as the Cascadia fold and fault belt) is mapped as close as 60 miles west of the site.

3.1.2 Soils Mapping

The near-surface native soils at the site are mapped in the U.S. Department of Agriculture (USDA) web soil survey (USDA 2018), as shown on Figure 5. The survey indicates the surficial soils at the site primarily consist of Spanaway gravelly sandy loam (0 to 3 percent slopes), Alderwood gravelly sandy loam (8 to 15 percent slopes), and Everett very gravelly sandy loam (8 to 15 percent slopes). Indianola loamy sand (0 to 5 percent slopes) is mapped in the central-western portion of the site, along Gateway Boulevard NE.

The Spanaway soils are described as gravelly to extremely gravelly sandy loam derived from gravelly outwash with an estimated hydraulic conductivity in the most restrictive layer of high (approximately 2 to 6 inches per hour) and are described as somewhat excessively drained. The Alderwood soils are described as very gravelly sandy loam derived from gravelly outwash with an estimated hydraulic conductivity in the most restrictive layer of very low to moderately low (approximately 0.0 to 0.06 inches per hour) and are described as moderately well drained. The Everett soils are described as very gravelly sandy loam to loamy sand derived from sandy and gravelly glacial outwash with an estimated hydraulic conductivity in the most restrictive layer of high (approximately 2 to 6 inches per hour) and are described as somewhat excessively drained. The Indianola soils are described as loamy sand to sand derived from sandy glacial outwash with an estimated hydraulic conductivity in the most limiting layer of high to very high (approximately 6 to 100 inches per hour) and are described as somewhat excessively drained.

3.2 SURFACE CONDITIONS

The ground surface at the site is generally flat to gently rolling topography and lightly to heavily wooded with brambles to low ground cover. The northern portion of the site is more heavily wooded and generally more trees are located along the existing roadways around the site. Gateway Boulevard NE, an asphalt-paved road, and the Cabela's store partially bisects the site in a north-south alignment, near the western site boundary. Main Street NE, an asphalt-paved road, partially bisects the site in an east-west alignment, along the eastern site boundary. A future I-5 off-ramp and outer road is located along the southern boundary of the site. Surficial soils appear to typically consist of sandy gravel and gravelly sand. Several vehicle pathways are present across the site consisting of gravel and quarry spalls. Construction debris and signs of previous grading are present at the surface in localized areas across the site, especially on the east portion of the site near Main Street NE, and the existing retail stores and associated parking areas.

The natural ground elevations vary from approximately Elevation (El.) 210 to 225 feet North American Vertical Datum 1988 (NAVD88) along the east side of the site adjacent to Marvin Road NE. Elevations vary from approximately El. 210 to 190 feet along the south side of the site adjacent to I- 5. Elevations vary from approximately El. 225 to 210 feet along the north side of the site adjacent to Britton Parkway NE. Generally, the site grades gradually down from north to south and from east to west, except for a mound near the middle of the site with a peak elevation of approximately El. 255 feet. Just west of the site, the grade slopes down to the adjacent sand and gravel pit.

Existing slopes on site are generally gradual slopes of 5 horizontal to 1 vertical (5H:1V) or flatter, with large portions of the site being relatively level. However, there may be small, localized slopes steeper than 5H:1V.

3.3 SUBSURFACE CONDITIONS

Our understanding of subsurface conditions at the site was developed from interpretation of geologic maps, our explorations, and historical explorations, in conjunction with soil properties inferred from field observations and laboratory tests. This understanding of subsurface conditions formed the basis for the conclusions and preliminary recommendations provided in this report.

Subsurface explorations performed at the site include the current exploration program performed by Haley & Aldrich in August 2022, and seven other geotechnical and environmental exploration programs performed on or near the site by Hart Crowser, Inc. (now Haley & Aldrich, Inc.) and others between 1966 and 2018 (Appendix C). The approximate locations and designations of the current and historical subsurface explorations are shown on Figures 2 and 3. The following serves as a summary of the various historical exploration programs:

1966 Carney-Gleason Road Undercrossing Subgrade Investigation (Pacific Testing Laboratories)

- Three exploratory borings (designated C2-1 to C2-3) were drilled near the site to depths ranging from 53.5 to 58 feet bgs.

1989 ULID No. 11 Sanitary Sewer Geotechnical Study (Hart Crowser)

- Six exploratory borings (designated HC-1 to HC-6) were drilled on and near the site to depths ranging from 27.8 to 37.8 feet bgs.

1996 Northeast Area LID Geotechnical Study (Hart Crowser)

- Eighteen (18) test pits (designated as TP-1 to TP-17) were excavated on and near the site to depths of 5 to 10.5 feet bgs using a tractor-mounted backhoe; and
- Four double-ring infiltration tests (at test pit locations TP-1, TP-2, TP-3, and TP-7) were performed to test the rate of hydraulic conductivity of the soils within the upper 1 to 6 feet of the site.

1997 SR-510, I-5 to Pacific Avenue Geotechnical Report (Hong West & Associates)

- Seven exploratory borings (designated as BH-1 to BH-7) were drilled near the site to depths of 14.4 to 45.6 feet bgs using a CME-55 or CME-850 drill rig; and
- One test pit (designated as TP-1) was excavated near the site to a depth of 8.8 feet bgs using a Case 580L backhoe.

1999 SR-510, SR-5 to Martin Way Geotechnical Report (GN Northern)

- One exploratory boring (designated as TH-1) was drilled near the site to a depth of 16.5 feet bgs using a drill rig.

2014 Lacey Gateway Geotechnical Report (GeoResources, LLC)

- Three monitoring wells performed by Terra Associates (designated as MW-1 to MW-3) were installed on the site to depths of 15.5 to 75 feet bgs. The logs from these wells were included in the 2014 GeoResources report.

2018 I-5/SR 510 Interchange Geotechnical Data Report (Washington State Department of Transportation [WSDOT])

- Twenty-one (21) exploratory borings (designated as H-1p-17 through H-21-17) were drilled near the site to depths of 20.4 to 100.4 feet bgs using a CME-55 drill rig.

The approximate locations of the borings, monitoring wells, test pits, and infiltration tests are indicated on Figures 2 and 3.

3.3.1 Soils

Subsurface conditions in the site vicinity and expected at the site are typically defined by a layer of organics (topsoil/forest duff) and/or loose to medium dense artificial fill and weathered native soils, overlying native dense to very dense glacial soils. The glacial soils typically consist of sandy gravel or gravelly sand with varying amounts of silt and occasional silt layers.

Generally current and historical borings and test pits encountered loose to medium dense fill or native soils to depths of up to about 10 feet bgs before encountering denser native materials. However, some historical explorations encountered dense glacial soils at or very near the ground surface such as: test pits TP-16 and TP-16A in the northwest corner of the site; and monitoring wells MW-1 and MW-2 in the southeast corner of the site.

Below the fill material, native glacial soils consisting of dense to very dense silty sand, sandy gravel and gravelly sand with occasional sandy silt layers typically extended to the bottom of borings, test pits, and wells around the site. Cobbles and boulders were also encountered in the glacial soils.

3.3.2 Groundwater

Depth to groundwater appears variable in the site vicinity and across the site according to the historical explorations. Historical test pits TP-2, TP-4, and TP-15 encountered groundwater seepage at depths of 7.5, 2.5, and 4.5 feet bgs, respectively, perched above the glacial till. Most of the reported seepage elevations on and near the site are within several feet of the interpreted fill-native (glacial till) contact, suggesting that several feet of perched water may typically be present above the glacial till across the site. However, as many of the test pits did not encounter seepage, the presence of perched water is interpreted to be variable across the site, and may vary with seasonal precipitation and other factors.

Historical boring and well logs reported encountering water at various elevations. Terra Associates monitoring wells MW-1 and MW-3 encountered free water at approximate El. 192 and El. 190 (depths of 15 and 10 feet bgs), respectively. WSDOT borings H-4p-17 and H-12-17 encountered free water at El. 202 and 186 (depths of 27 and 12 feet bgs), respectively. Hart Crowser borings HC-2 and HC-3 encountered free water at approximate El. 188 and 192 (depths of 22 and 30 feet bgs), respectively. As many of the borings did not report free water at or below these elevations, we interpret that the regional groundwater table varies across the site, and may vary according to seasonal precipitation and other factors.

3.3.3 Infiltration

We performed six *in-situ* infiltration tests at the project site between 16 and 18 August 2022. The tests were completed in shallow excavations adjacent to the test pits. The infiltration tests consisted of open-pipe, falling head tests performed by placing a 6-inch-diameter PVC pipe approximately 6 inches into the bottom of the excavation. The results of the field testing and associated fines content and soil type of tested soils are provided in Table 1. The drawdown values presented in Table 1 are not to be used for design but are provided to show the direct results of the field measurement.

Table 1. Infiltration Test Data – Haley & Aldrich 2022

Infiltration Test No.	**Test Pit No.**	**Approximate Test Depth (feet)** (Approximate Excavation Depth, feet)	**Field Drawdown Rate (inches per hour)**	**Soil Type (USCS)**	**Fines Content (percent)**
IT1	TP1	2.5 (2)	200	GP	3.7
IT2	TP2	2.5 (2)	22	SP	2.5
IT3	TP3	2.5 (2)	50	GP	0.7
IT4	TP4	2.5 (2)	200	GW	1.2
IT5	TP5	2.5 (2)	8.5	SM	21.3
IT6	TP6	2.5 (2)	15	SP	0.9

Hart Crowser performed four *in-situ* infiltration tests adjacent to the project site in 1996, near Britton Parkway NE on the north side of the site (NE Area LID Geotechnical Study). The tests were completed in shallow pits at or adjacent to select test pits. The infiltration tests consisted of double-ring infiltrometer falling head tests, based on ASTM International (ASTM) D3385. The results of the field testing and soil type of tested soils are provided in Table 2. The infiltration values presented in Table 2 are not intended to be used for design but are provided to show the direct results of the historical field measurements.

Table 2. Historical Infiltration Test Data – NE Area LID 1996

Test Pit No.	Approximate Test Depth (feet)	Average Field Infiltration Rate (inches per hour)	Soil Type
TP-1	1	13	Loose, silty, very gravelly SAND
TP-2	6	0	Dense, silty, gravelly SAND
TP-3	4	1.2	Dense, silty, very gravelly SAND
TP-7	3	1.4	Loose, silty, slightly gravelly SAND

Hart Crowser performed four *in-situ* infiltration tests near the project site in 1993, for a proposed infiltration pond along Willamette Drive NE, approximately 1 mile northeast of the site (Commerce Place PID, Meridian Campus Geotechnical Study). The tests were completed in shallow pits with the infiltrometer rings driven approximately 4 to 6 inches below grade; however, depth of the pits was not indicated. The infiltration tests consisted of double-ring infiltrometer constant head tests, based on ASTM D3385. The results of the field testing and soil type of tested soils are provided in Table 3. The infiltration values presented in Table 3 are not intended to be used for design but are provided to show the direct results of the historical field measurements.

Table 3. Historical Infiltration Test Data – Commerce Place PID/Meridian Campus 1993

Test Pit No.	Average Field Infiltration Rate (inches per hour)	Soil Type (Geologic Unit)
IT-1	9	Slightly silty, sandy GRAVEL (Recessional Outwash)
IT-2	3	Slightly silty, gravelly SAND (Recessional Outwash)
IT-3	0.25	Slightly silty, slightly gravelly SAND (Recessional Outwash)
IT-4	13	Slightly silty, slightly sandy GRAVEL (Recessional Outwash)

Hart Crowser also performed five *in-situ* infiltration tests near the project site in 1988, near Willamette Drive NE approximately 1 mile northeast of the site (Meridian Campus Geotechnical Report). The tests were completed in shallow pits at or adjacent to select test pits. The infiltration tests consisted of double-ring infiltrometer falling head tests. The results of the field testing and soil type of tested soils are provided in Table 4. The infiltration values presented in Table 4 are not intended to be used for design but are provided to show the direct results of the historical field measurements.

Table 4. Historical Infiltration Test Data – Meridian Campus 1988			
Test No. (Test Pit No.)	**Approximate Test Depth (feet)**	**Range of Field Infiltration Rate (inches per hour)**	**Soil Type**
IT-1 (TP-3)	1.7	9.4	Loose, silty, very gravelly SAND
IT-2 (TP-20)	1.2	45 to 60	Loose, sandy GRAVEL with occasional cobbles
IT-3 (TP-19)	1.5	63 to 120	Medium dense, slightly silty, sandy GRAVEL
IT-4 (TP-21)	1.3	62 to 220	Loose, very sandy GRAVEL with occasional cobbles
IT-5 (TP-16)	0.8	4.1	Loose, sandy, very silty GRAVEL

3.4 GEOLOGIC AND SEISMIC HAZARDS

3.4.1 Seismic Shaking

We evaluated potential seismic shaking at the site using guidelines presented by American Society of Civil Engineers (ASCE) 7-16, as referenced by the currently adopted 2018 International Building Code (IBC; ICC 2018). Code-based seismic design values for design-level recommendations for the proposed structures may vary if the subsequent version of the ASCE 7 guidelines (ASCE 7-22) is adopted at the time of design.

The expected peak bedrock acceleration having a 2 percent probability of exceedance in 50 years (2,475-year return period) is 0.585g per ASCE 7-16. This value represents the peak acceleration on bedrock beneath the site and does not account for ground motion amplification due to site-specific effects. The peak ground acceleration (PGA) is determined by applying a site class factor to the peak bedrock acceleration. The PGA accounting for site amplification is PGA_M = 0.64g for ASCE 7-16, and 0.71g for ASCE 7-22. Refer to *Section 4.4.2 Site Classification* for a discussion of ground motion amplification.

We obtained a deaggregation of the seismic sources contributing to the expected peak bedrock acceleration shown above from the USGS' Unified Hazard Tool website (USGS 2022). Seismic sources contributing to this potential ground shaking include the CSZ megathrust and intraplate sources. The data indicated that the "modal source" for shaking at the site at all potential periods of interest (0.0 to 2.0 seconds) is a magnitude 7.1 quake epicentered at the CSZ approximately 53 kilometers from the site. The modal source generally signifies the earthquake with the highest contribution to the site earthquake hazard, in this instance a rupture along the CSZ.

3.4.2 Site Classification

Thick sequences of unconsolidated, soft sediments typically amplify the shaking of long-period ground motions, such as those associated with subduction zone earthquakes; whereas areas underlain by shallow soil profiles are not likely to amplify seismic waves.

The "Site Class" is a designation used by the 2018 IBC and ASCE 7-16 and 7-22 to quantify ground motion amplification. The classification is based on the stiffness in the upper 100 feet of soil and bedrock materials at a site. Artificial fill and weathered glacial soils are likely present within the upper 10 feet of subsurface stratigraphy throughout much of the site, and is generally characterized by sand and gravel with varying fines content that ranges from loose to medium dense across the site. The artificial fill and weathered glacial soils are typically underlain by glacial till and outwash composed of dense to very dense granular soils. Based on our review of available local geologic conditions, it is reasonable to extrapolate the consistency of the materials encountered at the base of the borings to 100 feet. Based on these conditions and currently available information, the property has a **Site Class D**. However, with more detailed study and exploration at the site it is possible that the dense to very dense glacial soils may be sufficient for a Site Class C.

Refer to *Section 5.3 Seismic Design* of this report for additional discussion regarding the recommended site class value for design of structures.

3.4.3 Liquefaction

Liquefaction is a phenomenon caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles, resulting in the sudden loss of shear strength in the soil. Granular soils, which rely on interparticle friction for strength, are susceptible to liquefaction until the excess pore pressures can dissipate. Sand boils and flows observed at the ground surface after an earthquake are the result of excess pore pressures dissipating upwards, carrying soil particles with the draining water. In general, loose, saturated sand soils with low silt and clay contents are the most susceptible to liquefaction. Silty soils with low plasticity are moderately susceptible to liquefaction under relatively higher levels of ground shaking. For any soil type, the soil must be saturated for liquefaction to occur.

The Washington State Geologic Information Portal website maps the site as having a very low susceptibility to liquefaction. Based on the shallow depth to dense or very dense native glacial soils, we conclude that the liquefaction hazard within materials submerged by the regional groundwater table is low.

While the loose to medium dense artificial fill and weathered glacial soils that covers portions of the site is likely above the design groundwater table and is therefore assumed to be unsaturated, much of this material would be subject to liquefaction under saturated conditions. Perched groundwater has been identified at various depths throughout the site during previous subsurface exploration programs. Fill and loose to medium dense native soils saturated by perched water may be subject to localized liquefaction and liquefaction-induced settlements. While we consider the potential for such an occurrence to be low, the potential for localized liquefaction settlement will be further evaluated during a detailed geotechnical site assessment. We note that if the looser materials are removed or recompacted, then the potential for liquefaction would be low.

3.4.4 Dry Cyclic Densification

Seismically induced compaction or densification of non-saturated granular soil (such as sand above the groundwater table) due to earthquake vibrations can result in settlement of the ground surface. The non-engineered artificial fill at the site is largely composed of loose to medium dense granular soils with potential for susceptibility to cyclic densification. However, historical borings in the vicinity of the project site indicate the loose to medium dense fill and weathered glacial soil layer is approximately 10 feet or less in thickness.

We evaluated the potential for cyclic densification within the loose surficial soils logged at borings W-2-17, H-4p-17, H-5p-17, H-9p-17, H-14-17, and H-15-17, using the procedure described by Pradel (1998) and incorporating the refinements presented by Yee, Duku, and Stewart (2014). Our analyses indicate that the granular soils present within the upper approximately 10 feet bgs in the southern portion of the site may experience cyclic densification on the order of 0.5 inches or less, under seismic shaking from the design earthquake. We assume that fill and loose to medium dense native soils present in other portions of the site are similarly susceptible to cyclic densification. Overall, we conclude that the potential for cyclic densification at the site is low. However, due to lack of historical boring data in portions of the site, there is some uncertainty as to depth of loose soils and fill across the entire site, and the potential for cyclic densification may be variable across the site. However, if the looser materials are removed or recompacted, then the potential for cyclic densification would be further reduced.

3.4.5 Fault Rupture

There are no mapped earthquake faults passing through or near the site. The nearest mapped faults are the Olympia Structure faults located 4 miles west of the site, the Tacoma faults located 20.5 miles north of the site, and the Lucky Dog fault located 24 miles northwest of the site.

4. Conclusions

Based on research and experience with similar soils, it is our opinion that the site is suitable for the proposed development. The following provides a summary of key preliminary geotechnical findings and conclusions.

- Site soils are expected to include a layer (up to 10 feet in places) of loose to medium dense fill and native soils predominantly composed of sand and gravel with varying amounts of fines. The fill and loose to medium dense native soils are underlain by dense soils composed of sand and gravel with varying amounts of silt and occasional silt layers. Cobbles and boulders are present in both fill and native soil layers.
- Perched groundwater is expected to be present at various depths across the site, often near the ground surface. Areas of perched groundwater over the glacial till soils are likely to be encountered during construction. Localized pockets of "confined" water may be encountered where water upwells when exposed (e.g., artesian conditions).
- We anticipate the soils present at shallow depths beneath the existing ground surface will be suitable for support of conventional building foundations, building floor slabs, and pavements, once prepared and compacted in conformance with geotechnical recommendations.
  - Due to the variable and loose nature of the upper soils, replacement or recompaction of 1 to 3 feet of looser material materials will be required below building foundation/slab and pavement subgrades, unless that material is removed during site grading.
- Site soils have low to high hydraulic conductivity rates that are expected to vary significantly across the site, due to the preponderance of artificial fill, loose to medium dense surficial soils, and the relatively impermeable glacial till soils present at the site. We anticipate that areas of highly permeable soils will be present, but are potentially underlain at depth by dense till soils which may be relatively impermeable and may perch water or retard infiltration.
  - The use of stormwater infiltration systems is likely to be feasible; however, the use of deep or high-volume systems should be avoided. The use of small, disperse, low volume systems, such as bio-swales and infiltration trenches are preferred.
  - Where site grading significantly lowers site grades, relatively impermeable till soils may be exposed (or found at shallower depth) that will not infiltrate.
  - The preliminary design of infiltration systems should account for the potential for zones of impermeable soil at or near the bases of the systems. Therefore, systems should have overflows or be interconnected to one another.
  - Incorporation of infiltration systems into the stormwater design will require supplemental detailed site characterization and *in situ* infiltration testing to better characterize the infiltration capacity of site soils.
- The on-site soils are typically suitable for reuse as structural fill, provided they are properly moisture conditioned and oversized, deleterious, and organic materials are removed. We note that:
  - The presence of cobbles and boulders across the site may pose challenges for excavation.

  - The fines content of the soils may cause them to be easily disturbed during construction. The use of wet soil/weather earthwork practices will likely be required during construction.

The following sections present our preliminary design and construction considerations that can be used for initial planning of future development. These guidelines should not be used for final design of future improvements.

5. Preliminary Geotechnical Design Considerations

5.1 FOUNDATIONS

As discussed above, much of the site vicinity is underlain by variable (loose to medium dense) artificial fill and native soils that are expected to require removal and replacement, or reworking and recompaction. The potential for settlement may feasibly be addressed by performing overexcavation and/or recompaction of the artificial fill and loose native soils to provide an engineered fill subgrade that provides relatively uniform foundation support. Where site grading removes the loose soils and exposes the underlying dense materials, no reworking of the foundation subgrade would be required.

Based on the results of our investigation, it is our opinion that one- to three-story structures can be supported on conventional spread foundations or slabs-on-grade designed to gain support on a zone of overexcavated and recompacted structural fill or the native dense glacial soils.

Preliminary recommendations for spread foundations bearing are discussed below.

- Allowable bearing pressure: 4,000 pounds per square foot.
- Minimum footing width: 12 inches for strip footings and 24 inches for isolated footings.
- Minimum footing depth: 18 inches below exterior grade and 12 inches below interior grade.
- Allowable base friction coefficient: 0.4.
- Allowable passive resistance: 350 pounds per cubic foot acting as an equivalent fluid density.
- Any existing loose to medium dense soils that remain beneath proposed footings and slabs should be overexcavated and replaced with structural fill, or reworked and recompacted. The exact depth and lateral extent of reworking will be determined in the future based on actual building location, loads, configuration, and supplemental explorations (if completed).

5.2 FLOOR SLABS

We anticipate that most buildings will have concrete slab-on-grade floors. Due to the variable nature of the site soils, we recommend that the upper 12 to 18 inches of soil beneath floor slabs be recompacted, or consist of 12 to 18 inches of new structural fill over the existing subgrade, to provide a uniform bearing surface.

To reduce water moisture transmission through floor slabs, we recommend installing a capillary moisture break and a water vapor retarder beneath floors. Typically, finished spaces with slab-on-grade floors, such as offices, will utilize capillary moisture breaks and vapor retarders to reduce the potential for water vapor transmission through the floor, which can adversely impact flooring materials and carpeting. Depending upon the depth to perched groundwater and building floor elevations, it is conceivable that a sub-slab drainage system may be required, particularly if existing grades are lowered and expose areas which may perch water.

5.3 RETAINING WALLS

We anticipate that various retaining walls, primarily site landscaping walls, but possibly some building walls, will be required for the proposed development. For buildings and site walls, the use of conventional cast-in-place concrete walls supported by spread footings (as described above) will be feasible. For site walls, the use of mechanically stabilized earth walls and large block walls (e.g., Keystone, Ultrablock, etc.) can also be considered. The need to use specialized walls such as soldier pile and lagging, soil nails, etc. is deemed to be unlikely unless dictated by unique construction features.

5.4 SEISMIC DESIGN

We obtained the preliminary design parameters for the spectral acceleration from the U.S. Seismic Design Maps (USGS 2021a) for Latitude 47.0648 and Longitude -122.7784. The parameters provided in Table 5 are associated with the current code, ASCE 7-16, and with ASCE-7-22, in the event design occurs when it has been adopted by the State.

Table 5. Preliminary Seismic Design Values for Site Class D Conditions

Seismic Parameter	ASCE 7-16 Design Values	ASCE 7-22 Design Values
Site Class	D[1]	D
MCE_R[2] Ground Motion (Period = 0.2 seconds), S_s	1.39 g[3]	1.5 g
MCE_R Ground Motion (Period = 1.0 seconds), S_1	0.504 g	0.5 g
Peak Ground Acceleration, PGA	0.585 g	*See Note 7*
Site Amplification Factor at 0.2 seconds, F_a	1.0	*See Note 8*
Site Amplification Factor at 1.0 seconds, F_v	*See Note 4*	*See Note 8*
Site Amplification Factor for PGA, F_{PGA}	1.1	*See Note 7*
Site-Modified Peak Ground Acceleration, PGA_M	0.644 g	0.71 g
Site-Modified Spectral Acceleration Value at 0.2 seconds, S_{MS}	1.39 g	1.76 g
Site-Modified Spectral Acceleration Value at 1.0 seconds, S_{M1}	*See Note 4*	1.04 g
Design Spectral Acceleration at 0.2 seconds, S_{DS}	0.927 g	1.17 g
Design Spectral Acceleration at 1.0 seconds, S_{D1}	*See Note 4*	0.7 g

Notes:

1) *Per ASCE 7-16 Table 20.3-1.*
2) *MCER = Risk-targeted maximum considered earthquake.*
3) *g = acceleration of gravity.*
4) *Per ASCE 7-16 Supplement 1, Site Class D values for Fv, SM1, and SD1 are only valid for calculation of Ts = SD1 / SDS for the purpose of developing seismic response coefficients (Cs). Using Fv = 1.8, SM1 = 0.905, SD1 = 0.603, and Ts = 0.651.*
5) *Per ASCE 7-16 Section 11.4.8, Site Class D sites with S1 greater than or equal to 0.6g; Site Class E sites with Ss greater than or equal to 1.0 g; or Site Class D or E sites with S1 greater than or equal to 0.2g shall have a site-specific ground motion hazard analysis performed in accordance with Section 21.2 unless exceptions are taken, per Section 11.4.8.*
6) *Per Exception 2 of ASCE 7-16, Section 11.4.8, structures on Site Class D sites with S1 greater than or equal to 0.2g, a ground motion hazard analysis is not required provided the value of the seismic response coefficient Cs is determined by Eq. (12.8-2) for values of T ≤ 1.5Ts and taken as equal to 1.5 times the value computed in accordance with either Eq. (12.8-3) for TL ≥ T > TS or Eq. (12.8-4) for T > TL.*
7) *For ASCE 7-22, PGAm is directly calculated without the need for PGA and FPGA.*
8) *Multi-period response spectrum data for ASCE 7-22 eliminates the need for Fa and Fv coefficients.*

5.5 STORMWATER INFILTRATION SYSTEMS

The results of current and historical field infiltration testing in the project vicinity are described in *Section 3.3.3 Infiltration*. In general, we find that the tested soils generally have poor to good infiltration properties, although highly variable, exhibiting unfactored drawdown rates of 0.0 to approximately 200 inches per hour. These rates are quite low in some cases and are reflective of the moderate fines content and dense nature of the various soils. Other tests are quite high and are reflective of the more gravelly outwash soils found above the till soils. The tests are representative only of the soils at the location and elevation of the tests, and are unlikely to be representative of deeper, denser till soils which may underlie the test depths. We anticipate deeper soils will generally have lower permeability than surficial soils. However, the logs from deeper historical borings indicate fines content generally decreasing at greater depths. This suggests that deep infiltration systems may be possible as lower fines content could indicate increased permeability.

Considering the presence of shallow granular soils, the use of shallow or surface stormwater infiltration systems such as bioswales and shallow trenches are likely feasible around much of the site. Due to the high variability of the permeability of soils, we recommend the use of multiple low volume systems, as opposed to fewer large, high-volume infiltration systems. Also, the use of permeable pavements may be feasible. Because we anticipate that zones of impermeable soil will be encountered at the site, particularly in areas where site grades are lowered, the stormwater system design should be flexible to allow for the interconnection of systems or overflow of stormwater to surface detention features. If cut slopes are created on site and infiltration systems are installed proximate to them, then consideration should be given to the potential for lateral seepage to daylight through the slopes if a perching soil layer is present.

The nearby historical and on-site field infiltration rates range from 0 to 200 inches per hour, with an average value of approximately 38 inches per hour. When the two highest (200 inches per hour) and two lowest (0 and 0.25 inches per hour) rates are removed, the average rate is approximately 20 inches per hour. **Based on this data, for preliminary design purposes, we recommend using an average infiltration rate of 20 inches per hour as an unfactored rate.**

Once preliminary designs are completed, we recommend additional detailed site characterization and further *in-situ* infiltration testing to better characterize the infiltration capacity of site soils at the actual locations and elevations of the proposed infiltration systems.

As an alternative to the use of shallow infiltration systems, it may be feasible to consider deep infiltration systems that penetrate through the upper outwash and till soils, and penetrate into deeper advance outwash soils. We note that historical boring information from WSDOT (2018) indicates soils with lower fines content are typically encountered below a depth of 25 feet. This was the case in borings H-1p-17, H-12-17, H-16-17, H-17-17, and H-21-17, where a dense soil layer classified as “silty sand” was underlain by sandy or gravelly soils with lower fines content below 25 feet depth. Although the historical WSDOT borings do not indicate geologic units for the various soils encountered, we anticipate deep infiltration could be feasible in what we anticipate is deep advance outwash soils. However, additional exploration would be needed to determine the depth of the groundwater table and to verify the presence of more permeable soils at depth.

5.6 RIGID AND FLEXIBLE PAVEMENTS

Site pavements are expected to include flexible asphalt concrete (AC) sections and rigid Portland cement concrete (PCC) sections. The site soils are generally suitable for the support of such pavements, though looser materials may require some removal and/or recompaction to provide a stable pavement subgrade. The general preparation of subgrades is discussed in *Section 5.6 Earthwork*.

If the use of permeable pavements is proposed, they will need to be carefully evaluated as a stormwater infiltration system, as discussed above in *Section 5.4 Infiltration Systems.*

Design-level pavement recommendations will depend on expected traffic volumes at the site. However, based on the granular nature of the soils on site, we anticipate that a 6- to 8-inch aggregate base layer will be suitable for support of both flexible and rigid pavements. This assumes that the upper 12 to 18 inches of soil subgrade consists of new engineered fill or recompacted *in-situ* soil. The recommended AC pavement thicknesses will likely be on the order of 2.5 inches in parking stalls, 3 to 4 inches in parking lot drive aisles, and 4 to 6 inches in areas with heavy duty truck traffic (e.g., delivery routes). Recommended PCC pavement thicknesses are likely to be approximately 6 inches for reinforced and 5 inches for unreinforced.

5.7 EARTHWORK

Based on available information, we anticipate that earthwork will likely include moderate mass grading with cuts and fills up to 10 feet to level the site, with some deeper excavation and backfilling for utilities and foundations. We recommend that earthwork activities be conducted in accordance with the WSDOT *Standard Specifications* (WSS) (WSDOT 2022). We note the following conditions and recommendations relevant to earthwork:

- We noted a thick forest duff layer in the wooded/treed areas. We anticipate this forest duff layer will be about 1 to 3 feet thick in the more heavily wooded areas of the site.
- We expect that conventional earthmoving equipment in proper working condition should be capable of making necessary excavations for utilities, footings, and other earthwork at the site. However, the dense to very dense glacial soils that are present at the site will likely be more difficult and/or slower to excavate with conventional earthmoving equipment.
- The presence of oversize materials within the artificial fill and native soils may reduce the pace of earthwork activities and enlarge trench, footing, and other excavations beyond their planned limits. These oversize materials may require individual handling and their presence may inhibit usage of scrapers for mass grading operations.
- The artificial fill soils, and potentially some of the upper loose native soils, will need to be removed and/or recompacted beneath proposed foundations, slabs, and pavements.
  - Depending upon the proposed usage, composition of the existing fill, moisture content and relative density of the existing fill, and thickness of new fill (if any), the thickness of the recompacted layer will vary.
  - The soil can be reworked via a combination of removal and replacement, or scarification followed by compaction.
- The on-site near-surface artificial fill and native soils are expected to be suitable for reuse as structural fill, provided they are stripped of organics including wood debris, properly moisture conditioned, and screened for removal of oversize and deleterious material, such as roots, cobbles, boulders, and construction debris.
- While the *in-situ* soils are typically granular, they can have significant fines content and will be moderately susceptible to disturbance from construction activities, particularly when wet and/or during the rainy season. Due to the presence of perched water, wet soil conditions may be present even during dry weather.

    - Earthwork planning should include considerations for minimizing subgrade disturbance and employing wet weather/wet soil construction methodologies.
- The soils are generally granular and may have a tendency to run or slough when left in vertical cuts, and the contractor should anticipate that sloughing material could include large cobbles and boulders. Shoring or temporary cut-back slopes will be required for excavation stability.
- In general, we anticipate the local groundwater table is within native materials near El. 185 to 200 feet. However, higher perched groundwater layers are likely to be present around the site, as observed at many subsurface exploration locations. Excavations through perched water layer(s) are likely to experience seepage and may require the use of localized sump pumps. In some cases, it is possible that sump pumps may not be sufficient for dewatering and the use of well points may be required.

It is possible that zones of seepage will be encountered that require the installation of permanent passive dewatering system (e.g., French drains, sub-slab drains, etc.). The need for such systems should be evaluated as design progresses and at the time of construction.

6. Limitations

We have prepared this preliminary report for the exclusive use of Olson Engineering, a division of MacKay & Sposito, Inc., and their authorized agents, for the proposed Nisqually Quiemuth Village mixed-use development in Lacey, Washington. Our work was completed in general accordance with our agreement with Olson Engineering, a division of MacKay & Sposito, Inc., dated 20 March 2022, and our supplemental infiltration testing agreement, dated 22 July 2022. Our report is intended to provide our opinion of geotechnical conditions for planning purposes only. Site-specific investigation will be required in order to develop parameters for design and construction of the proposed improvements.

Within the limitations of scope, schedule, and budget, our services have been executed in accordance with generally accepted practices in the field of geotechnical engineering in this area at the time this report was prepared. No warranty, express or implied, should be understood.

Any electronic form, facsimile, or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by Haley & Aldrich and will serve as the official document of record.

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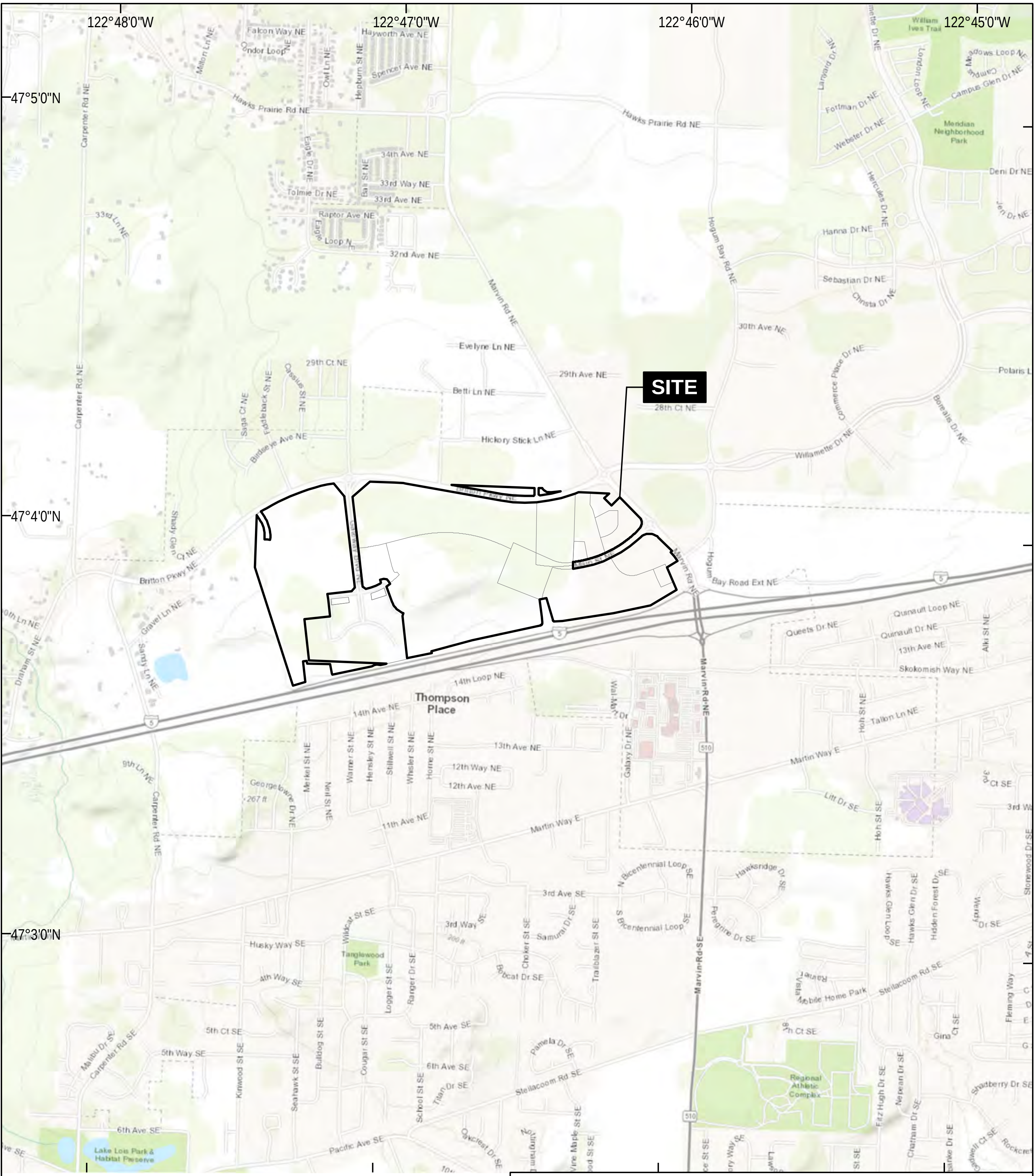
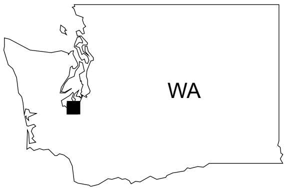
FIGURES





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MAP SOURCE: ESRI
SITE COORDINATES: 47°03'55"N, 122°46'46"W

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NISQUALLY QUIEMUTH VILLAGE
LACEY, WASHINGTON

VICINITY MAP

APPROXIMATE SCALE: 1 IN = 2000 FT
JANUARY 2023

FIGURE 1

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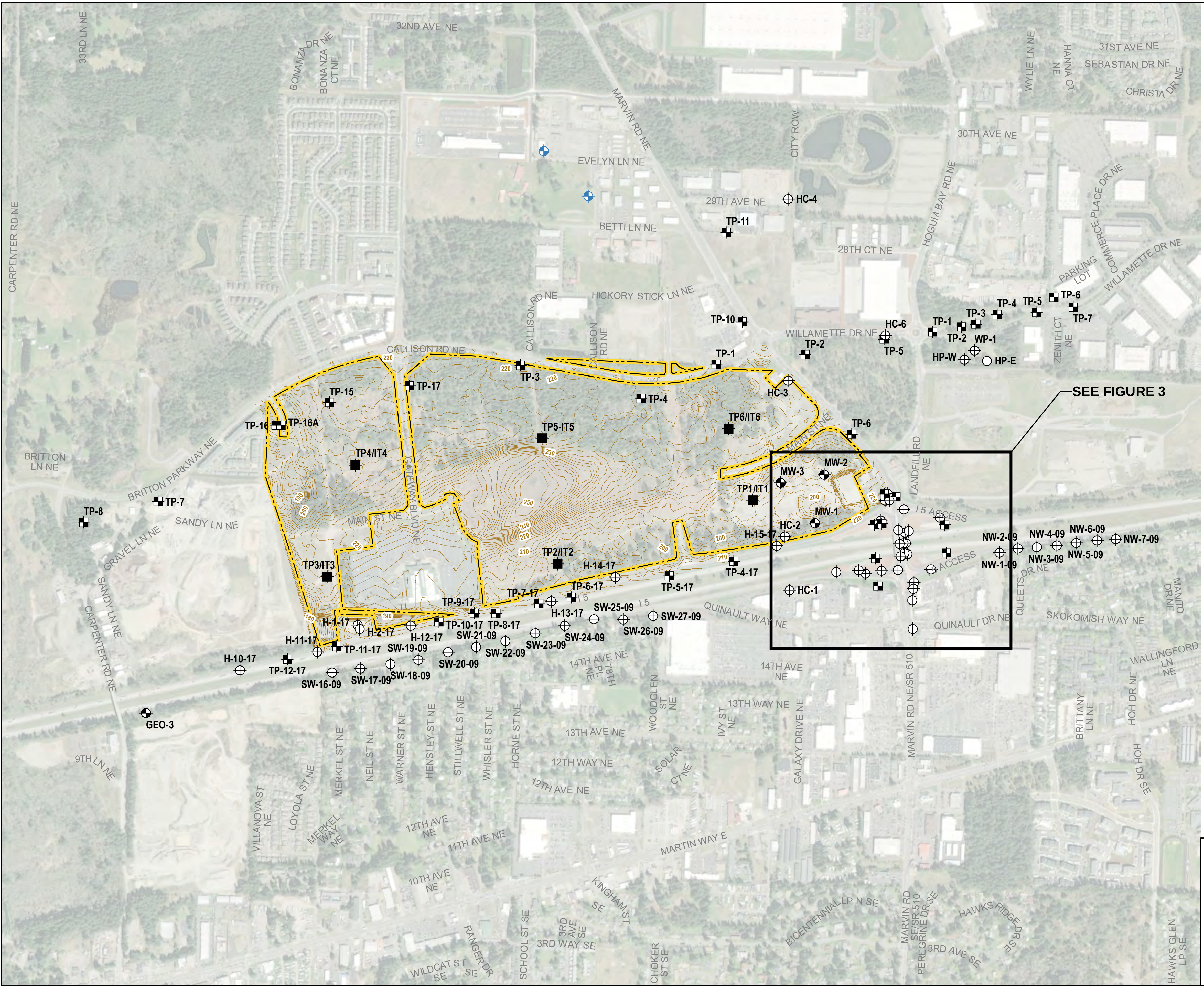

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LEGEND

■	TEST PIT WITH INFILTRATION TEST (2022)
◈	MONITORING WELL (HISTORICAL)
◈	WATER WELL (HISTORICAL)
⊕	SOIL BORING (HISTORICAL)
▚	TEST PIT (HISTORICAL)
—	TOPOGRAPHIC ELEVATION CONTOUR, 2-FT INTERVAL
▭	SITE BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. CONTOUR DATA SOURCE: OLSON ENGINEERING
3. HISTORICAL EXPLORATIONS DONE BY OTHERS BETWEEN 1966 AND 2018.
4. AERIAL IMAGERY SOURCE: ESRI

HALEY ALDRICH

NISQUALLY QUIEMUTH VILLAGE
LACEY, WASHINGTON

SITE PLAN AND EXPLORATIONS

JANUARY 2023

FIGURE 2

LEGEND

- ⊕ MONITORING WELL
- ⊕ WATER WELL
- ⊕ SOIL BORING
- ▚ TEST PIT
- ▭ SITE BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. AERIAL IMAGERY SOURCE: NEARMAP, 21 SEPTEMBER 2021

N

0 200 400
SCALE IN FEET

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NISQUALLY QUIEMUTH VILLAGE
LACEY, WASHINGTON

SITE PLAN DETAIL AND HISTORICAL EXPLORATIONS

JANUARY 2023

FIGURE 3

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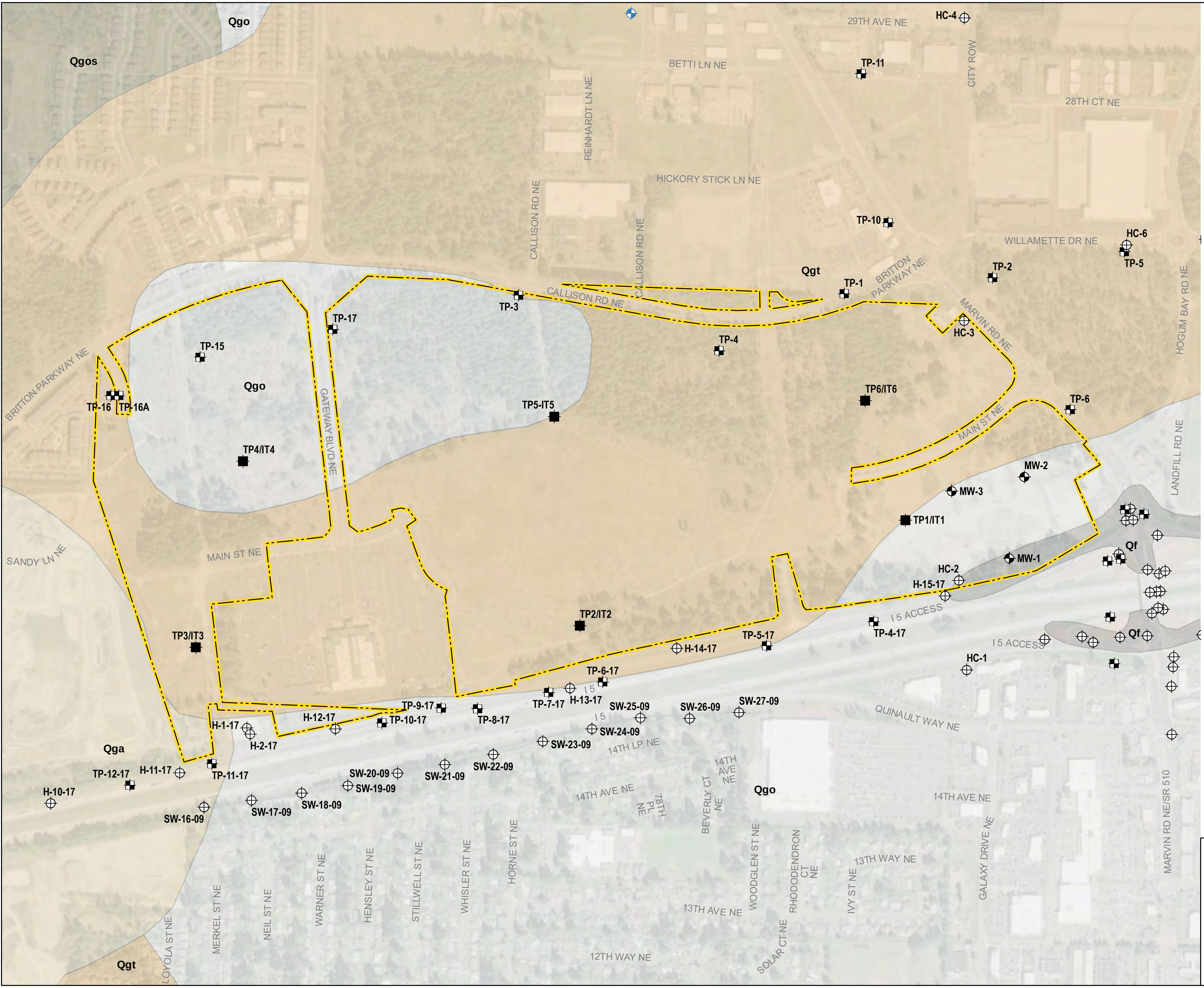

LEGEND

■	TEST PIT WITH INFILTRATION TEST (2022)
◈	MONITORING WELL (HISTORICAL)
◈	WATER WELL (HISTORICAL)
⊕	SOIL BORING (HISTORICAL)
▚	TEST PIT (HISTORICAL)
▨	HOLOCENE ARTIFICIAL FILL AND MODIFIED LAND (Qf)
▨	PLEISTOCENE CONTINENTAL GLACIAL TILL (Qgt)
▨	PLEISTOCENE CONTINENTAL GLACIAL DRIFT (Qga)
▨	PLEISTOCENE CONTINENTAL GLACIAL DRIFT (Qgo)
▨	PLEISTOCENE CONTINENTAL GLAICAL DRIFT (Qgos)
▭	SITE BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. GEOLOGIC DATA SOURCE: WASHINGTON DEPARTMENT OF NATURAL RESOURCES (DNR) GEOLOGIC INFORMATION PORTAL
3. HISTORICAL EXPLORATIONS DONE BY OTHERS BETWEEN 1966 AND 2018.
4. AERIAL IMAGERY SOURCE: ESRI

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NISQUALLY QUIEMUTH VILLAGE
LACEY, WASHINGTON

SURFACE GEOLOGY

JANUARY 2023

FIGURE 4

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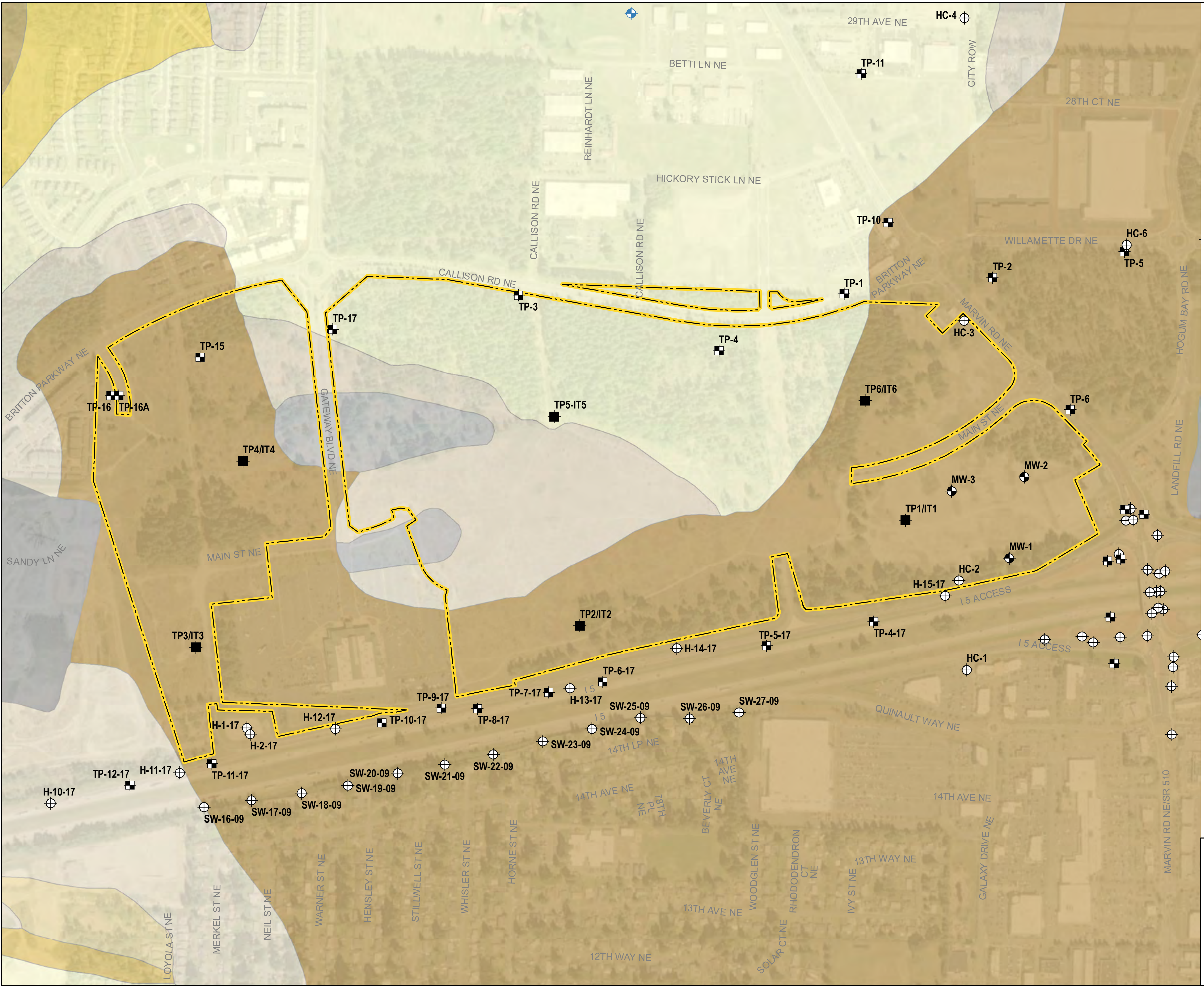

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LEGEND

■ TEST PIT WITH INFILTRATION TEST (2022)

◈ MONITORING WELL (HISTORICAL)

◈ WATER WELL (HISTORICAL)

⊕ SOIL BORING (HISTORICAL)

▣ TEST PIT (HISTORICAL)

▨ PITS, GRAVEL

▨ GILES SILT LOAM, 0 TO 3 PERCENT SLOPES

▨ SPANAWAY GRAVELLY SANDY LOAM, 0 TO 3 PERCENT SLOPES

▨ INDIANOLA LOAMY SAND, 0 TO 5 PERCENT SLOPES

▨ GILES SILT LOAM, 3 TO 15 PERCENT SLOPES

▨ INDIANOLA LOAMY SAND, 5 TO 15 PERCENT SLOPES

▨ ALDERWOOD GRAVELLY SANDY LOAM, 8 TO 15 PERCENT SLOPES

▨ EVERETT VERY GRAVELLY SANDY LOAM, 8 TO 15 PERCENT SLOPES

▨ ALDERWOOD GRAVELLY SANDY LOAM, 15 TO 30 PERCENT SLOPES

☐ SITE BOUNDARY

NOTES

1. ALL LOCATIONS AND DIMENSIONS ARE APPROXIMATE.
2. SOIL DATA SOURCE: UNITED STATES DEPARTMENT OF AGRICULTURE (USDA) NATURAL RESOURCES CONSERVATION SERVICE (NRCS)
3. HISTORICAL EXPLORATIONS DONE BY OTHERS BETWEEN 1966 AND 2018.
4. AERIAL IMAGERY SOURCE: ESRI

HALEY ALDRICH

NISQUALLY QUIEMUTH VILLAGE
LACEY, WASHINGTON

USDA NRCS SOIL SURVEY

JANUARY 2023

FIGURE 5

APPENDIX A
Field Explorations

APPENDIX A

Field Explorations

We evaluated subsurface conditions at the site by completing six test pits using a mini-excavator between 16 and 18 August 2022. The field explorations were coordinated and overseen by geotechnical staff from Haley & Aldrich, Inc., who classified the various soil units encountered, obtained representative soil samples for geotechnical testing, observed and recorded groundwater conditions, and maintained a detailed log of each test pit. Exploration logs are included in this appendix. Results of the laboratory testing are indicated on the exploration logs and are included in Appendix B.

Figure 2 of the report shows the approximate locations of the explorations. Explorations were located in the field using a hand-held Global Positioning System (GPS) unit.

TEST PITS

The test pits were excavated by Nisqually Construction of Lacey, Washington, using a Kubota mini-excavator. The test pit dimensions were approximately 10-feet-long by 3-feet-wide with total depths of approximately 8 to 12.5 feet.

SOIL SAMPLING AND CLASSIFICATION

Materials encountered in the explorations were classified in the field in general accordance with ASTM International Standard Practice D 2488 “Standard Practice for the Classification of Soils (Visual-Manual Procedure).”

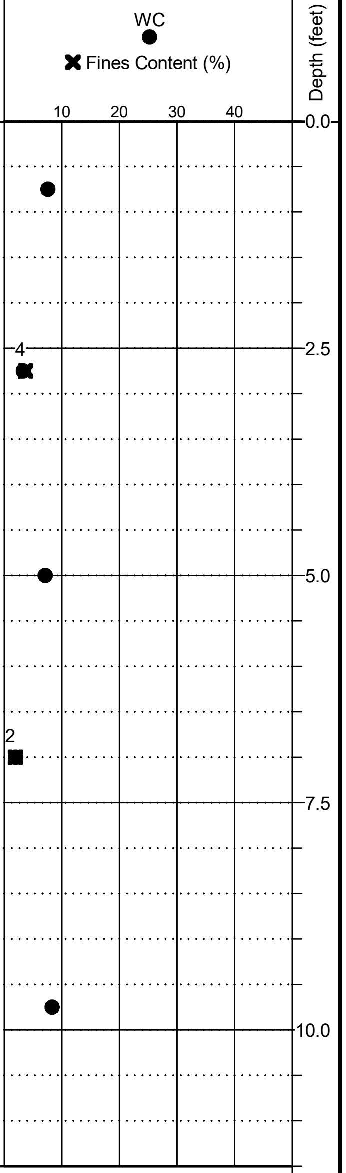
The exploration logs in this appendix show our interpretation of the exploration, sampling, and testing data. The logs indicate the depths where the soil composition appeared to change; note that the actual changes in soil composition may be gradual. In the field, we classified the samples taken from the explorations according to the methods presented on the Figure A - 1, Key to Exploration Logs. This figure also provides a legend explaining the symbols and abbreviations used in the logs.

Sampling of soils was completed at each soil strata within the test pits. The samples were collected by hand from the spoils pile as the test pits were dug.

Date Started: 08/16/2022
Date Completed: 08/16/2022
Contractor/Crew: Nisqually Construction
Logged by: T. Tremain
Checked by: J. Jacobe
Rig Model/Type: Mini excavator
Location: Lat: 47.064625 Long: -122.771320 (WGS 84)
Total Depth: 11.5 feet
Depth to Seepage: Not Encountered
Ground Surface Elevation: 202.90 feet (NAVD 88)
Comments: Infiltration testing completed in an adjacent pit at a depth of 2.0 ft. bgs. See report text for additional information.

Sample Data Number Tests	Material Description
TP1-1 WC	POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM), moist, red-brown.
TP1-2 GS, WC	POORLY GRADED GRAVEL WITH SAND (GP), moist, gray-brown, medium to coarse sand, coarse gravel.
TP1-3 WC	grades to brown, fine to coarse sand, fine gravel
TP1-4 GS, WC	POORLY GRADED GRAVEL (GP), trace medium to coarse sand, some cobbles, moist, gray-brown, fine to coarse gravel.
TP1-5 WC	POORLY GRADED SAND WITH GRAVEL (SP), wet, gray, fine to coarse sand, fine gravel.

Bottom of Test Pit at 11.5 feet.



Elevation (feet): 202.5, 200.0, 197.5, 195.0, 192.5, 190.0
Depth (feet): 0.0, 2.5, 5.0, 7.5, 10.0, 12.5

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

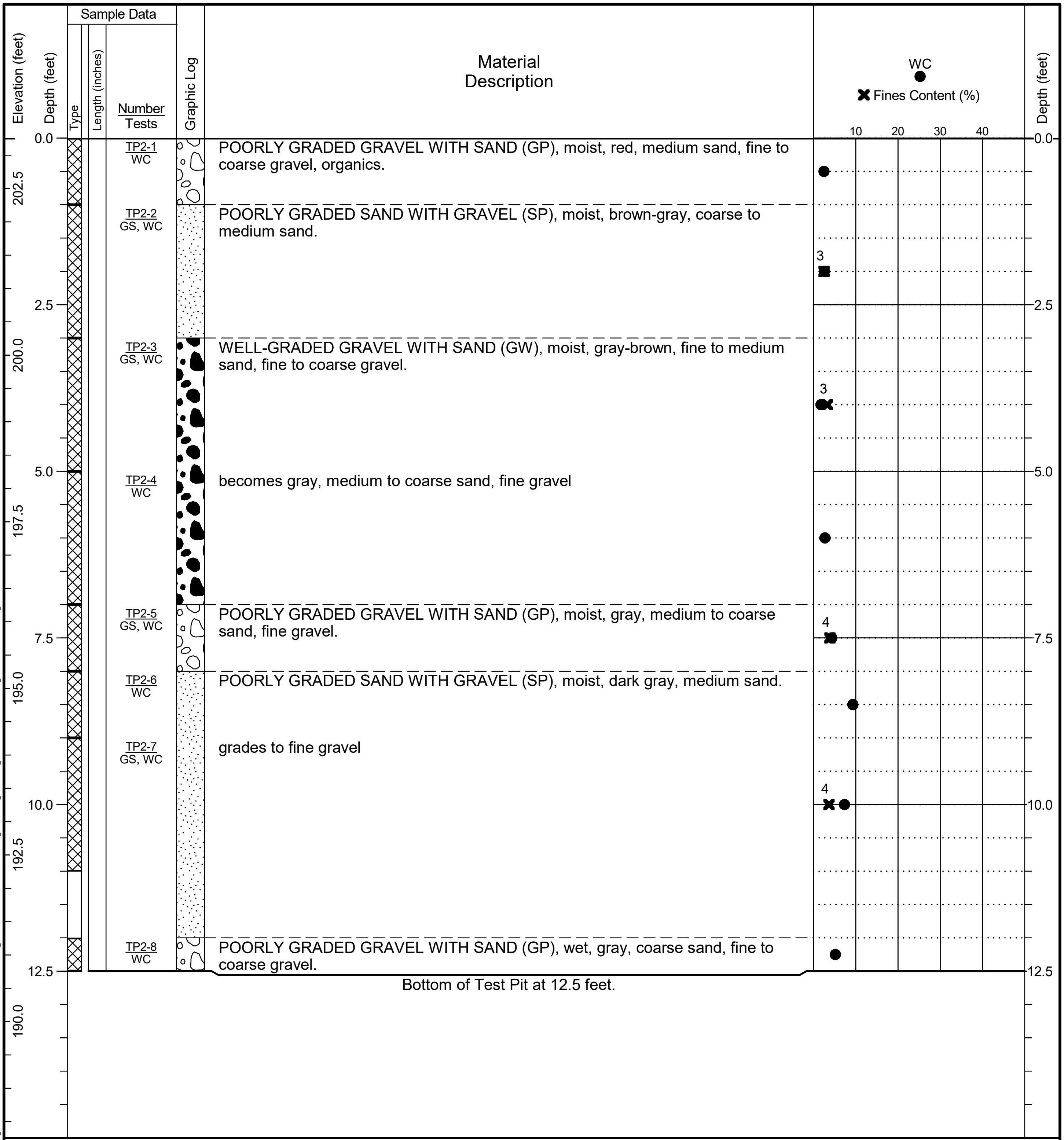
HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Test Pit Log
TP1/IT1

Figure **A**
Sheet **1 of 1**

Date Started: 08/16/2022
Date Completed: 08/16/2022
Contractor/Crew: Nisqually Construction
Logged by: T. Tremain
Checked by: J. Jacobe
Rig Model/Type: Mini excavator
Location: Lat: 47.062703 Long: -122.779216 (WGS 84)
Total Depth: 12.5 feet
Depth to Seepage: Not Encountered
Ground Surface Elevation: 203.26 feet (NAVD 88)
Comments: Infiltration testing completed in an adjacent pit at a depth of 2.0 ft. bgs. See report text for additional information.



Number Tests	Material Description
TP2-1 WC	POORLY GRADED GRAVEL WITH SAND (GP), moist, red, medium sand, fine to coarse gravel, organics.
TP2-2 GS, WC	POORLY GRADED SAND WITH GRAVEL (SP), moist, brown-gray, coarse to medium sand.
TP2-3 GS, WC	WELL-GRADED GRAVEL WITH SAND (GW), moist, gray-brown, fine to medium sand, fine to coarse gravel.
TP2-4 WC	becomes gray, medium to coarse sand, fine gravel
TP2-5 GS, WC	POORLY GRADED GRAVEL WITH SAND (GP), moist, gray, medium to coarse sand, fine gravel.
TP2-6 WC	POORLY GRADED SAND WITH GRAVEL (SP), moist, dark gray, medium sand.
TP2-7 GS, WC	grades to fine gravel
TP2-8 WC	POORLY GRADED GRAVEL WITH SAND (GP), wet, gray, coarse sand, fine to coarse gravel.

Bottom of Test Pit at 12.5 feet.

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

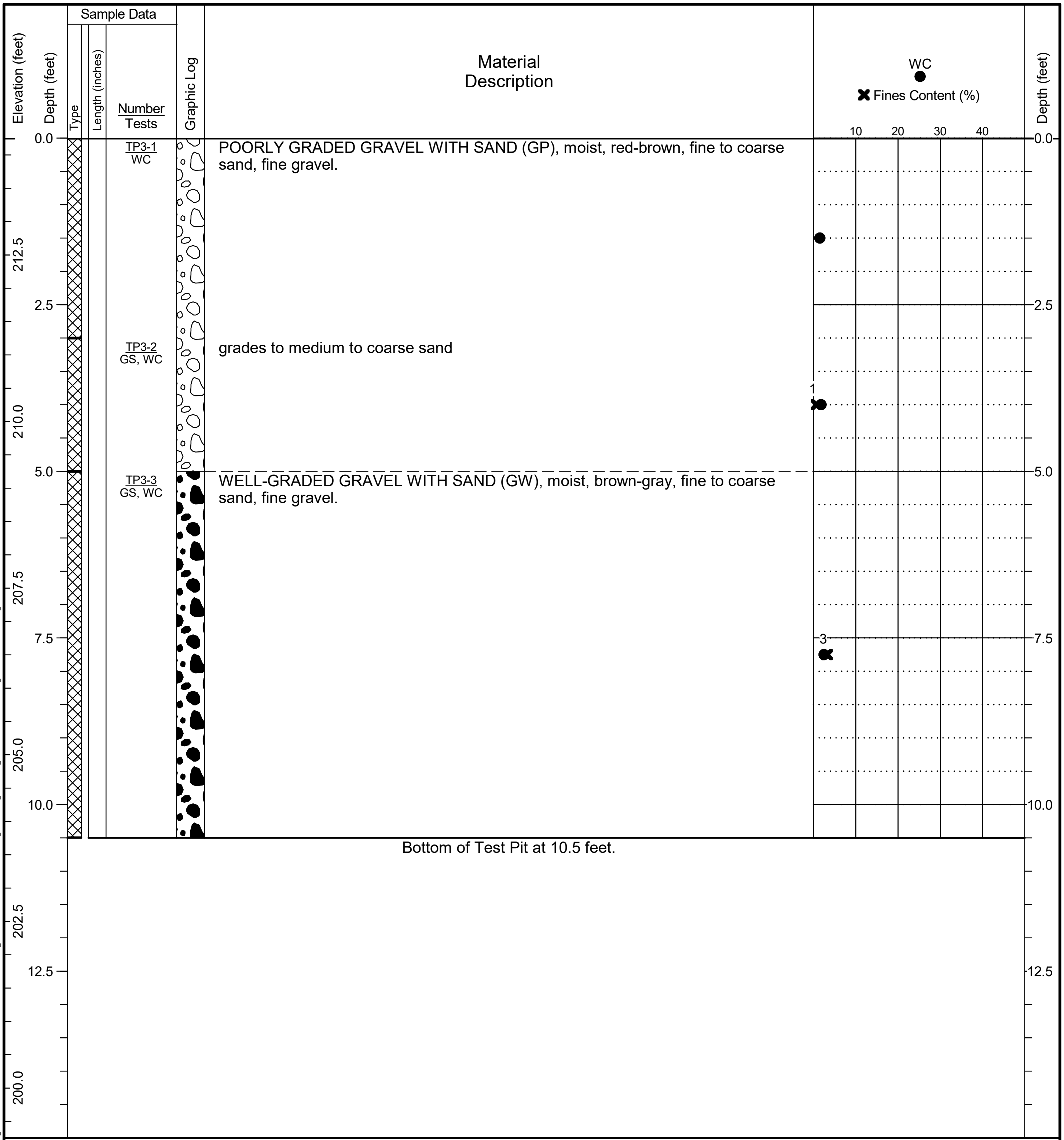
HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Test Pit Log
TP2/IT2

Figure **A**
Sheet **1 of 1**

Date Started: 08/16/2022
Date Completed: 08/16/2022
Contractor/Crew: Nisqually Construction
Logged by: T. Tremain
Checked by: J. Jacobe
Rig Model/Type: Mini excavator
Location: Lat: 47.062155 Long: -122.788604 (WGS 84)
Total Depth: 10.5 feet
Depth to Seepage: Not Encountered
Ground Surface Elevation: 214.25 feet (NAVD 88)
Comments: Infiltration testing completed in an adjacent pit at a depth of 2.0 ft. bgs. See report text for additional information.



Material Description

POORLY GRADED GRAVEL WITH SAND (GP), moist, red-brown, fine to coarse sand, fine gravel.

grades to medium to coarse sand

WELL-GRADED GRAVEL WITH SAND (GW), moist, brown-gray, fine to coarse sand, fine gravel.

Bottom of Test Pit at 10.5 feet.

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

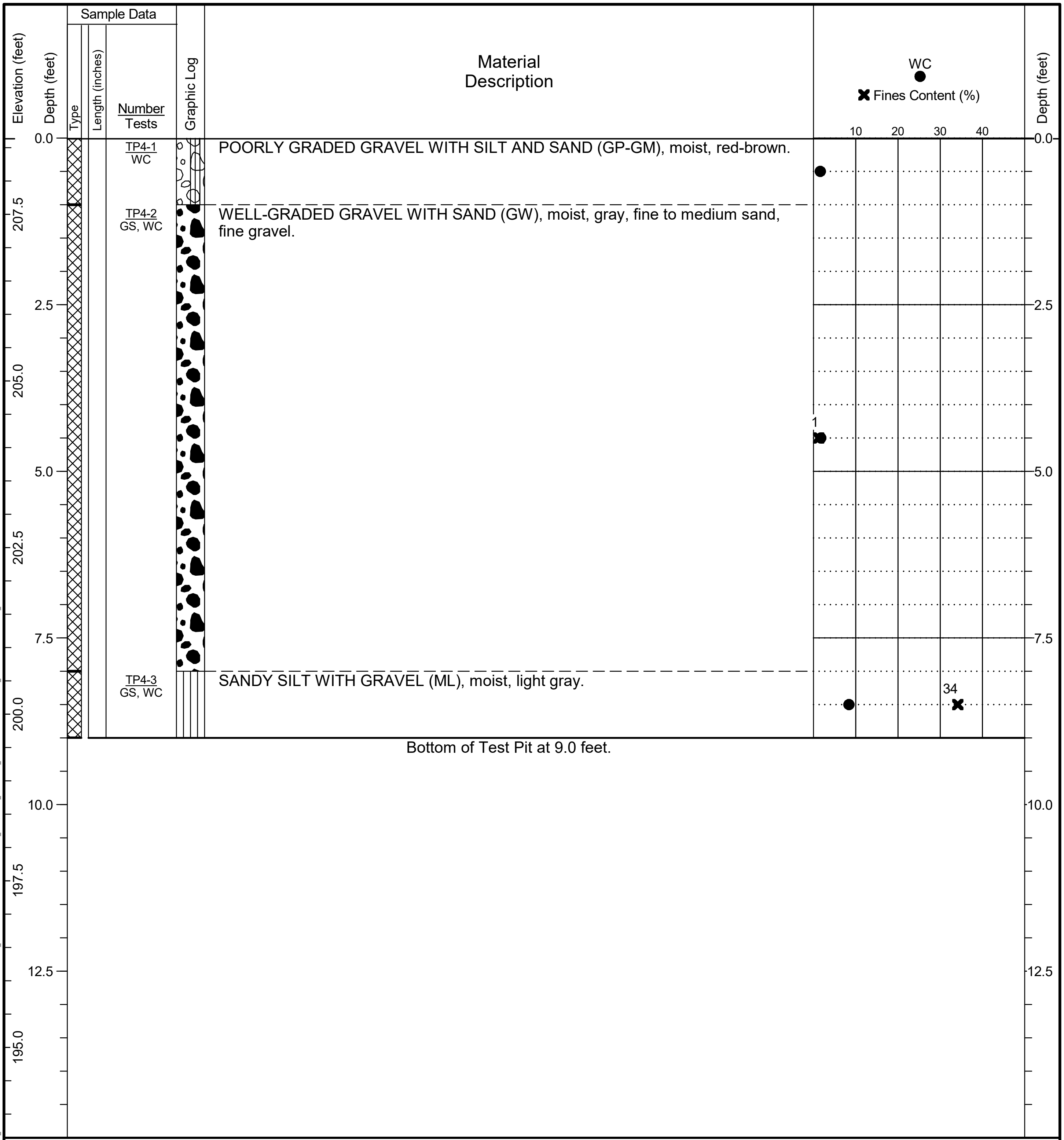
HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Test Pit Log
TP3/IT3

Figure **A**
Sheet **1 of 1**

Date Started: 08/17/2022 Date Completed: 08/17/2022 Contractor/Crew: Nisqually Construction
Logged by: T. Tremain Checked by: J. Jacobe Rig Model/Type: Mini excavator
Location: Lat: 47.065290 Long: -122.787585 (WGS 84) Total Depth: 9 feet Depth to Seepage: Not Encountered
Ground Surface Elevation: 208.64 feet (NAVD 88)
Comments: Infiltration testing completed in an adjacent pit at a depth of 2.0 ft. bgs. See report text for additional information.



POORLY GRADED GRAVEL WITH SILT AND SAND (GP-GM), moist, red-brown.

WELL-GRADED GRAVEL WITH SAND (GW), moist, gray, fine to medium sand, fine gravel.

SANDY SILT WITH GRAVEL (ML), moist, light gray.

Bottom of Test Pit at 9.0 feet.

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HALEY ALDRICH

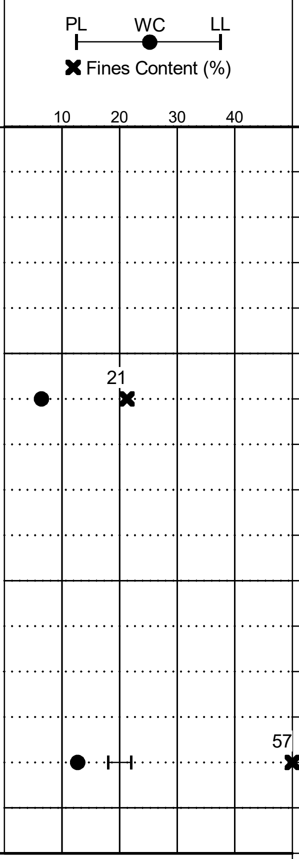
Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Test Pit Log
TP4/IT4

Figure **A**
Sheet **1 of 1**

Date Started: 08/17/2022
Date Completed: 08/17/2022
Contractor/Crew: Nisqually Construction
Logged by: T. Tremain
Checked by: J. Jacobe
Rig Model/Type: Mini excavator
Location: Lat: 47.066189 Long: -122.779989 (WGS 84)
Total Depth: 8 feet
Depth to Seepage: Not Encountered
Ground Surface Elevation: 220.39 feet (NAVD 88)
Comments: Infiltration testing completed in an adjacent pit at a depth of 2.0 ft. bgs. See report text for additional information.

Elevation (feet)	Depth (feet)	Sample Data: Type	Sample Data: Length (inches)	Sample Data: Number / Tests	Graphic Log	Material Description	Depth (feet)
220.0	0.0			TP5-1 GS, WC		SILTY SAND WITH GRAVEL (SM), moist, red-brown, organics.	0.0
217.5	2.5						2.5
215.0	5.0						5.0
				TP5-2 AL, GS, WC		SANDY SILT (ML), moist, light gray.	
212.5	7.5						7.5
						Bottom of Test Pit at 8.0 feet.	
210.0	10.0						10.0
207.5	12.5						12.5



General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

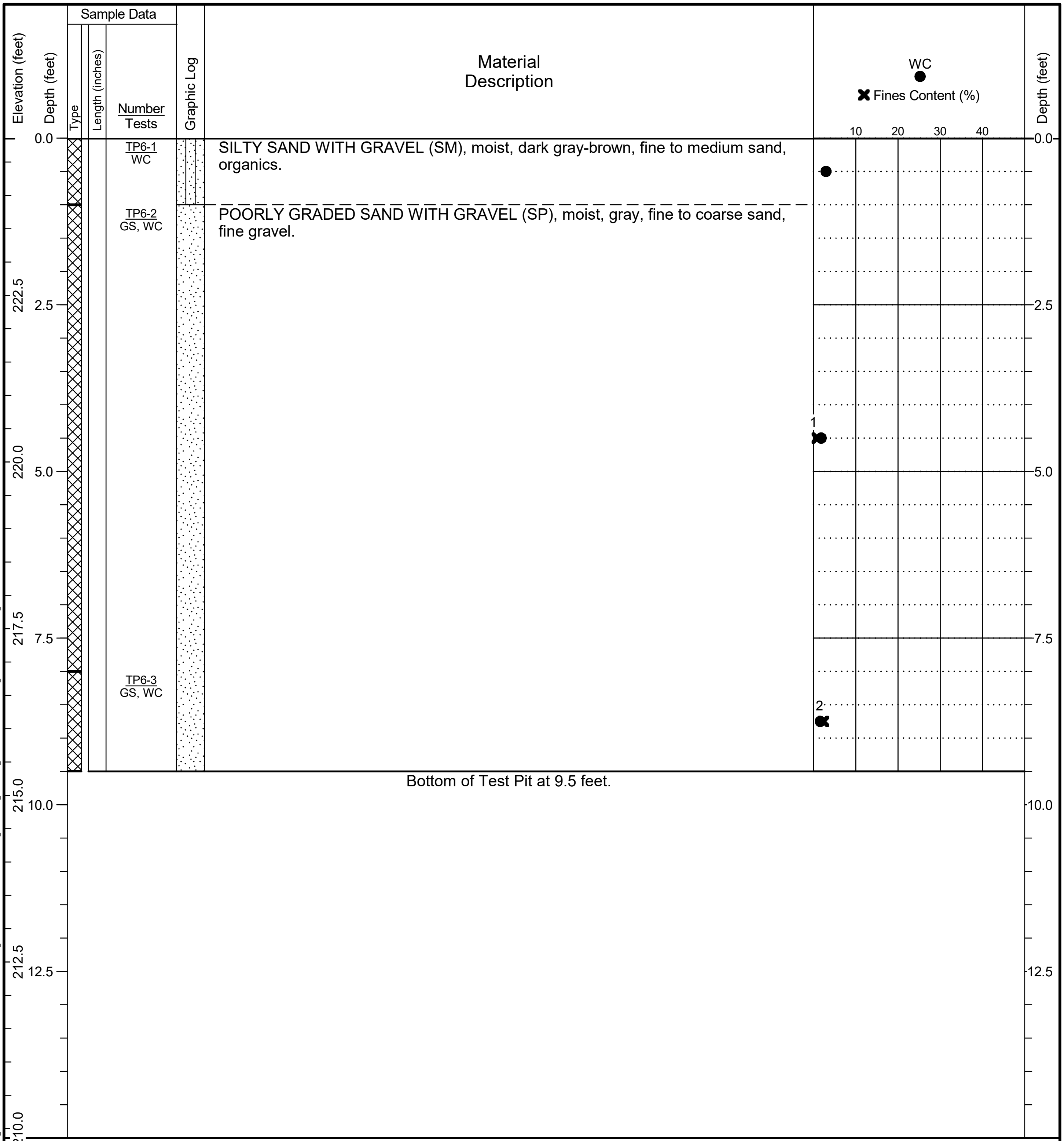
HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Test Pit Log
TP5/IT5

Figure **A**
Sheet **1 of 1**

Date Started: 08/17/2022
Date Completed: 08/17/2022
Contractor/Crew: Nisqually Construction
Logged by: T. Tremain
Checked by: J. Jacobe
Rig Model/Type: Mini excavator
Location: Lat: 47.066606 Long: -122.772393 (WGS 84)
Total Depth: 9.5 feet
Depth to Seepage: Not Encountered
Ground Surface Elevation: 224.86 feet (NAVD 88)
Comments: Infiltration testing completed in an adjacent pit at a depth of 2.0 ft. bgs. See report text for additional information.



Depth (feet)	Number / Tests	Material Description
0.0	TP6-1 WC	SILTY SAND WITH GRAVEL (SM), moist, dark gray-brown, fine to medium sand, organics.
1.0	TP6-2 GS, WC	POORLY GRADED SAND WITH GRAVEL (SP), moist, gray, fine to coarse sand, fine gravel.
8.0	TP6-3 GS, WC	

Bottom of Test Pit at 9.5 feet.

General Notes:
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Material stratum lines are interpretive and actual changes may be gradual. Solid lines indicate distinct contacts and dashed lines indicate gradual or approximate contacts.
3. USCS designations are based on visual-manual identification (ASTM D 2488), unless otherwise supported by laboratory testing (ASTM D 2487).
4. Groundwater level, if indicated, is at time of drilling/excavation (ATD) or for date specified. Level may vary with time.
5. Location and ground surface elevations are approximate.

HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Test Pit Log
TP6/IT6

Figure **A**
Sheet **1 of 1**

APPENDIX B
Laboratory Test Results

APPENDIX B

Laboratory Test Results

GENERAL

Soil samples obtained from the explorations were transported to our laboratory and evaluated to confirm or modify field classifications, as well as to assess engineering properties of the soils encountered. Representative samples were selected for laboratory testing. The tests were performed in general accordance with the test methods of the ASTM International (ASTM) or other applicable procedures. A summary of the test results is included as Figure B-1.

VISUAL CLASSIFICATIONS

Soil samples obtained from the explorations were visually classified in the field and in our geotechnical laboratory based on the Unified Soil Classification System and ASTM classification methods. ASTM Test Method D 2488 was used to classify soils using visual and manual methods. ASTM Test Method D 2487 was used to classify soils based on laboratory test results.

LABORATORY TEST RESULTS

Moisture Content

Moisture contents of samples were obtained in general accordance with ASTM Test Method D 2216. The results of the moisture content tests completed on samples from the explorations are presented on the exploration logs included in Appendix A and on Figure B-1 in this appendix.

Percent Fines

Fines content analyses were performed to determine the percentage of soils finer than the No. 200 sieve — the boundary between sand size particles and silt size particles. The tests were performed in general accordance with ASTM Test Method D 1140. The test results are indicated on the exploration logs included in Appendix A and on Figure B-1 in this appendix.

Particle Size Distribution

Sieve analysis tests were also performed to determine the quantitative distribution of particle sizes in the sample. The tests were performed in general accordance with ASTM Test Method D 6913. The “percent fines” portions of the test results are indicated on the appropriate exploration logs included in Appendix A and on Figure B-1 in this appendix. The full test results are shown on Figure B-2 in this appendix.

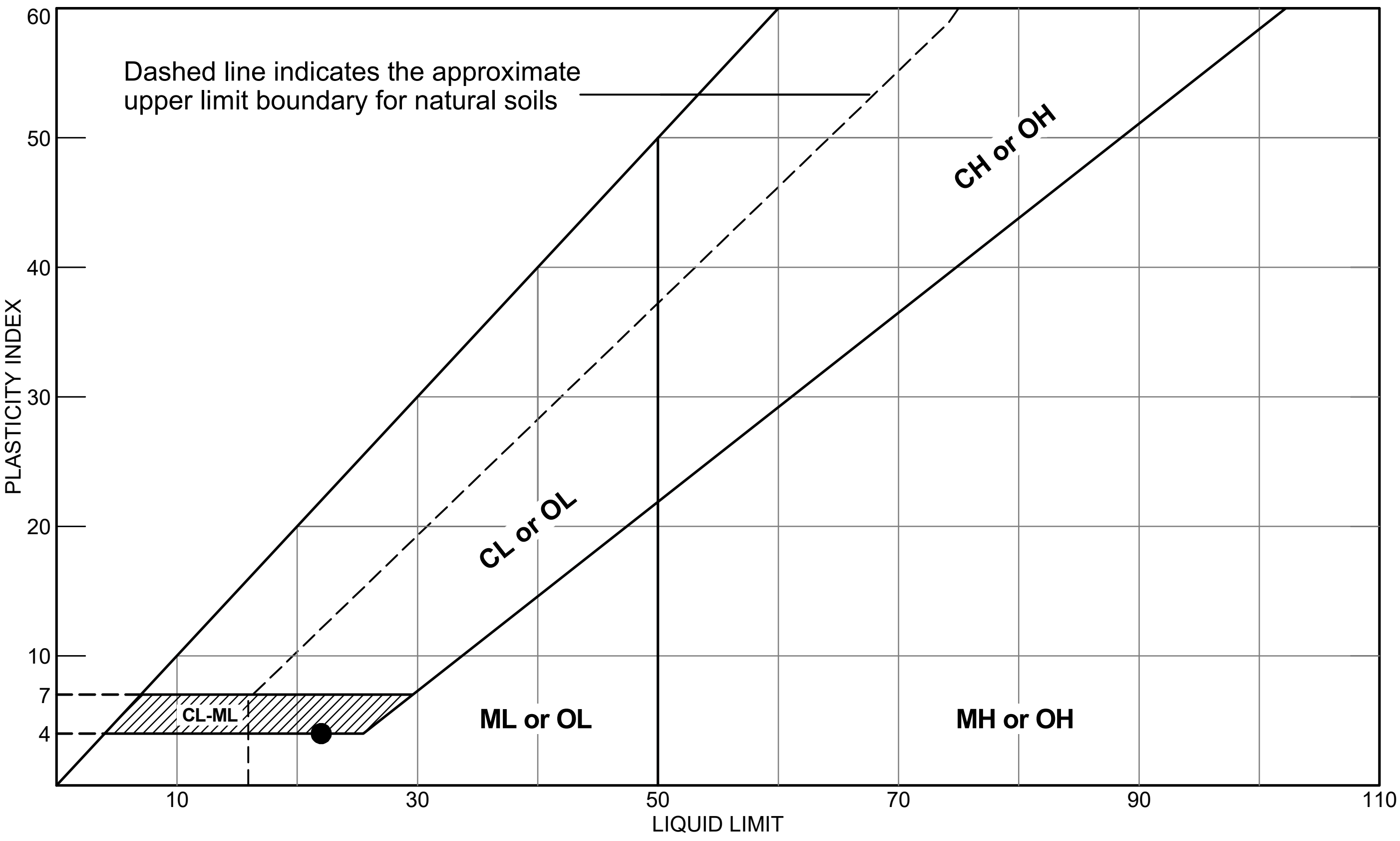
Exploration	Sample ID	Depth	Gravel (%)	Sand (%)	Fines (%)	Liquid Limit	Plastic Limit	Water Content (%)	USCS Group Symbol	Soil Description
TP1/IT1	TP1-1	0.0						7.6		
TP1/IT1	TP1-2	1.5	57.4	38.9	3.7			3.3	GP	POORLY GRADED GRAVEL WITH SAND
TP1/IT1	TP1-3	4.0						7.1		
TP1/IT1	TP1-4	6.0	83.5	14.6	1.9			2.0	GP	POORLY GRADED GRAVEL
TP1/IT1	TP1-5	8.0						8.3		
TP2/IT2	TP2-1	0.0						2.5		
TP2/IT2	TP2-2	1.0	21.6	75.8	2.5			2.6	SP	POORLY GRADED SAND WITH GRAVEL
TP2/IT2	TP2-3	3.0	70.0	26.7	3.3			1.8	GW	WELL-GRADED GRAVEL WITH SAND
TP2/IT2	TP2-4	5.0						2.7		
TP2/IT2	TP2-5	7.0	49.4	46.7	3.9			4.3	GP	POORLY GRADED GRAVEL WITH SAND
TP2/IT2	TP2-6	8.0						9.3		
TP2/IT2	TP2-7	9.0	47.0	49.3	3.7			7.3	SP	POORLY GRADED SAND WITH GRAVEL
TP2/IT2	TP2-8	12.0						5.2		
TP3/IT3	TP3-1	0.0						1.5		
TP3/IT3	TP3-2	3.0	58.3	41.0	0.7			1.8	GP	POORLY GRADED GRAVEL WITH SAND
TP3/IT3	TP3-3	5.0	64.1	32.7	3.2			2.5	GW	WELL-GRADED GRAVEL WITH SAND
TP4/IT4	TP4-1	0.0						1.6		
TP4/IT4	TP4-2	1.0	71.7	27.1	1.2			1.7	GW	WELL-GRADED GRAVEL WITH SAND
TP4/IT4	TP4-3	8.0	34.3	31.6	34.1			8.4	GM	SILTY GRAVEL WITH SAND
TP5/IT5	TP5-1	0.0	37.3	41.4	21.3			6.4	SM	SILTY SAND WITH GRAVEL
TP5/IT5	TP5-2	6.0	0.0	43.0	57.0	22	18	12.7	ML	SANDY SILT
TP6/IT6	TP6-1	0.0						3.0		
TP6/IT6	TP6-2	1.0	44.5	54.6	0.9			1.8	SP	POORLY GRADED SAND WITH GRAVEL
TP6/IT6	TP6-3	8.0	38.2	59.5	2.3			1.6	SP	POORLY GRADED SAND WITH GRAVEL

HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Summary of Laboratory Results

Figure **B-1**
Sheet **1 of 1**



Location and Description	LL	PL	PI	-#200	MC%	USCS
● **Source:** TP5/IT5 **Sample No.:** TP5-2 **Depth:** 6.0 to 8.0 SANDY SILT	22	18	4	57	13	ML

Remarks:

●

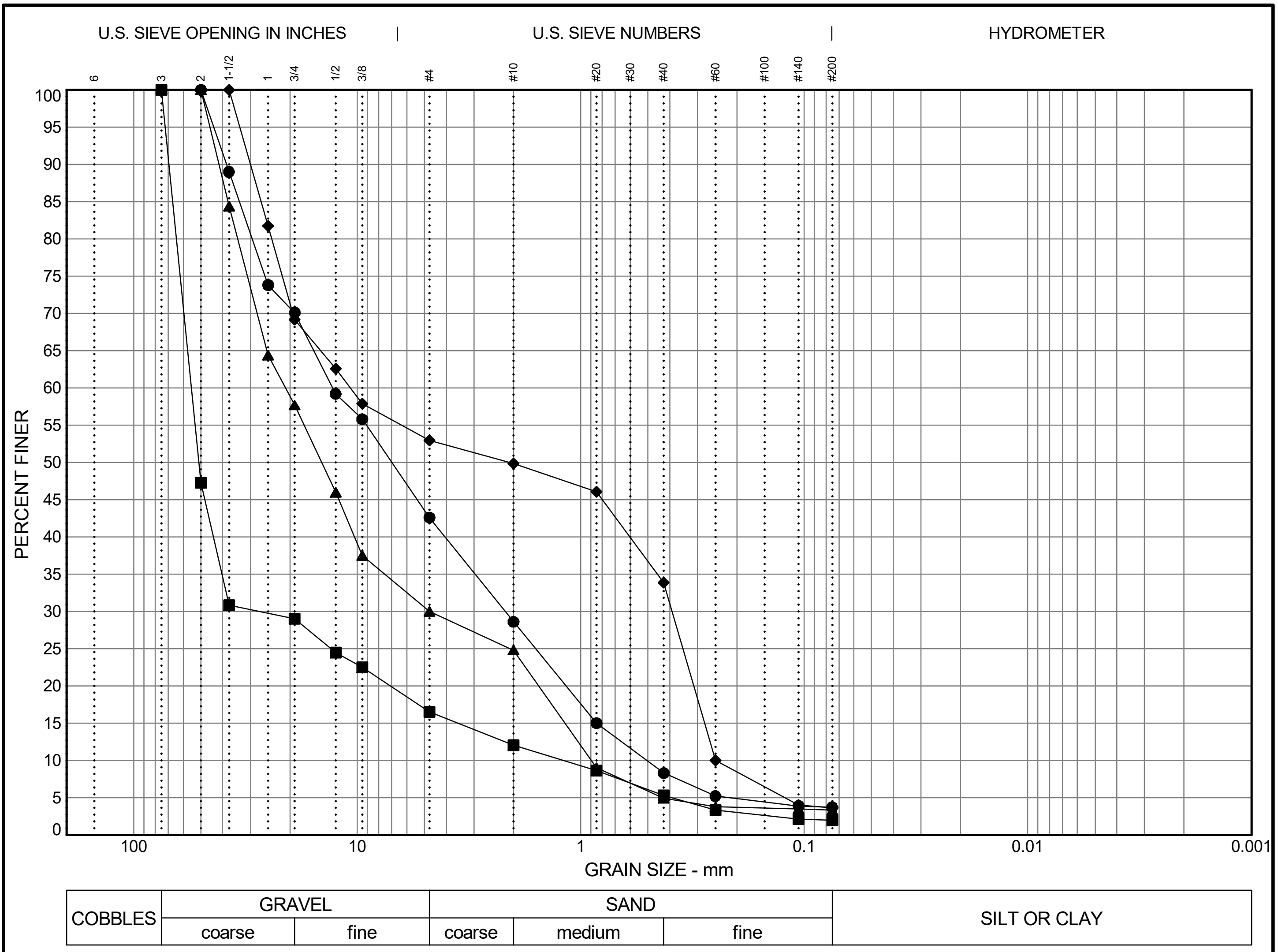
HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Liquid Limit, Plastic Limit, and Plasticity Index

Figure **B-2**
Sheet **1 of 1**

HA ATTERBERG LIMITS - \\HALEYALDRICH.COM\SHARE\PDX_DATA\GEOMATICS\GINT\HC_LIBRARY.GLB - 9/20/22 11:20 - \\HALEYALDRICH.COM\SHARE\SEA_PROJECTS\NOTEBOOKS\0205090-000_NISQUALLY_QUIEMUTH_VILLAGE\FIELD DATA\PERM_GINT FILES\0205090-000_GINT.GPJ - pkastens



Location and Description	% Cobbles	% Gravel	% Sand	% Silt	% Clay	MC%	USCS
● **Source:** TP1/IT1 **Sample No.:** TP1-2 **Depth:** 1.5 to 4.0 POORLY GRADED GRAVEL WITH SAND	0.0	57.4	38.9	3.7		3	GP
■ **Source:** TP1/IT1 **Sample No.:** TP1-4 **Depth:** 6.0 to 8.0 POORLY GRADED GRAVEL	0.0	83.5	14.6	1.9		2	GP
▲ **Source:** TP2/IT2 **Sample No.:** TP2-3 **Depth:** 3.0 to 5.0 WELL-GRADED GRAVEL WITH SAND	0.0	70.0	26.7	3.3		2	GW
◆ **Source:** TP2/IT2 **Sample No.:** TP2-7 **Depth:** 9.0 to 11.0 POORLY GRADED SAND WITH GRAVEL	0.0	47.0	49.3	3.7		7	SP

☒	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			33.705	12.890	7.006	2.181	0.850	0.507	0.73	25.44
■			66.824	55.130	51.047	27.423	3.561	1.201	11.35	45.89
▲			37.917	20.877	14.424	4.750	1.176	0.897	1.20	23.27
◆			26.893	10.744	2.072	0.390	0.279	0.249	0.06	43.17

Remarks:

●

■

▲

◆

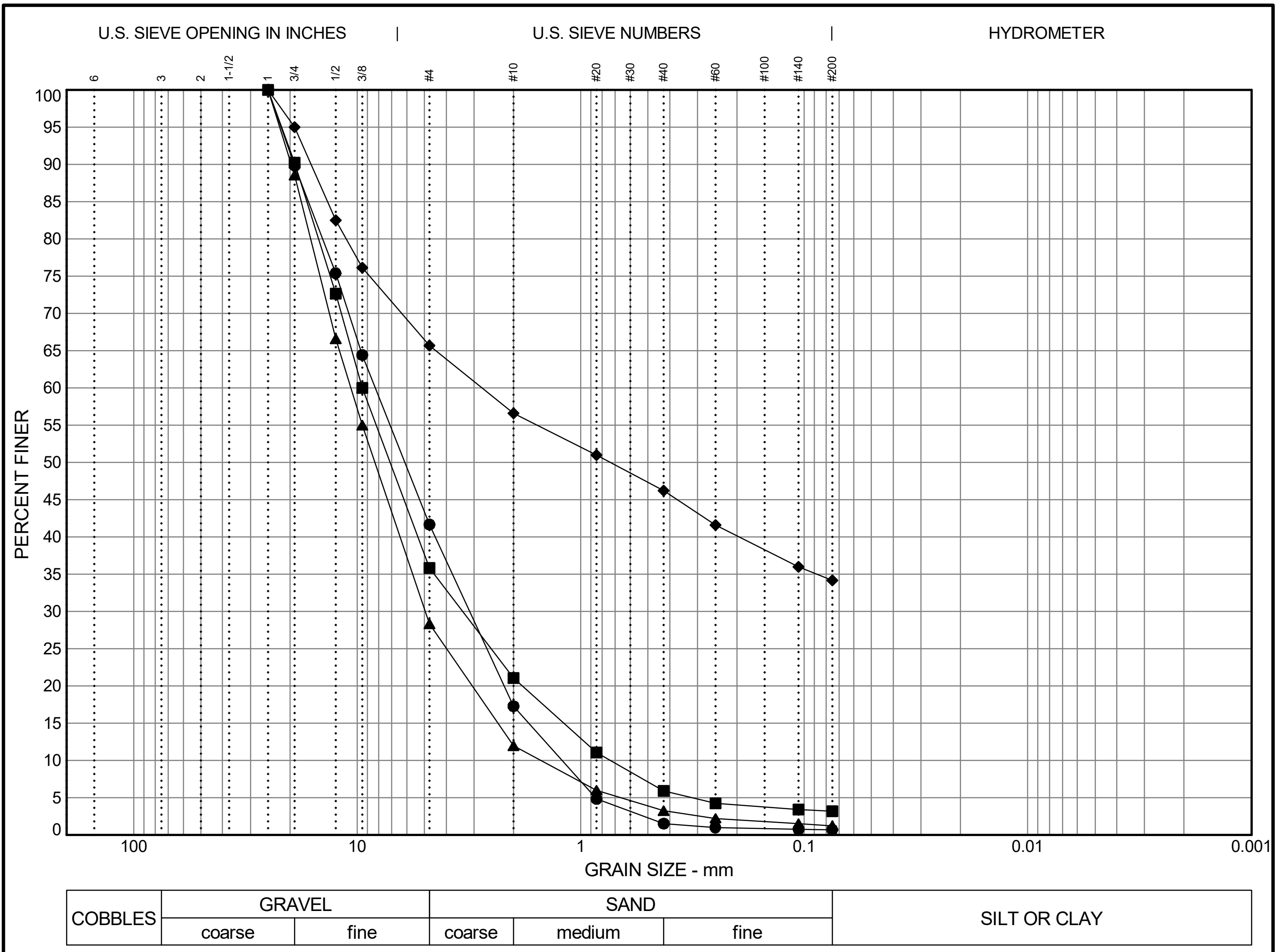
HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Particle-Size Analysis

Figure **B-3**
Sheet **1 of 3**

HA GRAIN SIZE - \\HALEYALDRICH.COM\SHARE\PDX_DATA\GEOMATICS\GINT\HC_LIBRARY.GLB - 9/16/22 15:10 - \\HALEYALDRICH.COM\SHARE\SEA_PROJECTS\NOTEBOOKS\0205090-000_NISQUALLY_QUIEMUTH_VILLAGE\FIELD DATA\PERM_GINT FILES\0205090-000_GINT.GPJ - pkastens



Location and Description	% Cobbles	% Gravel	% Sand	% Silt	% Clay	MC%	USCS
● **Source:** TP3/IT3 **Sample No.:** TP3-2 **Depth:** 3.0 to 5.0 POORLY GRADED GRAVEL WITH SAND	0.0	58.3	41.0	0.7		2	GP
■ **Source:** TP3/IT3 **Sample No.:** TP3-3 **Depth:** 5.0 to 10.5 WELL-GRADED GRAVEL WITH SAND	0.0	64.1	32.7	3.2		2	GW
▲ **Source:** TP4/IT4 **Sample No.:** TP4-2 **Depth:** 1.0 to 8.0 WELL-GRADED GRAVEL WITH SAND	0.0	71.7	27.1	1.2		2	GW
◆ **Source:** TP4/IT4 **Sample No.:** TP4-3 **Depth:** 8.0 to 9.0 SILTY GRAVEL WITH SAND	0.0	34.3	31.6	34.1		8	GM

☒	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			16.520	8.303	6.123	3.141	1.711	1.213	0.98	6.84
■			16.765	9.497	7.128	3.374	1.190	0.735	1.63	12.92
▲			17.754	10.695	8.341	4.960	2.348	1.508	1.53	7.09
◆			13.582	2.769	0.735					

Remarks:

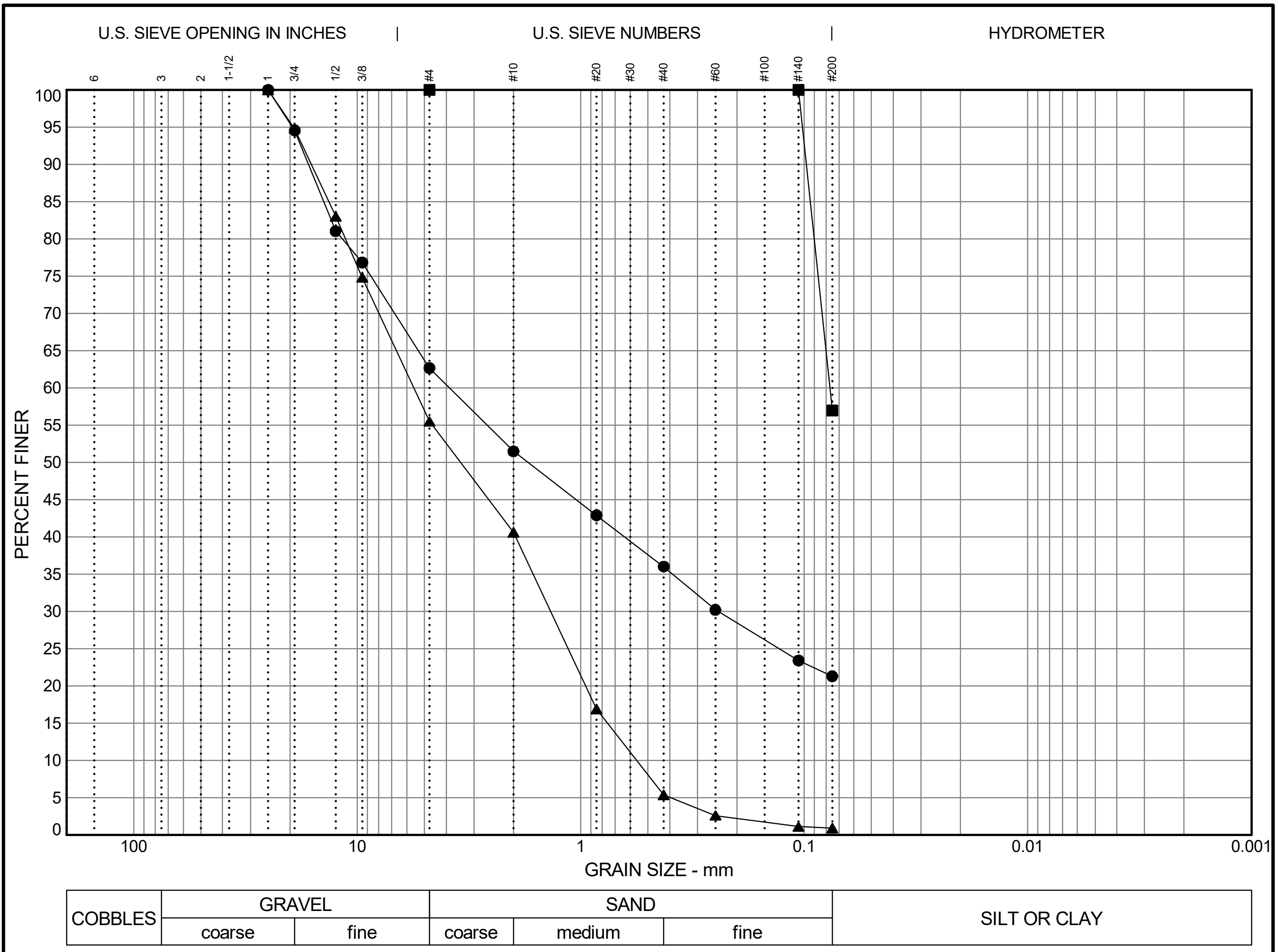
●
■
▲
◆

HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Particle-Size Analysis

Figure **B-3**
Sheet **2 of 3**



Location and Description	% Cobbles	% Gravel	% Sand	% Silt	% Clay	MC%	USCS
● **Source:** TP5/IT5 **Sample No.:** TP5-1 **Depth:** 0.0 to 6.0 SILTY SAND WITH GRAVEL	0.0	37.3	41.4	21.3		6	SM
■ **Source:** TP5/IT5 **Sample No.:** TP5-2 **Depth:** 6.0 to 8.0 SANDY SILT	0.0	0.0	43.0	57.0		13	ML
▲ **Source:** TP6/IT6 **Sample No.:** TP6-2 **Depth:** 1.0 to 8.0 POORLY GRADED SAND WITH GRAVEL	0.0	44.5	54.6	0.9		2	SP

☒	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			14.134	3.863	1.724	0.244				
■			0.094	0.077						
▲			13.419	5.583	3.452	1.364	0.758	0.561	0.59	9.96

Remarks:
●
■
▲

HALEY ALDRICH

Project: Nisqually Quiemuth Village
Location: Lacey, Washington
Project No.: 0205090-000

Particle-Size Analysis

Figure **B-3**
Sheet **3 of 3**

HA GRAIN SIZE - \\HALEYALDRICH.COM\SHARE\PDX_DATA\GEOMATICS\GINT\HC_LIBRARY.GLB - 9/16/22 15:11 - \\HALEYALDRICH.COM\SHARE\SEA_PROJECTS\NOTEBOOKS\0205090-000_NISQUALLY_QUIEMUTH_VILLAGE\FIELD DATA\PERM_GINT FILES\0205090-000_GINT.GPJ - pkastens

APPENDIX C

Historical Exploration Logs

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COHESIONLESS SOILS			COHESIVE SOILS		
Density	N (blows/ft)	Approximate Relative Density(%)	Consistency	N (blows/ft)	Approximate Undrained Shear Strength (psf)
Very Loose	0 to 4	0 - 15	Very Soft	0 to 2	<250
Loose	4 to 10	15 - 35	Soft	2 to 4	250 - 500
Medium Dense	10 to 30	35 - 65	Medium Stiff	4 to 8	500 - 1000
Dense	30 to 50	65 - 85	Stiff	8 to 15	1000 - 2000
Very Dense	over 50	85 - 100	Very Stiff	15 to 30	2000 - 4000
			Hard	over 30	>4000

TEST SYMBOLS

GS	Grain Size Distribution
%F	Percent Fines
CN	Consolidation
TX	Triaxial Compression
UC	Unconfined Compression
DS	Direct Shear
M	Resilient Modulus
PP	Pocket Penetrometer Approx. Compressive Strength (tsf)
TV	Torvane Approximate Shear Strength (tsf)
CBR	California Bearing Ratio
MD	Moisture/Density Relationship
PID	Photoionization Device Reading
AL	Atterberg Limits: PL Plastic Limit LL Liquid Limit

ASTM SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP DESCRIPTIONS		
Coarse Grained Soils	Gravel and Gravelly Soils	Clean Gravel (little or no fines)	▨	GW	Well-graded GRAVEL
			▨	GP	Poorly-graded GRAVEL
	More than 50% of Coarse Fraction Retained on No. 4 Sieve	Gravel with Fines (appreciable amount of fines)	▨	GM	Silty GRAVEL
			▨	GC	Clayey GRAVEL
More than 50% Retained on No. 200 Sieve Size	Sand and Sandy Soils	Clean Sand (little or no fines)	▨	SW	Well-graded SAND
			▨	SP	Poorly-graded SAND
	50% or More of Coarse Fraction Passing on No. 4 Sieve	Sand with Fines (appreciable amount of fines)	▨	SM	Silty SAND
			▨	SC	Clayey SAND
Fine Grained Soils	Silt and Clay	Liquid Limit Less than 50%	▨	ML	SILT
			▨	CL	Lean CLAY
			▨	OL	Organic SILT/Organic CLAY
50% or More Passing No. 200 Sieve Size	Silt and Clay	Liquid Limit 50% or More	▨	MH	Elastic SILT
			▨	CH	Fat CLAY
			▨	OH	Organic SILT/Organic CLAY
Highly Organic Soils			▨	PT	PEAT

SAMPLE TYPE SYMBOLS

☒	2.0" OD Split Spoon (SPT) (140 lb. hammer with 30 in. drop)
I	Shelby Tube
▣	3.0" OD Split Spoon with Brass Rings
○	Small Bag Sample
◧	Large Bag (Bulk) Sample
▯	Core Run
◪	Non-standard Penetration Test (with split spoon sampler)

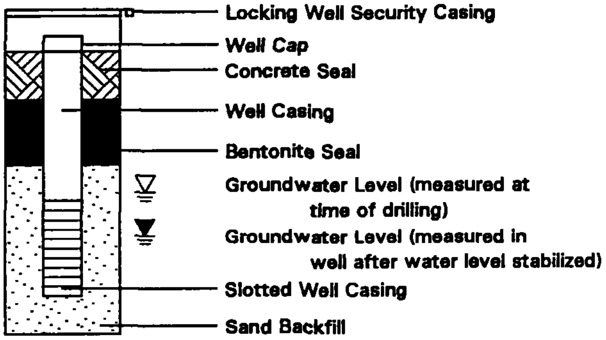
COMPONENT PROPORTIONS

DESCRIPTIVE TERMS	RANGE OF PROPORTION
Trace	0 - 5%
Few	5 - 10%
Little	15 - 25%
Some	30 - 45%
Mostly	50 - 100%

COMPONENT DEFINITIONS

COMPONENT	SIZE RANGE
Boulders	Larger than 12 in
Cobbles	3 in to 12 in
Gravel	3 in to No 4 (4.5mm)
Coarse gravel	3 in to 3/4 in
Fine gravel	3/4 in to No 4 (4.5mm)
Sand	No. 4 (4.5 mm) to No. 200 (0.074 mm)
Coarse sand	No. 4 (4.5 mm) to No. 10 (2.0 mm)
Medium sand	No. 10 (2.0 mm) to No. 40 (0.42 mm)
Fine sand	No. 40 (0.42 mm) to No. 200 (0.074 mm)
Silt and Clay	Smaller than No. 200 (0.074mm)

GROUNDWATER WELL COMPLETIONS



NOTES: Soil classifications presented on exploration logs are based on visual and laboratory observation in general accordance with ASTM D 2487 and ASTM D 2488. Soil descriptions are presented in the following general order:

Density/consistency, color, modifier (if any) GROUP NAME, additions to group name (if any), moisture content. Proportion, gradation, and angularity of constituents, additional comments. (GEOLOGIC INTERPRETATION)

Please refer to the discussion in the report text as well as the exploration logs for a more complete description of subsurface conditions.

MOISTURE CONTENT

DRY	Absence of moisture, dusty, dry to the touch.
MOIST	Damp but no visible water.
WET	Visible free water, usually soil is below water table.

HONG WEST
& ASSOCIATES, INC.

State Route 510
Lacey, WA

LEGEND OF TERMS AND SYMBOLS USED ON EXPLORATION LOGS

PROJECT NO.: 96178 FIGURE: A-1

LEGEND 96178 6/18/97

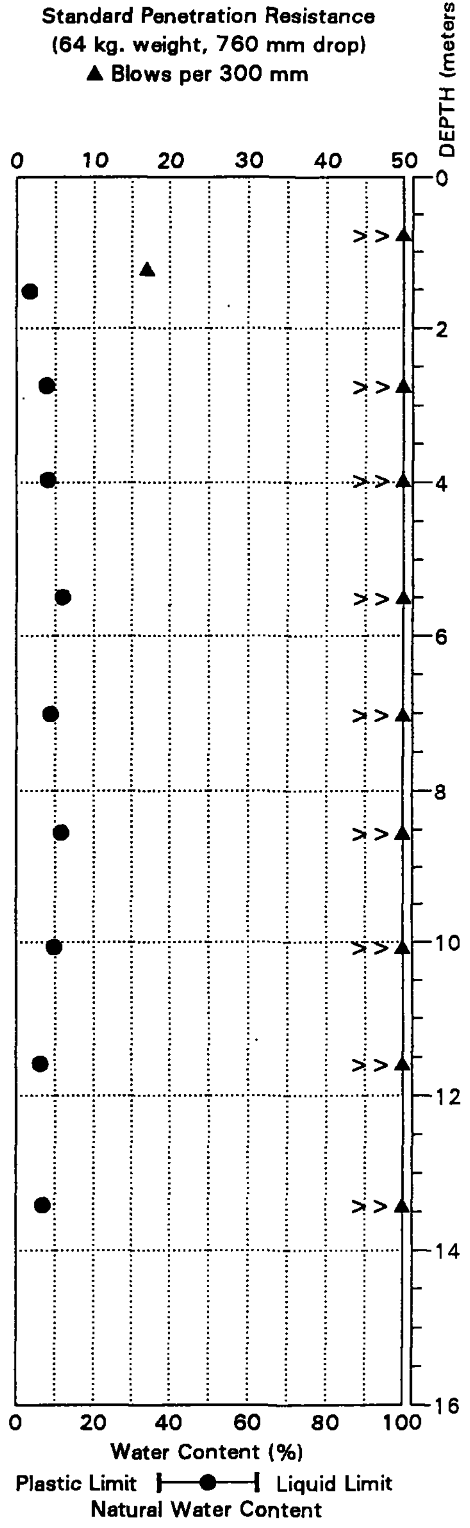
DRILLING COMPANY: WSDOT
DRILLING METHOD: CME 850, HSA, 21cm OD
SURFACE ELEVATION: 66.1 ± Meters

LOCATION: Sta 1+350.9, Offset 10.8 m Left
DATE COMPLETED: 3/17/97
LOGGED BY: Arnie Sugar

ASTM SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/150 mm)	OTHER TESTS	GROUNDWATER
GP GM	Medium dense to very dense, olive brown, poorly graded GRAVEL with silt and sand, moist. Some cobbles, and possible boulders. (FILL)	☒	S-1	3-50-20		
		☒	S-2	5-6-11		
		☒	S-3	15-31-37	GS	
SP SM	Very dense, olive brown to grayish brown, poorly graded SAND with silt and gravel, wet. Fine to coarse sand. (GLACIAL OUTWASH)	☒	S-4	31- 60/150mm		∇
		☒	S-5	46- 50/75mm	GS	
		☒	S-6	38-46- 50/100mm		
		☒	S-7	18-34-37		
		☒	S-8	19-44- 50/100mm	%F	
	Cobbles at approximately 12 m.	☒	S-9	41- 50/150mm		
		☒	S-10	26-42-55		

Bottom of hole at 13.9 m.
Groundwater observed at 4.1 m at time of drilling.

Note: Approx. 2 m dia "sinkhole", 0.6-1.0 m deep, formed around auger during drilling.



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

HONGWEST & ASSOCIATES, INC.

State Route 510
Lacey, WA

BORING: BH-1

PAGE: 1 of 1

PROJECT NO.: 96178

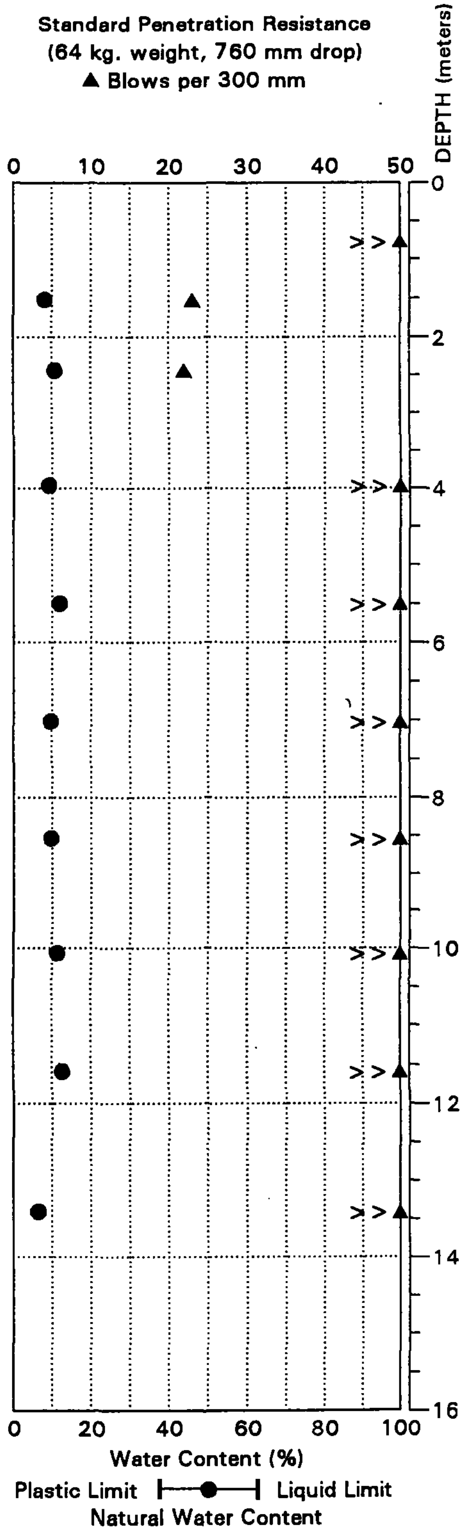
FIGURE: A-2

DRILLING COMPANY: WSDOT
DRILLING METHOD: CME 850, HSA, 21cm OD
SURFACE ELEVATION: 67.0 ± Meters

LOCATION: Sta 1+319.9, Offset 10.4 m Left
DATE COMPLETED: 3/18/97
LOGGED BY: Arnie Sugar

ASTM SOIL CLASS	DESCRIPTION	SAMPLE TYPE SAMPLE NUMBER	PEN. RESISTANCE (blows/150 mm)	OTHER TESTS	GROUNDWATER
GW GM	Medium dense to very dense, very dark brown, well graded GRAVEL with silt and sand, moist.				
		☒ S-1	6-34- 50/125mm		
	(FILL)	☒ S-2	3-8-15	GS	
SP	Medium dense, olive brown, poorly graded fine SAND, moist. (GLACIAL OUTWASH)	☒ S-3	7-10-12		
SP	Very dense, olive brown, poorly graded SAND with gravel, moist. Fine to coarse sand, fine gravel grading to coarse gravel with depth.				
		☒ S-4	19-34- 56/150mm		
SP SM	Very dense, light olive brown, poorly graded SAND with silt, wet. Fine to coarse sand.				▽
		☒ S-5	13-23-42	GS	
		☒ S-6	17-33-39		
GP GM	Light olive brown, poorly graded GRAVEL with silt and sand, wet.	☒ S-7	18-29-36	%F	
		☒ S-8	42- 50/75mm		
		☒ S-9	18- 50/75mm		
	Some cobbles, and possible boulders.				
		☒ S-10	10-35- 50/75mm		

Bottom of hole at 13.9 m.
Groundwater observed at 5.2 m at time of drilling.



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& ASSOCIATES, INC.

State Route 510
Lacey, WA

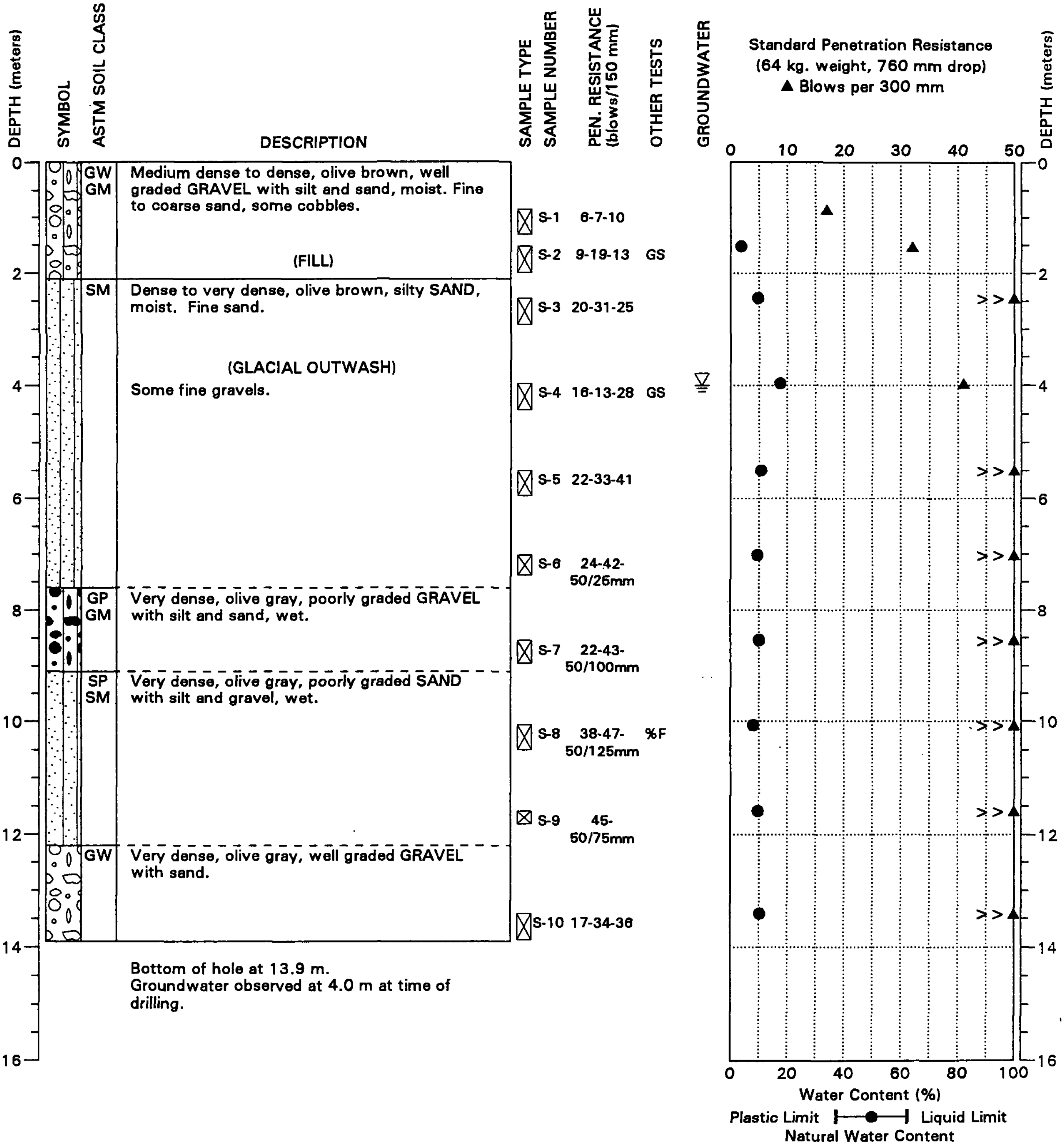
BORING: BH-2

PAGE: 1 of 1

PROJECT NO.: 96178 FIGURE: A-3

DRILLING COMPANY: WSDOT
DRILLING METHOD: CME 850, HSA, 21cm OD
SURFACE ELEVATION: 67.5 ± Meters

LOCATION: Sta 1+283.3, Offset 21.3 m Left
DATE COMPLETED: 3/19/97
LOGGED BY: Erik Andersen



ASTM SOIL CLASS	DESCRIPTION
GW GM	Medium dense to dense, olive brown, well graded GRAVEL with silt and sand, moist. Fine to coarse sand, some cobbles. (FILL)
SM	Dense to very dense, olive brown, silty SAND, moist. Fine sand. (GLACIAL OUTWASH) Some fine gravels.
GP GM	Very dense, olive gray, poorly graded GRAVEL with silt and sand, wet.
SP SM	Very dense, olive gray, poorly graded SAND with silt and gravel, wet.
GW	Very dense, olive gray, well graded GRAVEL with sand.

Bottom of hole at 13.9 m.
Groundwater observed at 4.0 m at time of drilling.

SAMPLE NUMBER	PEN. RESISTANCE (blows/150 mm)	OTHER TESTS
S-1	6-7-10	
S-2	9-19-13	GS
S-3	20-31-25	
S-4	16-13-28	GS
S-5	22-33-41	
S-6	24-42-50/25mm	
S-7	22-43-50/100mm	
S-8	38-47-50/125mm	%F
S-9	45-50/75mm	
S-10	17-34-36	

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HONG WEST & ASSOCIATES, INC.

State Route 510
Lacey, WA

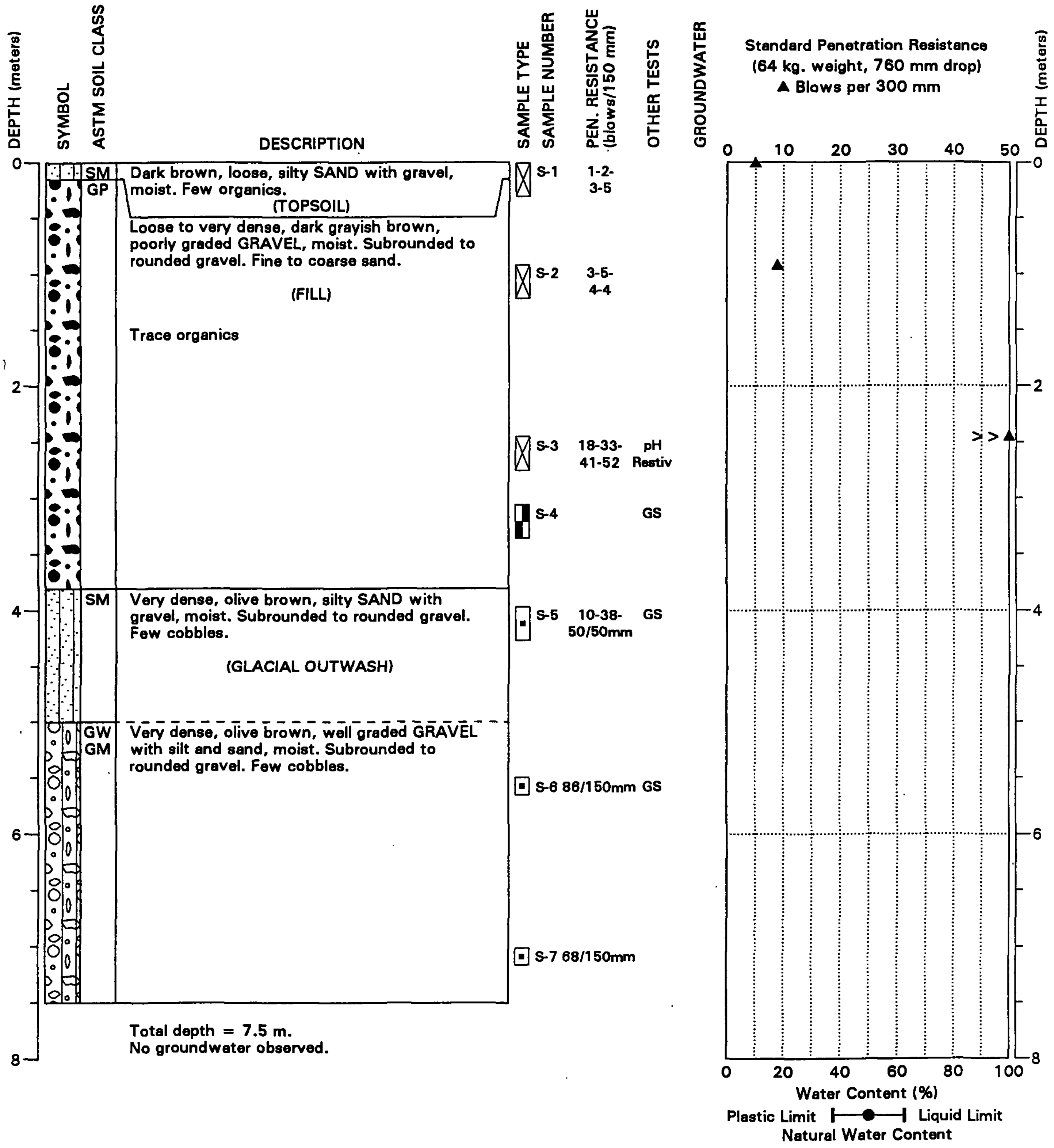
BORING: BH-3

PAGE: 1 of 1

PROJECT NO.: 96178 FIGURE: A-4

DRILLING COMPANY: WSDOT
DRILLING METHOD: CME 55, HSA, 21cm OD
SURFACE ELEVATION: ± Meters

LOCATION: Pond Area, See Fig. 3
DATE COMPLETED: 6/3/97
LOGGED BY: Erik Andersen



ASTM Soil Class	Description
SM	Dark brown, loose, silty SAND with gravel, moist. Few organics. (TOPSOIL)
GP	Loose to very dense, dark grayish brown, poorly graded GRAVEL, moist. Subrounded to rounded gravel. Fine to coarse sand. (FILL) Trace organics
SM	Very dense, olive brown, silty SAND with gravel, moist. Subrounded to rounded gravel. Few cobbles. (GLACIAL OUTWASH)
GW GM	Very dense, olive brown, well graded GRAVEL with silt and sand, moist. Subrounded to rounded gravel. Few cobbles.

Sample Number	Pen. Resistance (blows/150 mm)	Other Tests
S-1	1-2-3-5	
S-2	3-5-4-4	
S-3	18-33-41-52	pH Restiv
S-4		GS
S-5	10-38-50/50mm	GS
S-6	86/150mm	GS
S-7	68/150mm	

Total depth = 7.5 m.
No groundwater observed.

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

HWA
HONGWEST
& ASSOCIATES, INC.

State Route 510
Lacey, WA

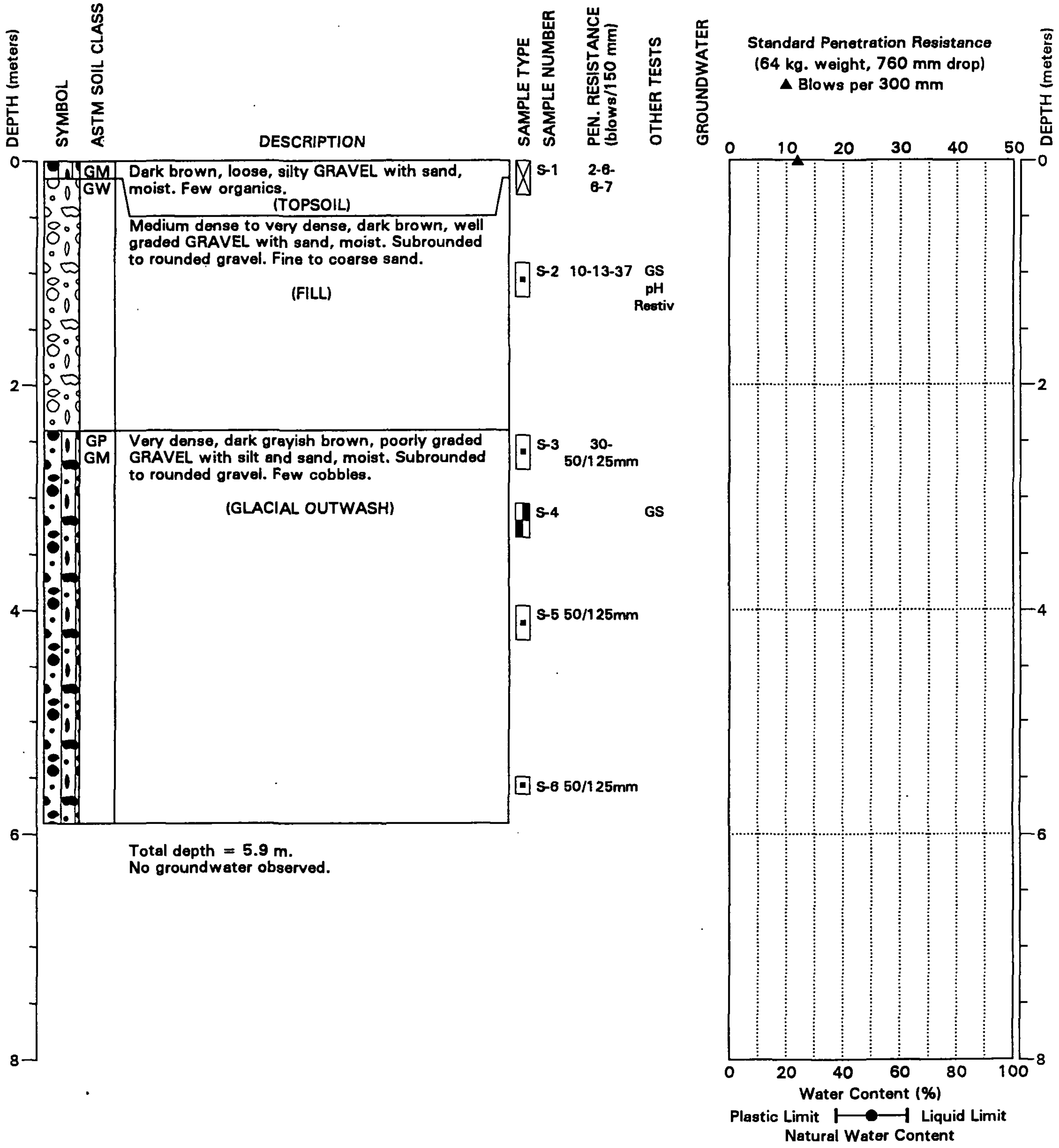
BORING: BH-4

PAGE: 1 of 1

PROJECT NO.: 96178 FIGURE: A-5

DRILLING COMPANY: WSDOT
DRILLING METHOD: CME 55, HSA, 21cm OD
SURFACE ELEVATION: ± Meters

LOCATION: Pond Area, See Fig. 3
DATE COMPLETED: 6/3/97
LOGGED BY: Erik Andersen



ASTM SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/150 mm)	OTHER TESTS	GROUNDWATER
GM	Dark brown, loose, silty GRAVEL with sand, moist. Few organics. (TOPSOIL)	☒	S-1	2-6-6-7		
GW	Medium dense to very dense, dark brown, well graded GRAVEL with sand, moist. Subrounded to rounded gravel. Fine to coarse sand. (FILL)	▣	S-2	10-13-37	GS pH Restiv	
GP GM	Very dense, dark grayish brown, poorly graded GRAVEL with silt and sand, moist. Subrounded to rounded gravel. Few cobbles. (GLACIAL OUTWASH)	▣	S-3	30-50/125mm		
		◧	S-4		GS	
		▣	S-5	50/125mm		
		▣	S-6	50/125mm		

Total depth = 5.9 m.
No groundwater observed.

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

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HONGWEST
& ASSOCIATES, INC.

State Route 510
Lacey, WA

BORING: BH-5

PAGE: 1 of 1

PROJECT NO.: 96178

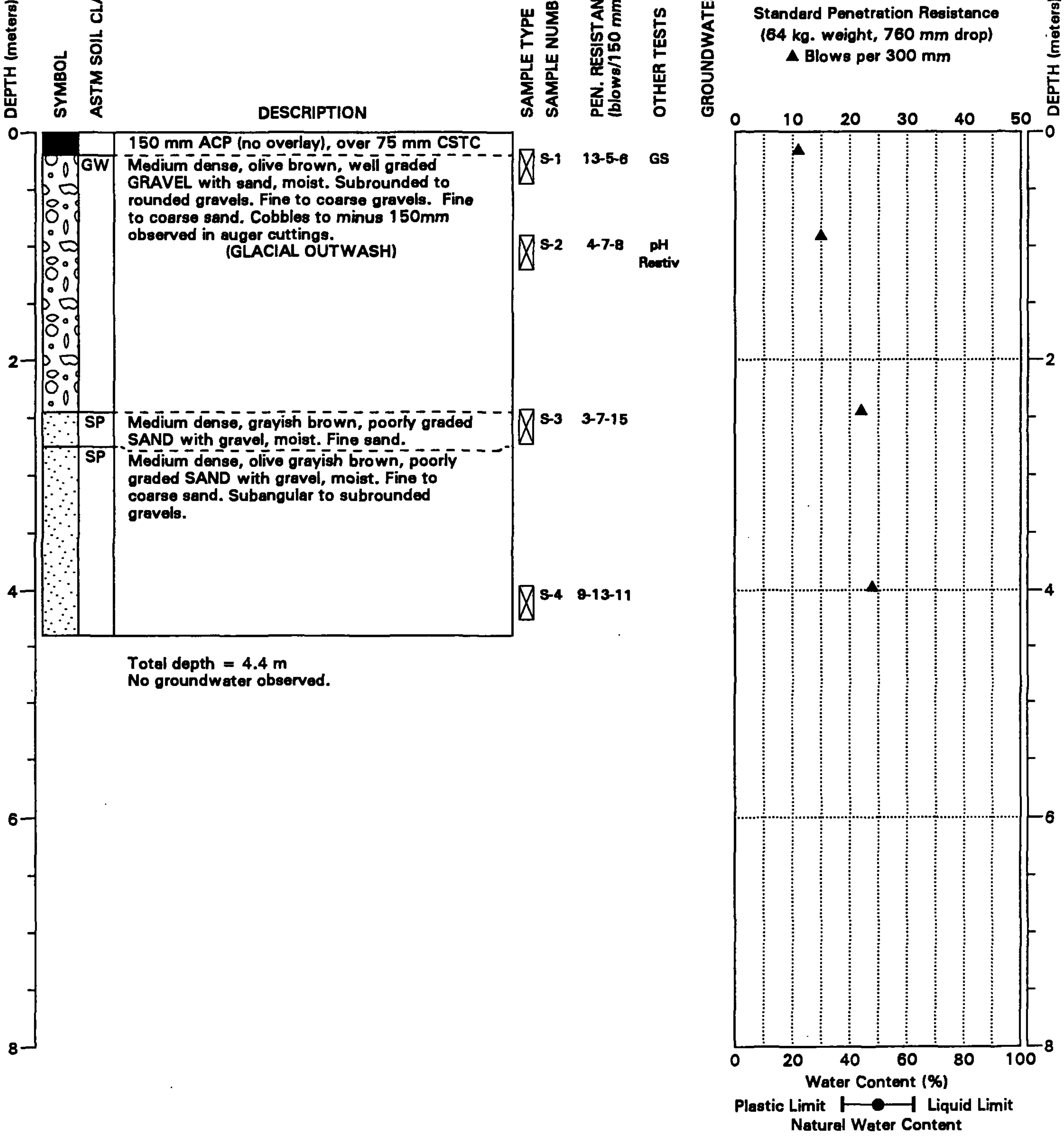
FIGURE: A-6

DRILLING COMPANY: WSDOT
DRILLING METHOD: CME 55, HSA, 21cm OD
SURFACE ELEVATION: 69 ± Meters

LOCATION: STA 3+025, Offset 3.2 L
DATE COMPLETED: 6/4/97
LOGGED BY: Erik Andersen

SYMBOL	ASTM SOIL CLASS	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	PEN. RESISTANCE (blows/150 mm)	OTHER TESTS	GROUNDWATER
■		150 mm ACP (no overlay), over 75 mm CSTC					
	GW	Medium dense, olive brown, well graded GRAVEL with sand, moist. Subrounded to rounded gravels. Fine to coarse gravels. Fine to coarse sand. Cobbles to minus 150mm observed in auger cuttings. (GLACIAL OUTWASH)	☒ ☒	S-1 S-2	13-5-6 4-7-8	GS pH Restiv	
	SP	Medium dense, grayish brown, poorly graded SAND with gravel, moist. Fine sand.	☒	S-3	3-7-15		
	SP	Medium dense, olive grayish brown, poorly graded SAND with gravel, moist. Fine to coarse sand. Subangular to subrounded gravels.	☒	S-4	9-13-11		

Total depth = 4.4 m
No groundwater observed.



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

HONGWEST & ASSOCIATES, INC.

State Route 510
Lacey, WA

BORING: BH-6

PAGE: 1 of 1

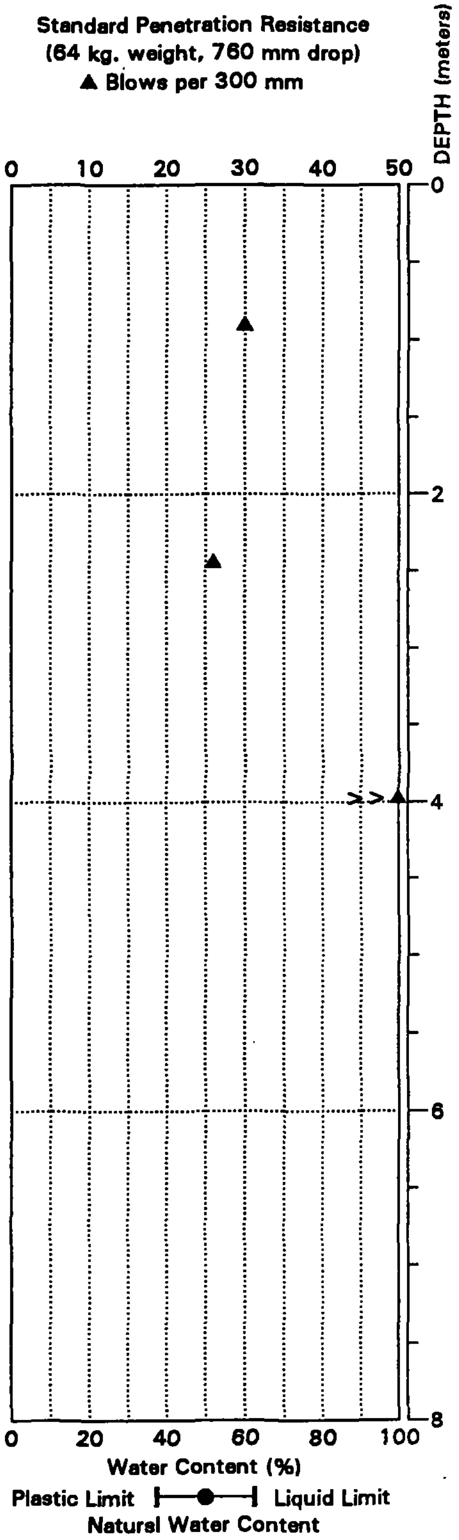
PROJECT NO.: 96178 FIGURE: A-7

DRILLING COMPANY: WSDOT
DRILLING METHOD: CME 55, HSA, 21cm OD
SURFACE ELEVATION: 65 ± Meters

LOCATION: STA 2+464, Offset 2.4 L
DATE COMPLETED: 6/4/97
LOGGED BY: Erik Andersen

DEPTH (meters)	ASTM SOIL CLASS	DESCRIPTION	SAMPLE NUMBER	PEN. RESISTANCE (blows/150 mm)	OTHER TESTS	GROUNDWATER
0		90 mm ACP (no overlay)				
	GP GM	Medium dense, olive brown, well graded GRAVEL with silt and sand, moist. Subrounded to rounded gravels. Fine to coarse gravels. Fine to coarse sand. Cobbles to minus 150mm observed in auger cuttings. (GLACIAL OUTWASH)	S-1	10-25-25	GS	
			S-2	7-10-20	pH Restiv	
		Hard drilling in gravels and cobbles				
2	GW GM	Medium dense to very dense, olive gray to olive brown, poorly graded GRAVEL with silt and sand, moist. Fine to coarse sand. Auger cuttings suggest fine to coarse gravel.	S-3	6-10-16		
4			S-4	10-30-40		

Total depth = 4.4 m
No groundwater observed.



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

HONGWEST & ASSOCIATES, INC.

State Route 510
Lacey, WA

BORING: BH-7

PAGE: 1 of 1

PROJECT NO.: 96178

FIGURE: A-8

BORINGM 96178 6/27/97

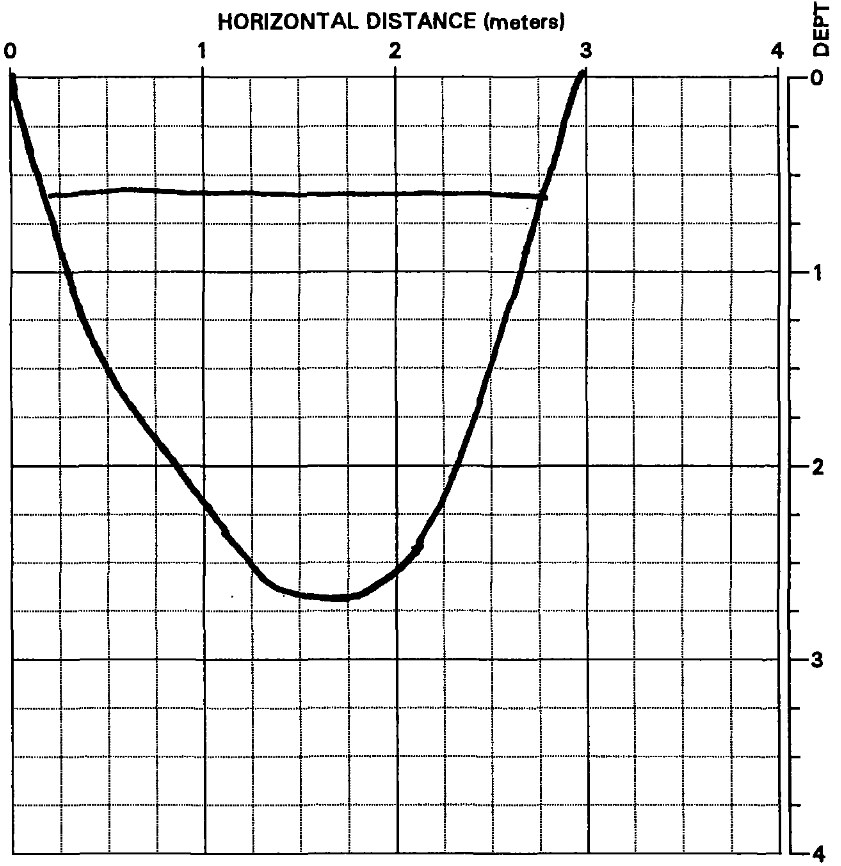
EXCAVATION COMPANY: WSDOT
EXCAVATING EQUIPMENT: Case 580L,
SURFACE ELEVATION: ± Meters

LOCATION: SN-W Ramp
DATE COMPLETED: 5/20/97
LOGGED BY: SRW

DEPTH (meters)	SYMBOL	ASTM SOIL CLASS.	DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	MOISTURE CONTENT (%)	OTHER TESTS	GROUNDWATER
0	▨	SM	Loose to medium dense, dark brown, silty SAND with gravel, moist. (FILL)	○	S-1			
	●	GP	Medium dense, light olive brown, well graded GRAVEL, moist. Trace cobbles. (GLACIAL OUTWASH)	○	S-2		GS	

Total depth = 2.7 m.
No groundwater observed.

SKETCH OF SIDE OF PIT



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HONGWEST
& ASSOCIATES, INC.

State Route 510
Lacey, WA

LOG OF TEST PIT
TP-1

PAGE: 1 of 1

PROJECT NO.: 96178 FIGURE: A-9

Northern, Inc.
Kirkland, Yakima, Kennewick, Hermiston (OR)

KEY CHART

RELATIVE DENSITY OR CONSISTENCY VERSUS SPT N-VALUE

COARSE-GRAINED SOILS			FINE-GRAINED SOILS		
DENSITY	**N (BLOWS/FT)**	**FIELD TEST**	**CONSISTENCY**	**N (BLOWS/FT)**	**FIELD TEST**
Very Loose	0 – 4	Easily penetrated with ½-inch reinforcing rod pushed by hand	Very Soft	0 – 2	Easily penetrated several inches by thumb
Loose	4 – 10	Difficult to penetrate with ½-inch reinforcing rod pushed by hand	Soft	2 – 4	Easily penetrated one inch by thumb
Medium -Dense	10 – 30	Easily penetrated with ½-inch rod driven with a 5-lb hammer	Medium-Stiff	4 – 8	Penetrated over ½-inch by thumb with moderate effort
Dense	30 – 50	Difficult to penetrate with ½-inch rod driven with a 5-lb hammer	Stiff	8 – 15	Indented about ½-inch by thumb but penetrated with great effort
Very Dense	> 50	penetrated only a few inches with ½-inch rod driven with a 5-lb hammer	Very Stiff	15 – 30	Readily indented by thumb
			Hard	> 30	Indented with difficulty by thumbnail

USCS SOIL CLASSIFICATION

MAJOR DIVISIONS			GROUP DESCRIPTION		
Coarse-Grained Soils <50% passes #200 sieve	**Gravel and Gravelly Soils** <50% coarse fraction passes #4 sieve	**Gravel** (with little or no fines)	▨	GW	Well-graded **Gravel**
			▨	GP	Poorly Graded **Gravel**
		Gravel (with >12% fines)	▨	GM	Silty **Gravel**
			▨	GC	Clayey **Gravel**
	Sand and Sandy Soils >50% coarse fraction passes #4 sieve	**Sand** (with little or no fines)	▨	SW	Well-graded **Sand**
			▨	SP	Poorly graded **Sand**
		Sand (with >12% fines)	▨	SM	Silty **Sand**
			▨	SC	Clayey **Sand**
Fine-Grained Soils >50% passes #200 sieve	**Silt and Clay** Liquid Limit < 50		▨	ML	**Silt**
			▨	CL	Lean **Clay**
			▨	OL	Organic **Silt** and **Clay** (low plasticity)
	Silt and Clay Liquid Limit > 50		▨	MH	Inorganic **Silt**
			▨	CH	Inorganic **Clay**
			▨	OH	Organic **Clay** and **Silt** (med. to high plasticity)
Highly Organic Soils			▨	PT	**Peat** ▨ **Top Soil**

LOG SYMBOLS

I	2S	2" OD Split Spoon (SPT)
■	3S	3" OD Split Spoon
⧄	NS	Non-Standard Split Spoon
◇	ST	Shelby Tube
◫	CR	Core Run
⊽	BG	Bag Sample
⧓	TV	Torvane Reading
⧗	PP	Penetrometer Reading
☐	NR	No Recovery
▽ ▼	GW	Groundwater Table

MODIFIERS

DESCRIPTION	RANGE
Trace	<5%
Little	5% – 12%
Some	>12%

MOISTURE CONTENT

DESCRIPTION	FIELD OBSERVATION
Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but not visible water
Wet	Visible free water

SOIL CLASSIFICATION INCLUDES

1. Group Name
2. Group Symbol
3. Color
4. Moisture content
5. Density / consistency
6. Cementation
7. Particle size (if applicable)
8. Odor (if present)
9. Comments

MAJOR DIVISIONS WITH GRAIN SIZE

<table>
<tr><th colspan="8">SIEVE SIZE</th></tr>
<tr><td>12"</td><td>3"</td><td>3/4"</td><td>4</td><td>10</td><td>40</td><td>200</td><td></td></tr>
<tr><th colspan="8">GRAIN SIZE (INCHES)</th></tr>
<tr><td>12</td><td>3</td><td>0.75</td><td>0.19</td><td>0.079</td><td>0.0171</td><td>0.0029</td><td></td></tr>
<tr><td rowspan="2">Boulders</td><td rowspan="2">Cobbles</td><td colspan="2">Gravel</td><td colspan="3">Sand</td><td rowspan="2">Silt and Clay</td></tr>
<tr><td>Coarse</td><td>Fine</td><td>Coarse</td><td>Medium</td><td>Fine</td></tr>
</table>

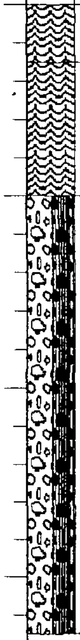
Conditions shown on boring and testpit logs represent our observations at the time and location of the fieldwork, modifications based on lab test, analysis, and geological and engineering judgment. These conditions may not exist at other times and locations, even in close proximity thereof. This information was gathered as part of our investigation, and we are not responsible for any use or interpretation of the information by others.

Northern, Inc.

Boring No. TH-1

SR-510
SR-5 to Martin Way
Lacey, Washington

Geo/Eng.:	J.H.	**Project No.:**	298-811
Driller:	W.S.D.O.T.	**Boring Date:**	04/16/99
Drilling Method:	Auger / SPT	**Elevation:**	N/A
Diameter: 4.25" I.D.	**Water Table (BGS):** N/E	**Logged By:**	J.H.

Sample No.	Sample Type	Recovery (%)	RQD (%)	Blow Count per 6 inches	Blows/Foot (N)	Water Table	Depth (ft BGS)	Graphic Log	Materials Description	Moisture (%)	Remarks
1				2,6,15	21		0		– 0.- 1.5' TOPSOIL: Gravel with sand, brown, moist.		
2				5,7,8	15				– 1.5' - 5.0' UNCONTROLLED FILL: Gravel with sand, brown, medium dense, moist.		
13				7,6,4	10		5		**GW-GM** 5.0' - 16.5' WELL GRADED GRAVEL WITH SILT AND SAND: Dark-brown, medium dense, moist.		
4				8,3,15	18						
		0		22,10,8	18		10				Bulk Sample
		0		6,15,11	16						
5				5,8,11	19		15				
									END End of Boring at 16.5' BGS		Sample is moist to wet from 16.2' BGS
							20				
							25				
							30				
							35				

F. 26.66 (Rev. 10-64)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

LOG OF TEST BORING

Original to Materials Engr.
Copy to Bridge Engr.
Copy to District Engr.
Copy to Pac. Testing Lab.
Y-888

S.R. No. 5
PSH #1 - St. Martins to Old Nisqually Rd.
P.S.H. / S.S.H. No. 1
Section Gleason - Carney Rd. U-Xing
Job No. L-1048
Hole No. C2-1
Station ℰ 7+48
Offset 15' Lt.
Ground Elev. 180'
Type of Boring Hollow stem auger
Water Table 21' below grade
Casing —
Inspector G.O. Teague
Date 3/22/66
Sheet No. 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
0				Dk. brown organic topsoil
	10		4 5 10	D-1, Drove 2-3½', Rec. 6" B 4899-1 Brown coarse gravel, dominantly ½' to 3", with 30-40% sand and organic topsoil
5				
	121		44 64 57	D-2, Drove 7-8½', Rec. 1½' -2
10				
	70		12 24 46	D-3, Drove 12-13½', Rec. 1' -3
15				
	44		22 106	D-4, Drove 17-18', Rec. 6" (note - rock jammed in shoe) -4 Yellow-brown coarse gravel, dominantly ½" to 3", with 40-60% silty sand. (Auger encounters occasional large boulders)
20				
	46		16 23 105	D-5, Drove 22-23½', Rec. 8" -5
25				
	84		27 42 95	D-6, Drove 27-28½', Rec. 1' -6
30				
	173		45 76 97	D-7, Drove 32-33½', Rec. 1' -7
5				

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DEPARTMENT OF HIGHWAYS

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S.R. No. 5
P.S.H. / S.S.H. No. 1
Section PSH#1- St. Martins to Old Nisqually Rd. Gleason-Carney Rd. U-Xing
Job No. Y-888 L-1048
Hole No. CL-1
Station ℄ 7+48
Offset 15' Lt.
Ground Elev. 180'
Type of Boring Hollow stem auger
Water Table 21' below grade
Casing —
Inspector G. O. Teague
Date 3/22/66
Sheet No. 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
35				
	105		45 45 60	D-8, Drove 37-38½', Rec. 1½' -8
40				
	142		48 68 74	D-9, Drove 42-43½', Rec. 1½' -9
				See ~~last~~ ~~page~~ sheet 1 for description
45				
	88		31 38 50	D-10, Drove 47-48½', Rec. 1½' -10
50				
	102		58 52 50	D-11, Drove 52-53½', Rec. 6" -11
55				
				Black medium to coarse water-bearing sand
	85/6"		35 85	D-12, Drove 57-58', Rec. 1' -12
		Bottom of hole 58'		
60				

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WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

LOG OF TEST BORING

Original to Materials Engr.
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Copy to District Engr.
Copy to Pac. Testing Lab.
Y-888

S.R. No. 5
P.S.H.
S.S.H. No. 1 Section PSH #1 - St. Martins to Old Nisqually Rd. Gleason - Carney Rd. U-Xing Job No. L-1048
Hole No. C2-2 Station ℄ CG9 +18 Offset 15' Lt. Ground Elev. 178'
Type of Boring Hollow stem auger Water Table 18' below grade Casing -
Inspector G. O. Teague Date 3/23/66 Sheet No. 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
0				Dark-brown organic topsoil
	22		3 6 16	D-1, Drove 2-3½', Rec. 8" R 4900 -1
5				
				Brown coarse gravel with 30-40% silty sand
	28		6 14 14	D-2, Drove 7-8½', Rec. 6" -2
10				
	12		4 5 7	D-3, Drove 12-13½', Rec. 4" -3
15				
	48		15 17 31	D-4, Drove 17-18½', Rec. 6" -4
20				
	157		52 63 94	D-5, Drove 22-23½', Rec. 1½' -5
25				Yellow-brown coarse gravel, 40-50% coarse silty sand. Gravel dominantly ½" to 3" with numerous large boulders encountered by auger.
	114		52 64 50	D-6, Drove 27-28½', Rec. 1½' -6
30				
	100/6"		43 100	D-7, Drove 32-33', Rec. 1' -7
35				

H. F. 26.66 (Rev. 10-64)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

LOG OF TEST BORING

Original to Materials Engr.
Copy to Bridge Engr.
Copy to District Engr.
Copy to Pac. Testing Lab.

S.R. No. 5
P.S.H. / S.S.H. No. 1 Section PSH #1 - St. Martins to Old Nisqually Rd. Gleason - Carney Rd. U-Xing Job No. Y-888 L-1048
Hole No. C2-2 Station CG9 + 18 Offset 15' Lt. Ground Elev. 178'
Type of Boring Hollow stem ouger Water Table 18' below grade Casing —
Inspector G.O. Teague Date 5/23/66 Sheet No. 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
35				
	152		39 56 96	D-8, Drove 37-38½', Rec. 1½' -8
40				
				sheet 1of2 See ~~last page~~ for description
	180		51 80 100	D-9, Drove 42-43½', Rec. 1½' -9
45				
	98		51 48 50	D-10, Drove 47-48½', Rec. 1½' -10
50				
	73		14 22 51	D-11, Drove 52-53½', Rec. 1½' -11 Blue-gray clayey-silt
55		Bottom of hole 53½'		
60				

H. F. 26.66 (Rev. 10-64)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS

LOG OF TEST BORING

Original to Materials Engr.
Copy to Bridge Engr.
Copy to District Engr.
Copy to Pac. Testing Lab.

Y-888

S.R. No. 5

P.S.H. PSH#1- St. Martins to Old Nisqually Rd.

S.S.H. No. 1 Section Gleason - Carney Rd. U-Xing Job No. L-1048

Hole No. C2-3 Station CG 11+04 Offset 15' Lt. Ground Elev. 187'

Type of Boring Hollow stem auger Water Table 30' below grade Casing —

Inspector G.O. Teague Date 3/23/66 Sheet No. 1 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
0				
				Dark-brown organic topsoil
				B4901-1
	21		10 11 10	D-1, Drove 2-3½', Rec. -NONE
				(note - Auger in coarse gravel
				with minimum sand matrix)
5				
	46		6 15 31	D-2, Drove 7-8½', Rec. 6"
				-2
				Dark brown coarse gravel
10				dominantly ½" to 3" with
				minimum coarse sand matrix.
				and occasional large boulders.
	71		16 33 38	D-3, Drove 12-13½', Rec. 1"
				-3
15				
	148		40 82 66	D-4, Drove 17-18½', Rec. 1½'
				-4
20				
	70		21 30 40	D-5, Drove 22-23½', Rec. 1'
				-5 Grey-brown sand with
25				10-15% gravel to ¼"
	84		35 40 44	D-6, Drove 27-28½', Rec. 1'
				-6
30				Grey-brown coarse gravel,
				40-50% coarse sand.
	167		43 67 100	D-7, Drove 32-33½', Rec. 6"
				-7
35				

H. F. 26.66 (Rev. 10-64)

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
LOG OF TEST BORING

Original to Materials Engr.
Copy to Bridge Engr.
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Copy to Pac. Testing Lab.

PSH#1 - St. Martins to Old Nisqually Rd.
Y-888

S.R. No. 5
P.S.H. / S.S.H. No. 1 Section Gleason - Carney Rd. U-Xing Job No. L-1048
Hole No. C2-3 Station ℄CG11 + 04 Offset 15' Lt. Ground Elev. 187'
Type of Boring Hollow stem auger Water Table 30' below grade Casing –
Inspector G. O. Teague Date 3/23/66 Sheet No. 2 of 2

DEPTH	BLOWS PER FT.	PROFILE	SAMPLE TUBE NOS.	DESCRIPTION OF MATERIAL
35				
	102		32 37 65	D-8, Drove 37-38½', Rec. 1' -8
40				
				-9 See ~~last page~~ Sheet 1of2 for description
	125		75 50	D-9, Drove 42-43', Rec. 2" (note) Driving against boulder
45				
	118		23 58 60	D-10, Drove 47-48½', Rec. 1' -10
50				
	125		44 44 81	D-11, Drove 52-53½', Rec. 1' -11
55		Bottom of hole 53½'		
60				

SOIL CLASSIFICATION SYSTEM

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS More than 50% Retained on No. 200 Sieve	GRAVEL More than 50% Of Coarse Fraction Retained on No. 4 Sieve	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND More than 50% Of Coarse Fraction Passes No. 4 Sieve	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS More than 50% Passes No. 200 Sieve	SILT AND CLAY Liquid Limit Less than 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY Liquid Limit 50 or more	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

NOTES:

1. Field classification is based on visual examination of soil in general accordance with ASTM D2488-90.
2. Soil classification using laboratory tests is based on ASTM D2487-90.
3. Description of soil density or consistency are based on interpretation of blow count data, visual appearance of soils, and or test data.

SOIL MOISTURE MODIFIERS:

Dry-	Absence of moisture, dry to the touch
Moist-	Damp, but no visible water
Wet-	Visible free water or saturated, usually soil is obtained from below water table

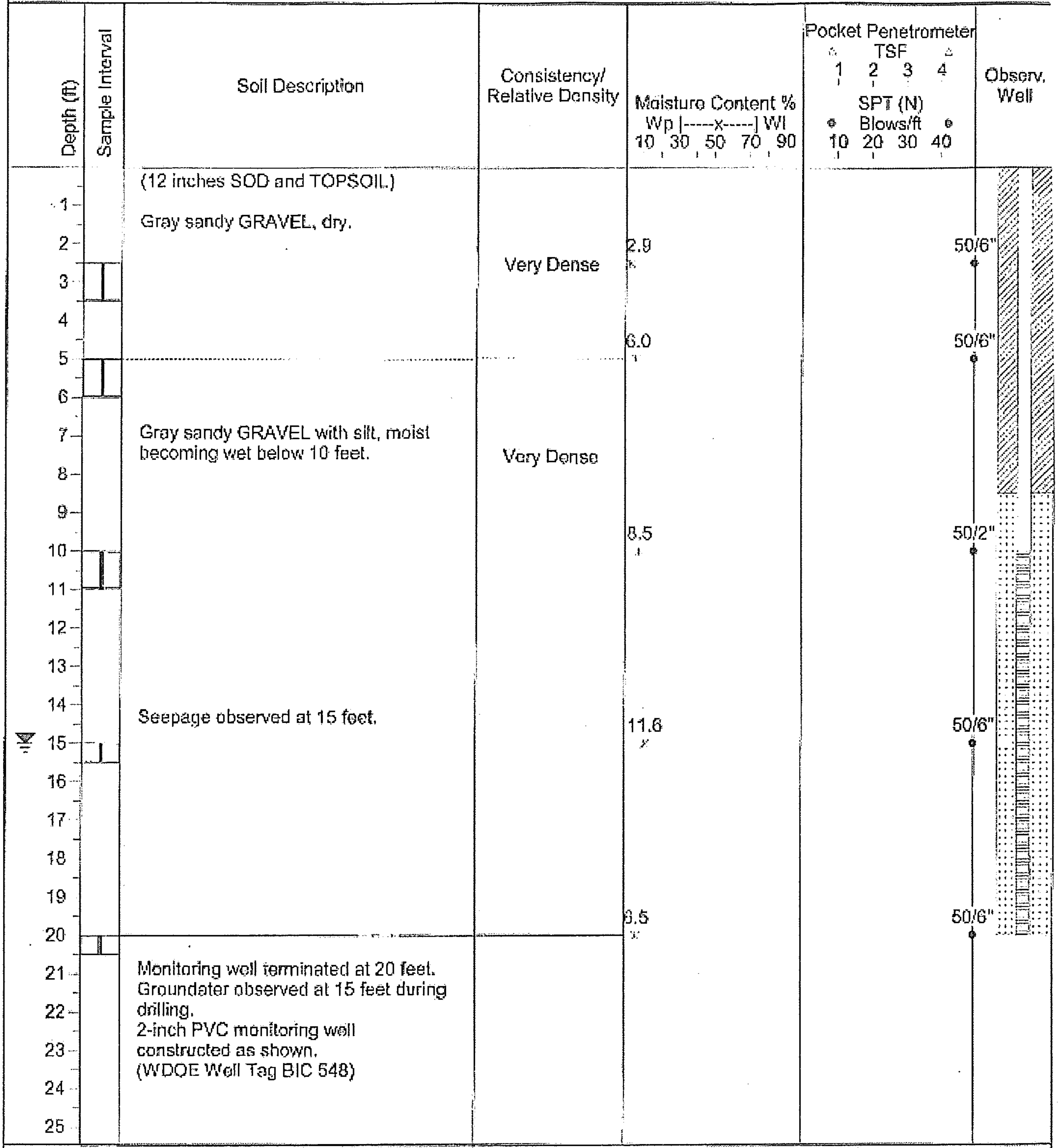
GeoResources, LLC
5007 Pacific Highway East, Suite 16
Fife, Washington 98424
Phone: 253-896-1011
Fax: 253-896-2633

Soil Classification System
Proposed Lacey Gateway Commercial Project
Parcels k, L, M, N, & O
Marvin Road NE & Britton Parkway NE
Lacey, Washington

DocID: WigProp.Gateway.F	**July 2013**	**Figure 5**

Client: Wig Properties LLC-Nisqually **Driller:** Cascade Drilling **Logged By:** CRL

Location: Lacey, Washington **Approx. Elev:** 307 +/- Feet



Depth (ft)	Soil Description	Consistency/ Relative Density	Moisture Content %	SPT (N) Blows/ft
0	(12 inches SOD and TOPSOIL.)			
1	Gray sandy GRAVEL, dry.	Very Dense		
2.5			2.9	50/6"
5			6.0	50/6"
7	Gray sandy GRAVEL with silt, moist becoming wet below 10 feet.	Very Dense		
10			8.5	50/2"
15	Seepage observed at 15 feet.		11.6	50/6"
20			8.5	50/6"

Monitoring well terminated at 20 feet.
Groundater observed at 15 feet during drilling.
2-inch PVC monitoring well constructed as shown.
(WDOE Well Tag BIC 548)

Note: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site.

Terra Associates, Inc.
Consultants in Geotechnical Engineering, Geology and Environmental Earth Sciences

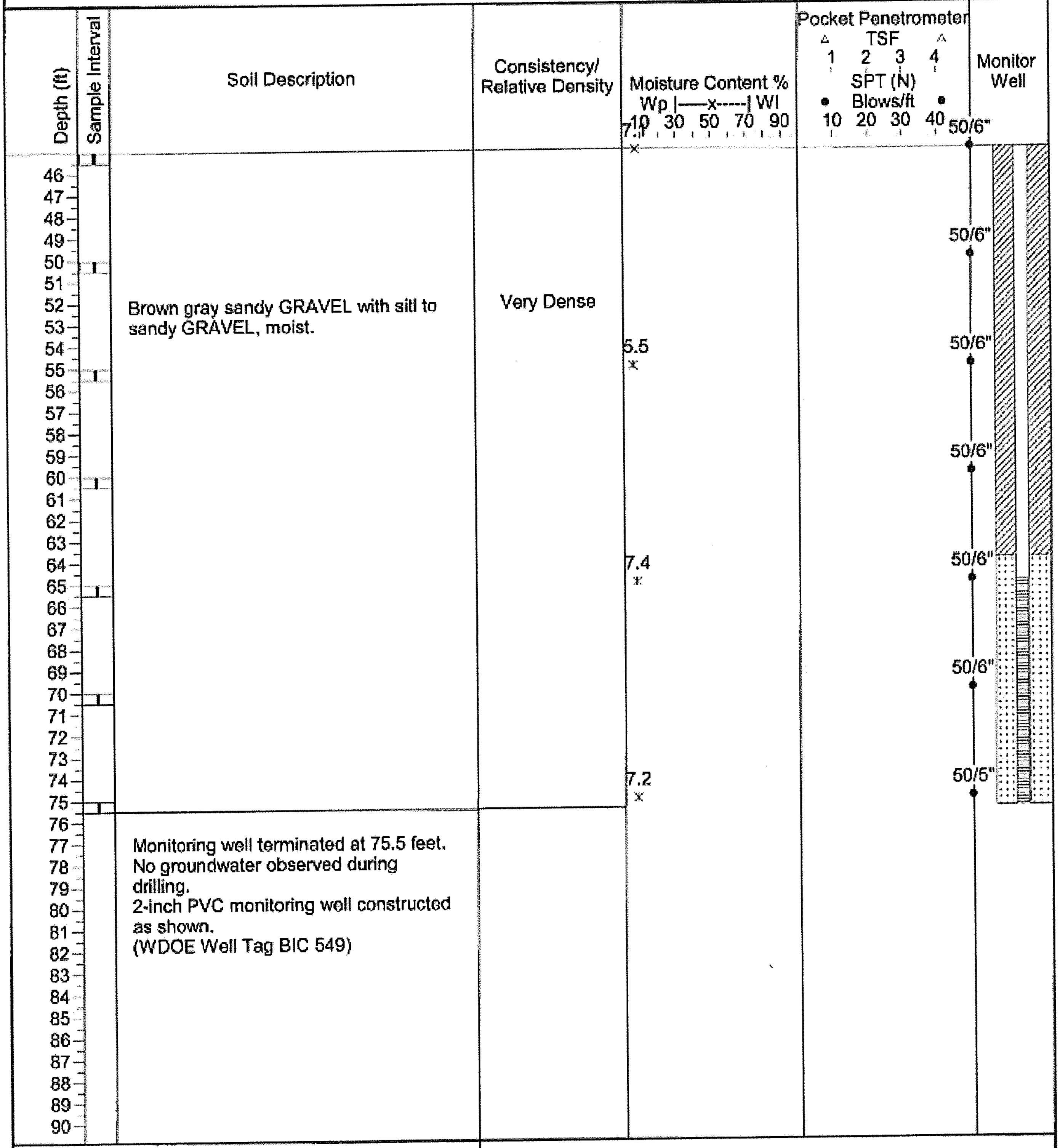
LOG OF MONITORING WELL MW-2

Figure No. A-2

Project: 37 Acre Site **Project No:** T-6537-3 **Date Drilled:** 8/23/13

Client: Wig Properties LLC-Nisqually **Driller:** Cascade Drilling **Logged By:** CRL

Location: Lacey, Washington **Approx. Elev:** 200 +/- Feet



Brown gray sandy GRAVEL with silt to sandy GRAVEL, moist.

Very Dense

Monitoring well terminated at 75.5 feet.
No groundwater observed during drilling.
2-inch PVC monitoring well constructed as shown.
(WDOE Well Tag BIC 549)

LOG OF MONITORING WELL MW-3

Figure No. A-3

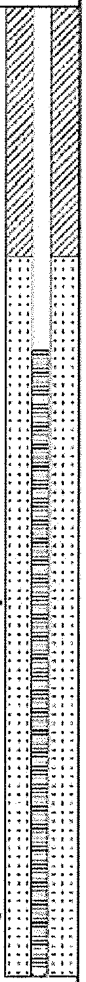
Project: 37 Acre Site **Project No:** T-6537-3 **Date Drilled:** 6/24/13

Client: Wig Properties LLC-Nisqually **Driller:** Cascade Drilling **Logged By:** CRL

Location: Lacey, Washington **Approx. Elev:** 200 +/- Feet

Depth (ft)	Sample Interval	Soil Description	Consistency/ Relative Density	Moisture Content % Wp |-----x-----| Wl 10 30 50 70 90	Pocket Penetrometer △ TSF △ 1 2 3 4 SPT (N) ● Blows/ft ● 10 20 30 40
		(Upper 18 inches removed prior to drilling)			
1					
2		Brown-gray sandy GRAVEL with silt, dry.			
3					
4					
5	▮		Dense to	5.6 ×	36 ●
6	▮		Very Dense		
7					
8					
9					
▼ 10	▮			10.3 ×	50/6" ●
11					
12					
13		Brown gravelly SAND with silt, wet.	Very Dense		
14					
15	▮			8.3 ×	50/6" ●
16		Monitoring well terminated at 15.5 feet. Groundwater observed below 10 feet. 2-inch PVC monitoring well constructed as shown. (WDOE Well Tag BIC 550)			
17					
18					
19					
20					

Observ. Well



Note: This borehole log has been prepared for geotechnical purposes. This information pertains only to this boring location and should not be interpeted as being indicative of other areas of the site.

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Consultants in Geotechnical Engineering, Geology and Environmental Earth Sciences

Key to Exploration Logs

Sample Description

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

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

Density/Consistency

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

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

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

	Estimated Percentage
Not identified in description	0 – 5
Slightly (clayey, silty, etc.)	5 – 12
Clayey, silty, sandy, gravelly	12 – 30
Very (clayey, silty, etc.)	30 – 50

Legends

Sampling Test Symbols

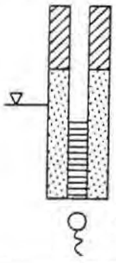
BORING SAMPLES

☒	Split Spoon
⧅	Shelby Tube
▥	Cuttings
◫	Core Run
*	No Sample Recovery
P	Tube Pushed, Not Driven

TEST PIT SAMPLES

☒	Grab (Jar)
⧄	Bag
⧅	Shelby Tube

Groundwater Observations



Surface Seal

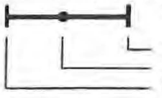
Groundwater Level on Date (ATD) At Time of Drilling

Observation Well Tip or Slotted Section

Groundwater Seepage (Test Pits)

Test Symbols

GS	Grain Size Classification
CN	Consolidation
TUU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits
PID	Photoionization Reading
CA	Chemical Analysis



Water Content in Percent

Liquid Limit
Natural
Plastic Limit

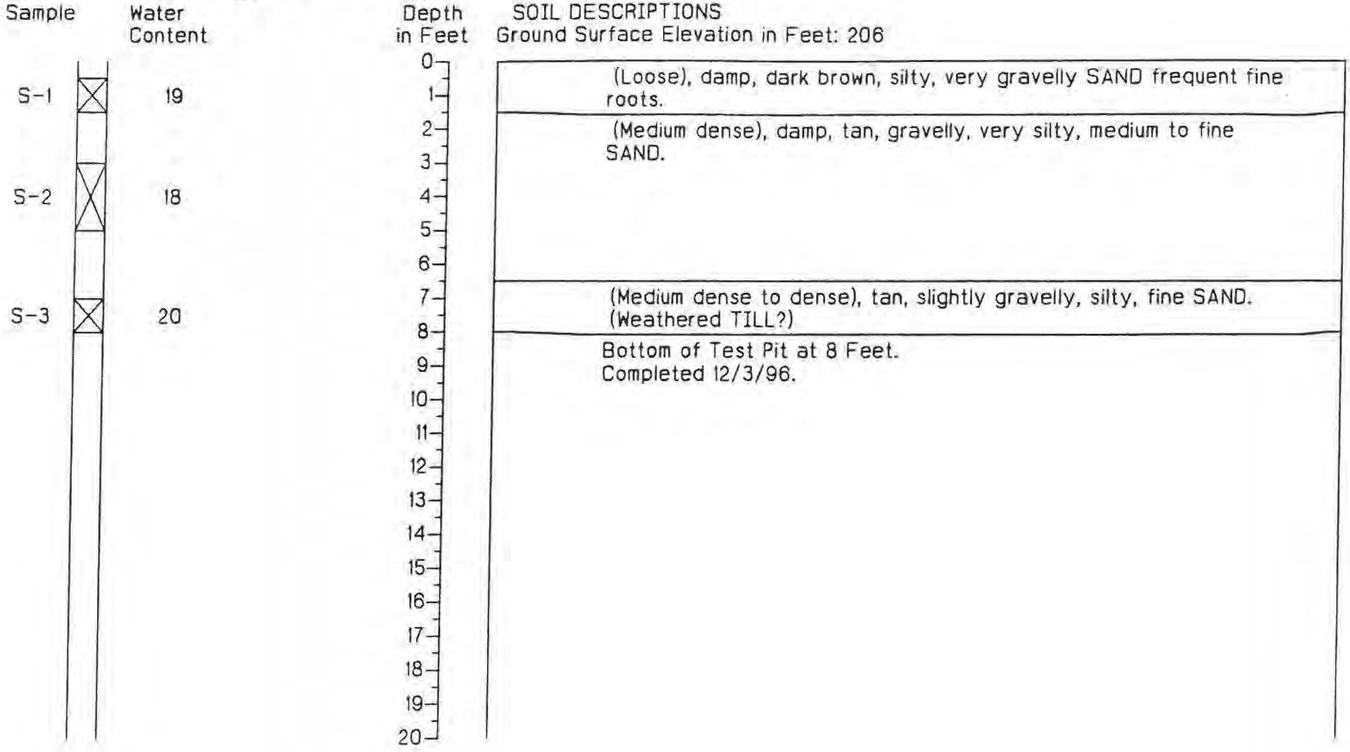
1=1 A1\KEY 1

HARTCROWSER

J-4668 12/96

Figure A-1

Test Pit Log TP-1



Sample	Water Content
S-1	19
S-2	18
S-3	20

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 206

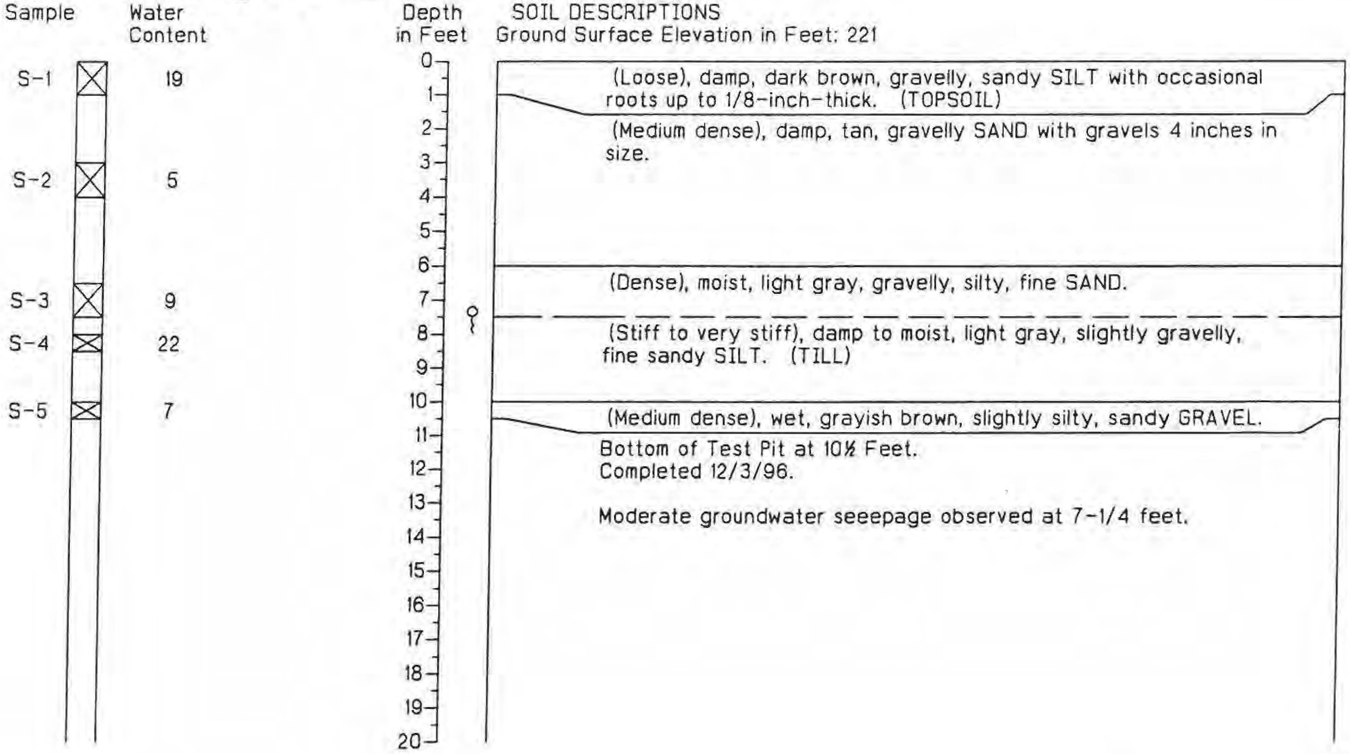
(Loose), damp, dark brown, silty, very gravelly SAND frequent fine roots.

(Medium dense), damp, tan, gravelly, very silty, medium to fine SAND.

(Medium dense to dense), tan, slightly gravelly, silty, fine SAND. (Weathered TILL?)

Bottom of Test Pit at 8 Feet.
Completed 12/3/96.

Test Pit Log TP-2



Sample	Water Content
S-1	19
S-2	5
S-3	9
S-4	22
S-5	7

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 221

(Loose), damp, dark brown, gravelly, sandy SILT with occasional roots up to 1/8-inch-thick. (TOPSOIL)

(Medium dense), damp, tan, gravelly SAND with gravels 4 inches in size.

(Dense), moist, light gray, gravelly, silty, fine SAND.

(Stiff to very stiff), damp to moist, light gray, slightly gravelly, fine sandy SILT. (TILL)

(Medium dense), wet, grayish brown, slightly silty, sandy GRAVEL.

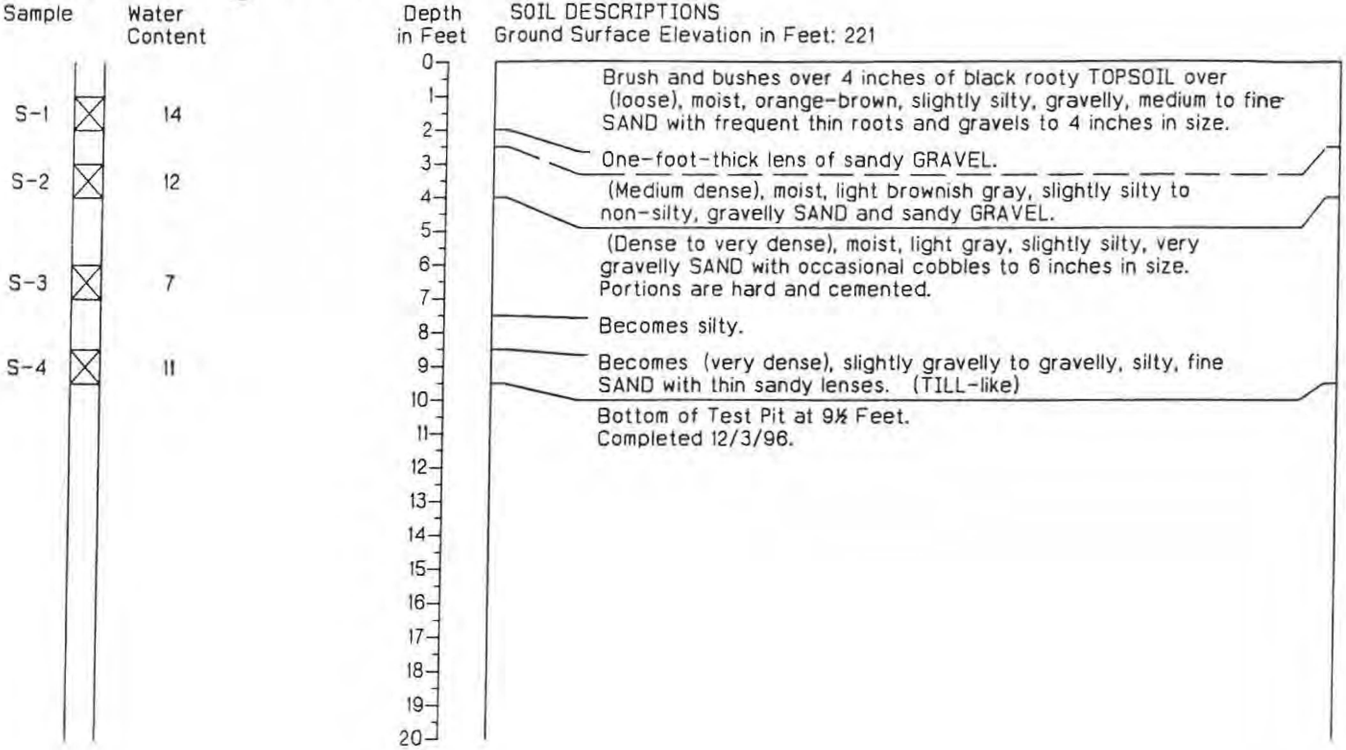
Bottom of Test Pit at 10½ Feet.
Completed 12/3/96.

Moderate groundwater seeepage observed at 7-1/4 feet.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER
J-4668 12/96
Figure A-2

Test Pit Log TP-3



Sample	Water Content
S-1	14
S-2	12
S-3	7
S-4	11

Depth in Feet

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 221

Brush and bushes over 4 inches of black rooty TOPSOIL over (loose), moist, orange-brown, slightly silty, gravelly, medium to fine SAND with frequent thin roots and gravels to 4 inches in size.

One-foot-thick lens of sandy GRAVEL.

(Medium dense), moist, light brownish gray, slightly silty to non-silty, gravelly SAND and sandy GRAVEL.

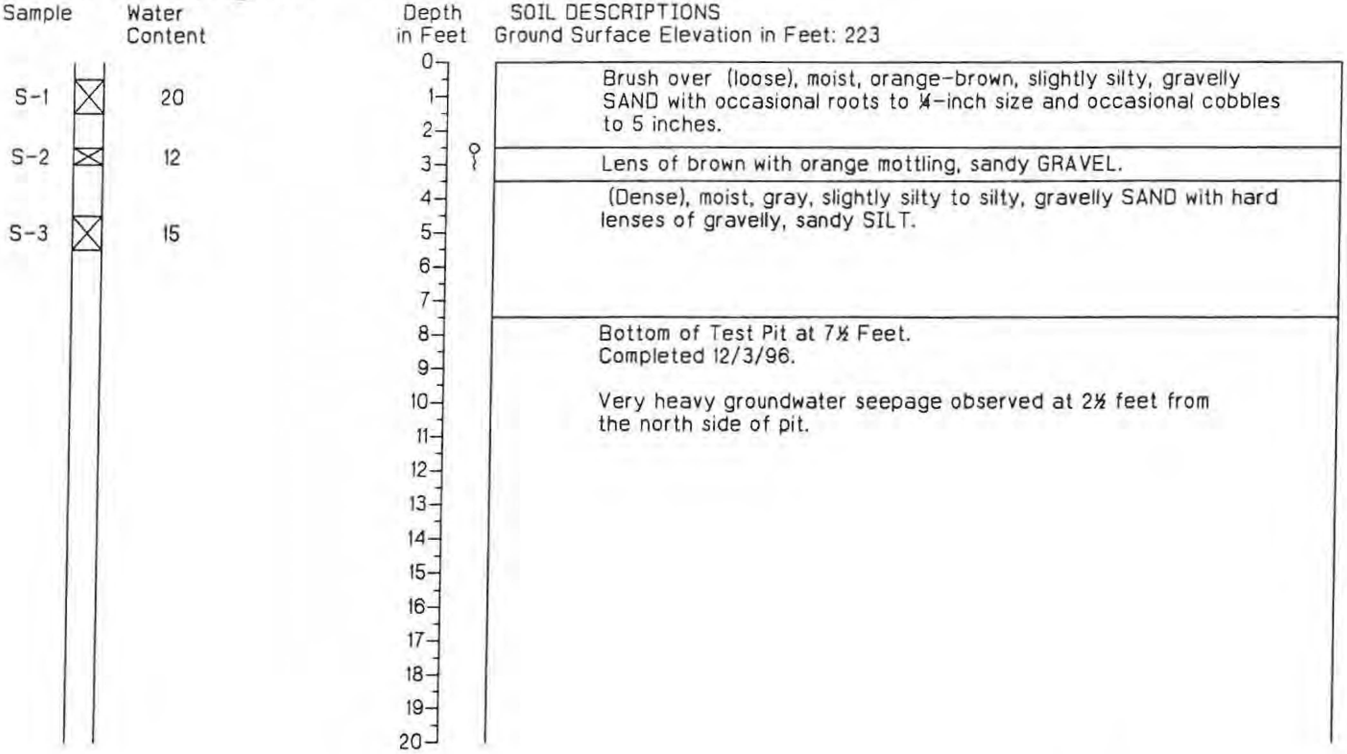
(Dense to very dense), moist, light gray, slightly silty, very gravelly SAND with occasional cobbles to 6 inches in size. Portions are hard and cemented.

Becomes silty.

Becomes (very dense), slightly gravelly to gravelly, silty, fine SAND with thin sandy lenses. (TILL-like)

Bottom of Test Pit at 9½ Feet.
Completed 12/3/96.

Test Pit Log TP-4



Sample	Water Content
S-1	20
S-2	12
S-3	15

Depth in Feet

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 223

Brush over (loose), moist, orange-brown, slightly silty, gravelly SAND with occasional roots to ¼-inch size and occasional cobbles to 5 inches.

Lens of brown with orange mottling, sandy GRAVEL.

(Dense), moist, gray, slightly silty to silty, gravelly SAND with hard lenses of gravelly, sandy SILT.

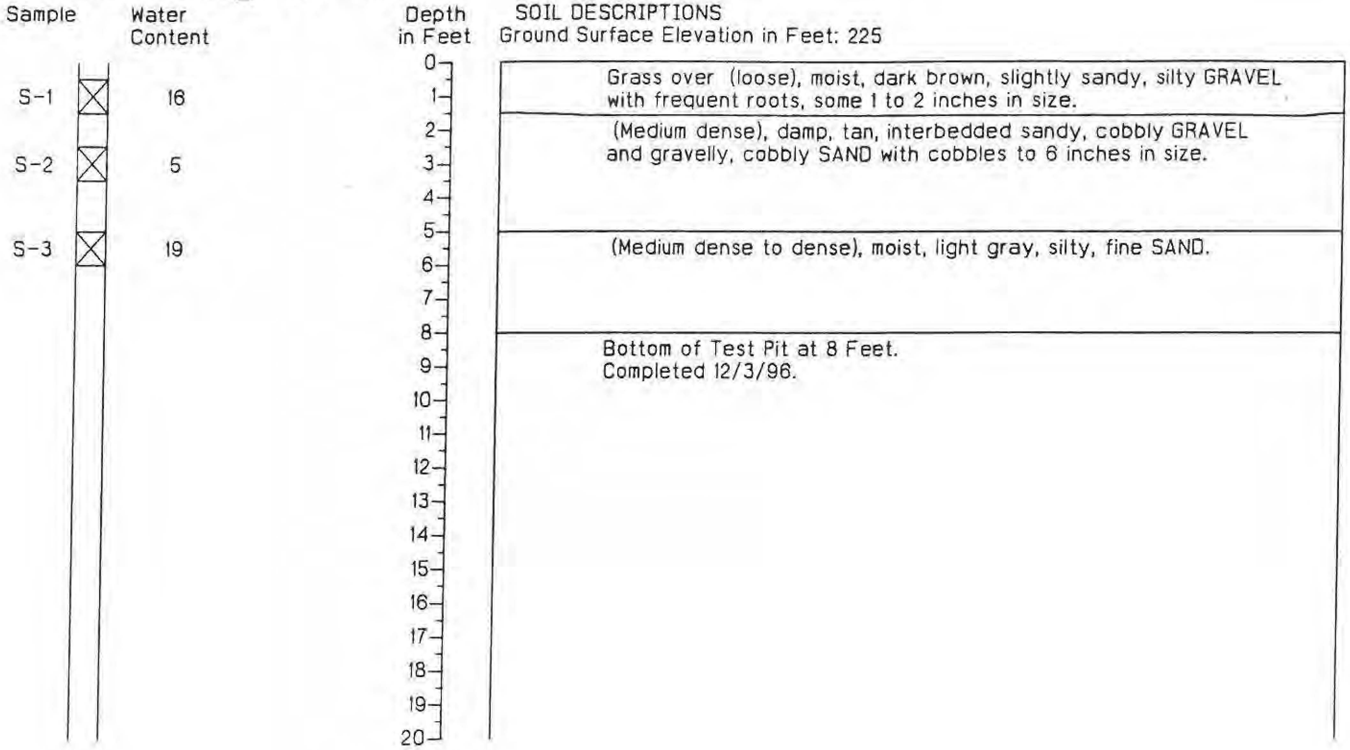
Bottom of Test Pit at 7½ Feet.
Completed 12/3/96.

Very heavy groundwater seepage observed at 2½ feet from the north side of pit.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER
J-4668 12/96
Figure A-3

Test Pit Log TP-5



Sample	Water Content
S-1	16
S-2	5
S-3	19

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 225

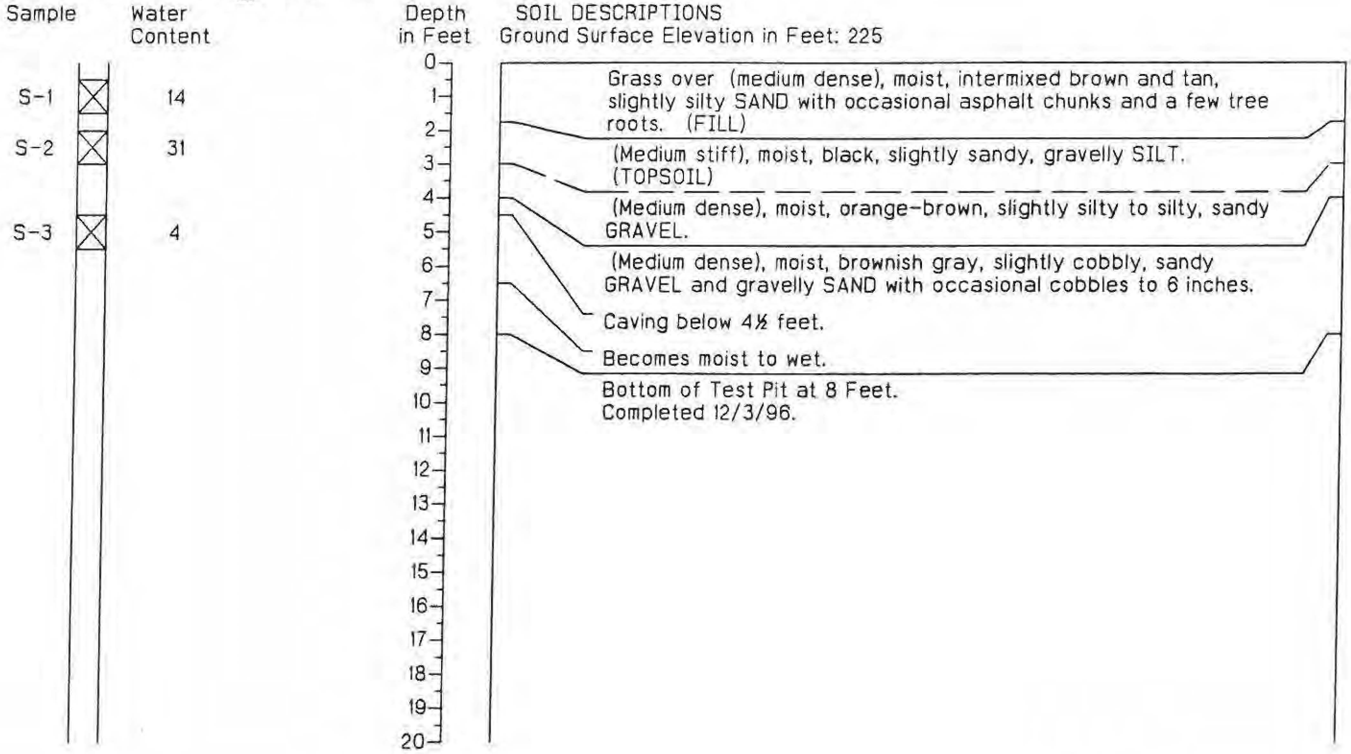
Grass over (loose), moist, dark brown, slightly sandy, silty GRAVEL with frequent roots, some 1 to 2 inches in size.

(Medium dense), damp, tan, interbedded sandy, cobbly GRAVEL and gravelly, cobbly SAND with cobbles to 6 inches in size.

(Medium dense to dense), moist, light gray, silty, fine SAND.

Bottom of Test Pit at 8 Feet.
Completed 12/3/96.

Test Pit Log TP-6



Sample	Water Content
S-1	14
S-2	31
S-3	4

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 225

Grass over (medium dense), moist, intermixed brown and tan, slightly silty SAND with occasional asphalt chunks and a few tree roots. (FILL)

(Medium stiff), moist, black, slightly sandy, gravelly SILT. (TOPSOIL)

(Medium dense), moist, orange-brown, slightly silty to silty, sandy GRAVEL.

(Medium dense), moist, brownish gray, slightly cobbly, sandy GRAVEL and gravelly SAND with occasional cobbles to 6 inches.

Caving below 4½ feet.

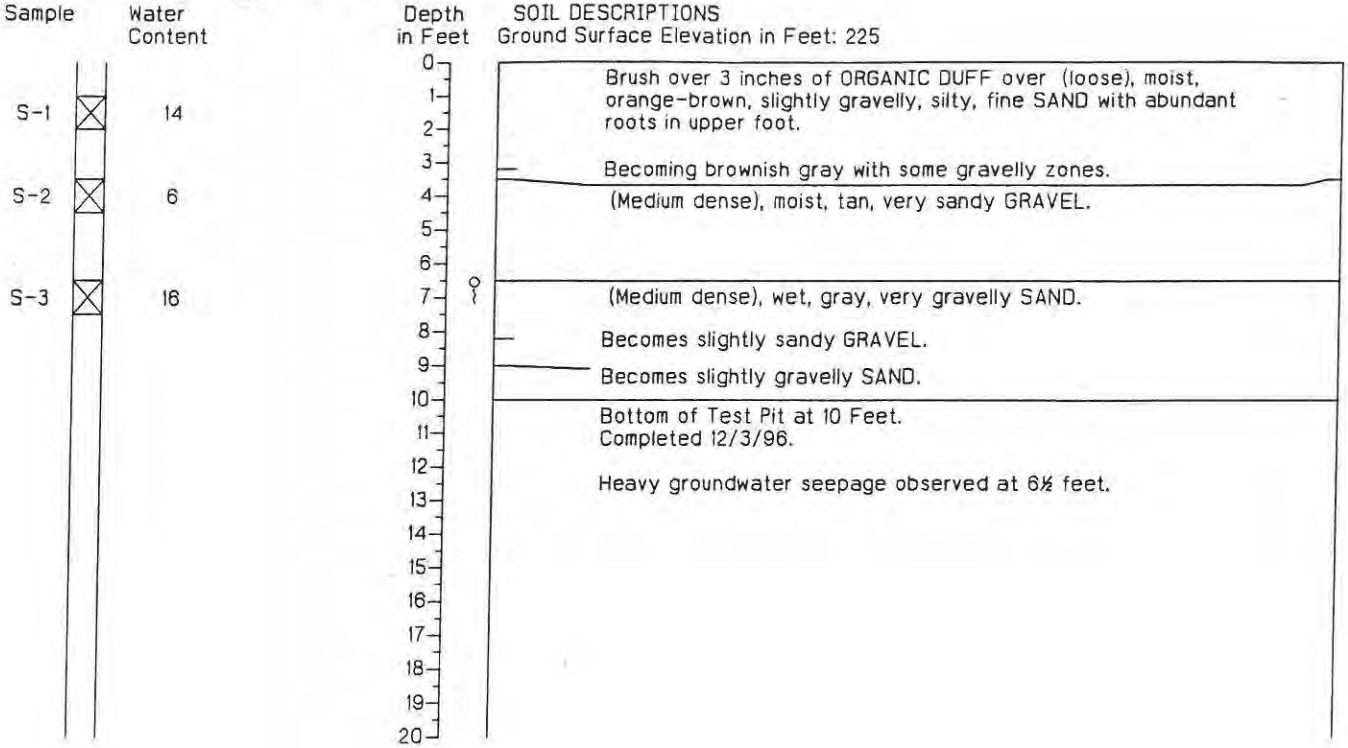
Becomes moist to wet.

Bottom of Test Pit at 8 Feet.
Completed 12/3/96.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER
J-4668 12/96
Figure A-4

Test Pit Log TP-7



Sample	Water Content
S-1	14
S-2	6
S-3	16

Depth in Feet

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 225

Brush over 3 inches of ORGANIC DUFF over (loose), moist, orange-brown, slightly gravelly, silty, fine SAND with abundant roots in upper foot.

Becoming brownish gray with some gravelly zones.

(Medium dense), moist, tan, very sandy GRAVEL.

(Medium dense), wet, gray, very gravelly SAND.

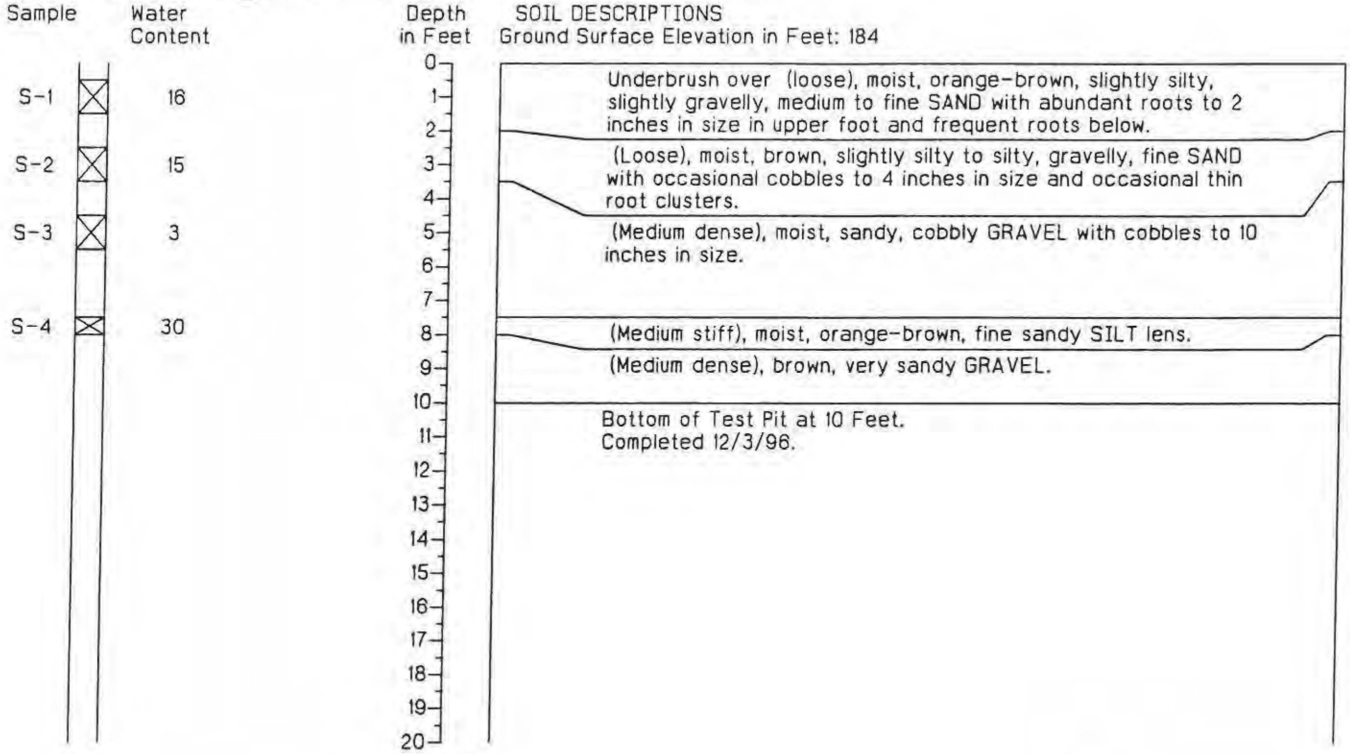
Becomes slightly sandy GRAVEL.

Becomes slightly gravelly SAND.

Bottom of Test Pit at 10 Feet.
Completed 12/3/96.

Heavy groundwater seepage observed at 6½ feet.

Test Pit Log TP-8



Sample	Water Content
S-1	16
S-2	15
S-3	3
S-4	30

Depth in Feet

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 184

Underbrush over (loose), moist, orange-brown, slightly silty, slightly gravelly, medium to fine SAND with abundant roots to 2 inches in size in upper foot and frequent roots below.

(Loose), moist, brown, slightly silty to silty, gravelly, fine SAND with occasional cobbles to 4 inches in size and occasional thin root clusters.

(Medium dense), moist, sandy, cobbly GRAVEL with cobbles to 10 inches in size.

(Medium stiff), moist, orange-brown, fine sandy SILT lens.

(Medium dense), brown, very sandy GRAVEL.

Bottom of Test Pit at 10 Feet.
Completed 12/3/96.

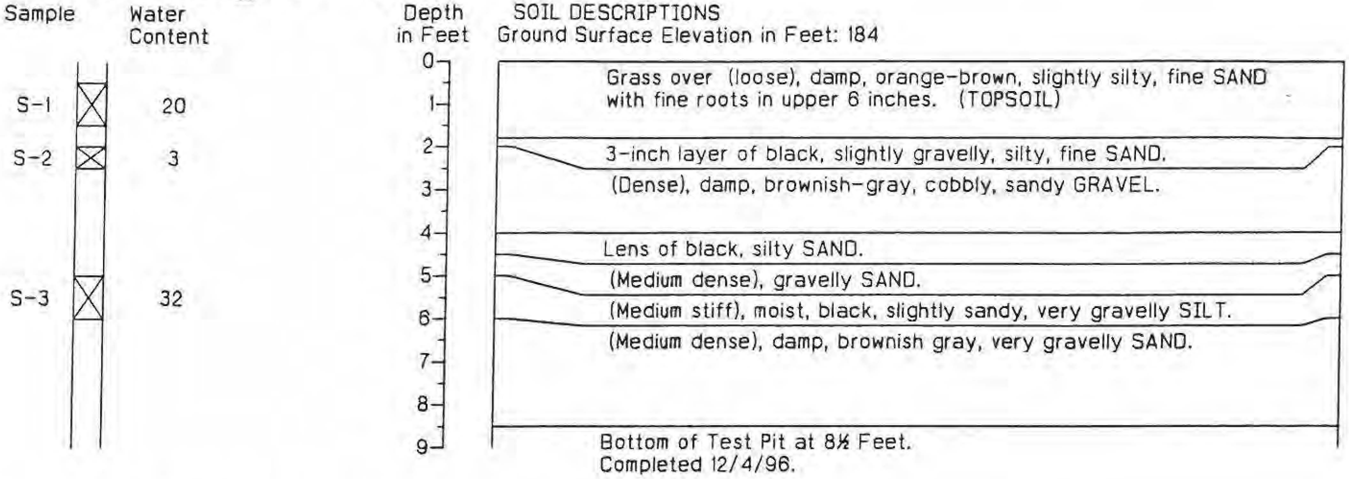
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER

J-4668 12/96

Figure A-5

Test Pit Log TP-9



Sample	Water Content
S-1	20
S-2	3
S-3	32

Depth in Feet

SOIL DESCRIPTIONS

Ground Surface Elevation in Feet: 184

Grass over (loose), damp, orange-brown, slightly silty, fine SAND with fine roots in upper 6 inches. (TOPSOIL)

3-inch layer of black, slightly gravelly, silty, fine SAND.

(Dense), damp, brownish-gray, cobbly, sandy GRAVEL.

Lens of black, silty SAND.

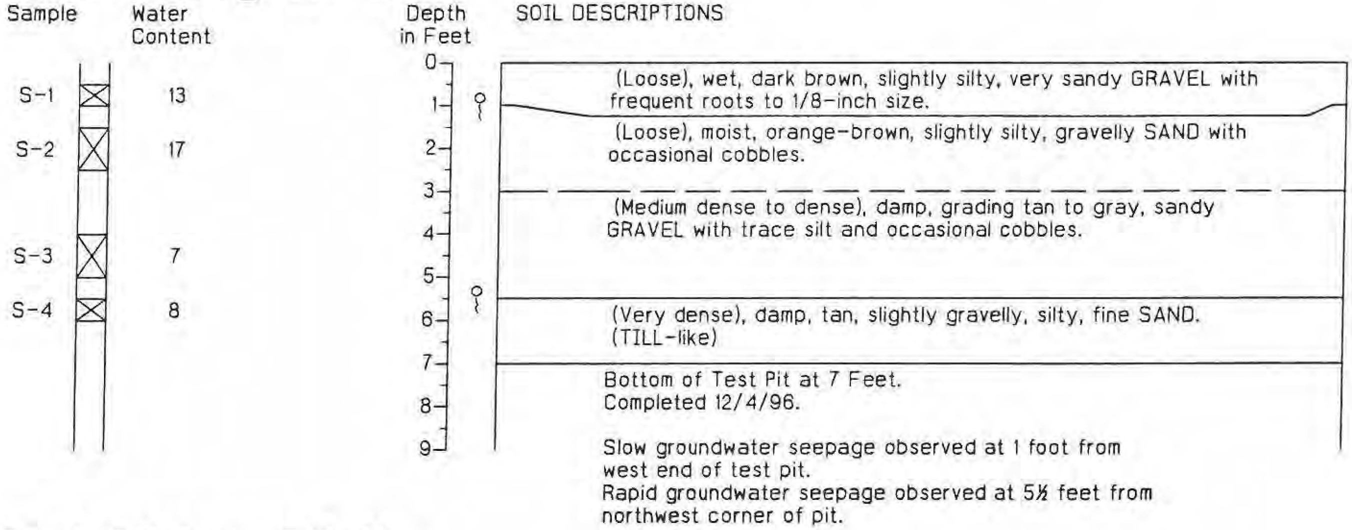
(Medium dense), gravelly SAND.

(Medium stiff), moist, black, slightly sandy, very gravelly SILT.

(Medium dense), damp, brownish gray, very gravelly SAND.

Bottom of Test Pit at 8½ Feet.
Completed 12/4/96.

Test Pit Log TP-10



Sample	Water Content
S-1	13
S-2	17
S-3	7
S-4	8

Depth in Feet

SOIL DESCRIPTIONS

(Loose), wet, dark brown, slightly silty, very sandy GRAVEL with frequent roots to 1/8-inch size.

(Loose), moist, orange-brown, slightly silty, gravelly SAND with occasional cobbles.

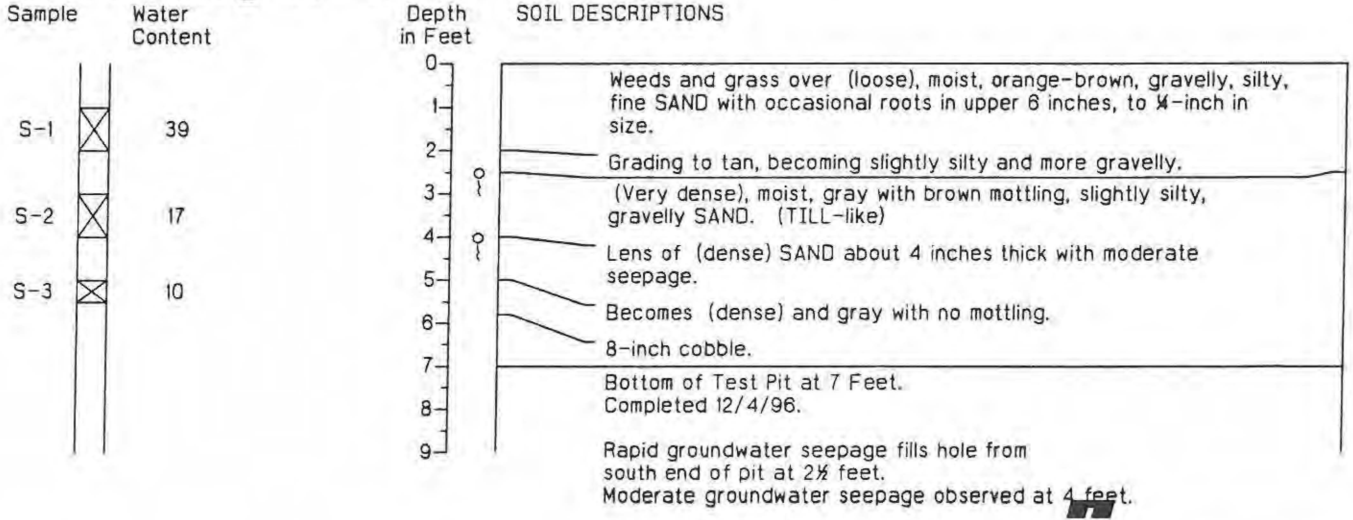
(Medium dense to dense), damp, grading tan to gray, sandy GRAVEL with trace silt and occasional cobbles.

(Very dense), damp, tan, slightly gravelly, silty, fine SAND. (TILL-like)

Bottom of Test Pit at 7 Feet.
Completed 12/4/96.

Slow groundwater seepage observed at 1 foot from west end of test pit.
Rapid groundwater seepage observed at 5½ feet from northwest corner of pit.

Test Pit Log TP-11



Sample	Water Content
S-1	39
S-2	17
S-3	10

Depth in Feet

SOIL DESCRIPTIONS

Weeds and grass over (loose), moist, orange-brown, gravelly, silty, fine SAND with occasional roots in upper 6 inches, to ¼-inch in size.

Grading to tan, becoming slightly silty and more gravelly.

(Very dense), moist, gray with brown mottling, slightly silty, gravelly SAND. (TILL-like)

Lens of (dense) SAND about 4 inches thick with moderate seepage.

Becomes (dense) and gray with no mottling.

8-inch cobble.

Bottom of Test Pit at 7 Feet.
Completed 12/4/96.

Rapid groundwater seepage fills hole from south end of pit at 2½ feet.
Moderate groundwater seepage observed at 4 feet.

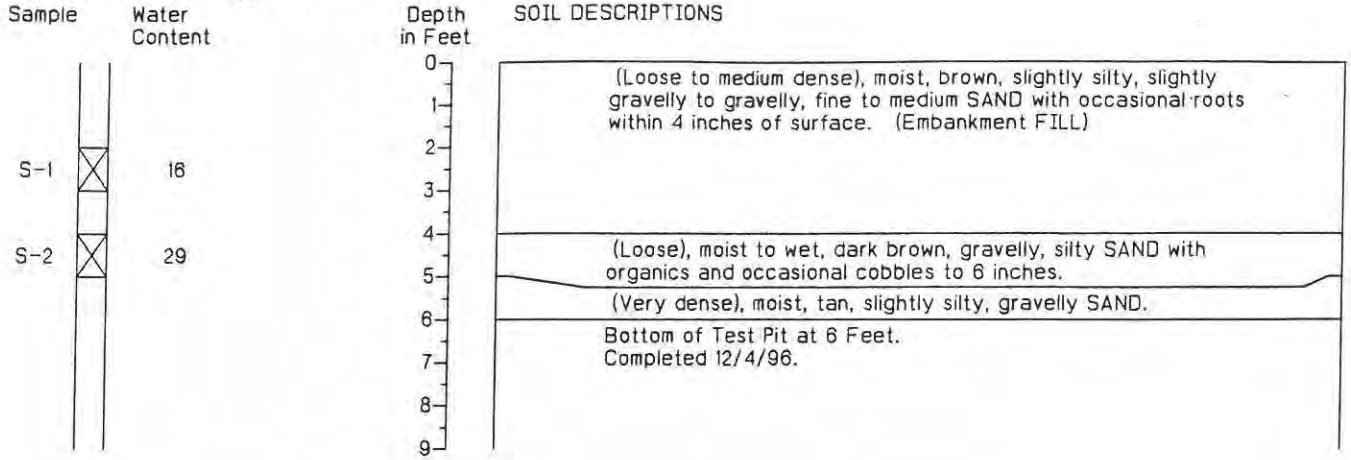
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER

J-4668 12/96

Figure A-6

Test Pit Log TP-12



SOIL DESCRIPTIONS

Sample	Water Content
S-1	16
S-2	29

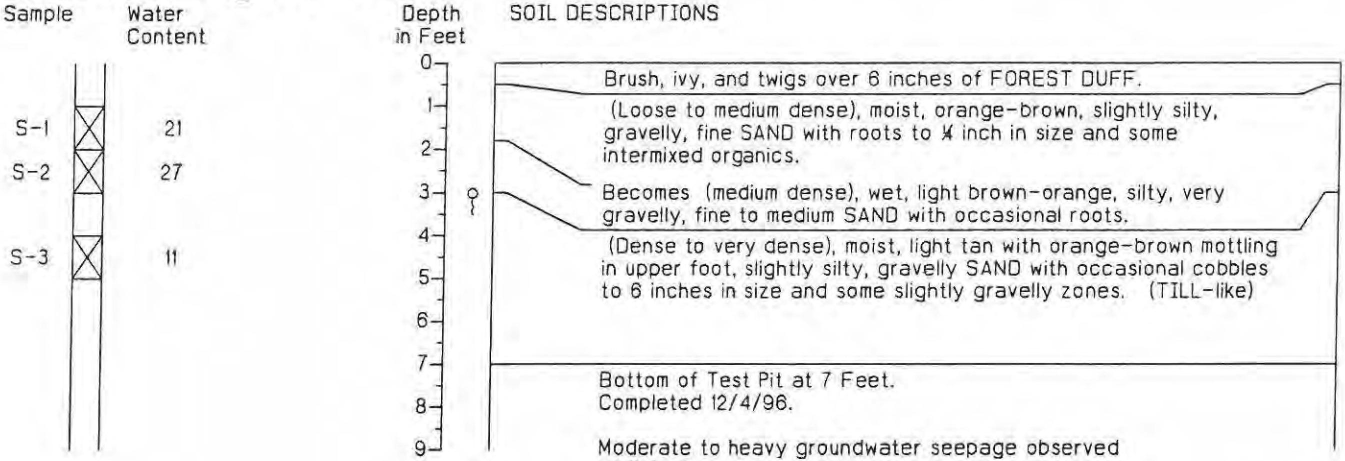
(Loose to medium dense), moist, brown, slightly silty, slightly gravelly to gravelly, fine to medium SAND with occasional roots within 4 inches of surface. (Embankment FILL)

(Loose), moist to wet, dark brown, gravelly, silty SAND with organics and occasional cobbles to 6 inches.

(Very dense), moist, tan, slightly silty, gravelly SAND.

Bottom of Test Pit at 6 Feet.
Completed 12/4/96.

Test Pit Log TP-13



SOIL DESCRIPTIONS

Sample	Water Content
S-1	21
S-2	27
S-3	11

Brush, ivy, and twigs over 6 inches of FOREST DUFF.

(Loose to medium dense), moist, orange-brown, slightly silty, gravelly, fine SAND with roots to ¼ inch in size and some intermixed organics.

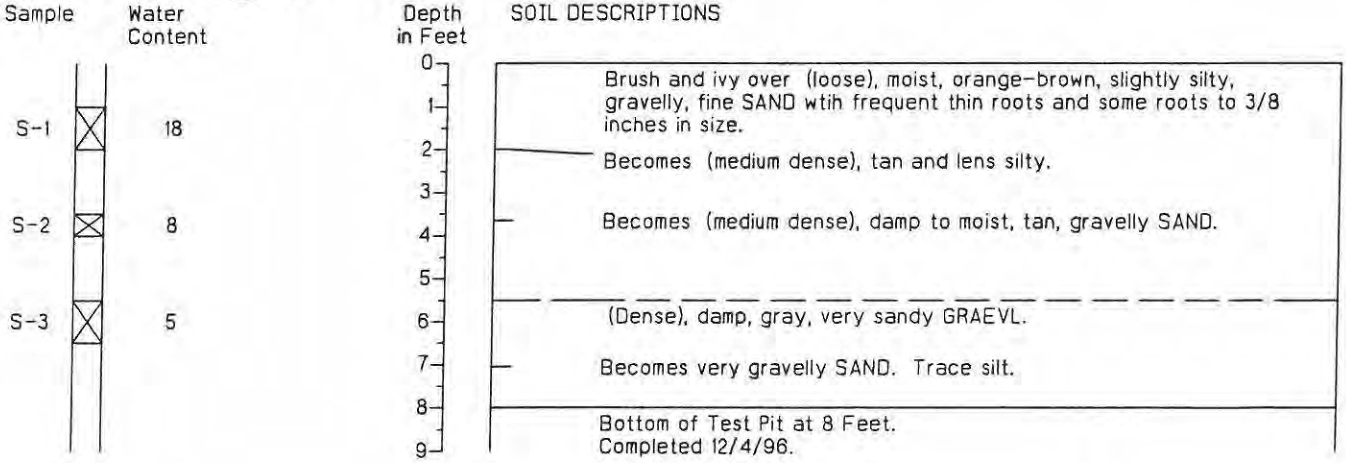
Becomes (medium dense), wet, light brown-orange, silty, very gravelly, fine to medium SAND with occasional roots.

(Dense to very dense), moist, light tan with orange-brown mottling in upper foot, slightly silty, gravelly SAND with occasional cobbles to 6 inches in size and some slightly gravelly zones. (TILL-like)

Bottom of Test Pit at 7 Feet.
Completed 12/4/96.

Moderate to heavy groundwater seepage observed at 3 feet.

Test Pit Log TP-14



SOIL DESCRIPTIONS

Sample	Water Content
S-1	18
S-2	8
S-3	5

Brush and ivy over (loose), moist, orange-brown, slightly silty, gravelly, fine SAND wtih frequent thin roots and some roots to 3/8 inches in size.

Becomes (medium dense), tan and lens silty.

Becomes (medium dense), damp to moist, tan, gravelly SAND.

(Dense), damp, gray, very sandy GRAEVL.

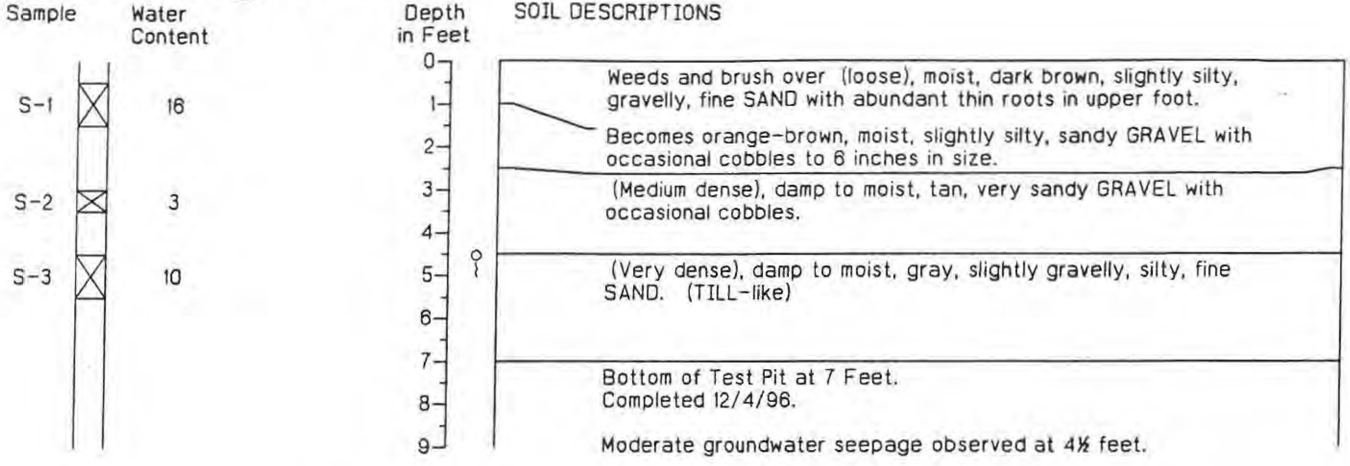
Becomes very gravelly SAND. Trace silt.

Bottom of Test Pit at 8 Feet.
Completed 12/4/96.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER
J-4668 12/96
Figure A-7

Test Pit Log TP-15



Sample	Water Content
S-1	16
S-2	3
S-3	10

SOIL DESCRIPTIONS

Weeds and brush over (loose), moist, dark brown, slightly silty, gravelly, fine SAND with abundant thin roots in upper foot.

Becomes orange-brown, moist, slightly silty, sandy GRAVEL with occasional cobbles to 6 inches in size.

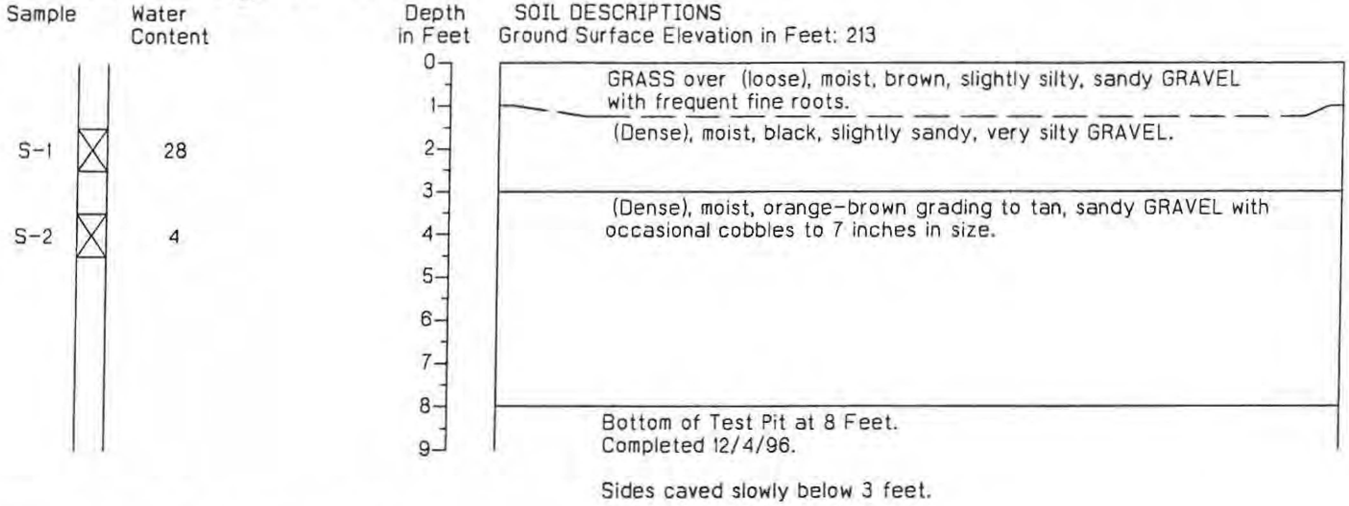
(Medium dense), damp to moist, tan, very sandy GRAVEL with occasional cobbles.

(Very dense), damp to moist, gray, slightly gravelly, silty, fine SAND. (TILL-like)

Bottom of Test Pit at 7 Feet.
Completed 12/4/96.

Moderate groundwater seepage observed at 4½ feet.

Test Pit Log TP-16



Sample	Water Content
S-1	28
S-2	4

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 213

GRASS over (loose), moist, brown, slightly silty, sandy GRAVEL with frequent fine roots.

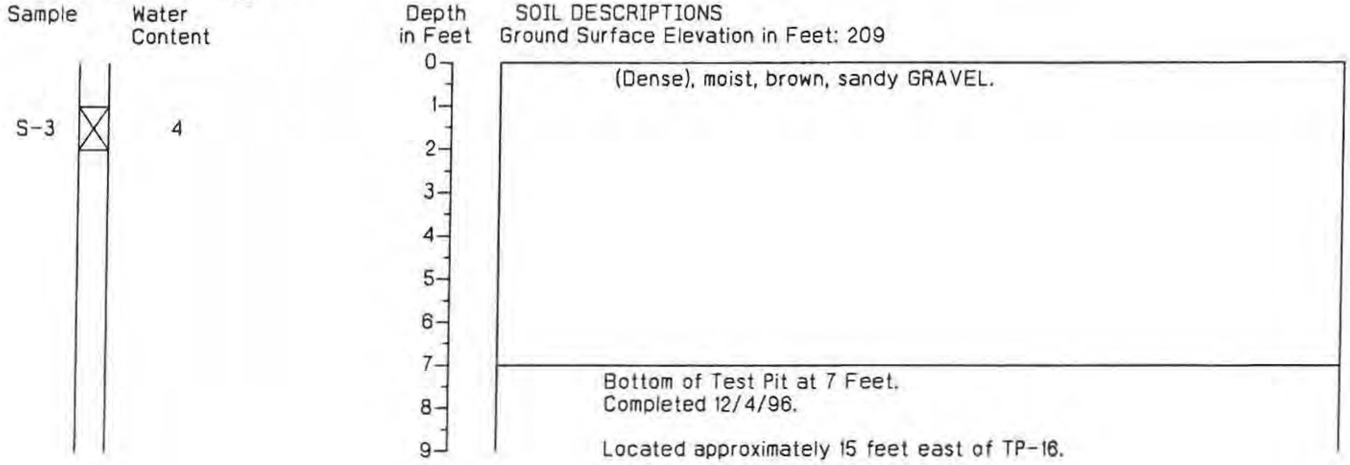
(Dense), moist, black, slightly sandy, very silty GRAVEL.

(Dense), moist, orange-brown grading to tan, sandy GRAVEL with occasional cobbles to 7 inches in size.

Bottom of Test Pit at 8 Feet.
Completed 12/4/96.

Sides caved slowly below 3 feet.

Test Pit Log TP-16A



Sample	Water Content
S-3	4

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 209

(Dense), moist, brown, sandy GRAVEL.

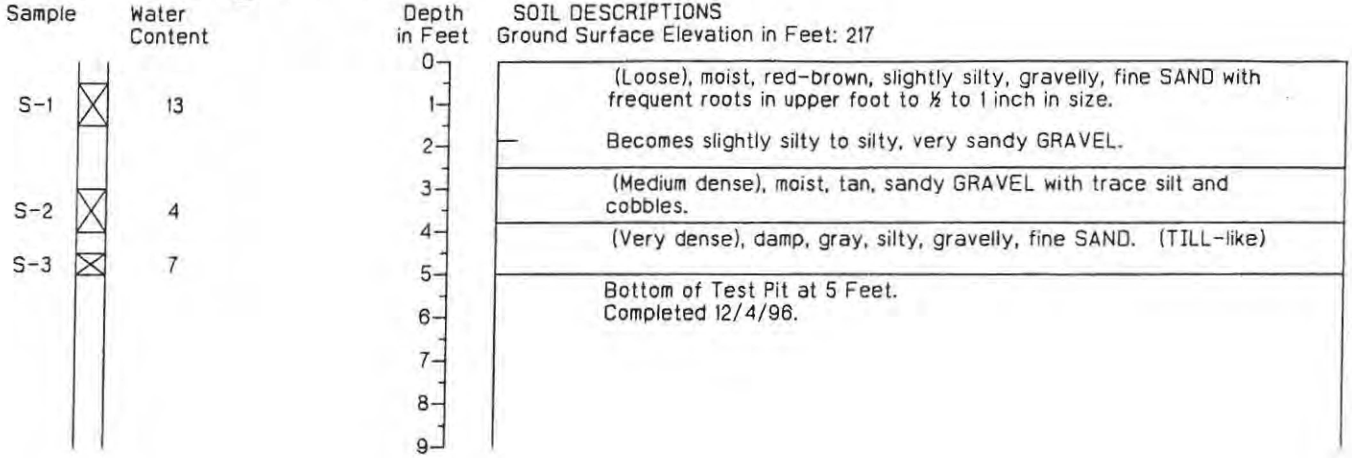
Bottom of Test Pit at 7 Feet.
Completed 12/4/96.

Located approximately 15 feet east of TP-16.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER
J-4668 **12/96**
Figure A-8

Test Pit Log TP-17



Sample	Water Content
S-1	13
S-2	4
S-3	7

SOIL DESCRIPTIONS
Ground Surface Elevation in Feet: 217

(Loose), moist, red-brown, slightly silty, gravelly, fine SAND with frequent roots in upper foot to ½ to 1 inch in size.

Becomes slightly silty to silty, very sandy GRAVEL.

(Medium dense), moist, tan, sandy GRAVEL with trace silt and cobbles.

(Very dense), damp, gray, silty, gravelly, fine SAND. (TILL-like)

Bottom of Test Pit at 5 Feet.
Completed 12/4/96.

1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater conditions, if indicated, are at the time of excavation. Conditions may vary with time.

HARTCROWSER
J-4688 12/96
Figure A-9

Key to Exploration Logs

Sample Descriptions

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

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

Density/Consistency

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

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

Moisture

Dry	Little perceptible moisture
Damp	Some perceptible moisture, probably below optimum
Moist	Probably near optimum moisture content
Wet	Much perceptible moisture, probably above optimum

Minor Constituents

	Estimated Percentage
Not identified in description	0 - 5
Slightly (clayey, silty, etc.)	5 - 12
Clayey, silty, sandy, gravelly	12 - 30
Very (clayey, silty, etc.)	30 - 50

Legends

Sampling

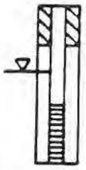
BORING SAMPLES

☒	Split Spoon
⧅	Shelby Tube
▥	Cuttings
◫	Core Run
*	No Sample Recovery
P	Tube Pushed, Not Driven

TEST PIT SAMPLES

☒	Grab (Jar)
⧄	Bag
⧅	Shelby Tube

Ground Water Observations



Surface Seal

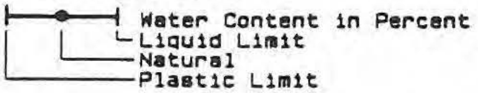
Ground Water Level on Date (ATD) At Time of Drilling

Observation Well Tip or Slotted Section

♀ Ground Water Seepage (Test Pits)

Test Symbols

GS	Grain Size Classification
CN	Consolidation
TUU	Triaxial Unconsolidated Undrained
TCU	Triaxial Consolidated Undrained
TCD	Triaxial Consolidated Drained
QU	Unconfined Compression
DS	Direct Shear
K	Permeability
PP	Pocket Penetrometer Approximate Compressive Strength in TSF
TV	Torvane Approximate Shear Strength in TSF
CBR	California Bearing Ratio
MD	Moisture Density Relationship
AL	Atterberg Limits



HARTCROWSER

J-2276 8/89

Figure A-1

Boring Log HC-1

Soil Descriptions

Ground Surface Elevation in Feet 222.0

(Medium dense), dry, brown, slightly silty to silty, slightly sandy to sandy GRAVEL.

(Dense), moist, gray, slightly gravelly to gravelly, silty, fine to medium SAND.

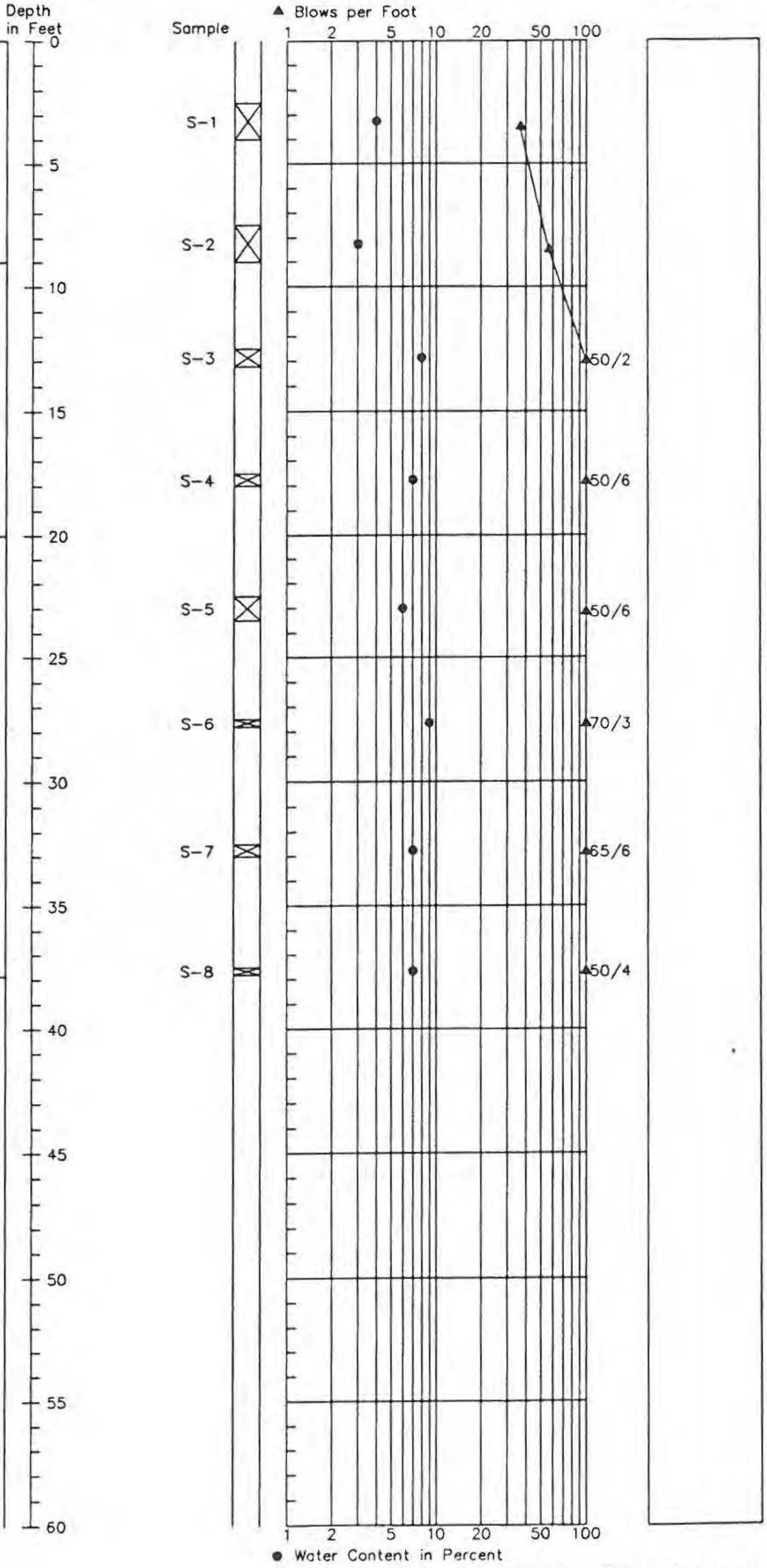
— Becomes wet.

(Dense), wet, tan, slightly gravelly to gravelly, silty SAND.

Bottom of Boring at 37.8 Feet.
Completed 8/11/89.

STANDARD PENETRATION RESISTANCE

LAB TESTS



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-2276 **8/89**
Figure A-2 **1/1**

Boring Log HC-2

Soil Descriptions

Ground Surface Elevation in Feet 210.0

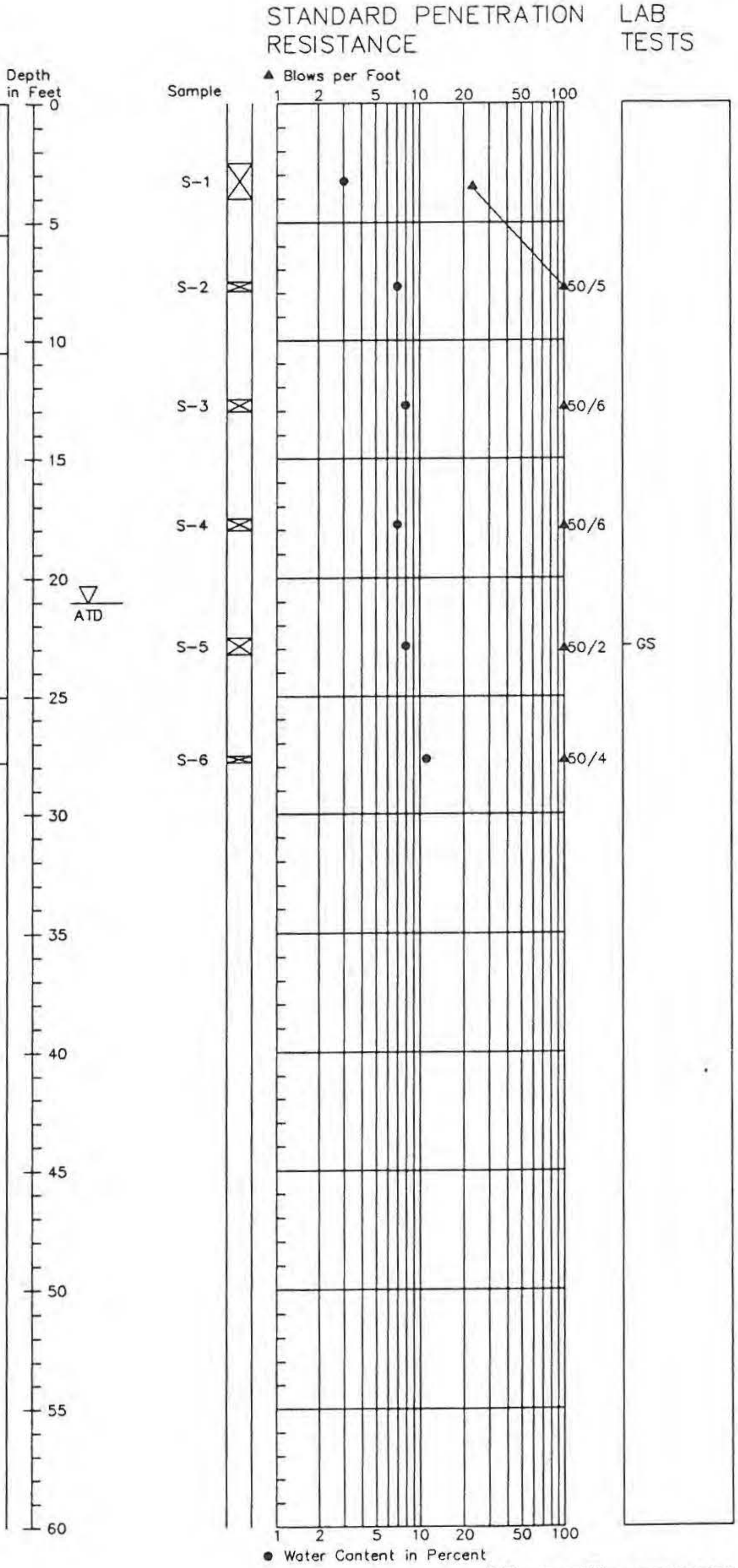
Medium dense, dry, brown, slightly sandy GRAVEL.

(Dense), wet, tan, slightly gravelly, silty SAND.

(Dense), wet, tan, slightly silty to silty, gravelly to very gravelly SAND.

(Dense), wet, tan, silty, sandy GRAVEL.

Bottom of Boring at 27.8 Feet.
Completed 8/11/89.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-2276 **8/89**

Figure A-3 **1/1**

Boring Log HC-3

Soil Descriptions

Ground Surface Elevation in Feet 222.0

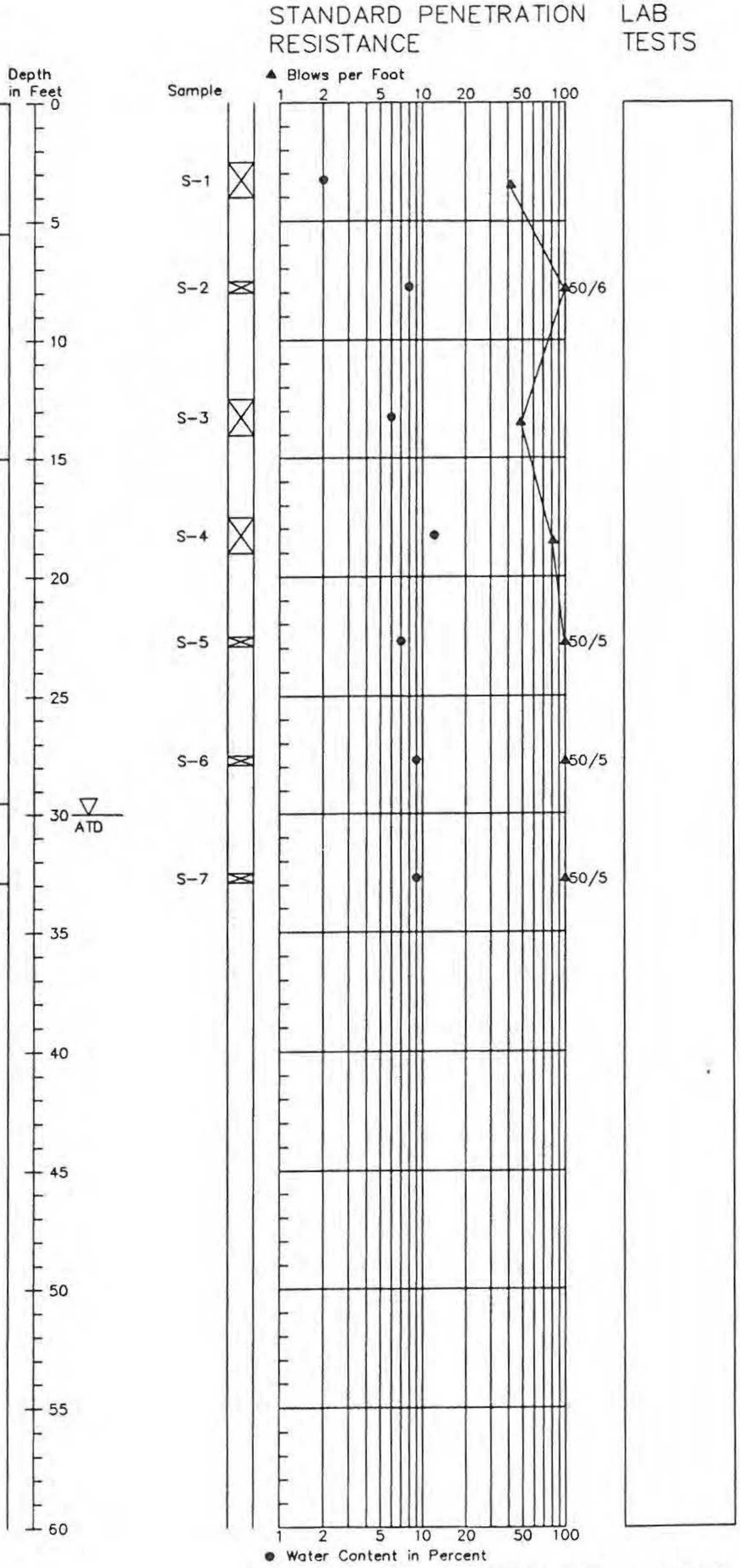
(Medium dense), dry, brown, slightly sandy GRAVEL.

(Dense), moist, tan, slightly gravelly, silty, fine to medium SAND.

(Dense), wet, tan, slightly gravelly to gravelly, silty to very silty SAND.

(Dense), wet, tan, silty, sandy GRAVEL.

Bottom of Boring at 32.9 Feet.
Completed 8/10/89.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-2276 **8/89**
Figure A-4 **1/1**

Boring Log HC-4

Soil Descriptions

Ground Surface Elevation in Feet 221.0

Medium dense, dry, brown, slightly sandy GRAVEL with interbeds of silty, gravelly SAND.

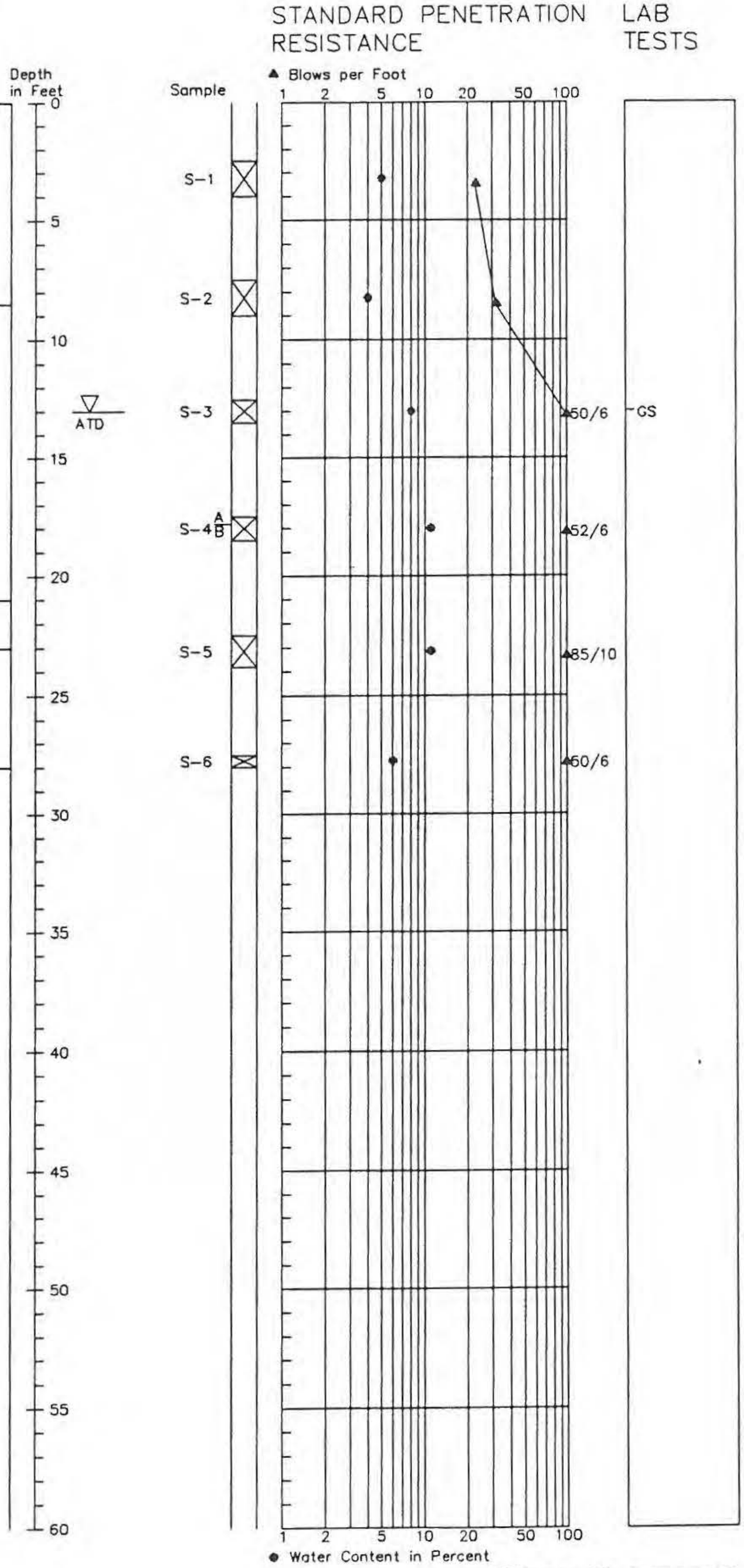
(Dense), moist, tan, slightly gravelly to gravelly, silty to very silty SAND.

— Becomes wet.

(Very stiff), moist, tan, sandy SILT.

(Dense), wet, tan, slightly gravelly to gravelly, silty SAND.

Bottom of Boring at 28.0 Feet.
Completed 8/10/89.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-2276 8/89
Figure A-5 1/1

Boring Log HC-5

Soil Descriptions

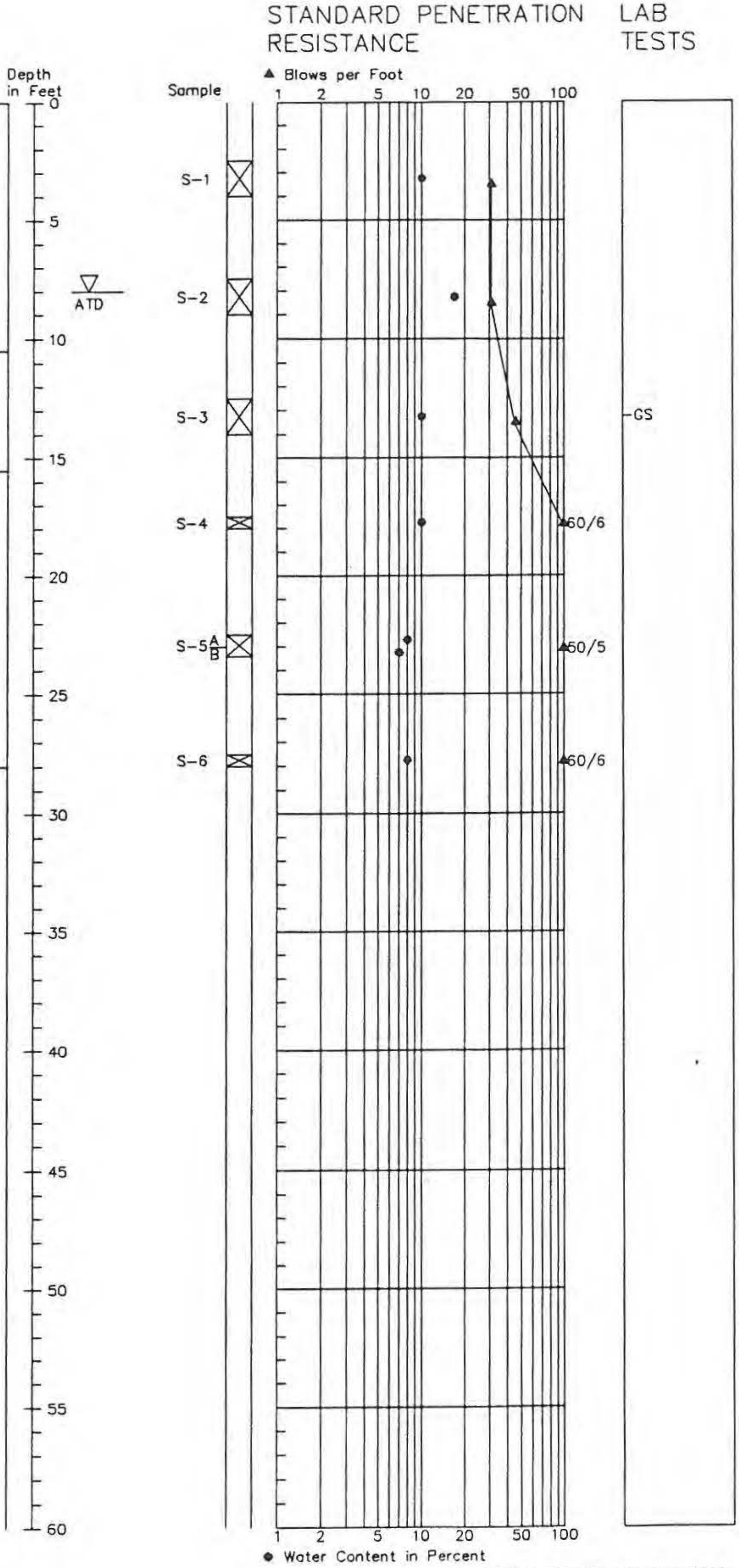
Ground Surface Elevation in Feet 222.0

(Medium dense), moist, brown to gray, slightly gravelly, silty SAND with interbeds of very silty, fine SAND.

Dense, moist, gray, slightly silty, fine to medium SAND.

(Dense), wet, gray, slightly silty to silty, slightly gravelly to gravelly SAND.

Bottom of Boring at 28.0 Feet.
Completed 8/10/89.



1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER

J-2276 8/89
Figure A-6 1/1

Boring Log HC-6

Soil Descriptions

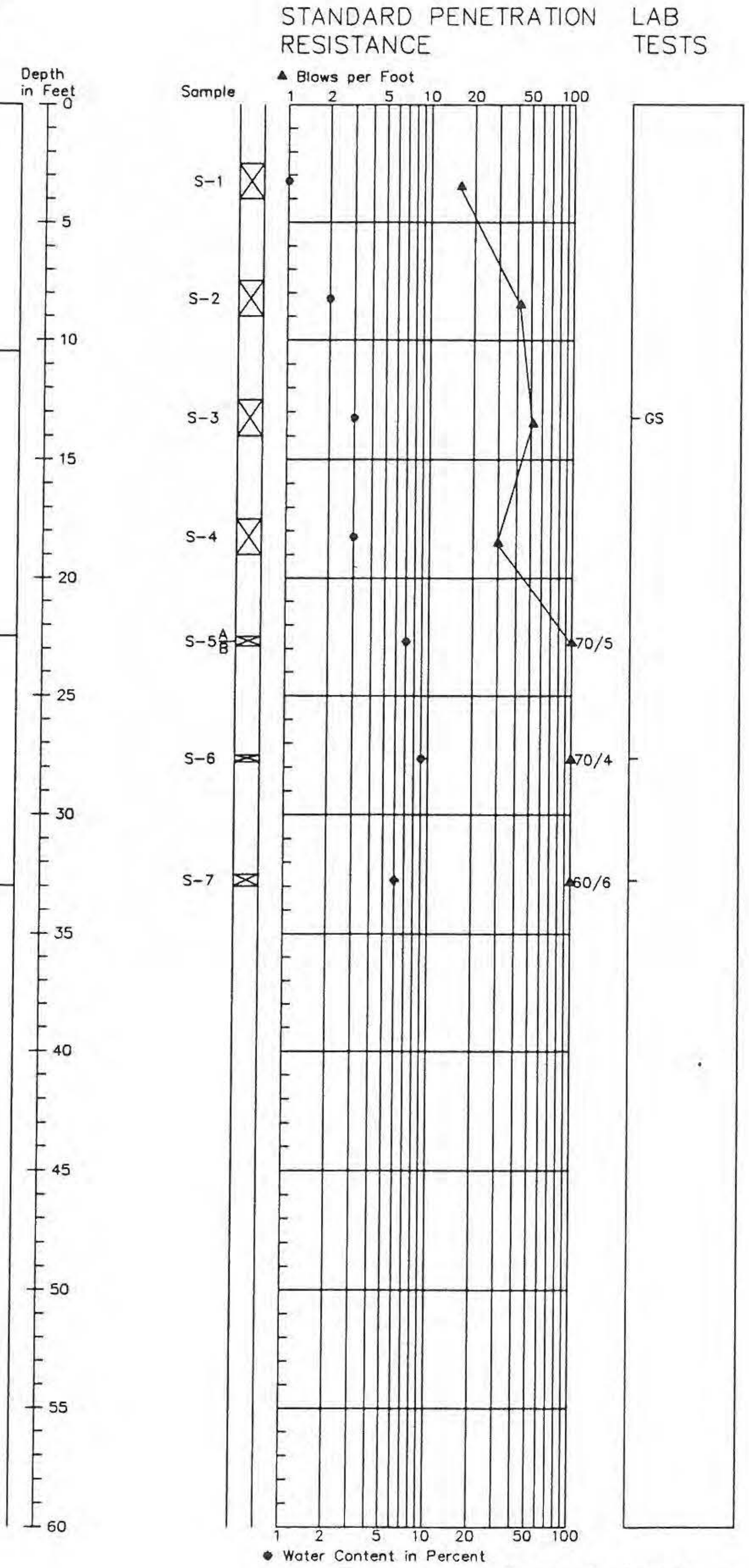
Ground Surface Elevation in Feet 227.0

(Medium dense), dry, brown, slightly sandy GRAVEL.

(Medium dense), dry, tan, sandy to very sandy GRAVEL.

(Dense), wet, tan, slightly gravelly to gravelly, silty SAND.

Bottom of Boring at 33.0 Feet.
Completed 8/10/89.



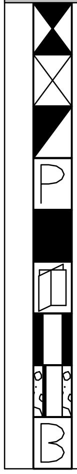
1. Refer to Figure A-1 for explanation of descriptions and symbols.
2. Soil descriptions and stratum lines are interpretive and actual changes may be gradual.
3. Groundwater level, if indicated, is at time of drilling (ATD) or for date specified. Level may vary with time.

HARTCROWSER
J-2276 8/89
Figure A-7 1/1

WSDOT

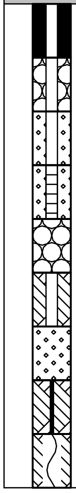
Boring and Test Pit Legend

Sampler Symbols



- Standard Penetration Test
- Non-Standard Sized Penetration Test
- Shelby Tube
- Piston Sample
- Washington Undisturbed
- Vane Shear Test
- Core
- Becker Hammer
- Bag Sample

Well Symbols



- Cement Surface Seal
- Piezometer Pipe in Granular Bentonite Seal
- Piezometer Pipe in Sand
- Well Screen in Sand
- Granular Bentonite Seal
- Inclinometer Casing or PVC Pipe in Cement Bentonite Grout
- Sand
- Vibe Wire in Grout
- Miscellaneous, noted on boring log

Laboratory Testing Codes

AL	Atterberg Limits
CD	Consolidated Drained Triaxial
CN	Consolidation Test
CSS	Cyclic Simple Shear
CU	Consolidated Undrained Triaxial
DG	Degradation
DN	Density
DS	Direct Shear Test
DSS	Direct Simple Shear
GS	Grain Size Distribution
HT	Hydrometer Test
JS	Jar Slake
LA	LA Abrasion
LOI	Loss on Ignition
MC	Moisture Content
pH	pH of Soil
PT	Point Load Compressive Test
RES	Resistivity
RM	Resilient Modulus
RS	Torsional Ring Shear Test
SG	Specific Gravity
SL	Slake Test
UC	Unconfined Compression Test
UU	Unconsolidated Undrained Triaxial
HC	Hydraulic Conductivity

Soil Density Modifiers

Gravel, Sand & Non-plastic Silt		Elastic Silts and Clay	
SPT Blows/ft	Density	SPT Blows/ft	Consistency
0 - 4	Very Loose	0 - 1	Very Soft
5 - 10	Loose	2 - 4	Soft
11 - 24	Medium Dense	5 - 8	Medium Stiff
25 - 50	Dense	9 - 15	Stiff
> 50	Very Dense	16 - 30	Very Stiff
(REF)	Refusal	31 - 60	Hard
		> 60	Very Hard

Angularity

Angular	Coarse particles have sharp edges and relatively plane sides with unpolished surfaces.
Subangular	Coarse grained particles are similar to angular but have rounded edges.
Subrounded	Coarse grained particles have nearly plane sides but have well rounded corners and edges.
Rounded	Coarse grained particles have smoothly curved sides and no edges.

Soil Moisture Modifiers

Dry	Absence of moisture; dusty, dry to touch
Moist	Damp but no visible water
Wet	Visible free water

Soil Structure

Stratified	Alternating layers of varying material or color at least 6 mm thick; note thickness and inclination.
Laminated	Alternating layers of varying material or color less than 6 mm thick; note thickness and inclination.
Fissured	Breaks along definite planes of fracture with little resistance to fracturing.
Slickensided	Fracture planes appear polished or glossy, sometimes striated.
Blocky	Cohesive soil that can be broken down into smaller angular lumps which resist further breakdown.
Disrupted	Soil structure is broken and mixed. Infers that material has moved substantially - landslide debris.
Homogeneous	Same color and appearance throughout.

HCl Reaction

No HCl Reaction	No visible reaction.
Weak HCl Reaction	Some reaction with bubbles forming slowly.
Strong HCl Reaction	Violent reaction with bubbles forming immediately.

Degree of Vesicularity of Pyroclastic Rocks

Slightly Vesicular	5 to 10 percent of total
Moderately Vesicular	10 to 25 percent of total
Highly Vesicular	25 to 50 percent of total
Scoriaceous	Greater than 50 percent of total

Boring and Test Pit Legend

Grain Size

Fine Grained	< 0.04 in	Few crystal boundaries/grains are distinguishable in the field or with hand lens.
Medium Grained	0.04 to 0.2 in	Most crystal boundaries/grains are distinguishable with the aid of a hand lens.
Coarse Grained	> 0.2 in	Most crystal boundaries/grains are distinguishable with the naked eye.

Weathered State

Term	Description	Grade
Fresh	No visible sign of rock material weathering; perhaps slight discoloration in major discontinuity surfaces.	I
Slightly Weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker externally than its fresh condition.	II
Moderately Weathered	Less than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as a continuous framework or as core stones.	III
Highly Weathered	More than half of the rock material is decomposed and/or disintegrated to soil. Fresh or discolored rock is present either as discontinuous framework or as core stone.	IV
Completely Weathered	All rock material is decomposed and/or disintegrated to soil. The original mass structure is still largely intact.	V
Residual Soil	All rock material is converted to soil. The mass structure and material fabric is destroyed. There is a large change in volume, but the soil has not been significantly transported.	VI

Relative Rock Strength

Grade	Description	Field Identification	Uniaxial Compressive Strength approx
R1	Very Weak	Specimen crumbles under sharp blow from point of geological hammer, and can be cut with a pocket knife.	0.15 to 3.6 ksi
R2	Moderately Weak	Shallow cuts or scrapes can be made in a specimen with a pocket knife. Geological hammer point indents deeply with firm blow.	3.6 to 7.3 ksi
R3	Moderately Strong	Specimen cannot be scraped or cut with a pocket knife, shallow indentation can be made under firm blows from a hammer.	7.3 to 15 ksi
R4	Strong	Specimen breaks with one firm blow from the hammer end of a geological hammer.	15 to 29 ksi
R5	Very Strong	Specimen requires many blows of a geological hammer to break intact sample.	Greater than 29 ksi

Discontinuities

Spacing

Very Widely	Greater than 10 ft
Widely	3 ft to 10 ft
Moderately	1 ft to 3 ft
Closely	2 inches to 12 inches
Very Closely	Less than 2 inches

RQD (%)

$$\frac{100(\text{length of core in pieces} > 100\text{mm})}{\text{Length of core run}}$$

Condition

Excellent	Very rough surfaces, no separation, hard discontinuity wall
Good	Slightly rough surfaces, separation less than 0.05 in, hard discontinuity wall.
Fair	Slightly rough surfaces, separation greater than 0.05 in, soft discontinuity wall.
Poor	Slickensided surfaces, or soft gouge less than 0.2 in thick, or open discontinuities 0.05 to 0.2 in.
Very Poor	Soft gouge greater than 0.2 in thick, or open discontinuities greater than 0.2 in.

Fracture Frequency (FF) is the average number of fractures per 1 ft of core. This does not include mechanical breaks caused by drilling or handling.

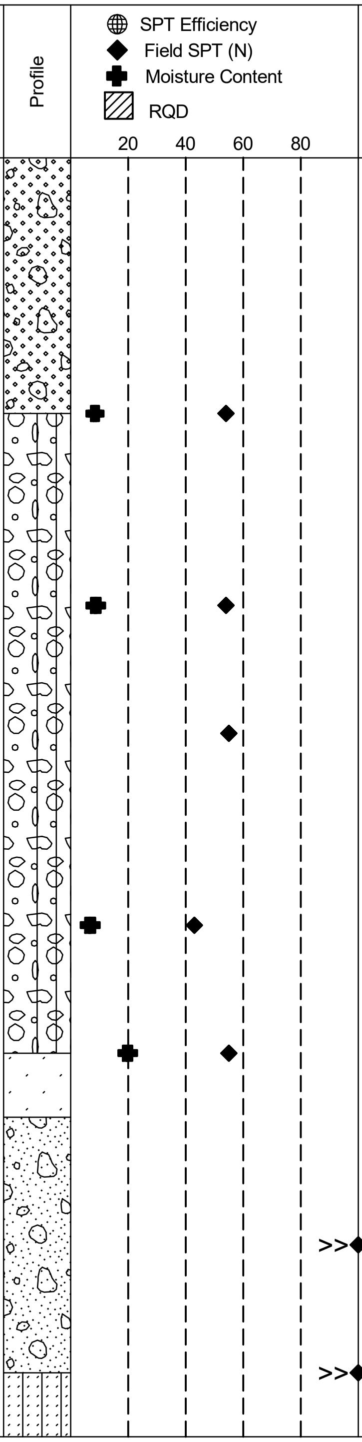
Datum:
NAD 83/91 HARN = North American Datum of 1983/1991 High Accuracy Reference Network
NAVD88 = North American Vertical Datum of 1988
SPN (ft) = State Plane North (ft)
SPS (ft) = State Plane South (ft)

WSDOT

LOG OF TEST BORING

Start Card RE-14607
HOLE No. H-1p-17
Sheet 1 of 3

Job No. XL-5001
SR 005
Elevation 229.4 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Henderson, Ted
Lic# 2902
Component Retaining Wall 1
Inspector Brun, Mike #1711
Start September 22, 2017
Completion September 23, 2017
Well ID# BJT-730
Equipment CME 55 (9C7-1)
Station MRW 104+59.95
Offset 77.0 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 87.2%
Northing 638667.0478
Easting 1076093.1799
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0624603
Long -122.7646415
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite and Polymer



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
					NOTE: From 0.0 to 4.0 ft, pot holed with vacuum truck. Well graded SAND with gravel, cobbles, and boulders, sub-rounded gravel, brown, dry, homogeneous. NOTE: From 0.0 to 49.5 ft, drilling action indicates cobbles.
5	225.0	20 32 22 (54)	D-1	MC GS	GW-GM, MC=9% Well graded GRAVEL with silt, sand, and cobbles, sub-angular, very dense, light brown, dry, homogeneous. Recovered: 1.3 ft Retained: 1.3 ft
		12 18 36 (54)	D-2	MC GS	GP-GM, MC=9% Poorly graded GRAVEL with silt, sand, and cobbles, sub-rounded, very dense, dark brown, dry, homogeneous. Recovered: 1.5 ft Retained: 1.5 ft
10	220.0	19 23 32 (55)	D-3		Well graded GRAVEL with silt and sand, sub-rounded, very dense, brown, moist, homogeneous. Recovered: 0.7 ft Retained: 0.7 ft
		10 14 29 (43)	D-4	MC GS	GW-GM, MC=7% Well graded GRAVEL with silt, sand, and cobbles, sub-rounded, dense, light brown, moist, homogeneous. Recovered: 0.9 ft Retained: 0.9 ft
15	215.0	15 23 32 (55)	D-5	MC GS AL	ML, MC=20%, LL=NA, PL=NP Sandy SILT, sub-rounded, very dense, light brown, moist, homogeneous. Recovered: 1.5 ft Retained: 1.5 ft NOTE: At 15.0 ft, becomes poorly graded SAND with gravel, sub-rounded gravel, very dense, light brown, moist, homogeneous.
		50/5" (REF)	D-6		NO RECOVERY.
20	210.0	26 50/6"	D-7		Silty SAND with gravel and cobbles, sub-rounded gravel, very dense, light brown, moist, homogeneous.

WSDOT

LOG OF TEST BORING

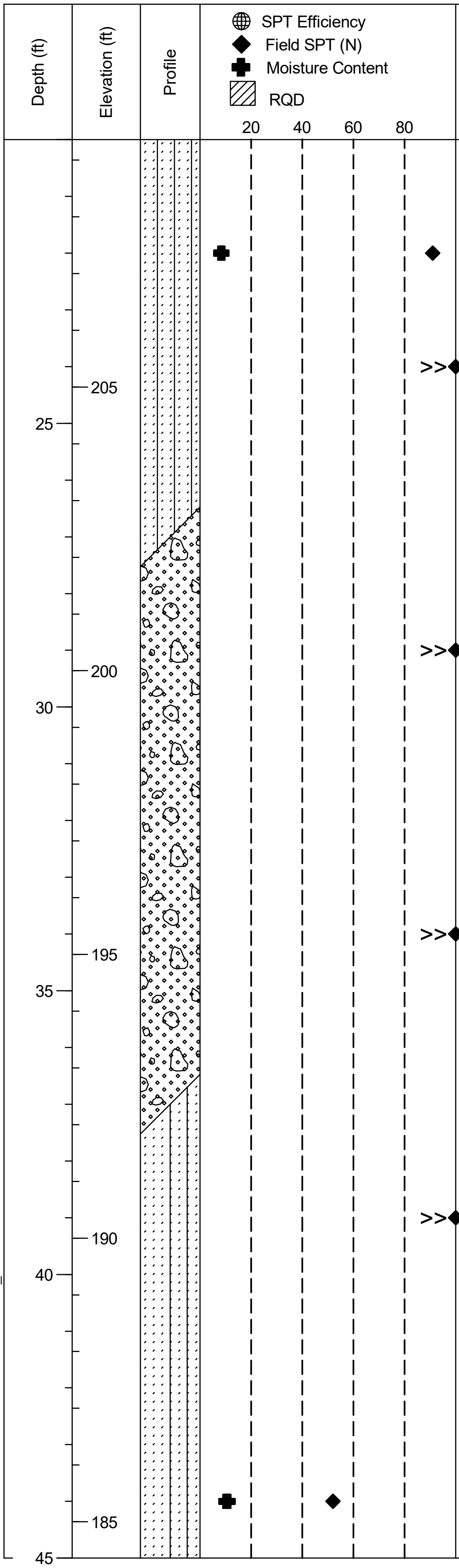
Job No. XL-5001 SR 005 Elevation 229.4 ft

HOLE No. H-1p-17

Sheet 2 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange

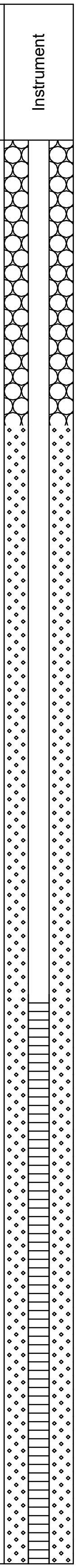
Driller Henderson, Ted



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
(REF)			Recovered: 1.0 ft Retained: 1.0 ft
28 41 50/6" (91)	D-8	MC GS	SM, MC=9% Silty SAND with gravel and cobbles, sub-rounded gravel, very dense, light brown, moist, homogeneous. Recovered: 1.1 ft Retained: 1.1 ft
36 50/6" (REF)	D-9		Silty SAND with gravel and cobbles, sub-rounded gravel, very dense, light brown, moist, homogeneous. Recovered: 0.7 ft Retained: 0.7 ft
50/4" (REF)	D-10		Well graded SAND with gravel and cobbles, sub-rounded gravel, very dense, light brown, moist, homogeneous. Recovered: 0.3 ft Retained: 0.3 ft
50/4" (REF)	D-11		Well graded SAND with gravel and cobbles, sub-rounded gravel, very dense, light brown, moist, homogeneous. Recovered: 0.1 ft Retained: 0.1 ft
50/6" (REF)	D-12		Poorly graded SAND with silt, gravel, and cobbles, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. Recovered: 0.5 ft Retained: 0.5 ft
10 9	D-13	MC GS	SP-SM, MC=11% Poorly graded SAND with silt, gravel, and cobbles,

Groundwater

Instrument



WSDOT

LOG OF TEST BORING

Job No. XL-5001 SR 005 Elevation 229.4 ft

HOLE No. H-1p-17

Sheet 3 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Henderson, Ted

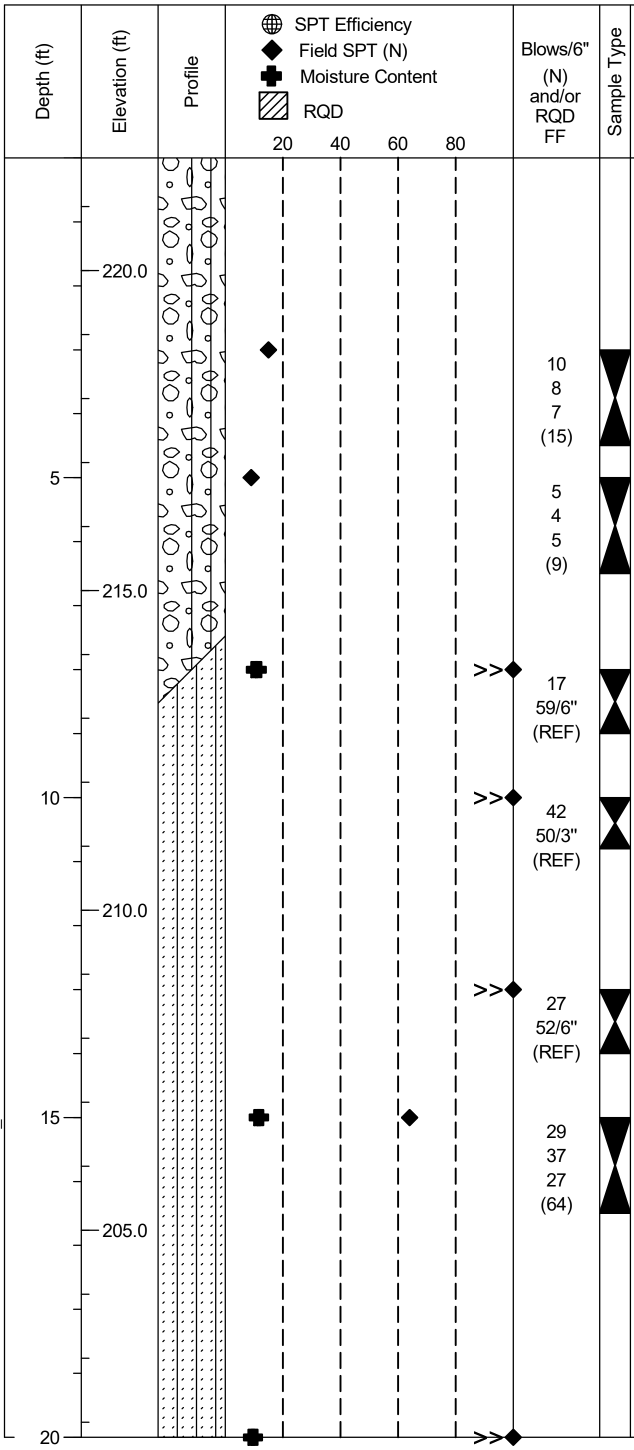
Depth (ft)	Elevation (ft)	Profile	⊕ SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				43 (52)	⧗			sub-rounded gravel, very dense, grayish brown, moist, homogeneous. Recovered: 0.7 ft Retained: 0.7 ft		
	180		>>◆	50/6" (REF)	⧗	D-14		Well graded SAND with gravel and cobbles, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. Recovered: 0.4 ft Retained: 0.4 ft		
50								A flush mount monument was installed on this boring.		
								The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
	175									
55								End of test hole boring at 49.5 ft below ground surface. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
								Bail/Recharge test: Hole Diameter: 4 in. Depth of boring during bail test: 49.5 ft. Depth of casing during bail test: 49.0 ft. Water depth before bailing: 14.0 ft. Bailed bore hole water level to 35.5 ft. Recharge after 16 hours and 40 minutes: 32.0 ft.		
	170									
60								Manual Piezometer Readings: 9-28-2017: Dry to 45.0 ft. (bottom of piezometer screen). 10-30-2017: Dry to 45.0 ft. 12-13-2017: Dry to 45.0 ft. 1-22-2018: Dry to 45.0 ft.		
	165									
65										
	160									
70										

WSDOT

LOG OF TEST BORING

Start Card SE-62760 / AE-44015
HOLE No. W-2-17
Sheet 1 of 3

Job No. XL-5001
SR 005
Elevation 221.8 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie
Lic# 2941
Component Retaining Wall 1
Inspector Harvey, Thomas #2599
Start August 9, 2017
Completion August 9, 2017
Well ID# N/A
Equipment CME 45 (9C4-3)
Station MRW 105+10.23
Offset 61.0 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 86.1%
Northing 638604.25
Easting 1076082.5134
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0622873
Long -122.7646770
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite and Polymer



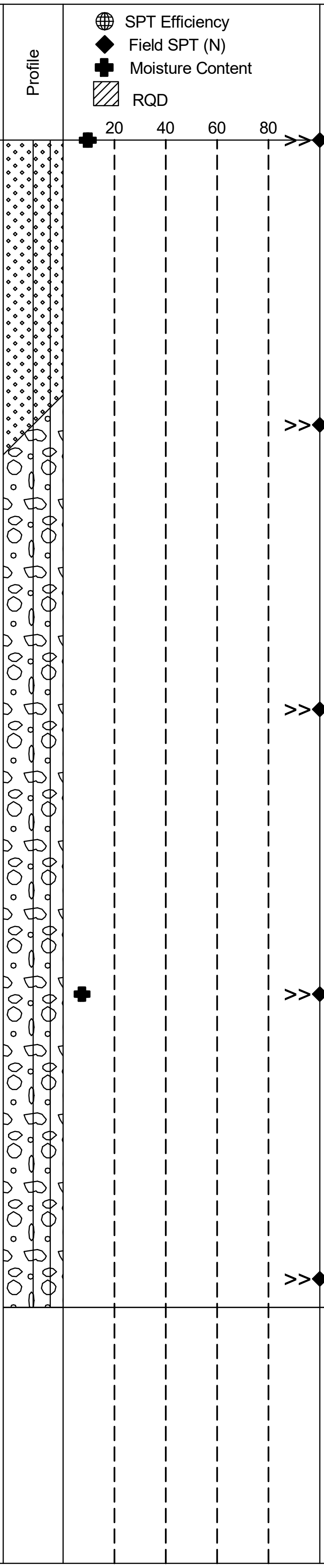
Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
10 8 7 (15)	D-1		Well graded GRAVEL with silt and sand, sub-rounded, medium dense, gray, wet, stratified. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
5 4 5 (9)	D-2		Well graded GRAVEL with silt and sand, sub-rounded, loose, gray, wet, stratified. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
17 59/6" (REF)	D-3	MC GS	SM, MC=11% Silty SAND with gravel, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
42 50/3" (REF)	D-4		Silty SAND with gravel, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
27 52/6" (REF)	D-5		Silty SAND with gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
29 37 27 (64)	D-6	MC GS	SM, MC=12% Silty SAND with gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft

Groundwater
Instrument

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 221.8 ft
HOLE No. W-2-17
Sheet 2 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
		21 51/6" (REF)	D-7	MC GS	SW-SM, MC=10% Well graded SAND with silt and gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
	200				
25		32 50/4" (REF)	D-8		Well graded GRAVEL with silt and sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
	195				
30		41 50/2" (REF)	D-9		Well graded GRAVEL with silt and sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
	190				
35		41 50/3" (REF)	D-10	MC GS	GW-GM, MC=8% Well graded GRAVEL with silt and sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.3 ft
	185				
40		53/6" (REF)	D-11		Well graded GRAVEL with silt and sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.4 ft The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew. End of test hole boring at 40.5 ft below ground surface. This is a summary Log of Test Boring.
	180				
45					

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 221.8 ft
HOLE No. W-2-17
Sheet 3 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie

Depth (ft)	Elevation (ft)	Profile	◍ SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	175							Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal Bail/Recharge test: Hole Diameter: 4 in. Depth of boring during bail test: 40.5 ft. Depth of casing during bail test: 35.0 ft. Water depth before bailing: 9.2 ft. Bailed bore hole water level to 38.3 ft. Recharge after 5 minutes: 38.1 ft. Recharge after 10 minutes: 38.1 ft. Recharge after 15 minutes: 38.0 ft. Recharge after 20 minutes: 37.9 ft. Recharge after 25 minutes: 37.9 ft. Recharge after 30 minutes: 37.9 ft.		
50										
	170									
55										
	165									
60										
	160									
65										
	155									
70										

WSDOT

LOG OF TEST BORING

Start Card RE-14607
HOLE No. H-3p-17
Sheet 1 of 3

Job No. XL-5001
SR 005
Elevation 219.6 ft

Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie
Lic# 2941

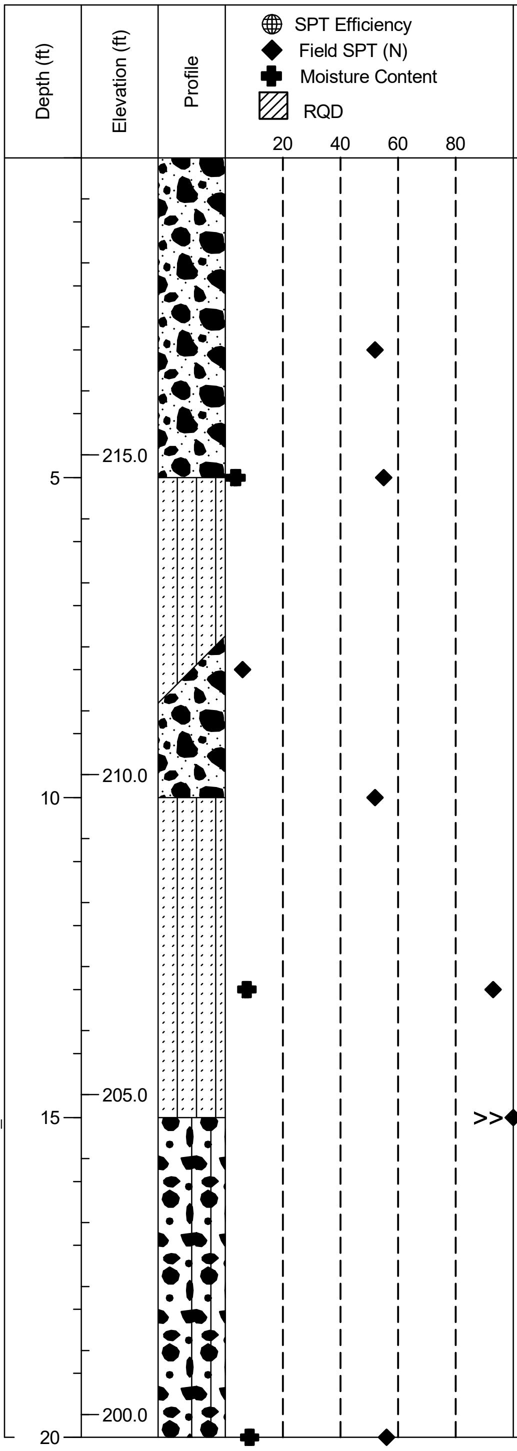
Component Retaining Wall 1
Inspector Harvey, Thomas #2599

Start August 8, 2017
Completion August 14, 2017
Well ID# BJT-731
Equipment CME 55 (9C7-1)

Station MRW 106+24.12
Offset 52.3 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 87.2%

Northing 638488.8689
Easting 1076073.4769
Collected by Region Survey Crew
Method Casing Advancer

Lat 47.0619704
Long -122.7647000
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
18 24 28 (52)		D-1		Well graded GRAVEL with sand, sub-angular, very dense, light brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
15 24 31 (55)		D-2	MC GS	SM, MC=4% Silty SAND with gravel and organics, sub-rounded, very dense, light brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
2 3 3 (6)		D-3		Well graded GRAVEL with sand, sub-rounded, loose, brown, wet, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
4 11 41 (52)		D-4		Silty SAND with gravel, sub-angular, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
24 44 49 (93)		D-5	MC GS	SM, MC=8% Silty SAND with gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
21 53/6" (REF)		D-6		Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft

Groundwater

Instrument

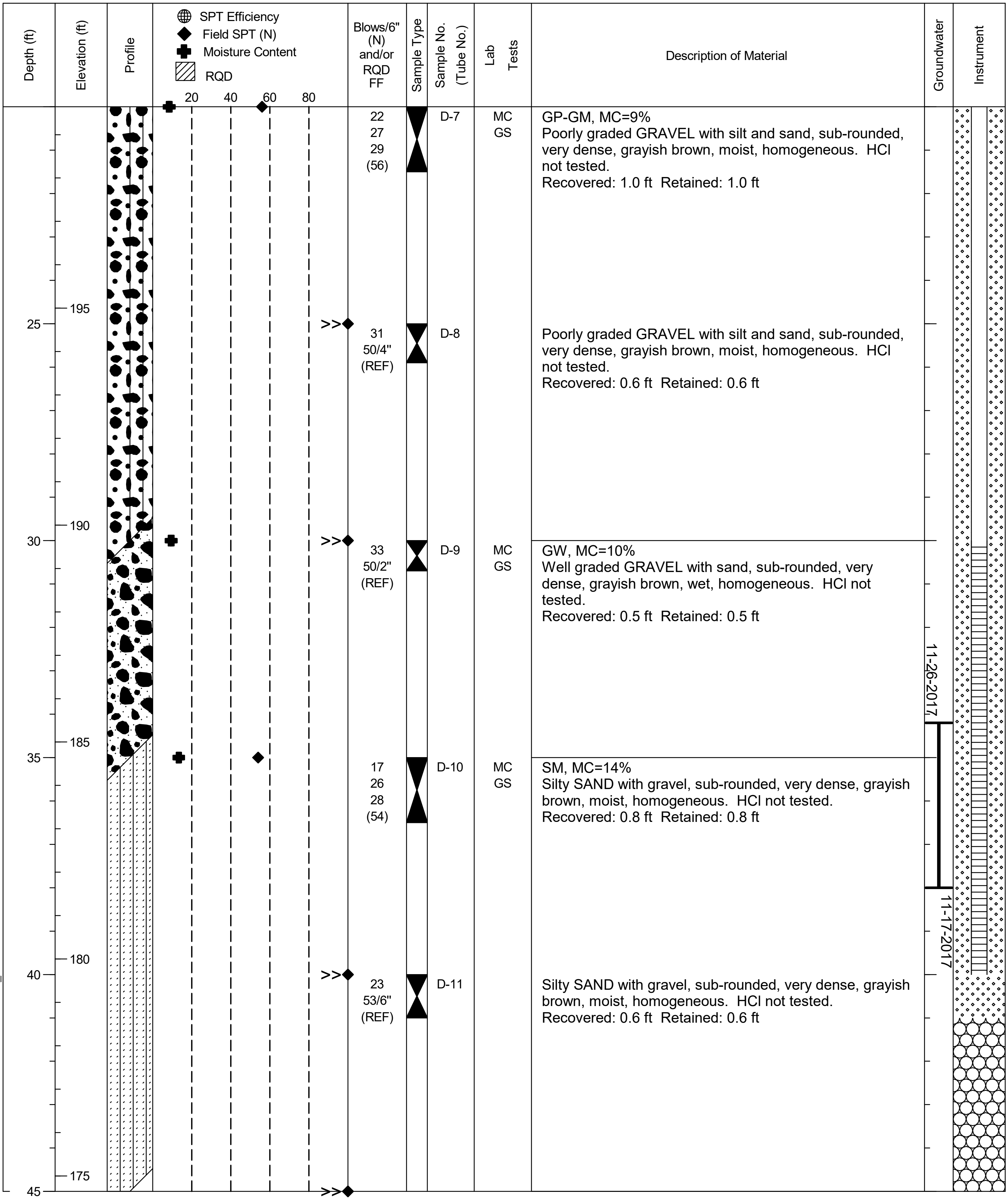
Groundwater readings were taken from 08-14-2017 to 01-22-2018

LOG OF TEST BORING

Job No. XL-5001　SR 005　Elevation 219.6 ft　HOLE No. H-3p-17

Sheet 2 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange　Driller Wilson, Jamie



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
		22 27 29 (56)	D-7	MC GS	GP-GM, MC=9% Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
25	195	31 50/4" (REF)	D-8		Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
30	190	33 50/2" (REF)	D-9	MC GS	GW, MC=10% Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
35	185	17 26 28 (54)	D-10	MC GS	SM, MC=14% Silty SAND with gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
40	180	23 53/6" (REF)	D-11		Silty SAND with gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
45	175				

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 219.6 ft
HOLE No. H-3p-17
Sheet 3 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie

Depth (ft)	Elevation (ft)	Profile	SPT Efficiency Field SPT (N) Moisture Content RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				29 50/3" (REF)	⧗	D-12		Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
50	170									
55	165									
60	160									
65	155									
70	150									

A flush mount monument was installed on this boring.

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 45.8 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 45.8 ft.
Depth of casing during bail test: 45.0 ft.
Water depth before bailing: 11.9 ft.
Bailed bore hole water level to 40.0 ft.
Recharge after 5 minutes: 39.1 ft.
Recharge after 10 minutes: 38.2 ft.
Recharge after 15 minutes: 37.6 ft.
Recharge after 20 minutes: 37.1 ft.
Recharge after 25 minutes: 36.5 ft.
Recharge after 30 minutes: 36.6 ft.
Recharge after 35 minutes: 36.6 ft.

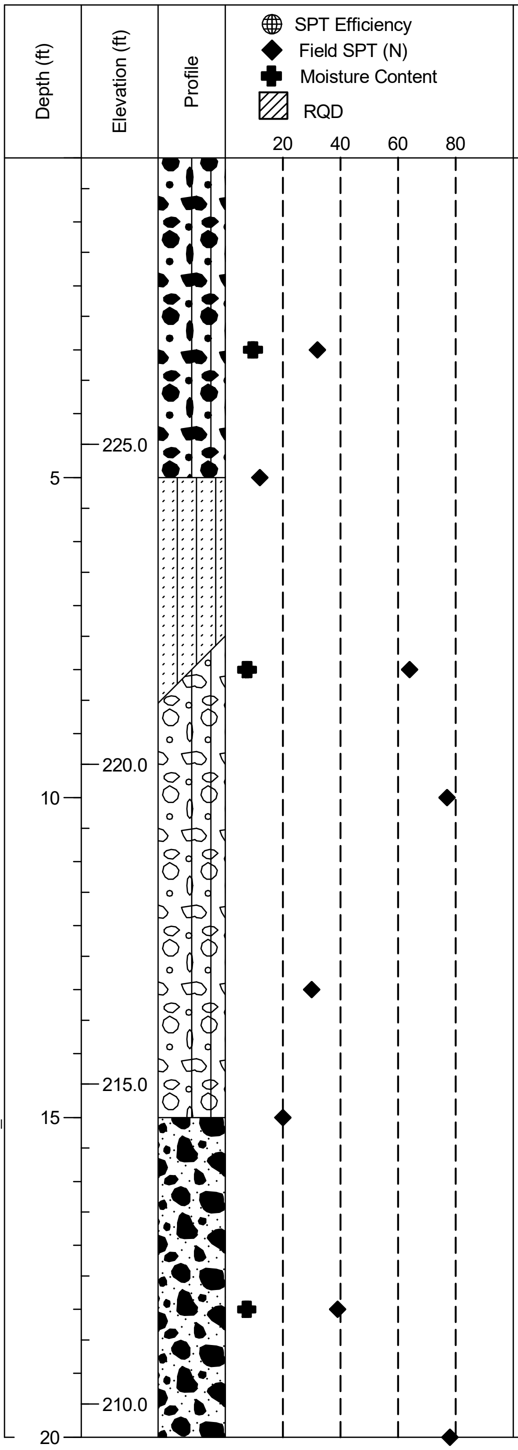
Manual Piezometer Readings:
9-25-2017: Dry to 40.0 ft. (bottom of piezometer screen).
10-30-2017: Dry to 40.0 ft.
12-13-2017: 37.4 ft.
1-22-2018: 37.1 ft.

WSDOT

LOG OF TEST BORING

Start Card RE-14607
HOLE No. H-4p-17
Sheet 1 of 3

Job No. XL-5001
SR 005
Elevation 229.5 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert
Lic# 2779
Component Retaining Wall 2
Inspector Harvey, Thomas #2599
Start August 2, 2017
Completion August 2, 2017
Well ID# BJT-732
Equipment CME 55 (9C7-1)
Station MRW 94+94.48
Offset 81.7 feet right
Hole Dia (inches) 4
Historical SPT Efficiency 87.2%
Northing 639573.8608
Easting 1075792.8861
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0649219
Long -122.7659504
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite



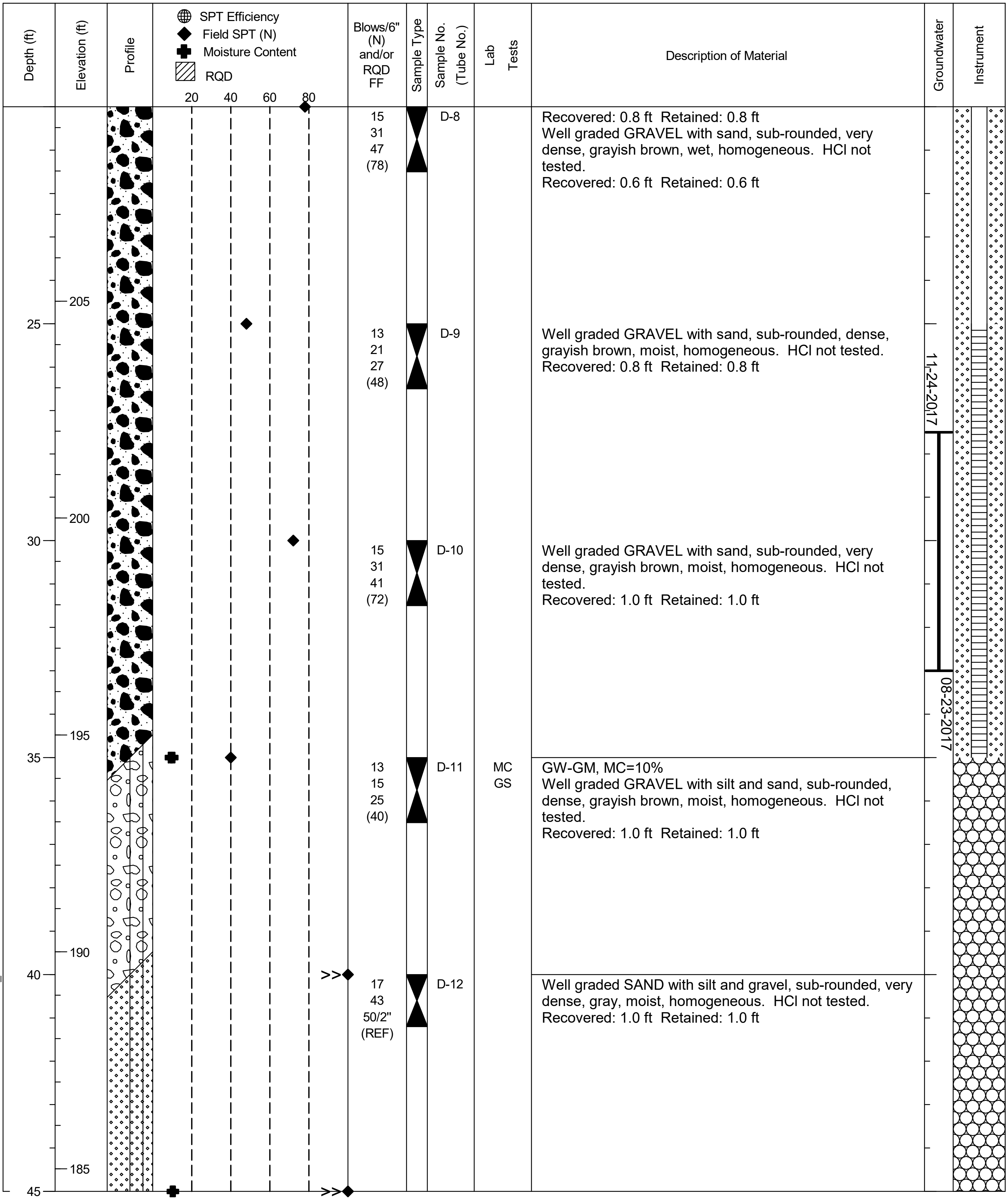
Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
8 21 11 (32)	D-1	MC GS	GP-GM, MC=10% Poorly graded GRAVEL with silt and sand, sub-rounded, dense, dark brown, moist, stratified. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
6 7 5 (12)	D-2		Silty SAND with gravel and organics, sub-rounded, medium dense, dark brown, wet, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
16 27 37 (64)	D-3	MC GS	GW-GM, MC=8% Well graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
13 34 43 (77)	D-4		Well graded GRAVEL with silt and sand, sub-angular, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft
			NOTE: At 12 ft, lost drilling fluid.
17 15 15 (30)	D-5		Well graded GRAVEL with silt and sand, sub-angular, dense, gray, moist, stratified. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
11 9 11 (20)	D-6		Well graded GRAVEL, sub-rounded, medium dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
12 15 24 (39)	D-7	MC GS	NOTE: At 18 ft, regain drilling fluid. GW, MC=8% Well graded GRAVEL with sand and organics, sub-rounded, dense, brown, wet, homogeneous. HCl not tested.

Groundwater readings were taken from 08-14-2017 to 01-22-2018

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 229.5 ft
HOLE No. H-4p-17
Sheet 2 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert



Depth (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
	15 31 47 (78)	D-8		Recovered: 0.8 ft Retained: 0.8 ft Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
25	13 21 27 (48)	D-9		Well graded GRAVEL with sand, sub-rounded, dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
30	15 31 41 (72)	D-10		Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
35	13 15 25 (40)	D-11	MC GS	GW-GM, MC=10% Well graded GRAVEL with silt and sand, sub-rounded, dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
40	17 43 50/2" (REF)	D-12		Well graded SAND with silt and gravel, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 229.5 ft
HOLE No. H-4p-17
Sheet 3 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert

Depth (ft)	Elevation (ft)	Profile	SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			>>◆	41 53/6" (REF)	⧗	D-13	MC GS	SW-SM, MC=11% Well graded SAND with silt and gravel, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
	180									
50			>>◆	27 50/3" (REF)	⧗	D-14		Well graded SAND with silt and gravel, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
	175									
55										
	170									
60										
	165									
65										
	160									
70										

A flush mount monument was installed on this boring.

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 50.8 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 50.8 ft.
Depth of casing during bail test: 50.0 ft.
Water depth before bailing: 12.3 ft.
Bailed bore hole water level to 48.2 ft.
Recharge after 5 minutes: 47.7 ft.
Recharge after 10 minutes: 47.4 ft.
Recharge after 15 minutes: 47.3 ft.
Recharge after 20 minutes: 47.3 ft.
Recharge after 25 minutes: 47.3 ft.
Recharge after 30 minutes: 47.3 ft.

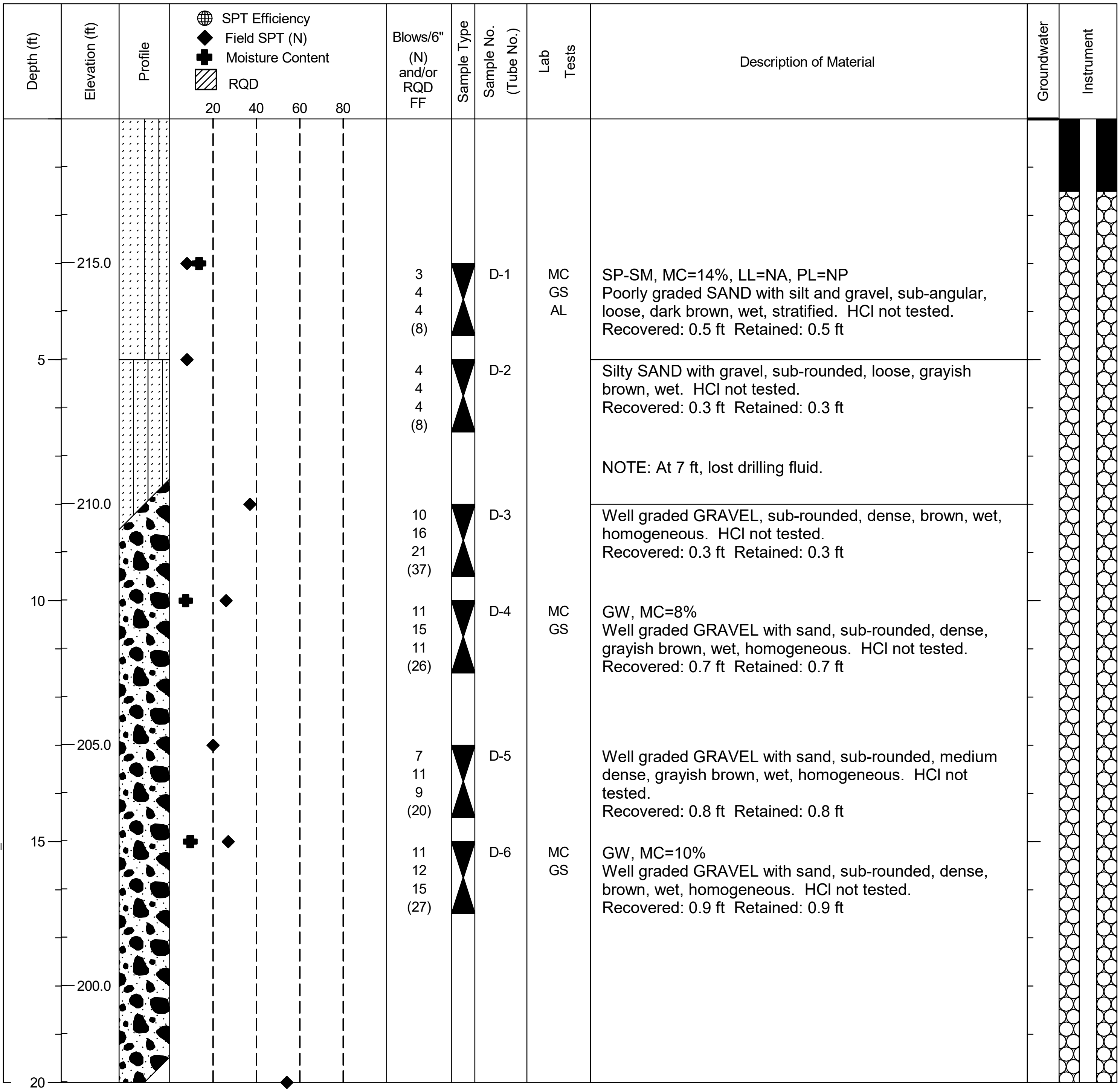
Manual Piezometer Readings:
8-14-2017: 31.9 ft.
9-28-2017: 33.7 ft.
10-30-2017: 29.4 ft.
12-13-2017: 30.0 ft.
1-22-2018: 29.3 ft.

LOG OF TEST BORING

WSDOT

Start Card RE-14607
HOLE No. H-5p-17
Sheet 1 of 3

Job No. XL-5001
SR 005
Elevation 218.0 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert
Lic# 2779
Component Retaining Wall 2
Inspector Harvey, Thomas #2599
Start July 31, 2017
Completion August 1, 2017
Well ID# BJT-733
Equipment CME 55 (9C7-1)
Station MRW 96+01.22
Offset 112.1 feet right
Hole Dia (inches) 4
Historical SPT Efficiency 87.2%
Northing 639500.6575
Easting 1075764.8406
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0647191
Long -122.7660545
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
3 4 4 (8)	D-1	MC GS AL	SP-SM, MC=14%, LL=NA, PL=NP Poorly graded SAND with silt and gravel, sub-angular, loose, dark brown, wet, stratified. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
4 4 4 (8)	D-2		Silty SAND with gravel, sub-rounded, loose, grayish brown, wet. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
			NOTE: At 7 ft, lost drilling fluid.
10 16 21 (37)	D-3		Well graded GRAVEL, sub-rounded, dense, brown, wet, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
11 15 11 (26)	D-4	MC GS	GW, MC=8% Well graded GRAVEL with sand, sub-rounded, dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
7 11 9 (20)	D-5		Well graded GRAVEL with sand, sub-rounded, medium dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
11 12 15 (27)	D-6	MC GS	GW, MC=10% Well graded GRAVEL with sand, sub-rounded, dense, brown, wet, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft

WSDOT

LOG OF TEST BORING

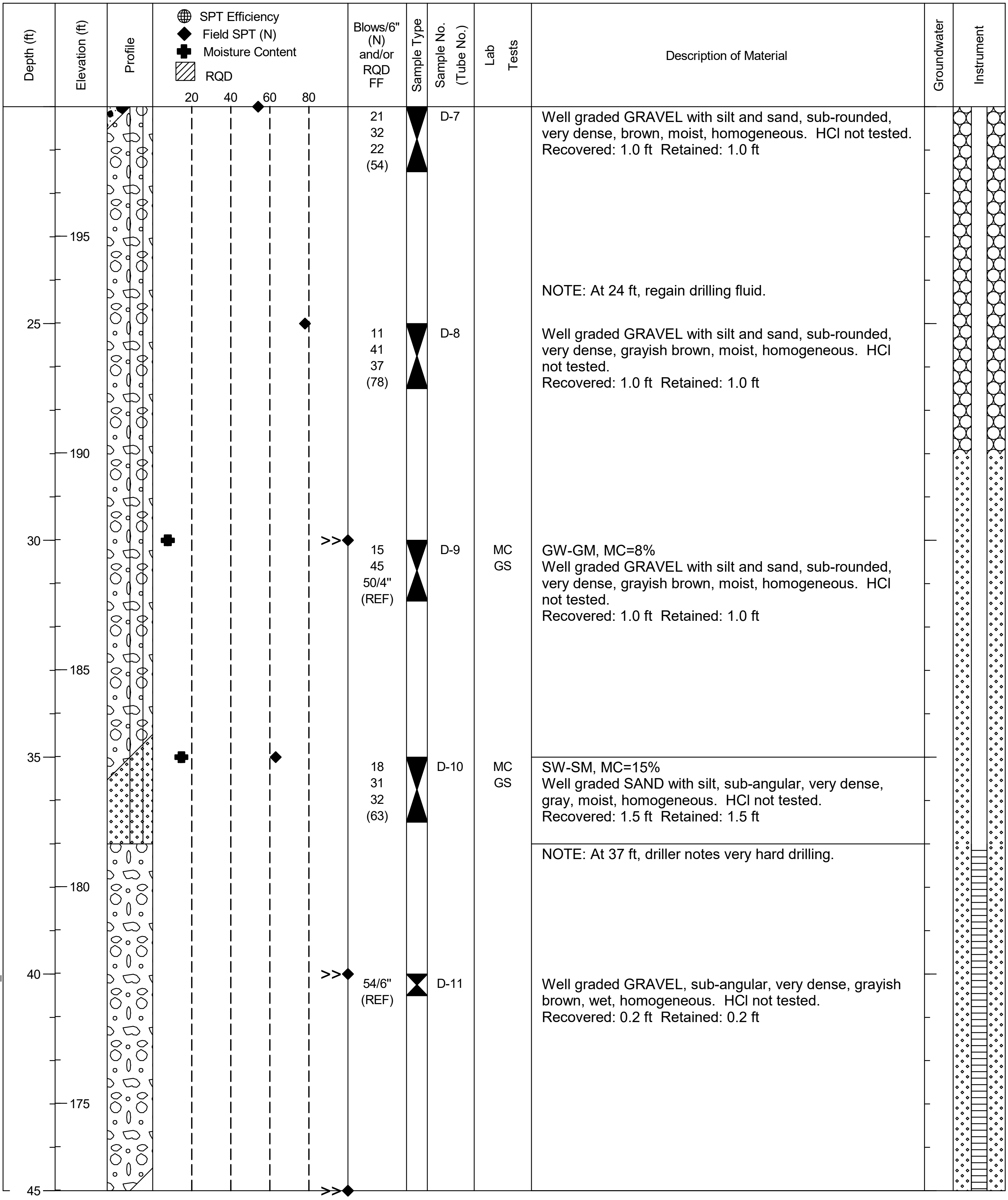
Job No. XL-5001 SR 005 Elevation 218.0 ft

HOLE No. H-5p-17

Sheet 2 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Haller, Robert



Depth (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
	21 32 22 (54)	D-7		Well graded GRAVEL with silt and sand, sub-rounded, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
				NOTE: At 24 ft, regain drilling fluid.
25	11 41 37 (78)	D-8		Well graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
30	15 45 50/4" (REF)	D-9	MC GS	GW-GM, MC=8% Well graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
35	18 31 32 (63)	D-10	MC GS	SW-SM, MC=15% Well graded SAND with silt, sub-angular, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft
				NOTE: At 37 ft, driller notes very hard drilling.
40	54/6" (REF)	D-11		Well graded GRAVEL, sub-angular, very dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 218.0 ft
HOLE No. H-5p-17
Sheet 3 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert

🌐 SPT Efficiency
◆ Field SPT (N)
✚ Moisture Content
▨ RQD

Depth (ft)	Elevation (ft)	Profile	20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			>>◆	13 50/6" (REF)		D-12		Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft		
	170									
50			✚ >>◆	35 60/6" (REF)		D-13	MC GS	GP-GM, MC=10% Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft		
	165									
55										
	160									
60										
	155									
65										
	150									
70										

A flush mount monument was installed on this boring.

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 51.0 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 50.0 ft.
Depth of casing during bail test: 49.0 ft.
Water depth before bailing: 21.5 ft.
Bailed bore hole water level to 47.0 ft.

Bail test not complete.

A water level of 47.5 ft below ground surface was observed on the morning of 8-1-2017, prior to the start of drilling operations.

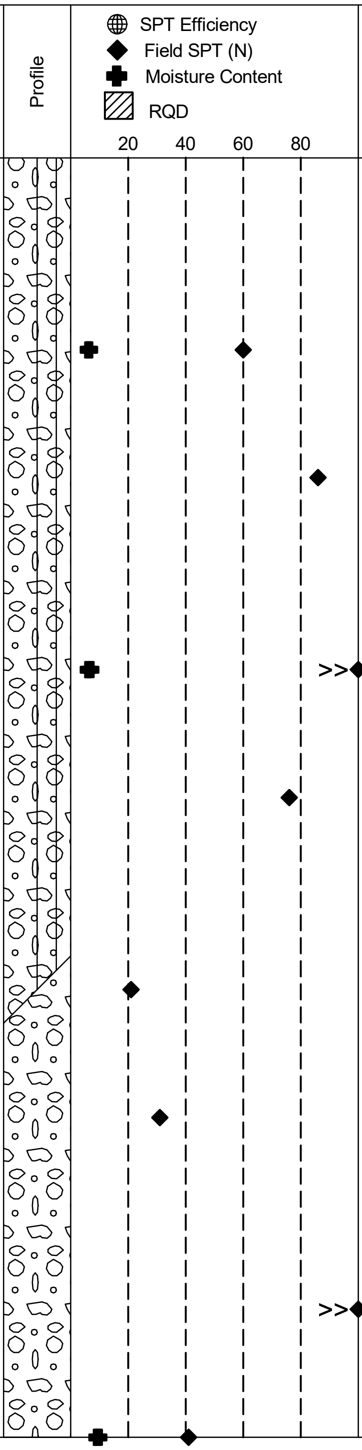
Manual Piezometer Readings:
8-14-2017: 43.3 ft.
9-28-2017: Dry to 49.5 ft. (bottom of piezometer screen).
10-30-2017: 45.5 ft.
12-13-2017: Dry to 49.5 ft.
1-22-2018: Dry to 46.2 ft.

WSDOT

LOG OF TEST BORING

Start Card SE-62760 / AE-44015
HOLE No. H-6-17
Sheet 1 of 3

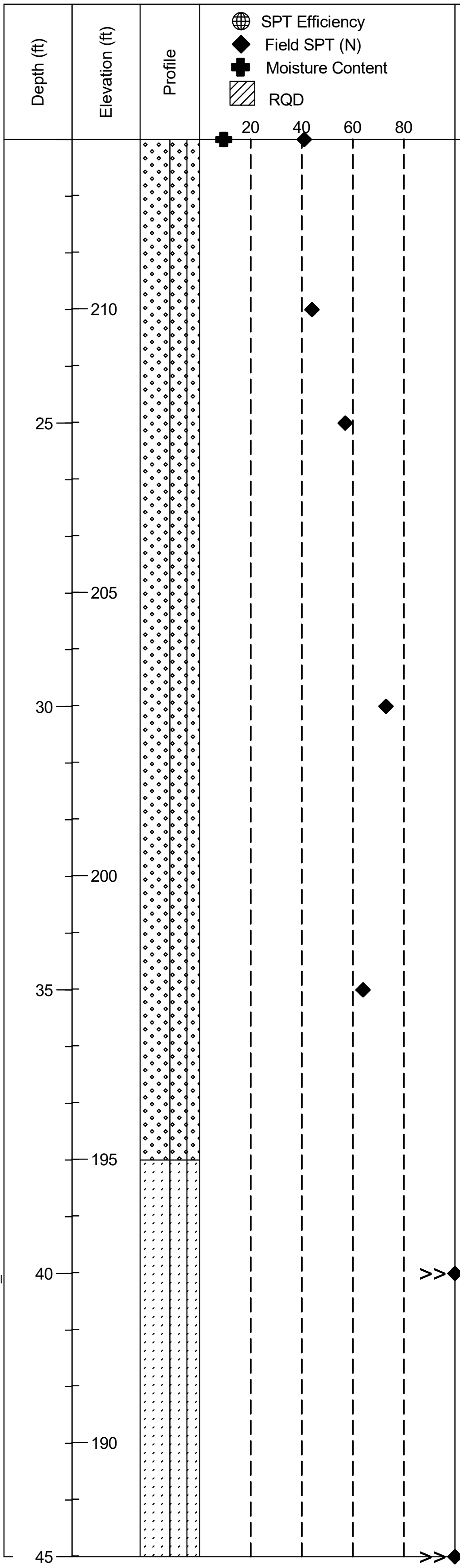
Job No. XL-5001
SR 005
Elevation 233.0 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert
Lic# 2779
Component Retaining Wall 2
Inspector Harvey, Thomas #2599
Start August 1, 2017
Completion August 1, 2017
Well ID# N/A
Equipment CME 55 (9C7-1)
Station MRW 95+92.23
Offset 68.9 feet right
Hole Dia (inches) 4
Historical SPT Efficiency 87.2%
Northing 639504.3053
Easting 1075808.8483
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0647326
Long -122.7658784
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	230.0	11 24 36 (60)		D-1	MC GS	GW-GM, MC=7% Well graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
5		11 38 48 (86)		D-2		Well graded GRAVEL with silt and sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
	225.0	27 50/6" (REF)		D-3	MC GS	GW-GM, MC=7% Well graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
10		21 35 41 (76)		D-4		Well graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
	220.0	7 7 14 (21)		D-5		Well graded GRAVEL with organics, sub-angular, medium dense, dark brown, wet, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft		
15		11 15 16 (31)		D-6		Well graded GRAVEL, sub-rounded, dense, brown, wet, homogeneous. HCl not tested. Recovered: 0.1 ft Retained: 0.1 ft		
						NOTE: At 17 ft, lost drilling fluid.		
	215.0	23 50/2" (REF)		D-7		Well graded GRAVEL, sub-rounded, very dense, gray, wet, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft		
20								

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 233.0 ft
HOLE No. H-6-17
Sheet 2 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
15 20 21 (41)	D-8	MC GS	SW-SM, MC=10% Well graded SAND with silt and gravel, sub-rounded, dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
13 21 23 (44)	D-9		Well graded SAND with silt and gravel, sub-rounded, dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
12 24 33 (57)	D-10		Well graded SAND with silt and gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
15 32 41 (73)	D-11		Well graded SAND with silt and gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
26 31 33 (64)	D-12		Well graded SAND with silt and gravel, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
			NOTE: At 38 ft, driller notes very hard drilling.
21 50/3" (REF)	D-13		Poorly graded SAND with silt and gravel, sub-rounded, very dense, grayish brown, wet, stratified. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft

WSDOT

LOG OF TEST BORING

HOLE No. H-6-17

Job No. XL-5001 SR 005 Elevation 233.0 ft

Sheet 3 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange

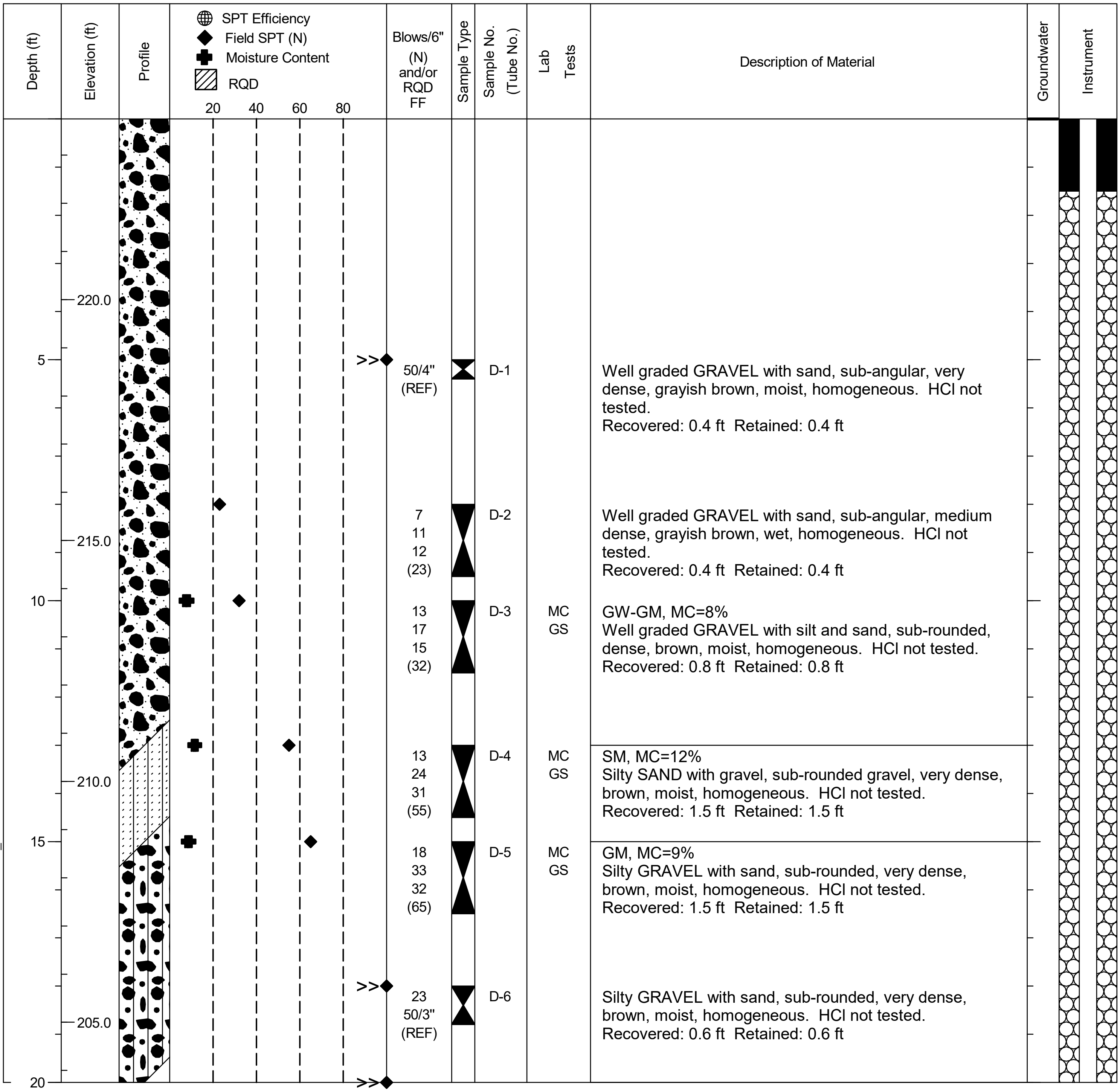
Driller Haller, Robert

Depth (ft)	Elevation (ft)	Profile	🌐 SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			>>◆	22 58/6" (REF)	⧗	D-14		Poorly graded SAND with silt and gravel, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft		
	185									
50			✚ >>◆	36 50/6" (REF)	⧗	D-15	MC GS	SP-SM, MC=9% Poorly graded SAND with silt and gravel, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
								The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
	180									
55								End of test hole boring at 51.0 ft below ground surface. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
								Bail/Recharge test: Hole Diameter: 4 in. Depth of boring during bail test: 51.0 ft. Depth of casing during bail test: 50.0 ft. Water depth before bailing: 30.2 ft. Bailed bore hole water level to 47.8 ft. Recharge after 5 minutes: 47.9 ft. Recharge after 10 minutes: 47.9 ft. Recharge after 30 minutes: 47.9 ft.		
	175									
60										
	170									
65										
	165									
70										

WSDOT

LOG OF TEST BORING

Start Card RE-14608
HOLE No. H-7p-17
Sheet 1 of 5
Job No. XL-5001
SR 005
Elevation 223.8 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert
Lic# 2779
Component Bridge Widening - Pier 3 (Abutment)
Inspector Harvey, Thomas #2599
Start August 22, 2017
Completion August 24, 2017
Well ID# BJT-727
Equipment CME 45 (9C4-3)
Station MRW 101+53.78
Offset 93.2 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 86.1%
Northing 638950.2575
Easting 1076008.1422
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0632298
Long -122.7650152
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Varied



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
50/4" (REF)	D-1		Well graded GRAVEL with sand, sub-angular, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
7 11 12 (23)	D-2		Well graded GRAVEL with sand, sub-angular, medium dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
13 17 15 (32)	D-3	MC GS	GW-GM, MC=8% Well graded GRAVEL with silt and sand, sub-rounded, dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
13 24 31 (55)	D-4	MC GS	SM, MC=12% Silty SAND with gravel, sub-rounded gravel, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft
18 33 32 (65)	D-5	MC GS	GM, MC=9% Silty GRAVEL with sand, sub-rounded, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft
23 50/3" (REF)	D-6		Silty GRAVEL with sand, sub-rounded, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft

WSDOT

LOG OF TEST BORING

Job No. XL-5001

SR 005

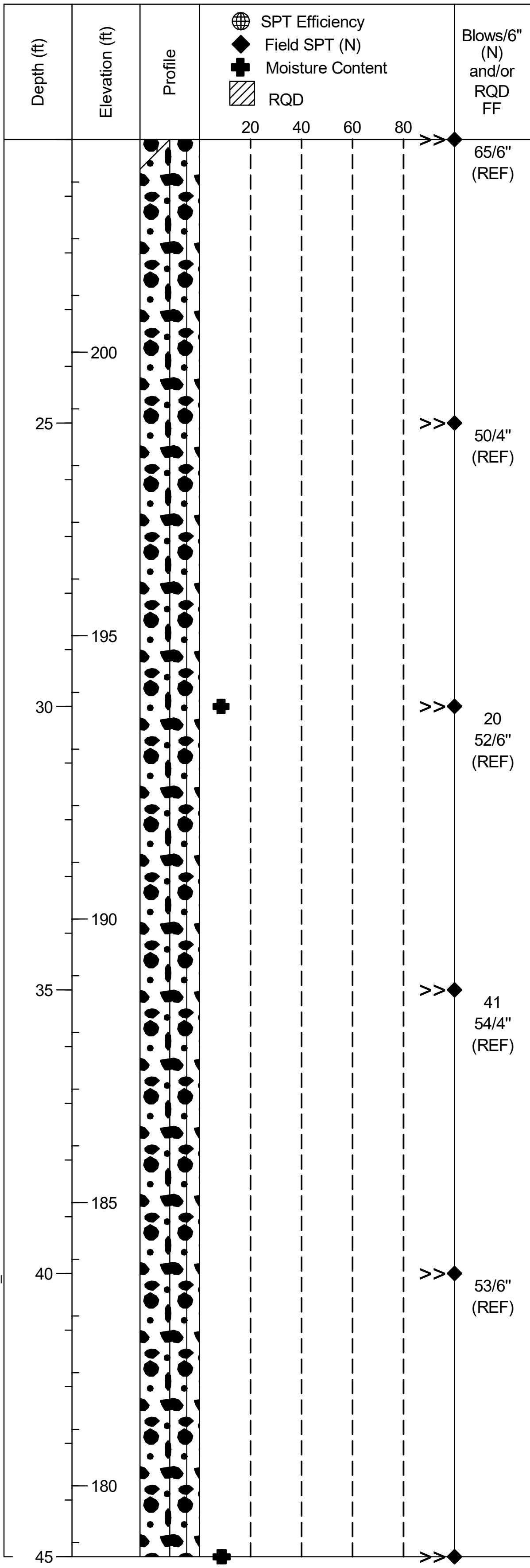
Elevation 223.8 ft

HOLE No. H-7p-17

Sheet 2 of 5

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Haller, Robert



Depth (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
	65/6" (REF)	D-7		Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
25	50/4" (REF)	D-8		Silty SAND with gravel, sub-rounded gravel, very dense, brown, wet, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
30	20 52/6" (REF)	D-9	MC GS	GP-GM, MC=9% Poorly graded GRAVEL with silt and sand, sub-angular, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
35	41 54/4" (REF)	D-10		Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
40	53/6" (REF)	D-11		Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft

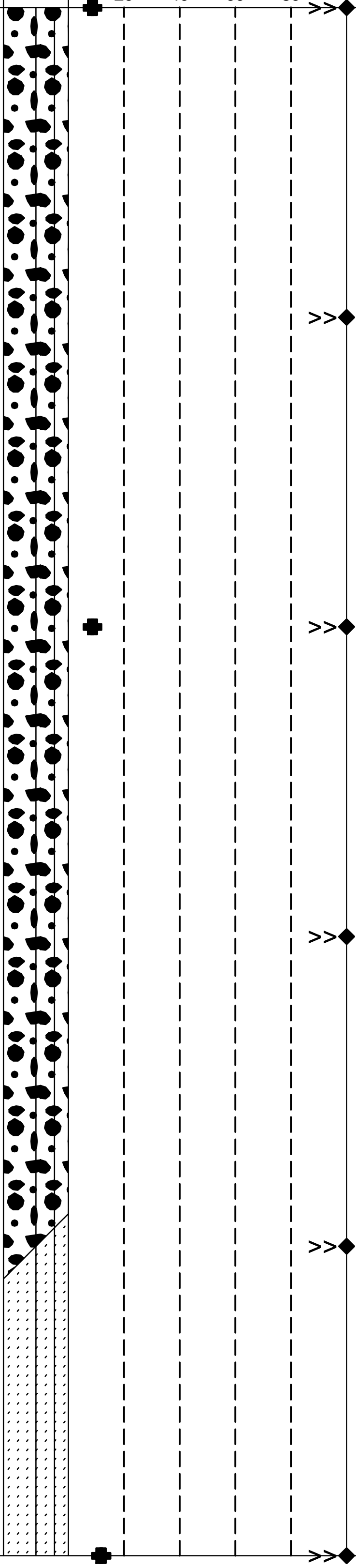
Groundwater

Instrument

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 223.8 ft
HOLE No. H-7p-17
Sheet 3 of 5
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert

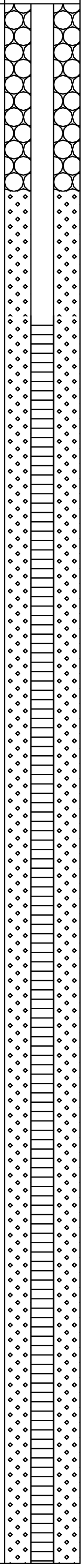
◍ SPT Efficiency
◆ Field SPT (N)
✚ Moisture Content
▨ RQD



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
		52/6" (REF)	⧗	D-12	MC GS	GP-GM, MC=9% Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
	175					
50		27 50/3" (REF)	⧗	D-13		Well graded GRAVEL with sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
	170					
55		29 50/4" (REF)	⧗	D-14	MC GS	GP-GM, MC=9% Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
	165					
60		50/4" (REF)	⧗	D-15		Well graded GRAVEL with sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
	160					
65		50/3" (REF)	⧗	D-16		Poorly graded SAND with silt and gravel, sub-angular gravel, very dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
	155					
70						

Groundwater

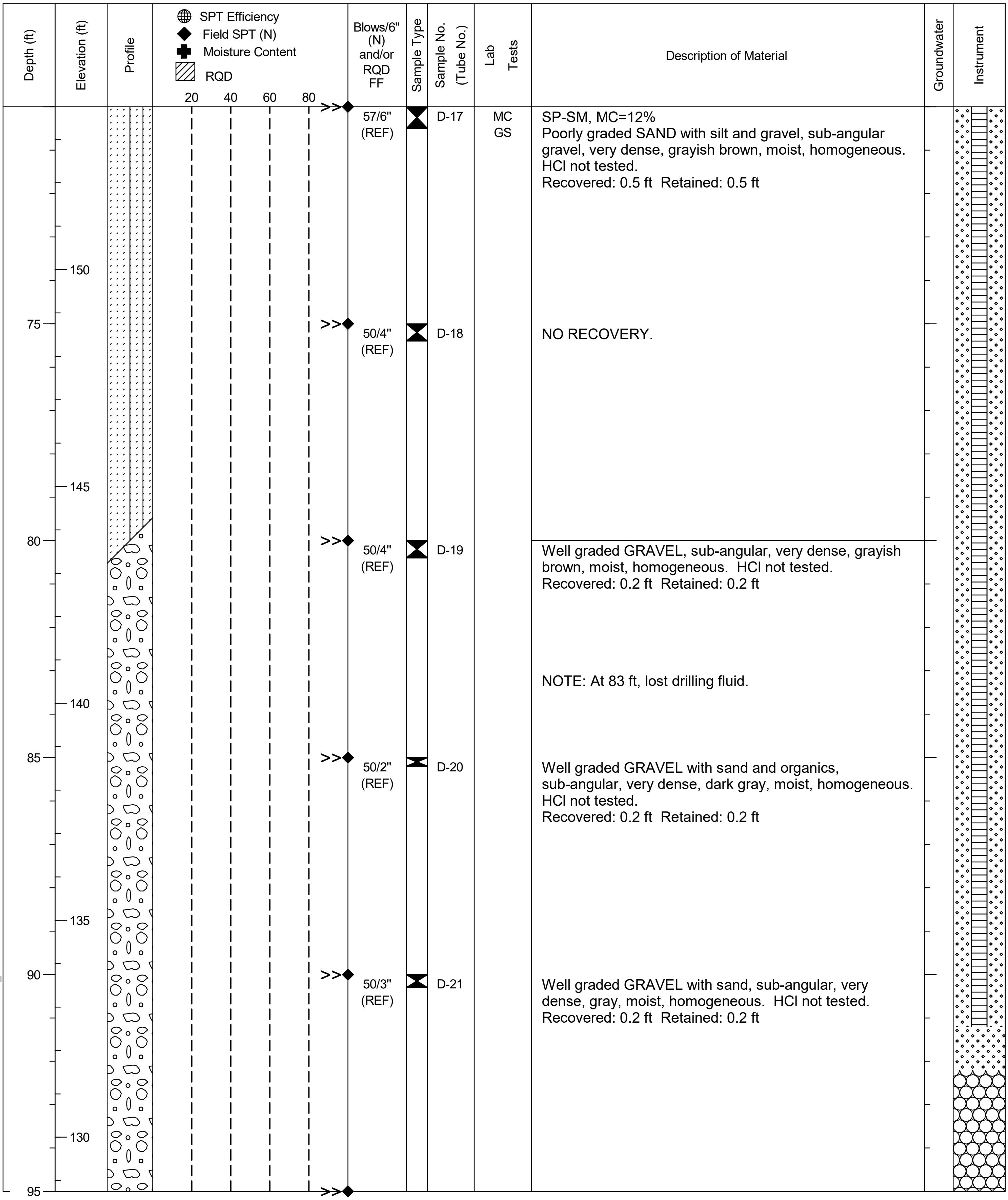
Instrument



WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 223.8 ft
HOLE No. H-7p-17
Sheet 4 of 5
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert



Depth (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
72.5	57/6" (REF)	⧗	D-17	MC GS	SP-SM, MC=12% Poorly graded SAND with silt and gravel, sub-angular gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
75	50/4" (REF)	⧗	D-18		NO RECOVERY.
80	50/4" (REF)	⧗	D-19		Well graded GRAVEL, sub-angular, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
					NOTE: At 83 ft, lost drilling fluid.
85	50/2" (REF)	⧗	D-20		Well graded GRAVEL with sand and organics, sub-angular, very dense, dark gray, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
90	50/3" (REF)	⧗	D-21		Well graded GRAVEL with sand, sub-angular, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 223.8 ft
HOLE No. H-7p-17
Sheet 5 of 5
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Haller, Robert

- 🌐 SPT Efficiency
- ◆ Field SPT (N)
- ✚ Moisture Content
- ▨ RQD

20 40 60 80

Depth (ft)	Elevation (ft)	Field SPT (N)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
		>>◆	50/2" (REF)	⧗	D-22		Well graded GRAVEL with sand, sub-angular, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
	125						
100		>>◆	50/3" (REF)	⧗	D-23		Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
	120						
105							
	115						
110							
	110						
115							
	105						
120							

A standpipe monument was installed on this boring.

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 100.3 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 100.3 ft.
Depth of casing during bail test: 90.0 ft.
Water depth before bailing: 27.7 ft.
Bailed bore hole water level to 90.0 ft.
Recharge after 5 minutes: 94.2 ft.
Recharge after 10 minutes: 94.2 ft.
Recharge after 15 minutes: 94.3 ft.
Recharge after 20 minutes: 94.3 ft.
Recharge after 25 minutes: 94.3 ft.
Recharge after 30 minutes: 94.3 ft.
Recharge after 45 minutes: 94.3 ft.

Manual Piezometer Readings:
8-30-2017: Dry to 91.2 ft. (bottom of piezometer screen).
9-25-2017: 85.1 ft.
10-30-2017: 88.2 ft.
12-13-2017: 90.3 ft.
1-22-2018: 90.1 ft.

WSDOT

LOG OF TEST BORING

Start Card RE-14608
HOLE No. H-8p-17
Sheet 1 of 5

Job No. XL-5001
SR 005
Elevation 223.7 ft

Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Shepherd, Robert Lic# 2710

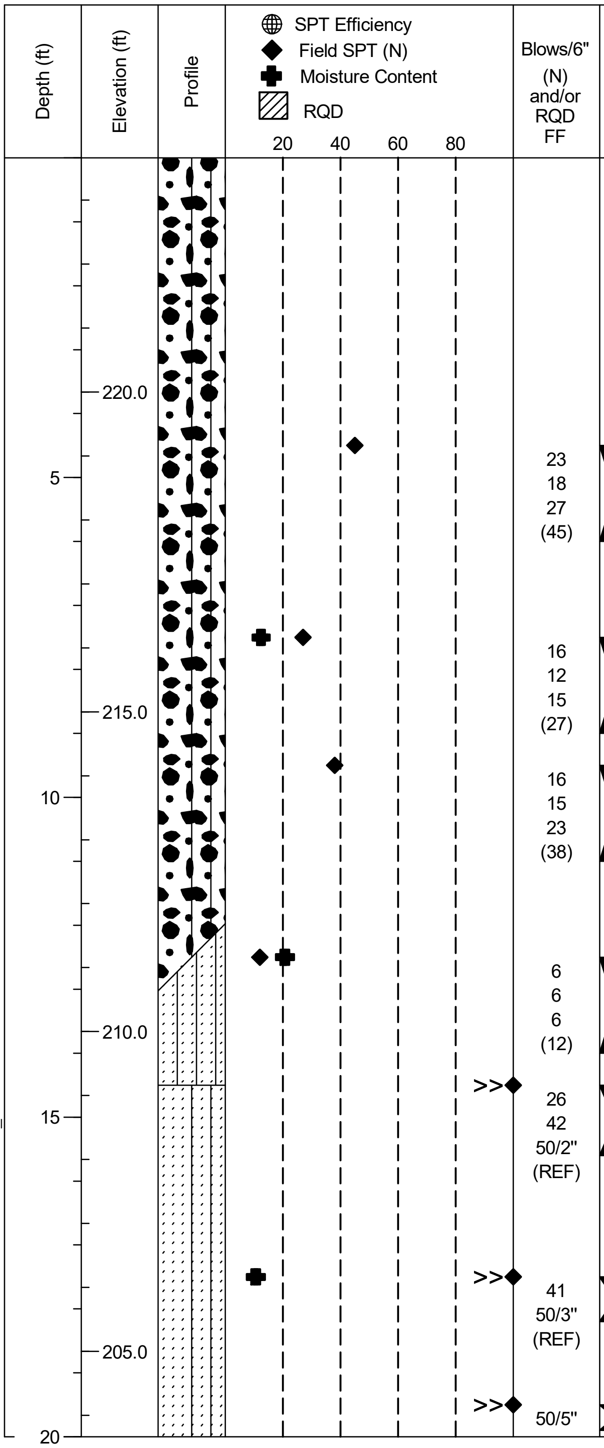
Component Bridge Widening - Pier 2 (Center)
Inspector Fetterly, Jamie #2507

Start August 14, 2017
Completion August 17, 2017
Well ID# BJT-728
Equipment CME 850 (9C2-5)

Station MRW 100+44.43
Offset 85.7 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 92.8%

Northing 639057.732
Easting 1075988.0182
Collected by Region Survey Crew
Method Casing Advancer

Lat 47.0635228
Long -122.7651083
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
23 18 27 (45)	D-1		Poorly graded GRAVEL with silt and sand, sub-angular, dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
16 12 15 (27)	D-2	MC GS	GP-GM, MC=13% Poorly graded GRAVEL with silt and sand, sub-angular, dense, olive brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
16 15 23 (38)	D-3		Poorly graded GRAVEL with silt and sand, sub-rounded, dense, olive brown, moist, stratified. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
6 6 6 (12)	D-4	MC GS	SM, MC=21% Silty SAND, medium dense, light brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
26 42 50/2" (REF)	D-5		Poorly graded SAND with silt and gravel, sub-angular gravel, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft
41 50/3" (REF)	D-6	MC GS	SP-SM, MC=11% Poorly graded SAND with silt and gravel, sub-angular gravel, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
50/5"	D-7		Poorly graded SAND with silt and gravel, sub-rounded

Groundwater

Instrument

LOG OF TEST BORING

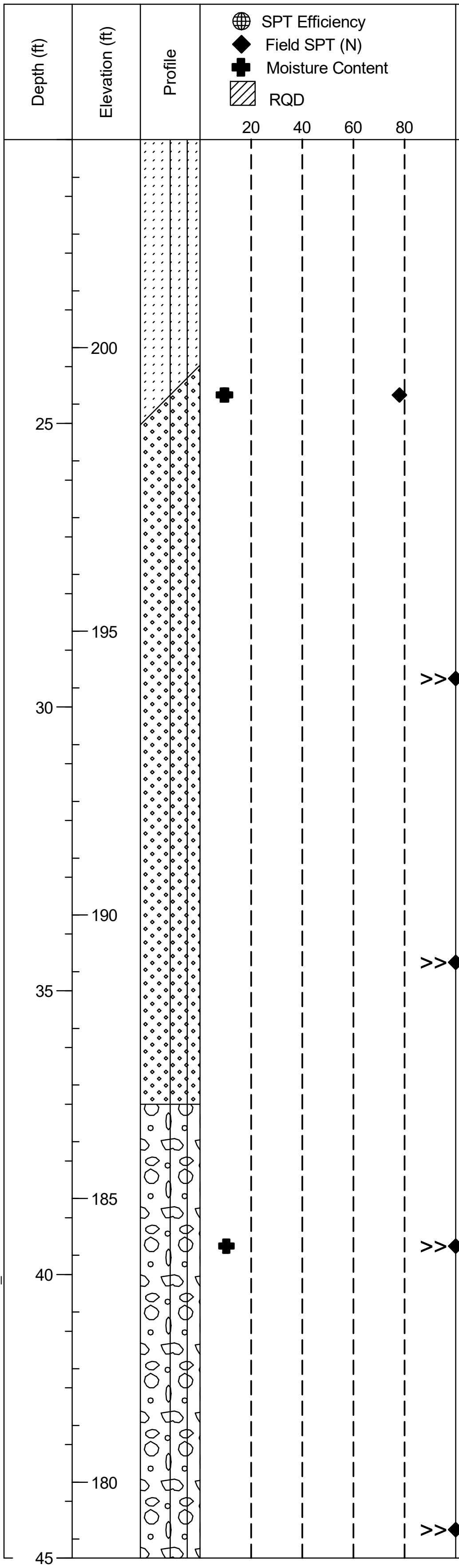
Job No. XL-5001   SR 005   Elevation 223.7 ft

HOLE No. H-8p-17

Sheet 2 of 5

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Shepherd, Robert



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
(REF)			gravel, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
29 33 45 (78)	D-8	MC GS	SW-SM, MC=10% Well graded SAND with silt and gravel, angular gravel, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
37 50/6" (REF)	D-9		Well graded SAND with silt and gravel, angular gravel, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
28 50/4" (REF)	D-10		Well graded SAND with silt and gravel, angular gravel, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
30 50/5" (REF)	D-11	MC GS	GW-GM, MC=11% Well graded GRAVEL with silt and sand, sub-rounded, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
50/4"	D-12		Well graded GRAVEL with sand, sub-rounded, very

Sample Type | Groundwater | Instrument

WSDOT

LOG OF TEST BORING

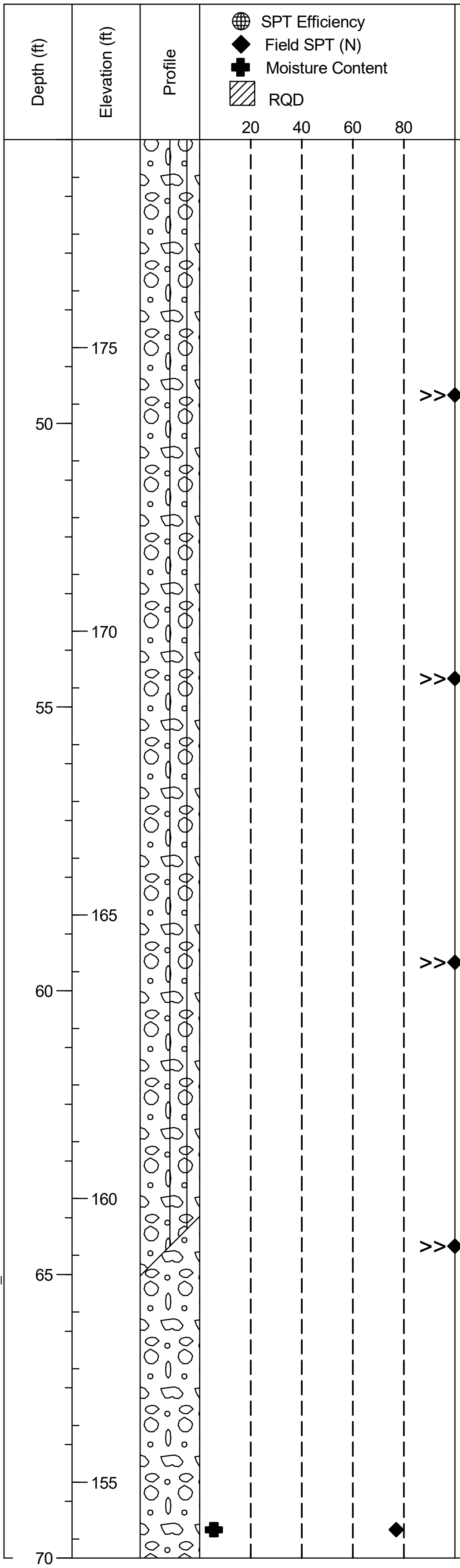
Job No. XL-5001 SR 005 Elevation 223.7 ft

HOLE No. H-8p-17

Sheet 3 of 5

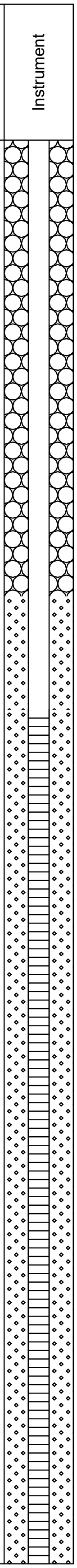
Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Shepherd, Robert



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
(REF)				dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
				NOTE: At 47.5 ft, lost drilling fluid.
34 50/4" (REF)	⧗	D-13		Well graded GRAVEL with silt and sand, sub-rounded, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
50/4" (REF)	⧗	D-14		Well graded GRAVEL with silt and sand, sub-rounded, very dense, olive, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
50/2" (REF)	⧗	D-15		NO RECOVERY.
50/3" (REF)	⧗	D-16		Well graded GRAVEL with sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
30	⧗	D-17	MC	GW, MC=6%

Groundwater



LOG OF TEST BORING

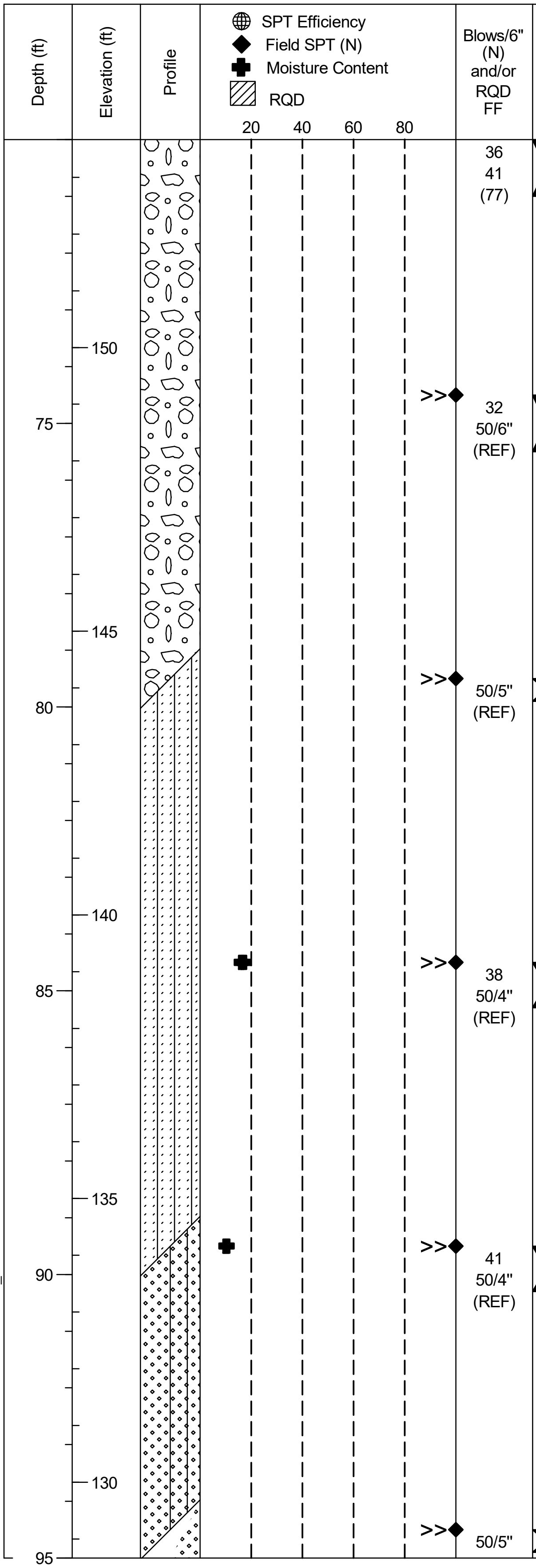
Job No. XL-5001 SR 005 Elevation 223.7 ft

HOLE No. H-8p-17

Sheet 4 of 5

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Shepherd, Robert



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
36 41 (77)			GS	Well graded GRAVEL with sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft NOTE: At 70 ft, lost drilling fluid. NOTE: From 71 to 74.5 ft, drilling action indicates cobbles and boulders.
32 50/6" (REF)		D-18		Well graded GRAVEL with sand, sub-rounded, very dense, gray, wet, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
50/5" (REF)		D-19		Silty SAND with gravel, sub-rounded gravel, very dense, light gray, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
38 50/4" (REF)		D-20	MC GS	SM, MC=17% Silty SAND with gravel, sub-rounded gravel, very dense, light gray, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
41 50/4" (REF)		D-21	MC GS	SW-SM, MC=11% Well graded SAND with silt and gravel, sub-rounded gravel, very dense, light brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft
50/5"		D-22		Well graded SAND with gravel, sub-rounded gravel, very

WSDOT

LOG OF TEST BORING

Job No. XL-5001 SR 005 Elevation 223.7 ft

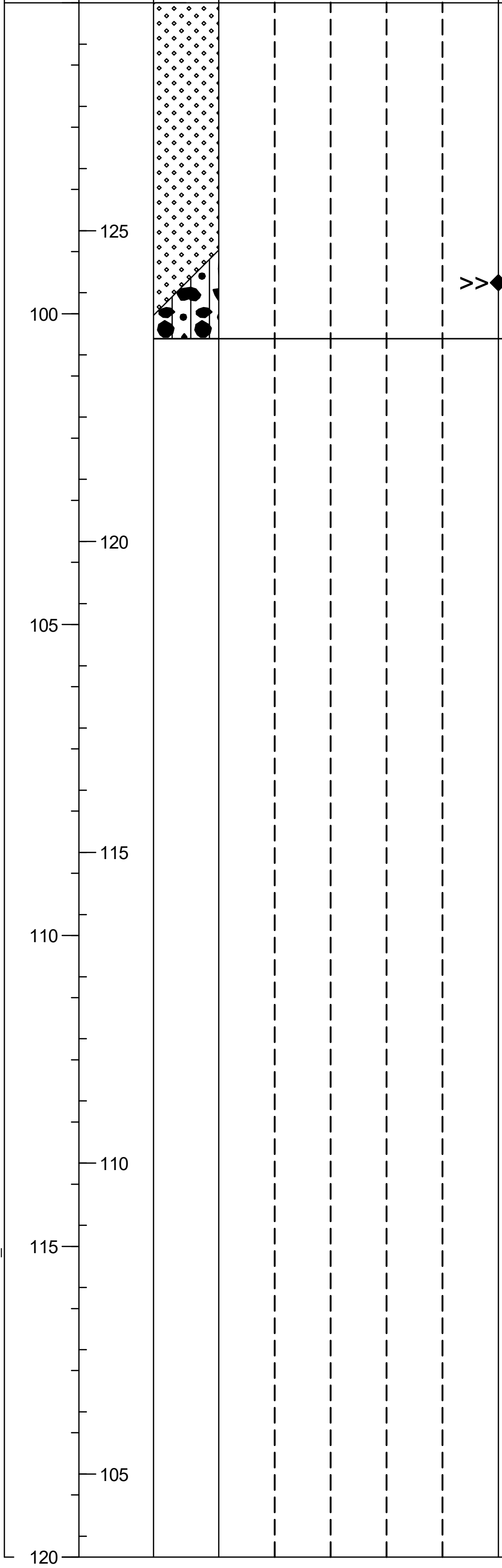
HOLE No. H-8p-17

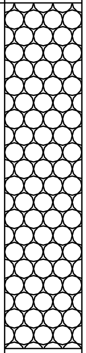
Sheet 5 of 5

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Shepherd, Robert

Depth (ft)	Elevation (ft)	Profile	SPT Efficiency / Field SPT (N) / Moisture Content / RQD (20 40 60 80)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				(REF)				dense, olive brown, wet, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		
			>>	49 50/5" (REF)		D-23		Silty GRAVEL with sand, sub-rounded, very dense, olive brown, wet, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		





A flush mount monument was installed on this boring.

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 100.4 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 100.4 ft.
Depth of casing during bail test: 99.0 ft.
Water depth before bailing: 74.0 ft.
Bailed bore hole water level to 100.0 ft.
Recharge after 1 minutes: 100.0 ft.
Recharge after 2 minutes: 100.0 ft.
Recharge after 3 minutes: 100.0 ft.
Recharge after 4 minutes: 100.0 ft.
Recharge after 5 minutes: 100.0 ft.

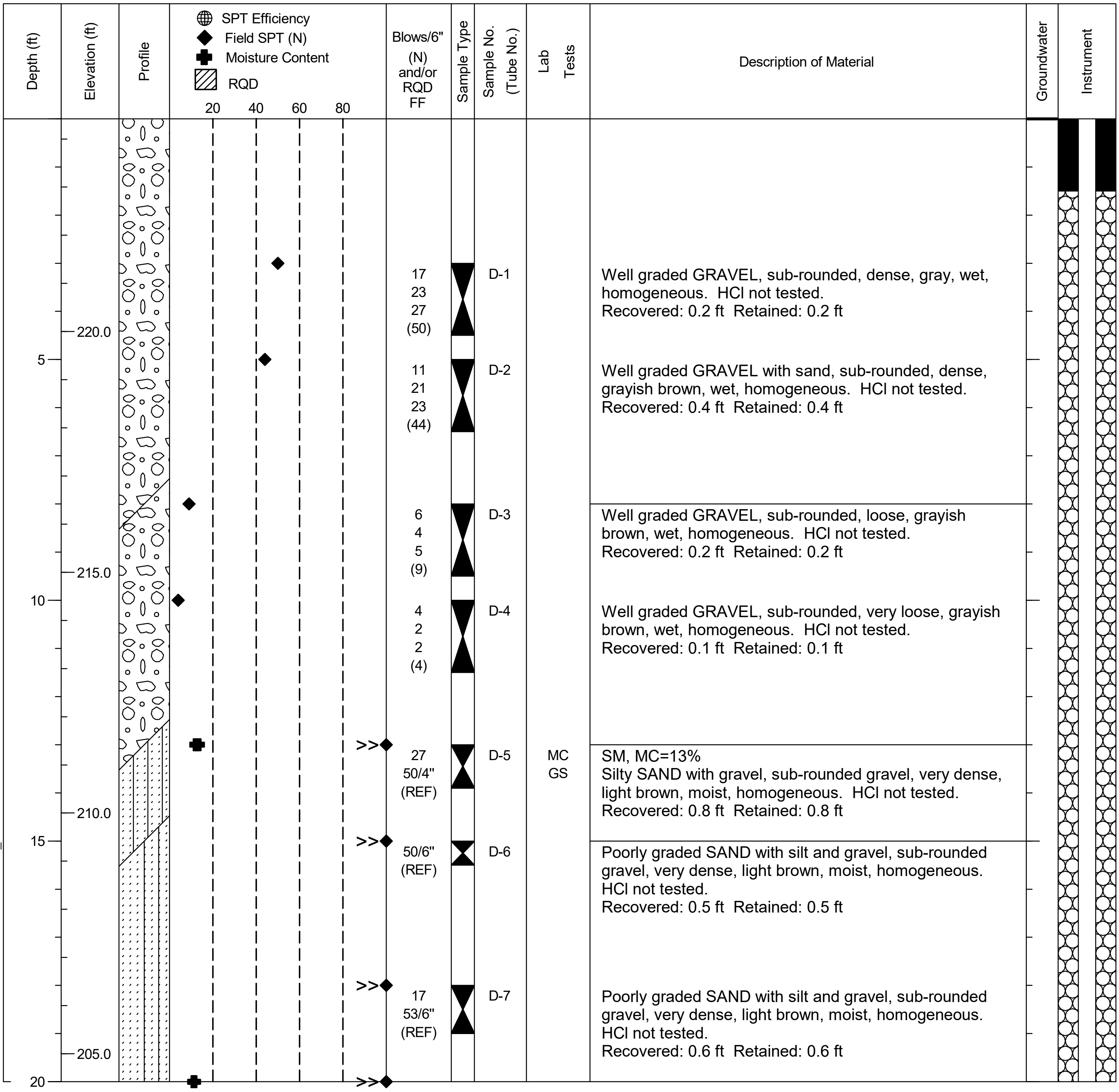
Manual Piezometer Readings:
8-24-2017: 88.5 ft.
9-25-2017: 89.4 ft.
10-30-2017: Dry to 95.0 ft. (bottom of piezometer screen).
12-13-2017: Dry to 95.0 ft.
1-22-2018: 92.1 ft.

WSDOT

LOG OF TEST BORING

Start Card RE-14608
HOLE No. H-9p-17
Sheet 1 of 5

Job No. XL-5001
SR 005
Elevation 224.4 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie
Lic# 2941
Component Bridge Widening - Pier 1 (Abutment)
Inspector Harvey, Thomas #2599
Start August 15, 2017
Completion August 21, 2017
Well ID# BJT-729
Equipment CME 45 (9C4-3)
Station MRW 99+40.62
Offset 86.6 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 86.1%
Northing 639164.5196
Easting 1075976.4148
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0638145
Long -122.7651671
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite and Polymer

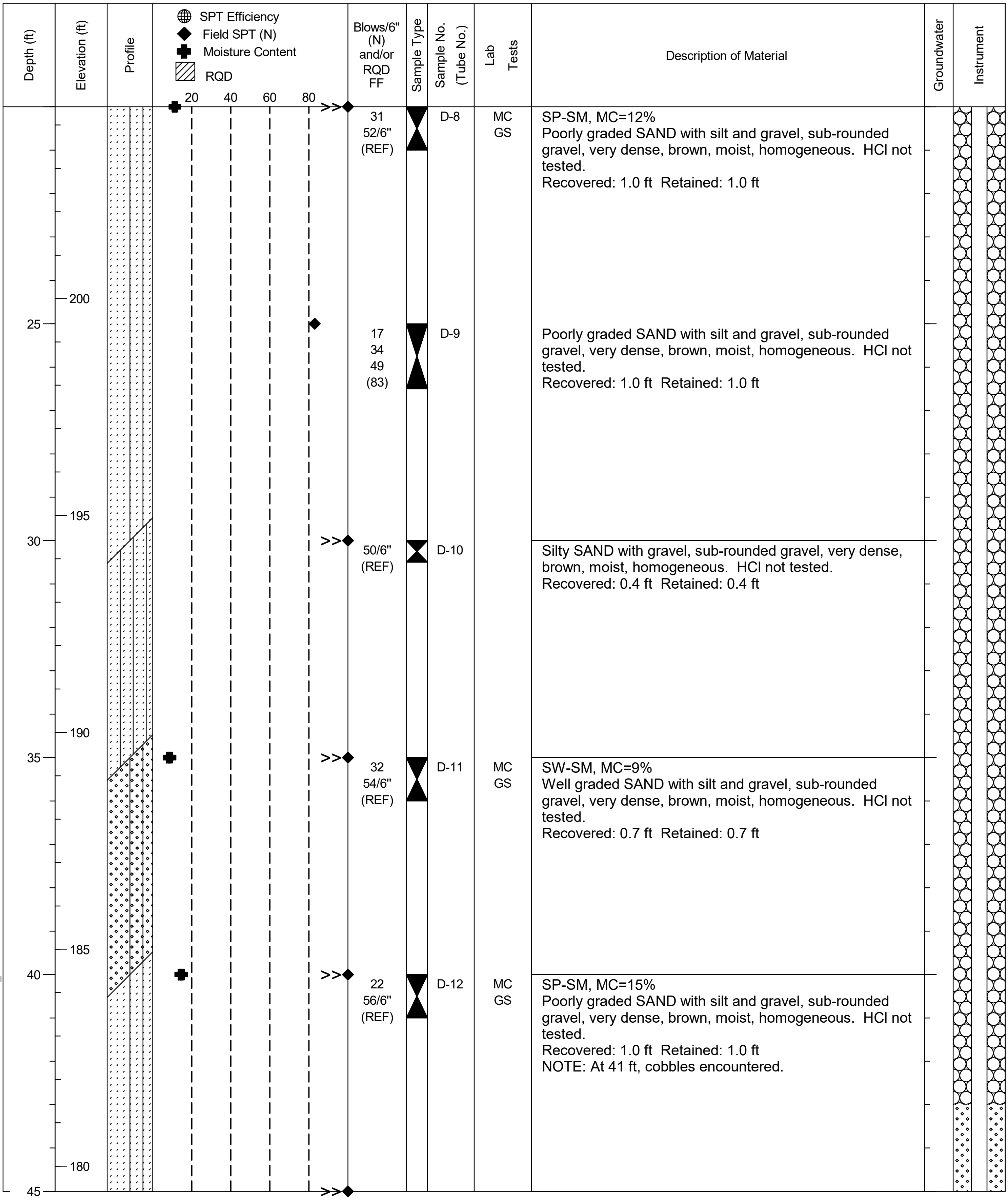


Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
17 23 27 (50)	D-1		Well graded GRAVEL, sub-rounded, dense, gray, wet, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
11 21 23 (44)	D-2		Well graded GRAVEL with sand, sub-rounded, dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
6 4 5 (9)	D-3		Well graded GRAVEL, sub-rounded, loose, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
4 2 2 (4)	D-4		Well graded GRAVEL, sub-rounded, very loose, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.1 ft Retained: 0.1 ft
27 50/4" (REF)	D-5	MC GS	SM, MC=13% Silty SAND with gravel, sub-rounded gravel, very dense, light brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
50/6" (REF)	D-6		Poorly graded SAND with silt and gravel, sub-rounded gravel, very dense, light brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
17 53/6" (REF)	D-7		Poorly graded SAND with silt and gravel, sub-rounded gravel, very dense, light brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft

ENTERPRISE BORING LOG XL-5001 005_510 IC - RECONSTRUCT INTERCHANGE.GPJ ENTERPRISE DATA TEMPLATE.GDT 2/8/18

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 224.4 ft
HOLE No. H-9p-17
Sheet 2 of 5
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie



Depth (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
	31 52/6" (REF)	D-8	MC GS	SP-SM, MC=12% Poorly graded SAND with silt and gravel, sub-rounded gravel, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
25	17 34 49 (83)	D-9		Poorly graded SAND with silt and gravel, sub-rounded gravel, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
30	50/6" (REF)	D-10		Silty SAND with gravel, sub-rounded gravel, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
35	32 54/6" (REF)	D-11	MC GS	SW-SM, MC=9% Well graded SAND with silt and gravel, sub-rounded gravel, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft
40	22 56/6" (REF)	D-12	MC GS	SP-SM, MC=15% Poorly graded SAND with silt and gravel, sub-rounded gravel, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft NOTE: At 41 ft, cobbles encountered.

LOG OF TEST BORING

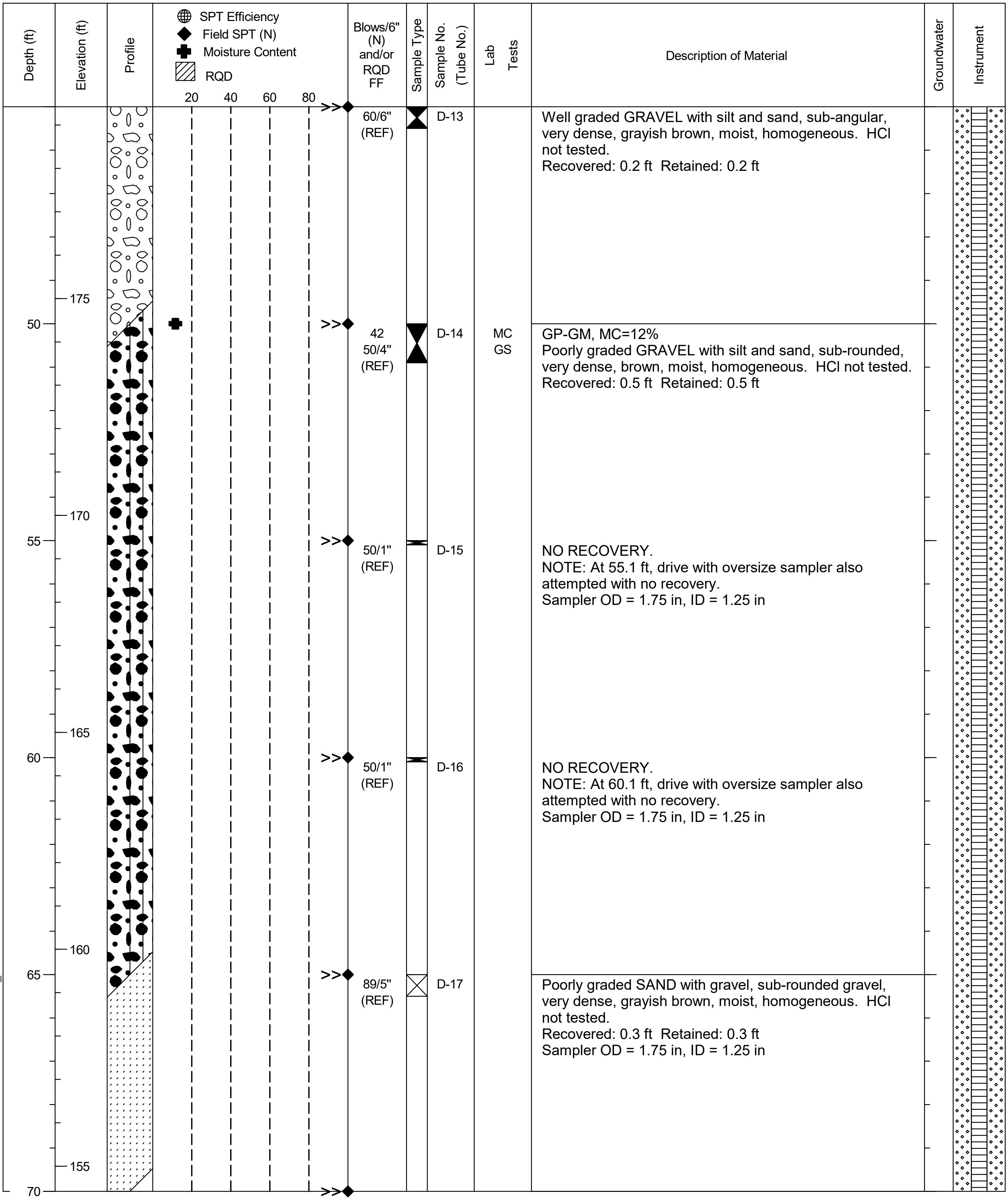
Job No. XL-5001 SR 005 Elevation 224.4 ft

HOLE No. H-9p-17

Sheet 3 of 5

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie



Depth (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
	60/6" (REF)	D-13		Well graded GRAVEL with silt and sand, sub-angular, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
50	42 50/4" (REF)	D-14	MC GS	GP-GM, MC=12% Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
55	50/1" (REF)	D-15		NO RECOVERY. NOTE: At 55.1 ft, drive with oversize sampler also attempted with no recovery. Sampler OD = 1.75 in, ID = 1.25 in
60	50/1" (REF)	D-16		NO RECOVERY. NOTE: At 60.1 ft, drive with oversize sampler also attempted with no recovery. Sampler OD = 1.75 in, ID = 1.25 in
65	89/5" (REF)	D-17		Poorly graded SAND with gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft Sampler OD = 1.75 in, ID = 1.25 in

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 224.4 ft
HOLE No. H-9p-17
Sheet 4 of 5
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie

Depth (ft)	Elevation (ft)	Profile	⊕ SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
			>>◆	62/6" (REF)	⧗	D-18		Well graded GRAVEL, sub-rounded, very dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.1 ft Retained: 0.1 ft		
	150									
75			>>◆	60/6" (REF)	⧗	D-19		Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
	145									
80			>>◆	50/2" (REF)	⧗	D-20		NO RECOVERY. NOTE: At 80.2 ft, drive with oversize sampler also attempted with no recovery. Sampler OD = 1.75 in, ID = 1.25 in		
								NOTE: At 83.8 ft, cobble encountered.		
	140									
85			>>◆	60/4" (REF)	⧗	D-21		Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft NOTE: At 86 ft, cobble encountered.		
								NOTE: At 89 ft, cobble encountered.		
	135									
90			>>◆	74/6" (REF)	⧗	D-22		Well graded GRAVEL, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft		
	130									
95			>>◆							

WSDOT

LOG OF TEST BORING

HOLE No. H-9p-17

Job No. XL-5001 SR 005 Elevation 224.4 ft

Sheet 5 of 5

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie

⊕ SPT Efficiency
◆ Field SPT (N)
✚ Moisture Content
▨ RQD

20 40 60 80

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
		>>◆ 70/3" (REF)	⧗	D-23		Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft
	125					
100		>>◆ 87/4" (REF)	⧗	D-24		Well graded GRAVEL with sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
	120					
105						
	115					
110						
	110					
115						
	105					
120						

A standpipe monument was installed on this boring.

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 100.4 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 100.4 ft.
Depth of casing during bail test: 100.0 ft.
Water depth before bailing: 27.8 ft.
Bailed bore hole water level to 97.9 ft.
Recharge after 5 minutes: 98.1 ft.
Recharge after 10 minutes: 98.1 ft.
Recharge after 15 minutes: 98.1 ft.
Recharge after 20 minutes: 98.2 ft.
Recharge after 25 minutes: 98.2 ft.
Recharge after 30 minutes: 98.2 ft.

Manual Piezometer Readings:
8-24-2017: 84.7 ft.
9-25-2017: Dry to 85.0 ft. (bottom of piezometer screen).
10-30-2017: Dry to 85.0 ft.
12-13-2017: Dry to 85.0 ft.
1-22-2018: 84.7 ft.

WSDOT

LOG OF TEST BORING

Start Card SE-64049 / AE-45932

HOLE No. H-10-17

Sheet 1 of 2

Job No. XL-5001

SR 005

Elevation 178.6 ft

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie

Lic# 2941

Component Illumination, Signals, Signs, and Traffic Systems

Inspector Harvey, Thomas #2599

Start November 9, 2017

Completion November 9, 2017

Well ID# N/A

Equipment CME 850 (9A2-523)

Station LL 1371+03.63

Offset 57.9 feet left

Hole Dia (inches) 4

Historical SPT Efficiency 89.7%

Northing 637795.24

Easting 1069261.04

Collected by Region Survey Crew

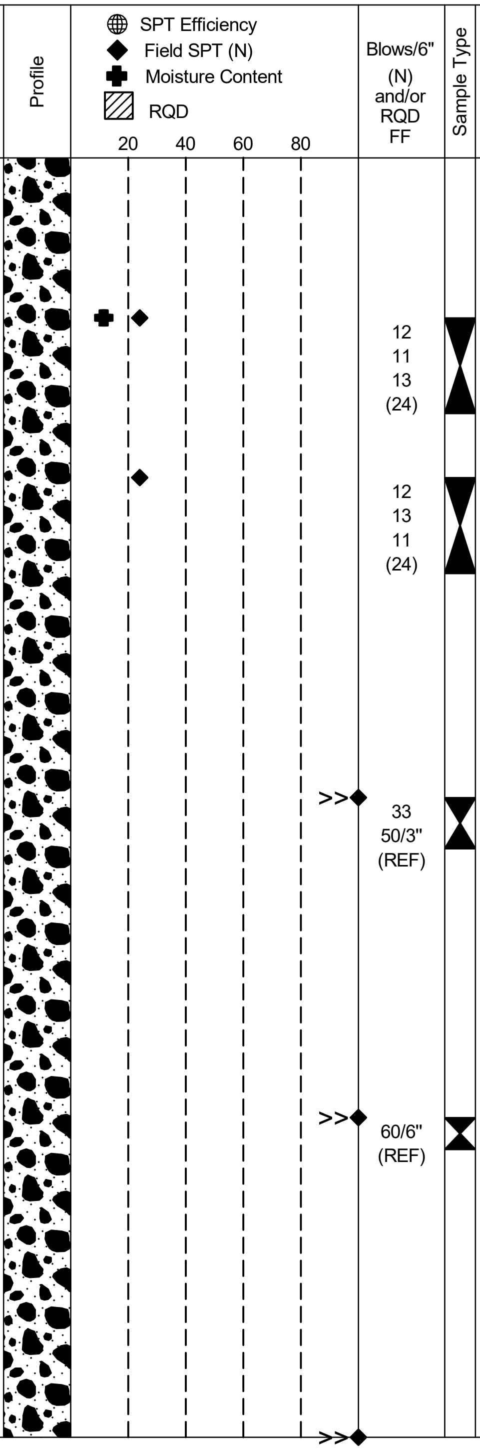
Method Casing Advancer

Lat 47.0595300

Long -122.7919420

Datum NAD 83/91 HARN, NAVD88, SPS (ft)

Drill Fluid Bentonite



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
		12 11 13 (24)	D-1	MC GS	GW, MC=12% Well graded GRAVEL with sand, sub-rounded, medium dense, brown, wet, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
	175.0						
5		12 13 11 (24)	D-2		Well graded GRAVEL with sand, sub-rounded, medium dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		
					NOTE: At 8 ft, lost drilling fluid.		
	170.0						
10		33 50/3" (REF)	D-3		Well graded GRAVEL with sand, sub-angular, very dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft		
	165.0						
15		60/6" (REF)	D-4		Well graded GRAVEL with sand, sub-angular, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft		
	160.0						
20							

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 178.6 ft
HOLE No. H-10-17
Sheet 2 of 2
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie

Depth (ft)	Elevation (ft)	Profile	⊕ SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				50/4" (REF)	⧗	D-5		Well graded GRAVEL with sand, sub-angular, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft		
	155									
25								The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
	150							End of test hole boring at 20.4 ft below ground surface. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
30								Borehole was dry at the end of drilling.		
	145									
35										
	140									
40										
	135									
45										

WSDOT

LOG OF TEST BORING

Start Card SE-64049 / AE-45932

HOLE No. H-11-17

Sheet 1 of 2

Job No. XL-5001

SR 005

Elevation 191.1 ft

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie

Lic# 2941

Component Illumination, Signals, Signs, and Traffic Systems

Inspector Harvey, Thomas #2599

Start November 7, 2017

Completion November 7, 2017

Well ID# N/A

Equipment CME 850 (9A2-523)

Station LL 1378+80.96

Offset 76.8 feet left

Hole Dia (inches) 4

Historical SPT Efficiency 89.7%

Northing 637977.34

Easting 1070017.07

Collected by Region Survey Crew

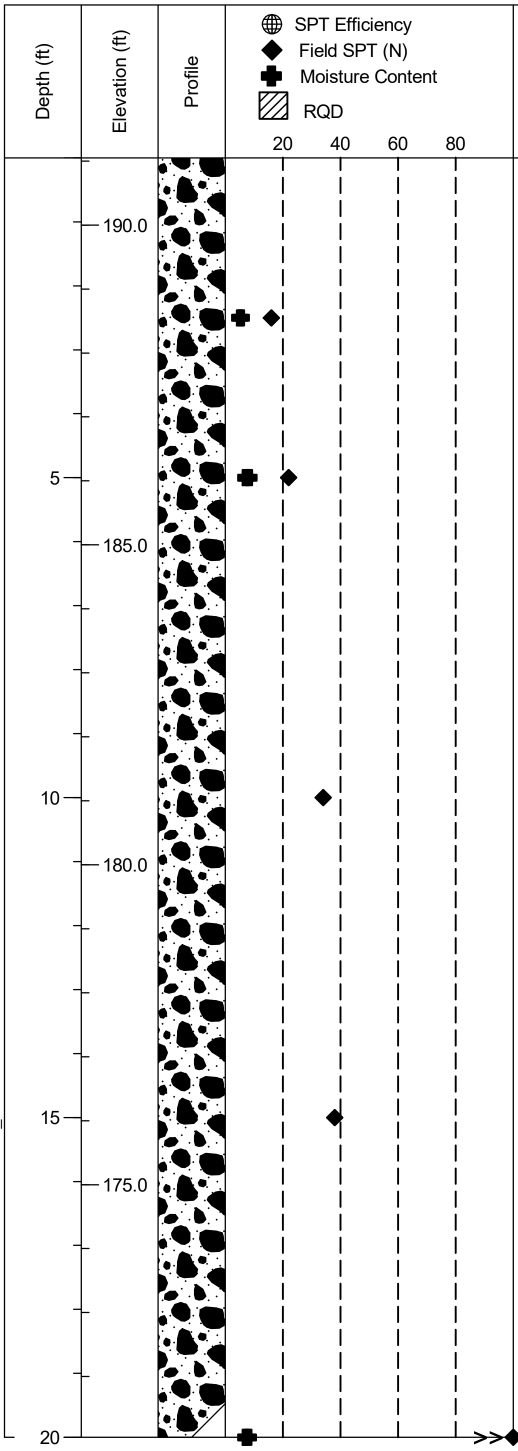
Method Casing Advancer

Lat 47.0600892

Long -122.7889311

Datum NAD 83/91 HARN, NAVD88, SPS (ft)

Drill Fluid Bentonite



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
4 7 9 (16)	D-1	MC GS	GW, MC=6% Well graded GRAVEL with sand, sub-rounded, medium dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft NOTE: At 3 ft, lost drilling fluid.
9 11 11 (22)	D-2	MC GS	GW, MC=8% Well graded GRAVEL with sand, sub-rounded, medium dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
13 17 17 (34)	D-3		Well graded GRAVEL with sand, sub-rounded, dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft
12 14 24 (38)	D-4		Well graded GRAVEL with sand, sub-rounded, dense, grayish brown, moist, stratified. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft

Sample Type

Groundwater

Instrument

LOG OF TEST BORING

WSDOT

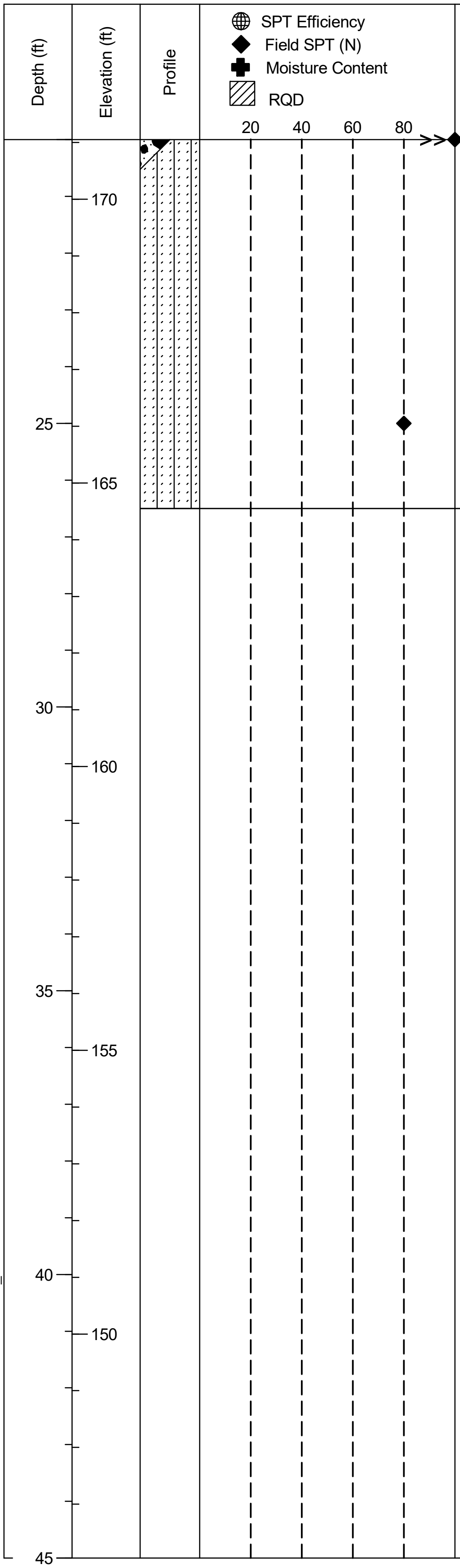
Job No. XL-5001 SR 005 Elevation 191.1 ft

HOLE No. H-11-17

Sheet 2 of 2

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material
39 50/6" (REF)	⧗	D-5	MC GS	SM, MC=8% Silty SAND with gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
29 37 43 (80)	⧗	D-6		Silty SAND with gravel, sub-rounded gravel, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft

Groundwater

Instrument

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 26.5 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

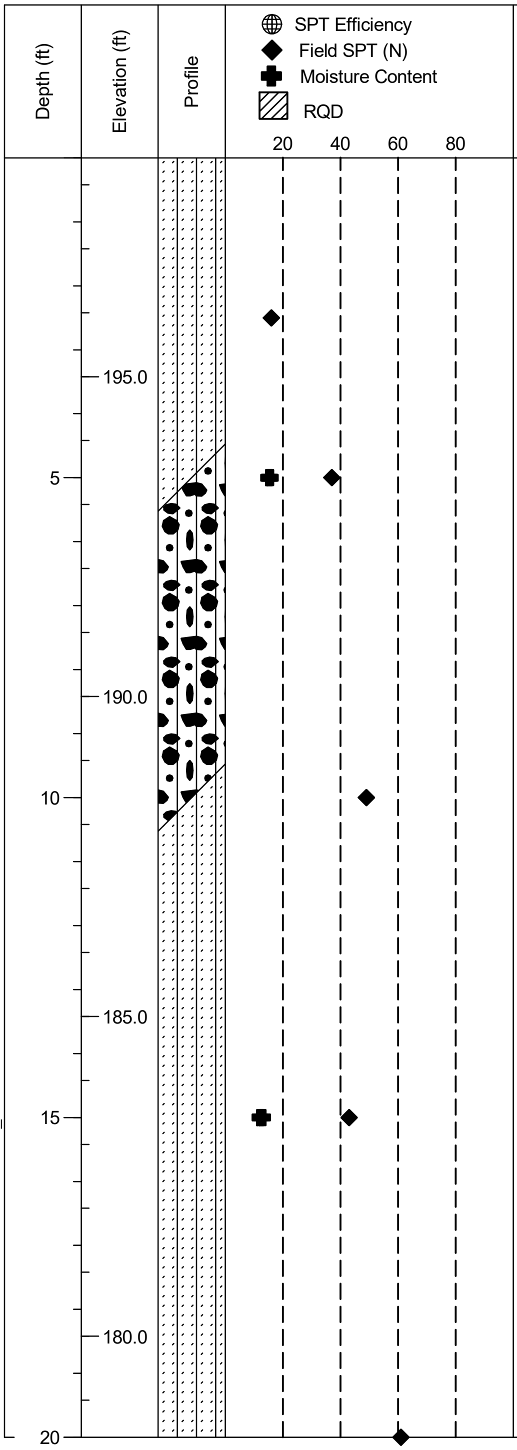
Borehole was dry at the end of drilling.

WSDOT

LOG OF TEST BORING

Start Card SE-64049 / AE-45932
HOLE No. H-12-17
Sheet 1 of 2

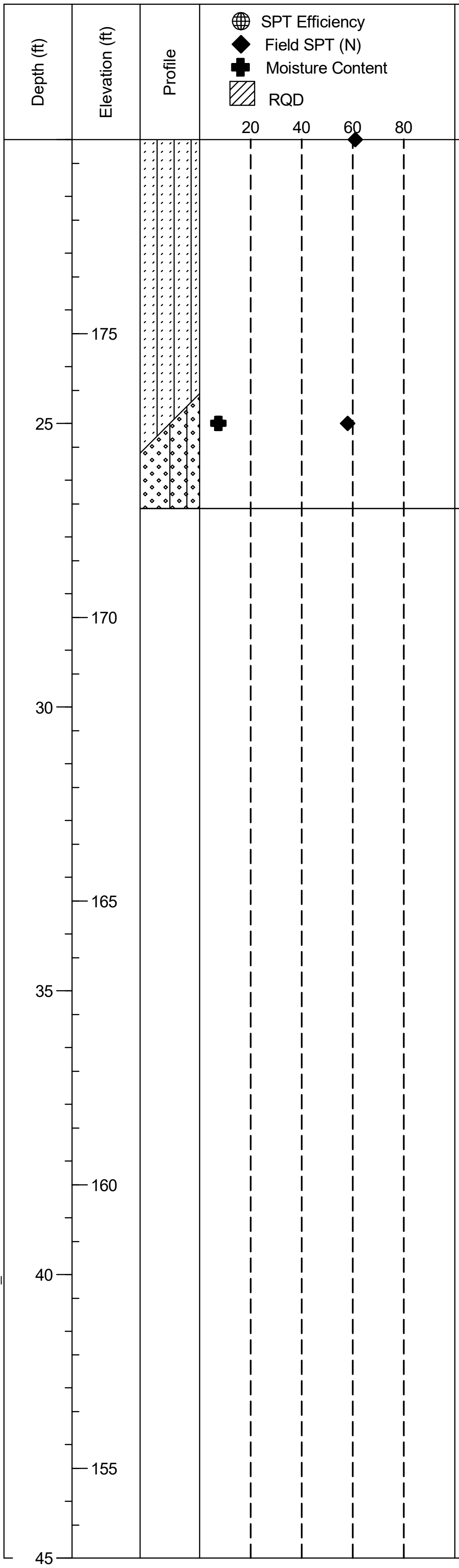
Job No. XL-5001
SR 005
Elevation 198.4 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie
Lic# 2941
Component Illumination, Signals, Signs, and Traffic Systems
Inspector Harvey, Thomas #2599
Start November 7, 2017
Completion November 7, 2017
Well ID# N/A
Equipment CME 850 (9A2-523)
Station LL 1388+79.25
Offset 135.4 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 89.7%
Northing 638244.77
Easting 1070974.41
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0608983
Long -122.7851226
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
6 8 8 (16)		D-1		Silty SAND with gravel, sub-rounded gravel, medium dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		
8 15 22 (37)		D-2	MC GS AL	GM, MC=16%, LL=NA, PL=NP Silty GRAVEL with sand, sub-rounded, dense, reddish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
26 27 22 (49)		D-3		Silty SAND with gravel, sub-angular gravel, dense, light brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft	11-07-2017	
14 15 28 (43)		D-4	MC GS AL	SM, MC=13%, LL=NA, PL=NP Silty SAND with gravel, sub-rounded gravel, dense, light brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 198.4 ft
HOLE No. H-12-17
Sheet 2 of 2
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
16 29 32 (61)	⧗	D-5		Silty SAND with gravel, sub-rounded gravel, very dense, light brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
18 27 31 (58)	⧗	D-6	MC GS	SW-SM, MC=8% Well graded SAND with silt and gravel, sub-rounded gravel, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 26.5 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 26.5 ft.
Depth of casing during bail test: 20.0 ft.
Water depth before bailing: 7.9 ft.
Bailed bore hole water level to 20.1 ft.
Recharge after 5 minutes: 17.3 ft.
Recharge after 10 minutes: 16.1 ft.
Recharge after 15 minutes: 15.2 ft.
Recharge after 20 minutes: 14.4 ft.
Recharge after 25 minutes: 13.2 ft.
Recharge after 30 minutes: 12.5 ft.
Recharge after 35 minutes: 11.9 ft.
Recharge after 40 minutes: 11.9 ft.
Recharge after 50 minutes: 11.8 ft.
Recharge after 60 minutes: 11.9 ft.

WSDOT

LOG OF TEST BORING

Start Card SE-64048 / AE-45931

HOLE No. H-13-17

Sheet 1 of 2

Job No. XL-5001

SR 005

Elevation 201.4 ft

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie

Lic# 2941

Component Illumination, Signals, Signs, and Traffic Systems

Inspector Harvey, Thomas #2599

Start November 6, 2017

Completion November 6, 2017

Well ID# N/A

Equipment CME 850 (9A2-523)

Station LL 1403+12.74

Offset 59.9 feet left

Hole Dia (inches) 4

Historical SPT Efficiency 89.7%

Northing 638476.9

Easting 1072396.77

Collected by Region Survey Crew

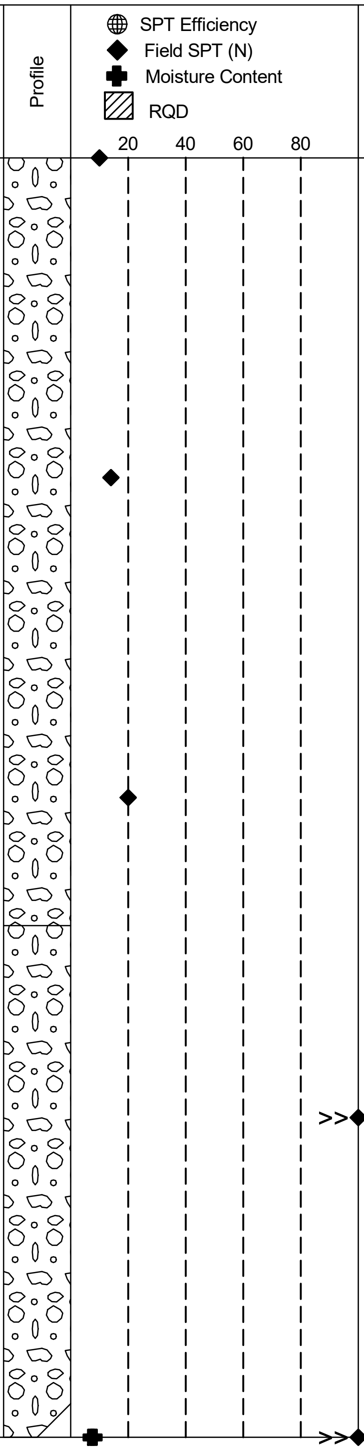
Method Casing Advancer

Lat 47.0616473

Long -122.7794449

Datum NAD 83/91 HARN, NAVD88, SPS (ft)

Drill Fluid Bentonite



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
		4 5 5 (10)	⧗	D-1		Well graded GRAVEL with sand and organics, sub-rounded, loose, dark gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
	200.0							
5		7 9 5 (14)	⧗	D-2		Well graded GRAVEL, sub-rounded, medium dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft		
	195.0					NOTE: At 7 ft, lost drilling fluid.		
10		8 12 8 (20)	⧗	D-3		Well graded GRAVEL, sub-rounded, medium dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft		
	190.0							
						NOTE: At 12 ft, drilling becomes more difficult.		
15		50/2" (REF)	⧗	D-4		NO RECOVERY.		
	185.0							
20								

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 201.4 ft
HOLE No. H-13-17
Sheet 2 of 2
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie

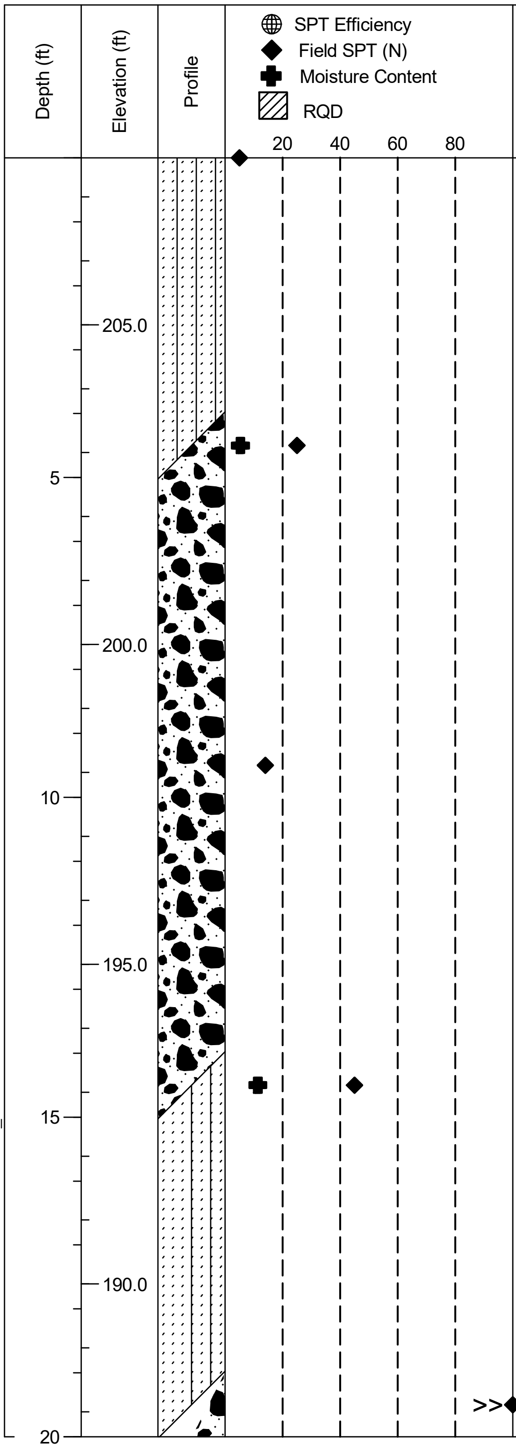
Depth (ft)	Elevation (ft)	Profile	🌐 SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				58/6" (REF)	⧗	D-5	MC GS	GP-GM, MC=8% Poorly graded GRAVEL with silt and sand, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
	180									
								The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
25										
	175							End of test hole boring at 20.5 ft below ground surface. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
								Borehole was dry at the end of drilling.		
30										
	170									
35										
	165									
40										
	160									
45										

LOG OF TEST BORING

WSDOT

Start Card SE-64048 / AE-45931
HOLE No. H-14-17
Sheet 1 of 2

Job No. XL-5001
SR 005
Elevation 207.6 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie
Lic# 2941
Component Illumination, Signals, Signs, and Traffic Systems
Inspector Harvey, Thomas #2599
Start November 2, 2017
Completion November 6, 2017
Well ID# N/A
Equipment CME 850 (9A2-523)
Station LL 1410+04.10
Offset 173.3 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 89.7%
Northing 638733.62
Easting 1073049.08
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0624025
Long -122.7768584
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite

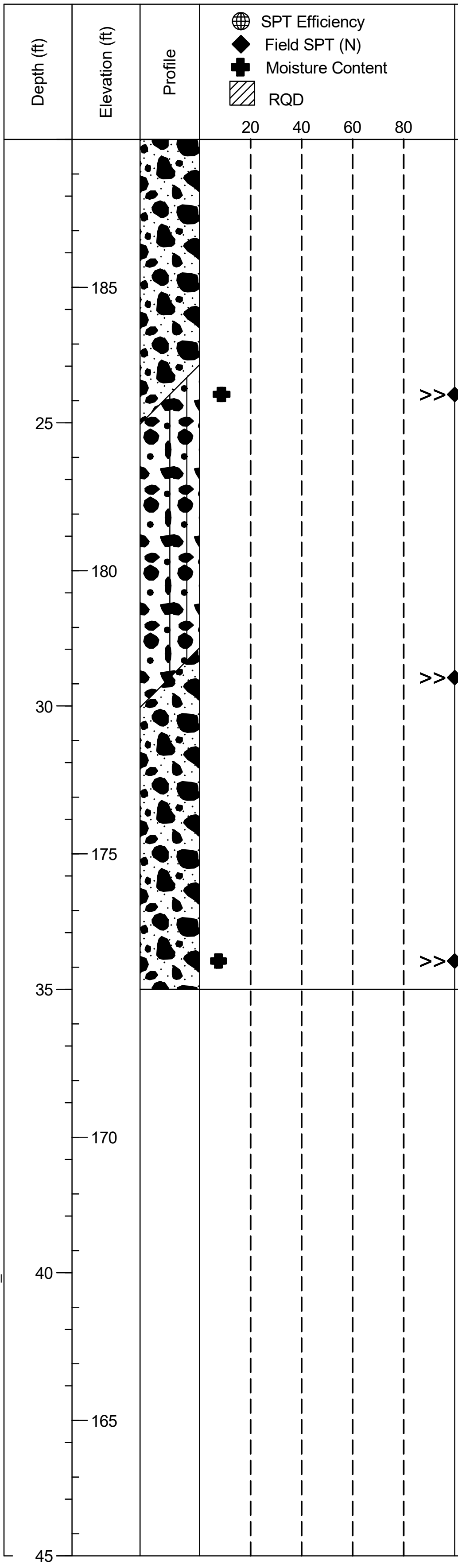


Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
3 3 2 (5)	D-1		Silty SAND with gravel and organics, sub-rounded gravel, loose, dark brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
10 13 12 (25)	D-2	MC GS	GW, MC=6% Well graded GRAVEL with sand, sub-rounded, dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
9 7 7 (14)	D-3		Well graded GRAVEL with sand, sub-rounded, medium dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
18 20 25 (45)	D-4	MC GS	SP-SM, MC=12% Poorly graded SAND with silt and gravel, angular gravel, dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
47	D-5		Well graded GRAVEL with sand, sub-rounded, very

Groundwater
Instrument

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 207.6 ft
HOLE No. H-14-17
Sheet 2 of 2
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
50/4" (REF)	⧗			dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft		
39 50/5" (REF)	⧗	D-6	MC GS	GP-GM, MC=9% Poorly graded GRAVEL with silt and sand, sub-angular, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
50/4" (REF)	⧗	D-7		Well graded GRAVEL with sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft		
50/6" (REF)	⧗	D-8	MC GS	GW, MC=8% Well graded GRAVEL with sand, sub-angular, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 35.0 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

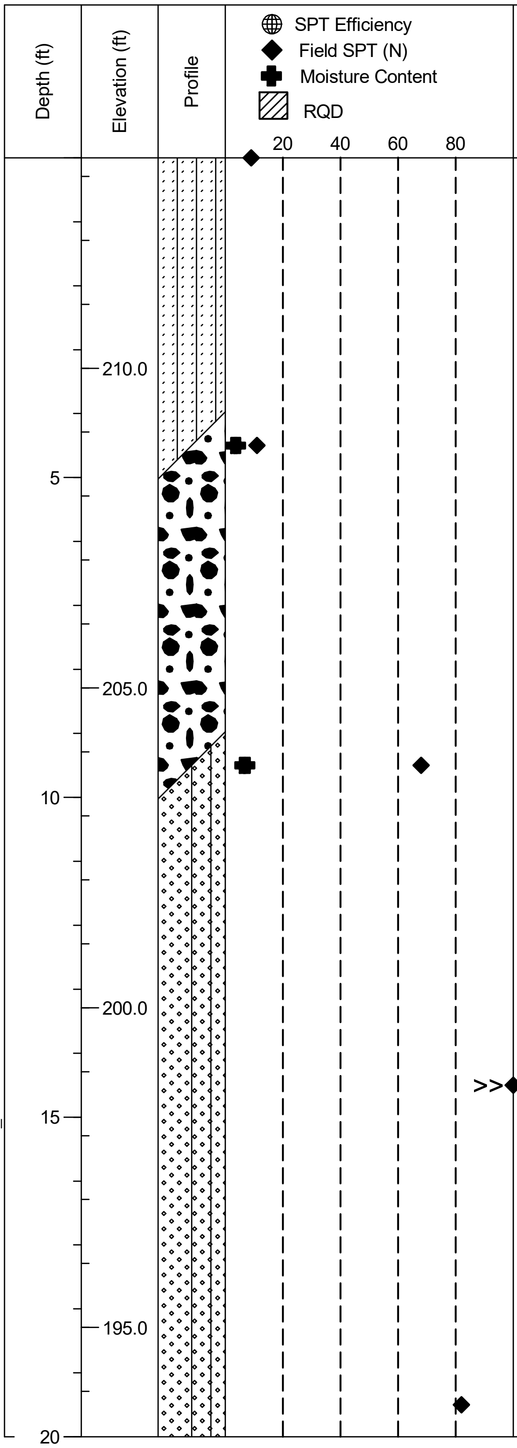
Borehole was dry at the end of drilling.

WSDOT

LOG OF TEST BORING

Start Card SE-64048 / AE-45931
HOLE No. H-15-17
Sheet 1 of 2

Job No. XL-5001
SR 005
Elevation 213.3 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie
Lic# 2941
Component Illumination, Signals, Signs, and Traffic Systems
Inspector Fetterly, Jamie #2507
Start November 2, 2017
Completion November 2, 2017
Well ID# N/A
Equipment CME 850 (9A2-523)
Station LL 1426+71.19
Offset 136.0 feet left
Hole Dia (inches) 4
Historical SPT Efficiency 89.7%
Northing 639050.4
Easting 1074685.65
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0634000
Long -122.7703311
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Polymer



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
3 4 5 (9)	D-1		Silty SAND with gravel and organics, angular, loose, dark brown, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft
			NOTE: At 2 ft, lost drilling fluid.
3 5 6 (11)	D-2	MC GS	GP, MC=4% Poorly graded GRAVEL, rounded, medium dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft
			NOTE: At 9 ft, regain drilling fluid.
20 28 40 (68)	D-3	MC GS	SW-SM, MC=7% Well graded SAND with silt and gravel, angular, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 1.2 ft Retained: 1.2 ft
40 50/4" (REF)	D-4		Well graded SAND with silt and gravel, angular, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
40	D-5		Well graded SAND with silt and gravel, sub-angular, very

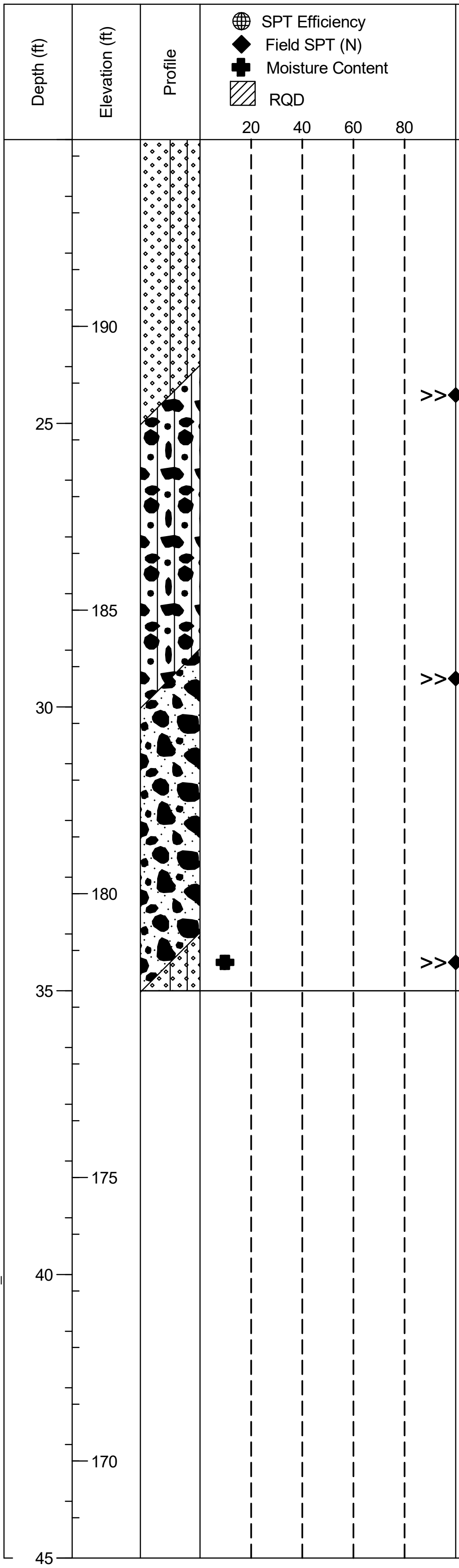
Groundwater

Instrument

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 213.3 ft
HOLE No. H-15-17
Sheet 2 of 2
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
42 40 (82)	⧗			dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
50/6" (REF)	⧗	D-6		Silty GRAVEL with sand, sub-rounded, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft NOTE: At 26 ft, drilling indicates larger gravels.		
50/6" (REF)	⧗	D-7		Well graded GRAVEL with sand, sub-angular, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.3 ft Retained: 0.3 ft		
50/6" (REF)	☒	D-8	MC GS	SW-SM, MC=10% Well graded SAND with silt and gravel, sub-angular, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft Sampler OD = 2.5 in, ID = 2 in		

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 35.0 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

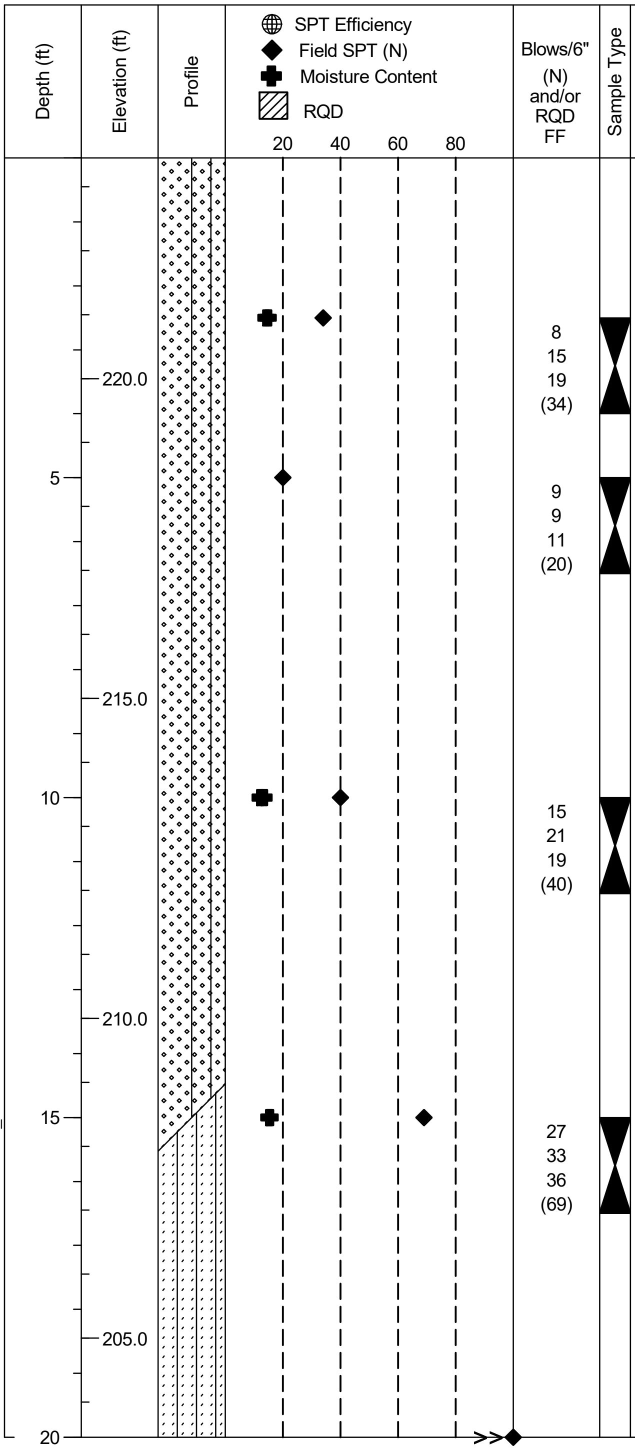
Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 35.0 ft.
Depth of casing during bail test: 34.5 ft.
Water depth before bailing: 0.0 ft.
Bailed bore hole water level to 34.0 ft.
Recharge after 45 minutes: 34.0 ft.

WSDOT

LOG OF TEST BORING

Start Card SE-64048 / AE-45931
HOLE No. H-16-17
Sheet 1 of 3

Job No. XL-5001 SR 005 Elevation 223.5 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Cooper, Richard Lic# 2964
Component Illumination, Signals, Signs, and Traffic Systems
Inspector Harvey, Thomas #2599
Start November 13, 2017 Completion November 14, 2017 Well ID# N/A
Equipment CME 850 (9A2-523)
Station LR 1431+68.56 Offset 127.1 feet right Hole Dia (inches) 4
Historical SPT Efficiency 89.7%
Northing 638777.88 Easting 1075295.42 Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0627012 Long -122.7678539 Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite



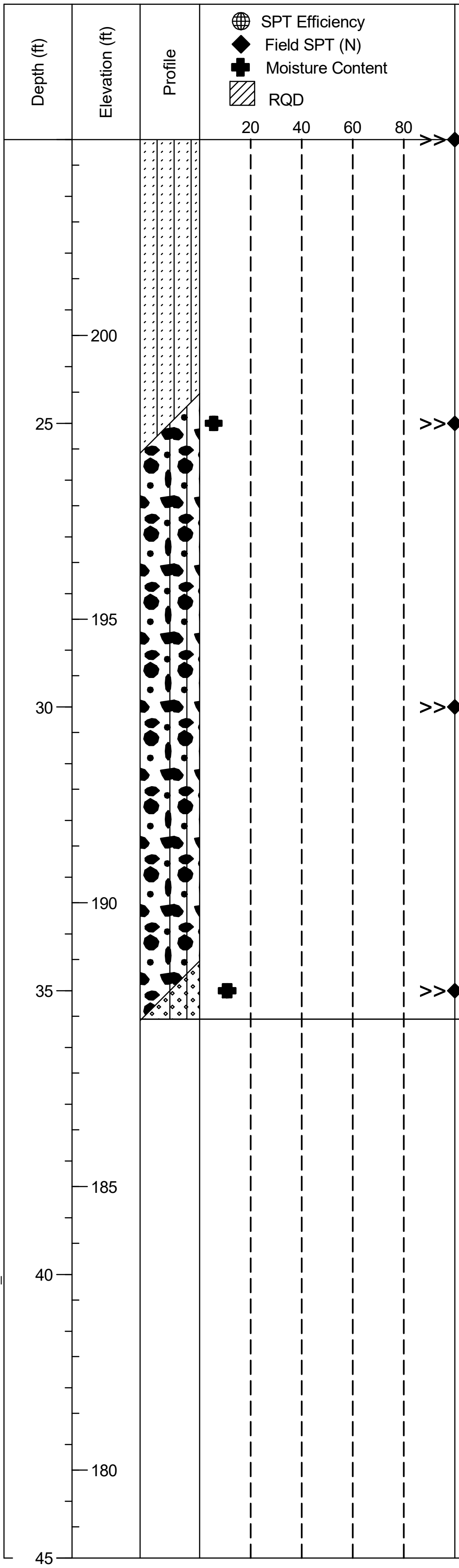
Depth (ft)	Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
2.5	8 15 19 (34)	D-1	MC GS	SW-SM, MC=15% Well graded SAND with silt, gravel, and organics, sub-rounded gravel, dense, dark brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
5	9 9 11 (20)	D-2		Well graded SAND with silt, gravel, and organics, sub-rounded gravel, medium dense, dark brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft
10	15 21 19 (40)	D-3	MC GS AL	SW-SM, MC=13%, LL=NA, PL=NP Well graded SAND with silt and gravel, sub-rounded gravel, dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
15	27 33 36 (69)	D-4	MC GS AL	SM, MC=16%, LL=NA, PL=NP Silty SAND, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft

Groundwater
Instrument

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 223.5 ft
HOLE No. H-16-17
Sheet 2 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Cooper, Richard



Depth (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	63/6" (REF)	⧗	D-5		Silty SAND, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
25	21 50/3" (REF)	⧗	D-6	MC GS	GP-GM, MC=6% Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
30	57/6" (REF)	⧗	D-7		Poorly graded GRAVEL with silt and sand, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		
35	50/6" (REF)	⧗	D-8	MC GS	SW-SM, MC=11% Well graded SAND with silt and gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 35.5 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

LOG OF TEST BORING

WSDOT

Job No. XL-5001
SR 005
Elevation 223.5 ft
HOLE No. H-16-17
Sheet 3 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Cooper, Richard

Depth (ft)	Elevation (ft)	Profile	SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								Bail/Recharge test: Hole Diameter: 4 in. Depth of boring during bail test: 35.5 ft. Depth of casing during bail test: 30.0 ft. Water depth before bailing: 6.5 ft. Bailed bore hole water level to 27.1 ft. Recharge after 5 minutes: 27.8 ft. Recharge after 10 minutes: 28.7 ft. Recharge after 15 minutes: 29.1 ft. Recharge after 20 minutes: 29.2 ft. Recharge after 25 minutes: 29.2 ft. Recharge after 30 minutes: 29.2 ft.		
	175									
50										
	170									
55										
	165									
60										
	160									
65										
	155									
70										

WSDOT

LOG OF TEST BORING

Start Card SE-64048 / AE-45931

HOLE No. H-17-17

Sheet 1 of 2

Job No. XL-5001

SR 005

Elevation 225.4 ft

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Cooper, Richard Lic# 2964

Component Illumination, Signals, Signs, and Traffic Systems

Inspector Harvey, Thomas #2599

Start November 14, 2017 Completion November 14, 2017 Well ID# N/A

Equipment CME 850 (9A2-523)

Station LR 1434+50.32 Offset 210.4 feet right Hole Dia (inches) 4

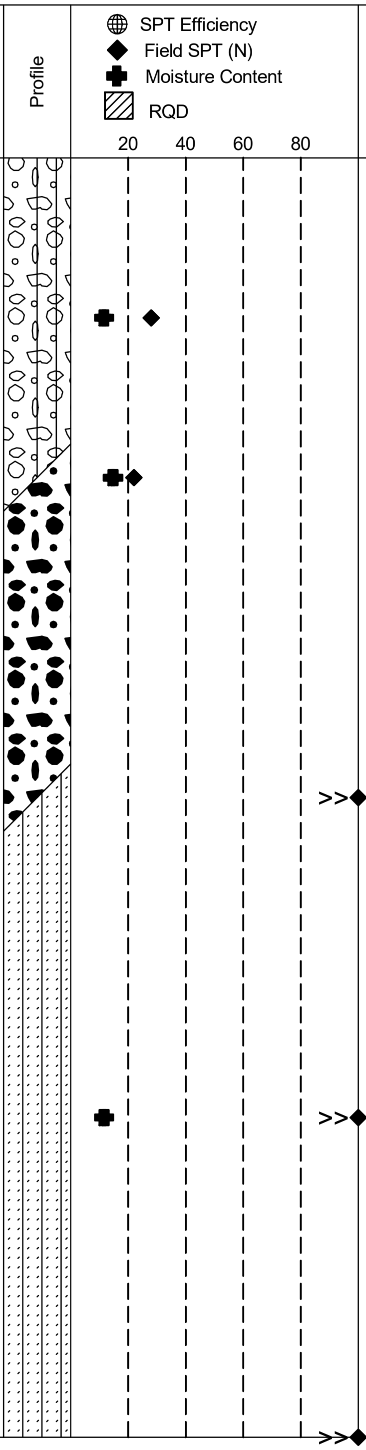
Historical SPT Efficiency 89.7%

Northing 638747.93 Easting 1075582.21 Collected by Region Survey Crew

Method Casing Advancer

Lat 47.0626417 Long -122.7667002 Datum NAD 83/91 HARN, NAVD88, SPS (ft)

Drill Fluid Bentonite



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	225.0							
		13 15 13 (28)		D-1	MC GS	GW-GM, MC=12% Well graded GRAVEL with silt and sand, sub-rounded, dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft NOTE: At 4 ft, lost drilling fluid.		
5	220.0	11 9 13 (22)		D-2	MC GS	GP, MC=15% Poorly graded GRAVEL with sand, sub-rounded, medium dense, grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
10	215.0	54/6" (REF)		D-3		Silty SAND with gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
15	210.0	41 50/6" (REF)		D-4	MC GS AL	SM, MC=12%, LL=22 Silty SAND with gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
20								

WSDOT

LOG OF TEST BORING

Job No. XL-5001 SR 005 Elevation 225.4 ft

HOLE No. H-17-17

Sheet 2 of 2

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Cooper, Richard

Legend: SPT Efficiency; ◆ Field SPT (N); ✚ Moisture Content; ▨ RQD (scale 20, 40, 60, 80)

Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
	205	50/3" (REF)	⧗	D-5		Silty SAND with gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft		
25	200	18 50/4" (REF)	⧗	D-6	MC GS	SW-SM, MC=6% Well graded SAND with silt and gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
30	195							
35	190							
40	185							
45								

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 25.9 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

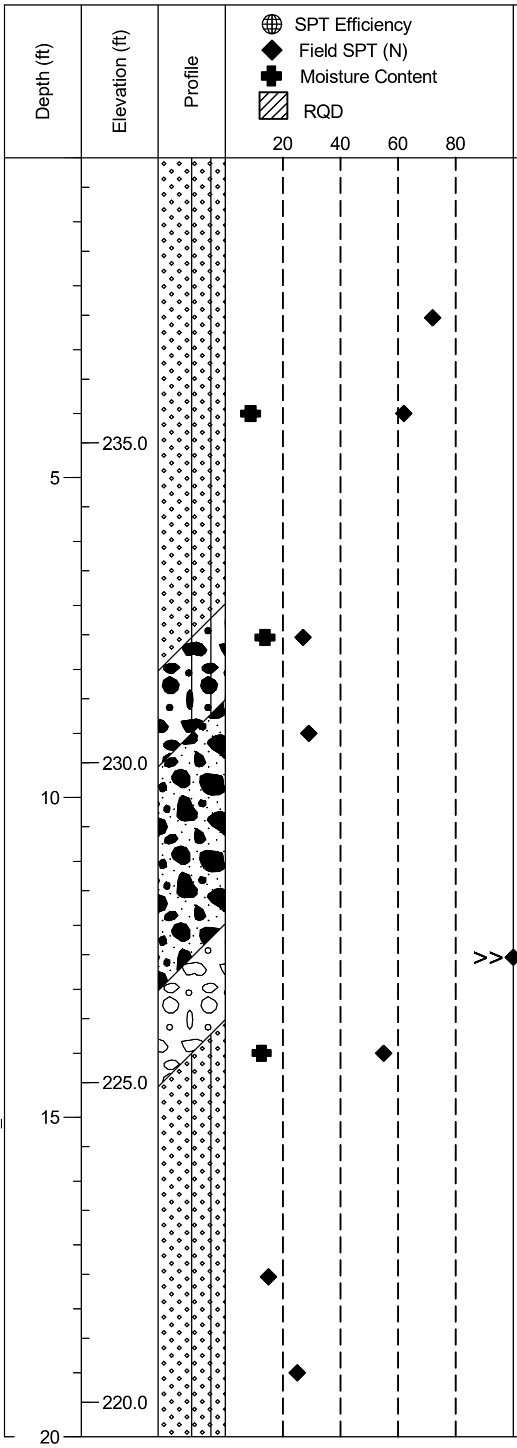
Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 25.9 ft.
Depth of casing during bail test: 20.0 ft.
Water depth before bailing: 3.5 ft.
Bailed bore hole water level to 22.0 ft.
Recharge after 2 minutes: 21.5 ft.
Recharge after 5 minutes: 20.5 ft.
Recharge after 10 minutes: 21.3 ft.
Recharge after 15 minutes: 22.7 ft.
Recharge after 20 minutes: 23.5 ft.
Recharge after 30 minutes: 25.1 ft.

WSDOT

LOG OF TEST BORING

Start Card SE-64048 / AE-45931
HOLE No. H-18-17
Sheet 1 of 3

Job No. XL-5001
SR 005
Elevation 239.5 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie
Lic# 2941
Component Illumination, Signals, Signs, and Traffic Systems
Inspector Haller, Robert #2779
Start November 30, 2017
Completion November 30, 2017
Well ID# N/A
Equipment CME 45 (9C4-2)
Station LR 1438+00.55
Offset 213.6 feet right
Hole Dia (inches) 4
Historical SPT Efficiency 89.3%
Northing 638789.5
Easting 1075914.94
Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0627819
Long -122.7653705
Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Polymer



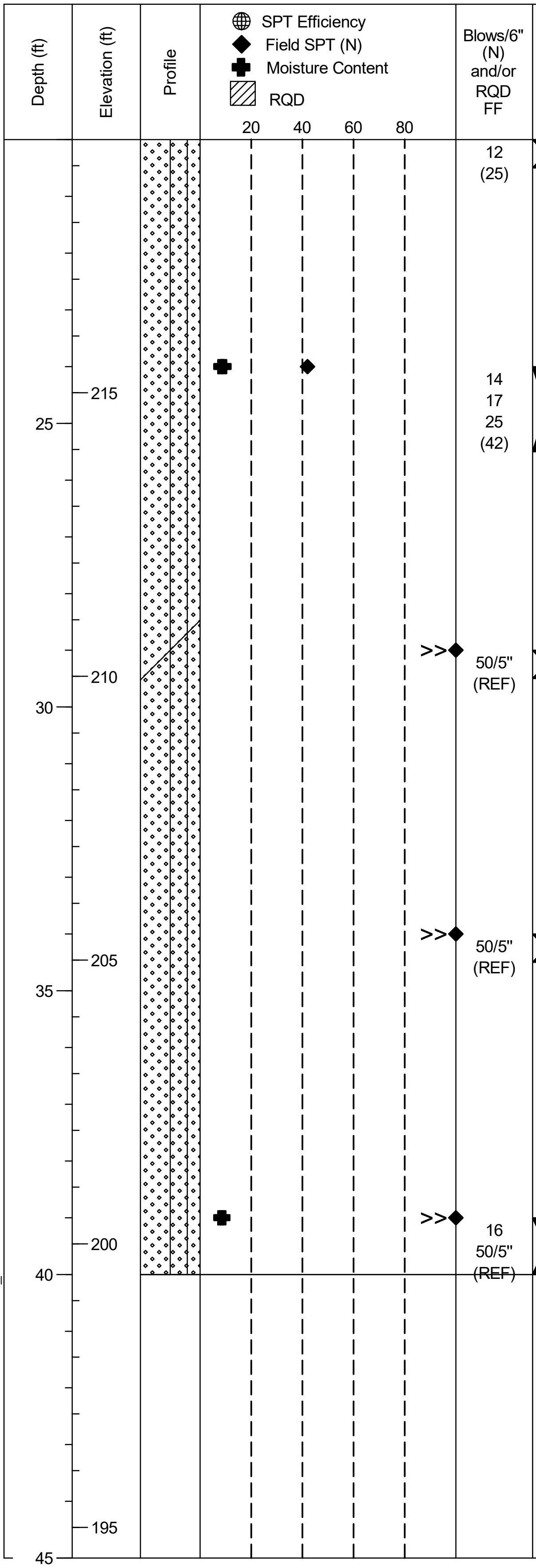
Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
11 35 37 (72)	▼▲	D-1		Well graded SAND with silt and gravel, sub-angular gravel, very dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
14 32 30 (62)	▼▲	D-2	MC GS	SW-SM, MC=9% Well graded SAND with silt and gravel, sub-angular gravel, very dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
8 12 15 (27)	▼▲	D-3	MC GS	GP-GM, MC=14% Poorly graded GRAVEL with silt and sand, sub-angular, dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft		
12 12 17 (29)	▼▲	D-4		Well graded GRAVEL with sand, sub-rounded, dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft		
50/5" (REF)	▼▲	D-5		Well graded GRAVEL, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.1 ft Retained: 0.1 ft		
12 20 35 (55)	▼▲	D-6	MC GS	SW-SM, MC=13% Well graded SAND with silt and gravel, sub-angular gravel, very dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
8 10 5 (15)	▼▲	D-7		Well graded SAND with silt and gravel, sub-angular gravel, medium dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
13 13	▼▲	D-8		Well graded SAND with silt and gravel, sub-rounded gravel, dense, dark grayish brown, moist, homogeneous.		

LOG OF TEST BORING

Job No. XL-5001　SR 005　Elevation 239.5 ft　HOLE No. H-18-17

Sheet 2 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange　Driller Wilson, Jamie



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
12 (25)			HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
14 17 25 (42)	D-9	MC GS	SW-SM, MC=9% Well graded SAND with silt and gravel, sub-angular gravel, dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
50/5" (REF)	D-10		Well graded SAND with silt and gravel, sub-angular gravel, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft
50/5" (REF)	D-11		Well graded SAND with silt and gravel, sub-angular gravel, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft
16 50/5" (REF)	D-12	MC GS	SW-SM, MC=9% Well graded SAND with silt and gravel, sub-angular gravel, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft

NOTE: Had 50% water loss throughout the boring.

The implied accuracy of the borehole location information displayed on this boring log is typically

WSDOT

LOG OF TEST BORING

Job No. XL-5001

SR 005

Elevation 239.5 ft

HOLE No. H-18-17

Sheet 3 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie

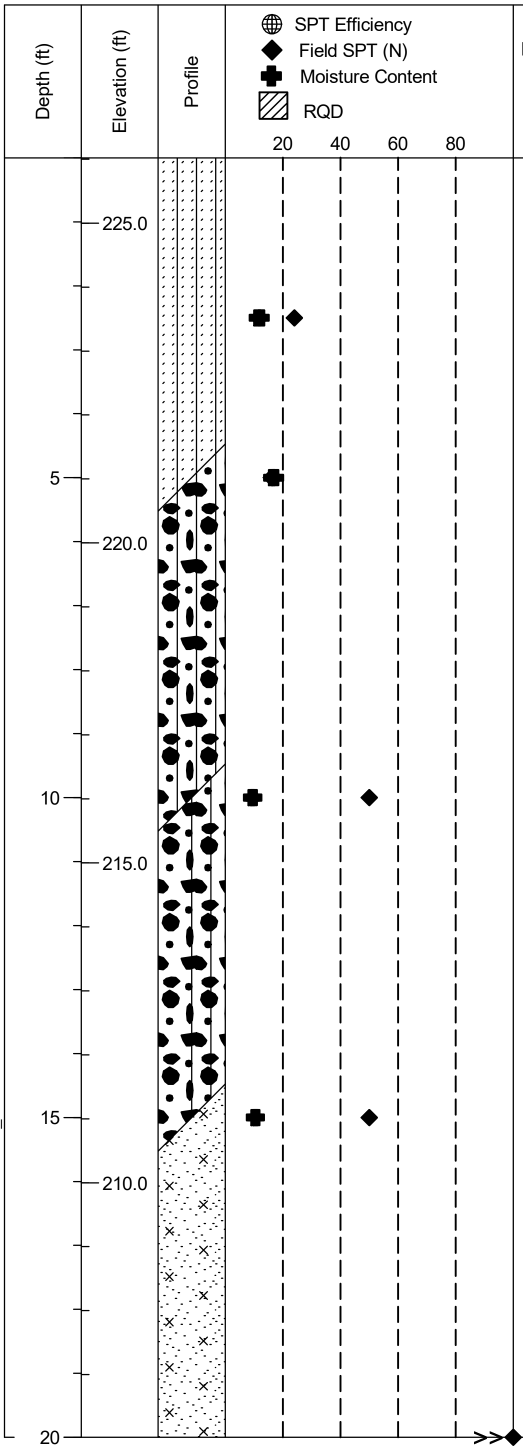
Depth (ft)	Elevation (ft)	Profile	⊕ SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew. End of test hole boring at 40.0 ft below ground surface. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
	190									
50								Bail/Recharge test: Hole Diameter: 4 in. Depth of boring during bail test: 40.0 ft. Depth of casing during bail test: 39.0 ft. Water depth before bailing: 7.6 ft. Bailed bore hole water level to 33.0 ft. Pull casing to 34.0 ft. Water level at 33.0 ft. Pull casing to 29.0 ft. Water level at 38.5 ft. Recharge after 5 minutes: 38.5 ft. Recharge after 10 minutes: 38.5 ft. Recharge after 15 minutes: 38.5 ft. Recharge after 20 minutes: 38.5 ft.		
	185									
55										
	180									
60										
	175									
65										
	170									
70										

WSDOT

LOG OF TEST BORING

Start Card SE-64048 / AE-45931
HOLE No. H-19-17
Sheet 1 of 2

Job No. XL-5001 SR 005 Elevation 226.0 ft
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Cooper, Richard Lic# 2964
Component Illumination, Signals, Signs, and Traffic Systems
Inspector Harvey, Thomas #2599
Start November 15, 2017 Completion November 15, 2017 Well ID# N/A
Equipment CME 850 (9A2-523)
Station LR 1441+42.29 Offset 237.2 feet right Hole Dia (inches) 4
Historical SPT Efficiency 89.7%
Northing 638798.07 Easting 1076255.65 Collected by Region Survey Crew
Method Casing Advancer
Lat 47.0628322 Long -122.7640049 Datum NAD 83/91 HARN, NAVD88, SPS (ft)
Drill Fluid Bentonite



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
7 11 13 (24)		D-1	MC GS AL	SM, MC=13%, LL=NA, PL=NP Silty SAND with gravel, sub-rounded gravel, medium dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft		
9 9 7 (16)		D-2	MC GS AL	GM, MC=17%, LL=NA, PL=NP Silty GRAVEL with sand, sub-rounded, medium dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
12 21 29 (50)		D-3	MC GS	GP-GM, MC=10% Poorly graded GRAVEL with silt and sand, sub-rounded, dense, dark brown, moist, homogeneous. HCl not tested. Recovered: 0.8 ft Retained: 0.8 ft		
19 21 29 (50)		D-4	MC GS AL	SC-SM, MC=11%, PI=6 Silty, clayey SAND, dense, brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 226.0 ft
HOLE No. H-19-17
Sheet 2 of 2
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Cooper, Richard

Depth (ft)	Elevation (ft)	Profile	🌐 SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
				50/4" (REF)	⧗	D-5		Silty, clayey SAND with gravel, sub-rounded gravel, very dense, brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		
	205									
25								The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
	200									
								End of test hole boring at 20.4 ft below ground surface. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
30										
	195							Borehole was dry at the end of drilling.		
35										
	190									
40										
	185									
45										

WSDOT

LOG OF TEST BORING

Start Card SE-64048 / AE-45931

HOLE No. H-20-17

Sheet 1 of 3

Job No. XL-5001 SR 005 Elevation 239.7 ft

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie Lic# 2941

Component Illumination, Signals, Signs, and Traffic Systems

Inspector Haller, Robert #2779

Start November 28, 2017 Completion November 28, 2017 Well ID# N/A

Equipment CME 45 (9C4-2)

Station LL 1439+71.66 Offset 305.6 feet left Hole Dia (inches) 4

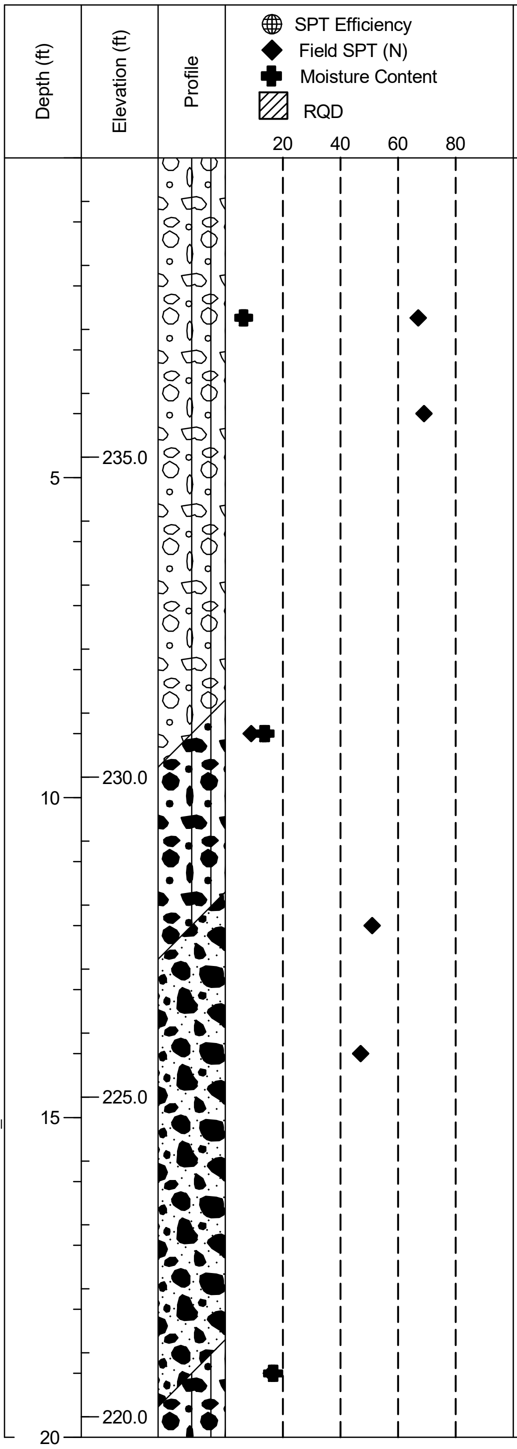
Historical SPT Efficiency 89.3%

Northing 639408.35 Easting 1075961.24 Collected by Region Survey Crew

Method Casing Advancer

Lat 47.0644816 Long -122.7652561 Datum NAD 83/91 HARN, NAVD88, SPS (ft)

Drill Fluid Polymer



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
12 21 46 (67)		D-1	MC GS	GW-GM, MC=7% Well graded GRAVEL with silt and sand, sub-angular, very dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
24 29 40 (69)		D-2		Well graded GRAVEL with silt and sand, sub-angular, very dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft		
3 4 5 (9)		D-3	MC GS	GP-GM, MC=14% Poorly graded GRAVEL with silt and sand, sub-angular, loose, dark grayish brown, wet, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
9 26 25 (51)		D-4		Well graded GRAVEL, sub-rounded, very dense, gray, moist, homogeneous. HCl not tested. Recovered: 0.2 ft Retained: 0.2 ft		
18 29 18 (47)		D-5		Well graded GRAVEL with sand, sub-rounded, dense, dark grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
10 6		D-6	MC GS	GP-GM, MC=17% Poorly graded GRAVEL with silt, sand, and organics/root		

LOG OF TEST BORING

Job No. XL-5001

SR 005

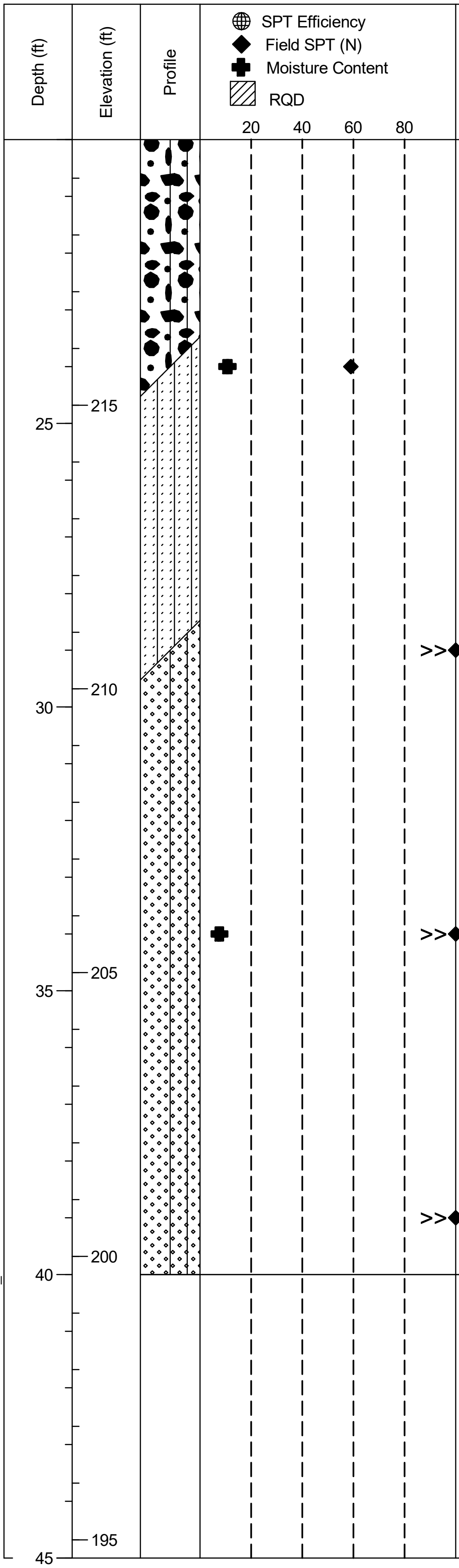
Elevation 239.7 ft

HOLE No. H-20-17

Sheet 2 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie



Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
10 (16)	⧗			hairs, sub-rounded, medium dense, dark brown, wet, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
18 27 32 (59)	⧗	D-7	MC GS AL	SM, MC=11%, LL=20 Silty SAND with gravel, sub-angular gravel, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft		
25 50/5" (REF)	⧗	D-8		Well graded SAND with silt and gravel, sub-angular gravel, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft		
17 50/5" (REF)	⧗	D-9	MC GS	SW-SM, MC=8% Well graded SAND with silt and gravel, sub-angular gravel, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.6 ft Retained: 0.6 ft		
19 50/5" (REF)	⧗	D-10		Well graded SAND with silt and gravel, sub-angular gravel, very dense, olive gray, moist, homogeneous. HCl not tested. Recovered: 0.5 ft Retained: 0.5 ft		
				Had 50% water loss throughout the boring.		
				The implied accuracy of the borehole location information displayed on this boring log is typically		

WSDOT

LOG OF TEST BORING

Job No. XL-5001
SR 005
Elevation 239.7 ft
HOLE No. H-20-17
Sheet 3 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie

Depth (ft)	Elevation (ft)	Profile	⊕ SPT Efficiency ◆ Field SPT (N) ✚ Moisture Content ▨ RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.		
								End of test hole boring at 40.0 ft below ground surface. This is a summary Log of Test Boring. Soil/Rock descriptions are derived from visual field identifications and laboratory test data. Note: REF = SPT Refusal		
50	190							Bail/Recharge test: Hole Diameter: 4 in. Depth of boring during bail test: 40.0 ft. Depth of casing during bail test: 39.0 ft. Water depth before bailing: 8.0 ft. Bailed bore hole water level to 31.0 ft. Recharge after 20 minutes: 39.0 ft.		
								Pull casing to 29.0 ft. Borehole was dry after casing was pulled.		
55	185									
60	180									
65	175									
70	170									

WSDOT

LOG OF TEST BORING

Start Card SE-64048 / AE-45931

HOLE No. H-21-17

Sheet 1 of 3

Job No. XL-5001 SR 005 Elevation 222.9 ft

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie Lic# 2941

Component Illumination, Signals, Signs, and Traffic Systems

Inspector Harvey, Thomas #2599

Start November 9, 2017 Completion November 9, 2017 Well ID# N/A

Equipment CME 850 (9A2-523)

Station 1443+33.94 Offset 175.9 feet left Hole Dia (inches) 4

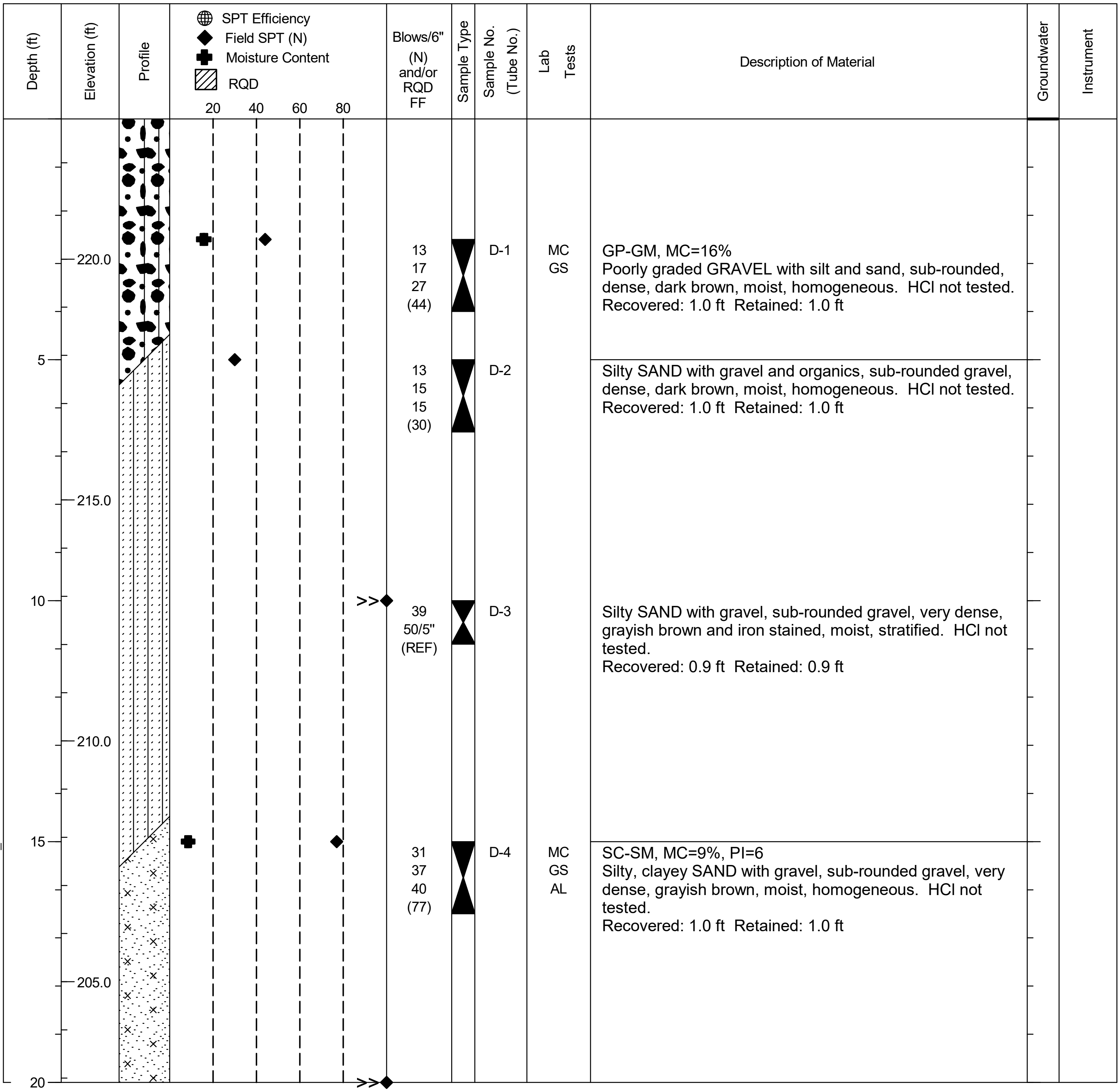
Historical SPT Efficiency 89.7%

Northing 639326.18 Easting 1076337.31 Collected by Region Survey Crew

Method Casing Advancer

Lat 47.0642860 Long -122.7637382 Datum NAD 83/91 HARN, NAVD88, SPS (ft)

Drill Fluid Bentonite



Blows/6" (N) and/or RQD FF	Sample No. (Tube No.)	Lab Tests	Description of Material
13 17 27 (44)	D-1	MC GS	GP-GM, MC=16% Poorly graded GRAVEL with silt and sand, sub-rounded, dense, dark brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
13 15 15 (30)	D-2		Silty SAND with gravel and organics, sub-rounded gravel, dense, dark brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft
39 50/5" (REF)	D-3		Silty SAND with gravel, sub-rounded gravel, very dense, grayish brown and iron stained, moist, stratified. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft
31 37 40 (77)	D-4	MC GS AL	SC-SM, MC=9%, PI=6 Silty, clayey SAND with gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.0 ft Retained: 1.0 ft

WSDOT

LOG OF TEST BORING

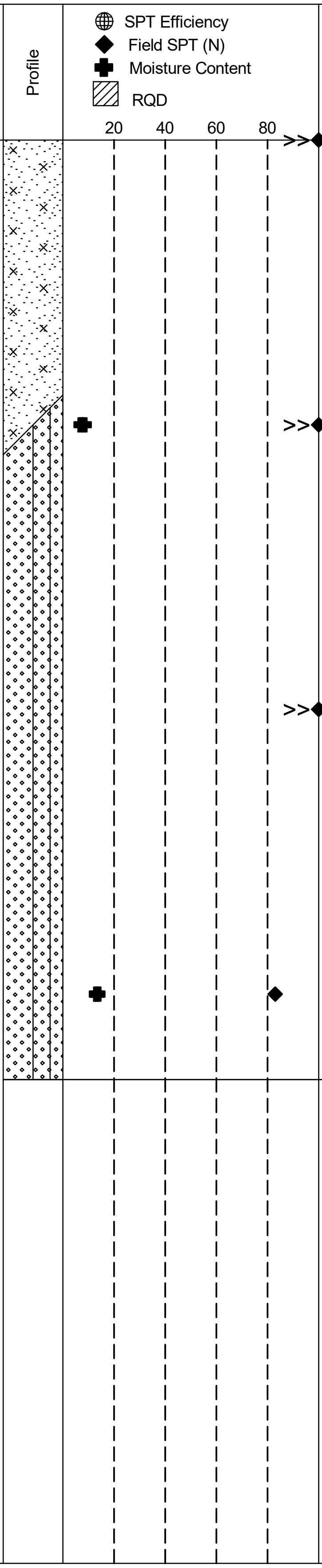
Job No. XL-5001   SR 005   Elevation 222.9 ft

HOLE No. H-21-17

Sheet 2 of 3

Project I-5/SR-510 Interchange - Reconstruct Interchange

Driller Wilson, Jamie



Depth (ft)	Elevation (ft)	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
20		41 50/6" (REF)		D-5		Silty, clayey SAND with gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.9 ft Retained: 0.9 ft		
	200							
25		41 50/4" (REF)		D-6	MC GS	SW-SM, MC=8% Well graded SAND with silt and gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.7 ft Retained: 0.7 ft		
	195							
30		57/6" (REF)		D-7		Well graded SAND with silt and gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 0.4 ft Retained: 0.4 ft		
	190							
35		31 41 42 (83)		D-8	MC GS AL	SW-SM, MC=14%, LL=NA, PL=NP Well graded SAND with silt and gravel, sub-rounded gravel, very dense, grayish brown, moist, homogeneous. HCl not tested. Recovered: 1.5 ft Retained: 1.5 ft		
	185							
40								
	180							
45								

The implied accuracy of the borehole location information displayed on this boring log is typically sub-meter in (X,Y) when collected by the HQ Geotech Office and sub-centimeter in (X,Y,Z) when collected by the Region Survey Crew.

End of test hole boring at 36.5 ft below ground surface.
This is a summary Log of Test Boring.
Soil/Rock descriptions are derived from visual field identifications and laboratory test data.
Note: REF = SPT Refusal

Bail/Recharge test:
Hole Diameter: 4 in.
Depth of boring during bail test: 30.5 ft.
Depth of casing during bail test: 25.0 ft.

WSDOT

LOG OF TEST BORING

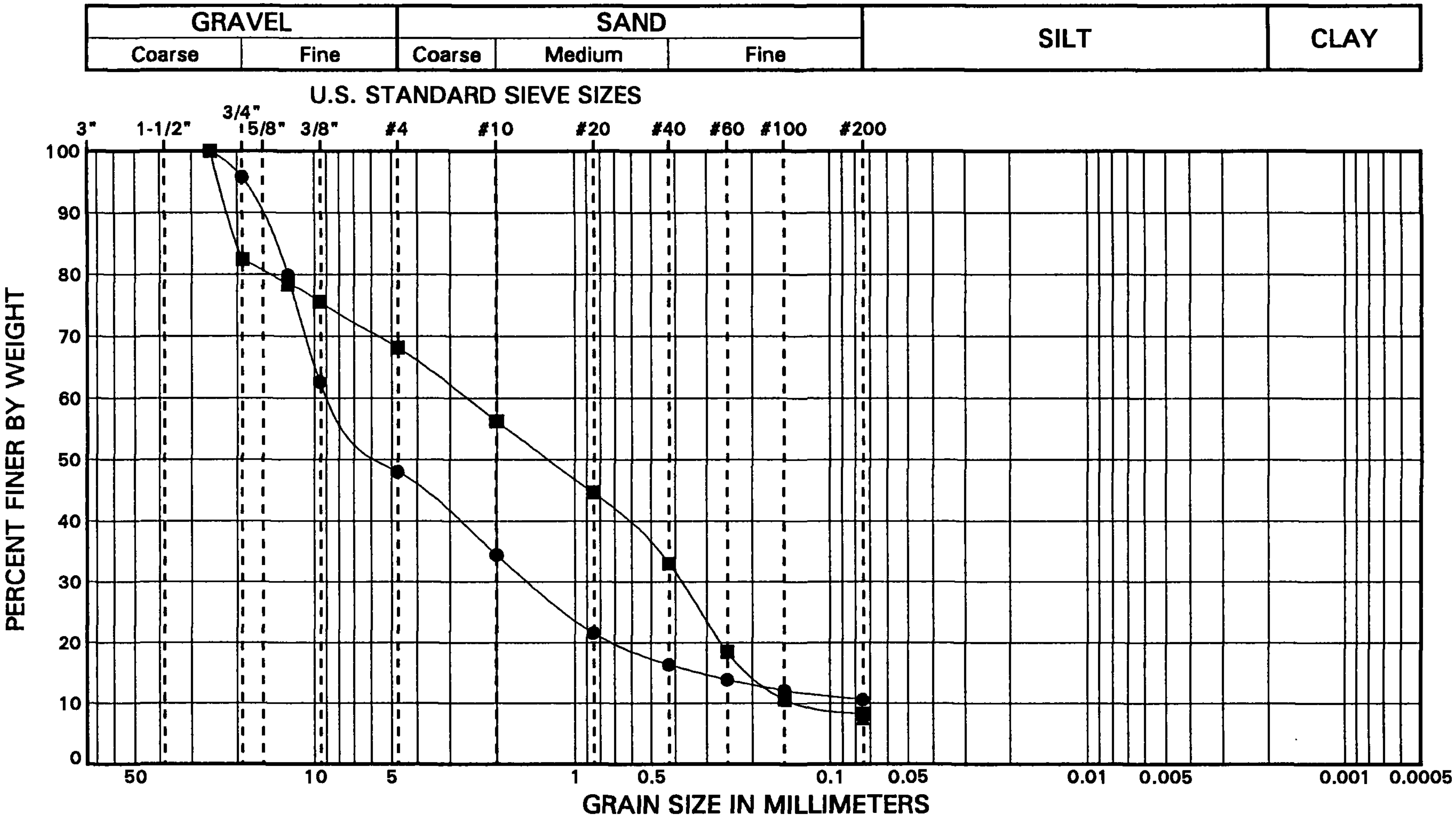
Job No. XL-5001
SR 005
Elevation 222.9 ft
HOLE No. H-21-17
Sheet 3 of 3
Project I-5/SR-510 Interchange - Reconstruct Interchange
Driller Wilson, Jamie

Depth (ft)	Elevation (ft)	Profile	SPT Efficiency Field SPT (N) Moisture Content RQD 20 40 60 80	Blows/6" (N) and/or RQD FF	Sample Type	Sample No. (Tube No.)	Lab Tests	Description of Material	Groundwater	Instrument
								Water depth before bailing: 7.9 ft. Bailed bore hole water level to 27.3 ft. Recharge after 5 minutes: 27.4 ft. Recharge after 10 minutes: 27.7 ft. Recharge after 15 minutes: 27.9 ft. Recharge after 20 minutes: 28.1 ft. Recharge after 25 minutes: 28.2 ft. Recharge after 30 minutes: 28.3 ft. Recharge after 40 minutes: 29.7 ft.		
	175									
50										
	170									
55										
	165									
60										
	160									
65										
	155									
70										

ENTERPRISE BORING LOG XL-5001 005_510 IC - RECONSTRUCT INTERCHANGE.GPJ ENTERPRISE DATA TEMPLATE.GDT 2/8/18

APPENDIX D

Historical Laboratory Testing Data



SYMBOL	SAMPLE		DEPTH (m)	CLASSIFICATION	% MC	LL	PL	PI	% Gravel	% Sand	% Fines
●	BH-1	S-3	2.7 - 3.2	(GP-GM) Olive brown, poorly graded GRAVEL with silt and sand.	8				52.0	37.4	10.6
■	BH-1	S-5	5.5 - 5.7	(SP-SM) Olive brown, poorly graded SAND with silt and gravel.	12				31.9	59.8	8.3
▲	BH-1	S-8	10.1 - 10.5	(SP-SM) Grayish brown, poorly graded SAND with silt and gravel.	10						7.4

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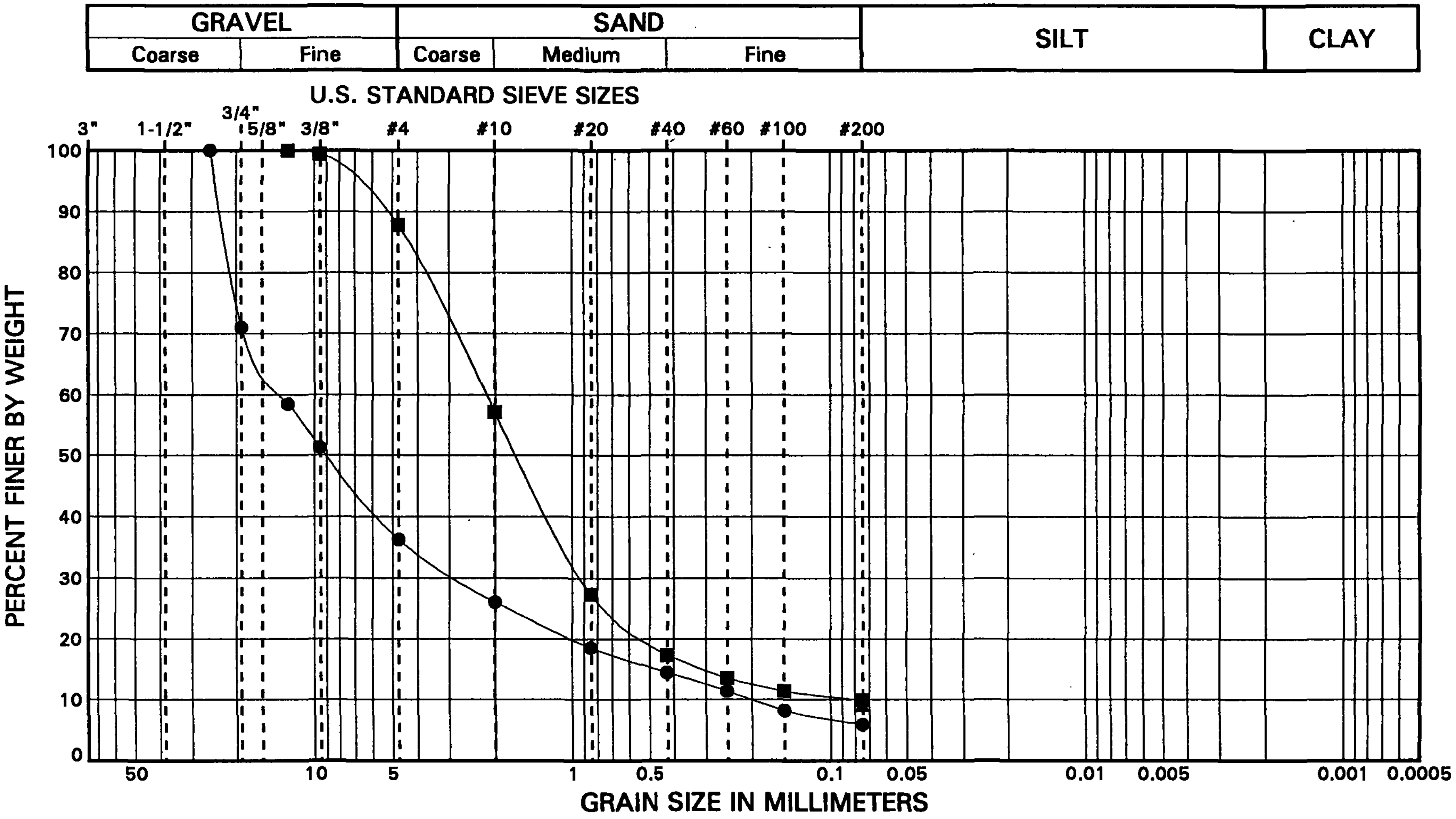
State Route 510
Lacey, WA

GRAIN SIZE DISTRIBUTION TEST RESULTS

PROJECT NO.: 96178 FIGURE: B-1

HWAGRSZM 96178 6/18/97



SYMBOL	SAMPLE		DEPTH (m)	CLASSIFICATION	% MC	LL	PL	PI	% Gravel	% Sand	% Fines
●	BH-2	S-2	1.5 - 2.0	(GW-GM) Very dark brown, well graded GRAVEL with silt and sand.	8				63.7	30.4	5.9
■	BH-2	S-5	5.5 - 6.0	(SP-SM) Light olive brown, poorly graded SAND with silt.	12				12.2	77.9	9.9
▲	BH-2	S-7	8.5 - 9.0	(GP-GM) Light olive brown, poorly graded GRAVEL with silt and sand.	10						9.0

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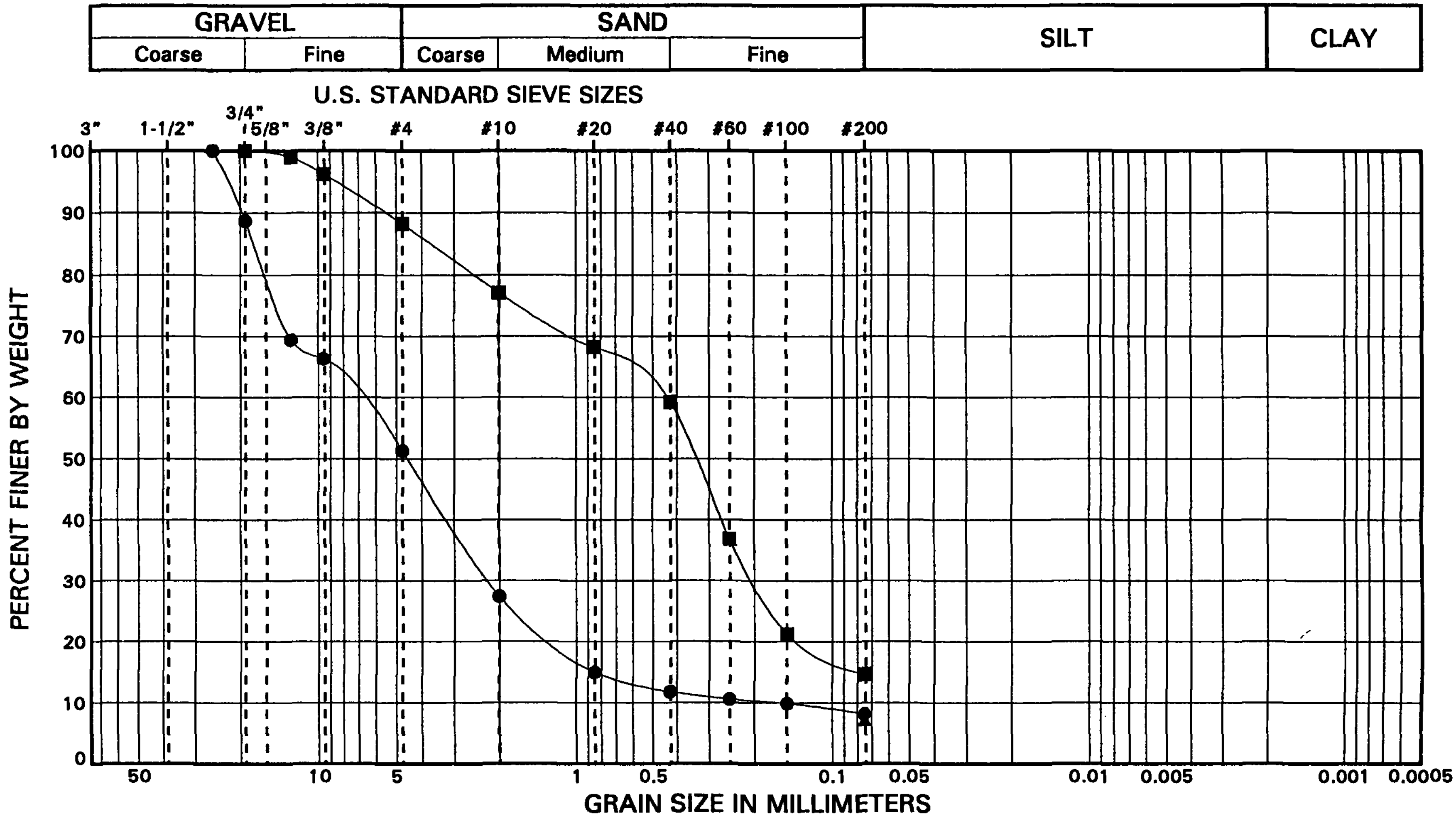
State Route 510
Lacey, WA

GRAIN SIZE DISTRIBUTION TEST RESULTS

PROJECT NO.: 96178 FIGURE: B-2

HWAGRSZM 96178 6/18/97



SYMBOL	SAMPLE		DEPTH (m)	CLASSIFICATION	% MC	LL	PL	PI	% Gravel	% Sand	% Fines
●	BH-3	S-2	1.5 - 2.0	(GW-GM) Olive brown, well graded GRAVEL with silt and sand.	4				48.7	43.1	8.2
■	BH-3	S-4	4.0 - 4.4	(SM) Olive brown, silty SAND.	17				11.8	73.5	14.7
▲	BH-3	S-8	10.1 - 10.5	(SP-SM) Olive gray, poorly graded SAND with silt and gravel.	8						7.2

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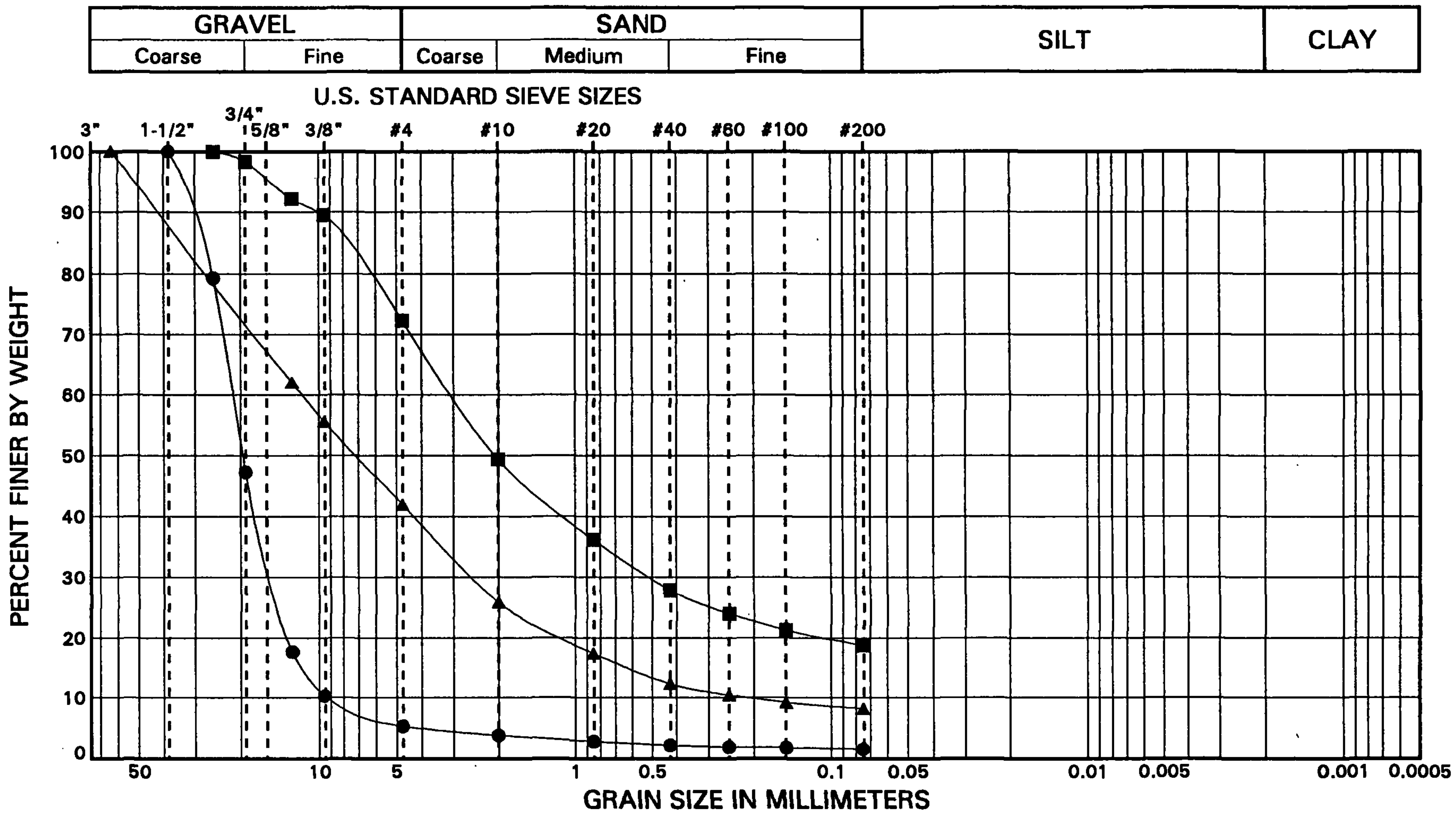
State Route 510
Lacey, WA

GRAIN SIZE DISTRIBUTION TEST RESULTS

PROJECT NO.: 96178 FIGURE: B-3

HWAGRSZM 96178 6/18/97



SYMBOL	SAMPLE		DEPTH (m)	CLASSIFICATION	% MC	LL	PL	PI	% Gravel	% Sand	% Fines
●	BH-4	S-4	3.1 - 3.4	(GP) Dark grayish brown, poorly graded GRAVEL.					94.7	3.7	1.6
■	BH-4	S-5	4.0 - 4.3	(SM) Olive brown, silty SAND with gravel.					27.7	53.5	18.8
▲	BH-4	S-6	5.5 - 5.6	(GW-GM) Olive brown, well graded GRAVEL with silt and sand.					58.0	33.8	8.2

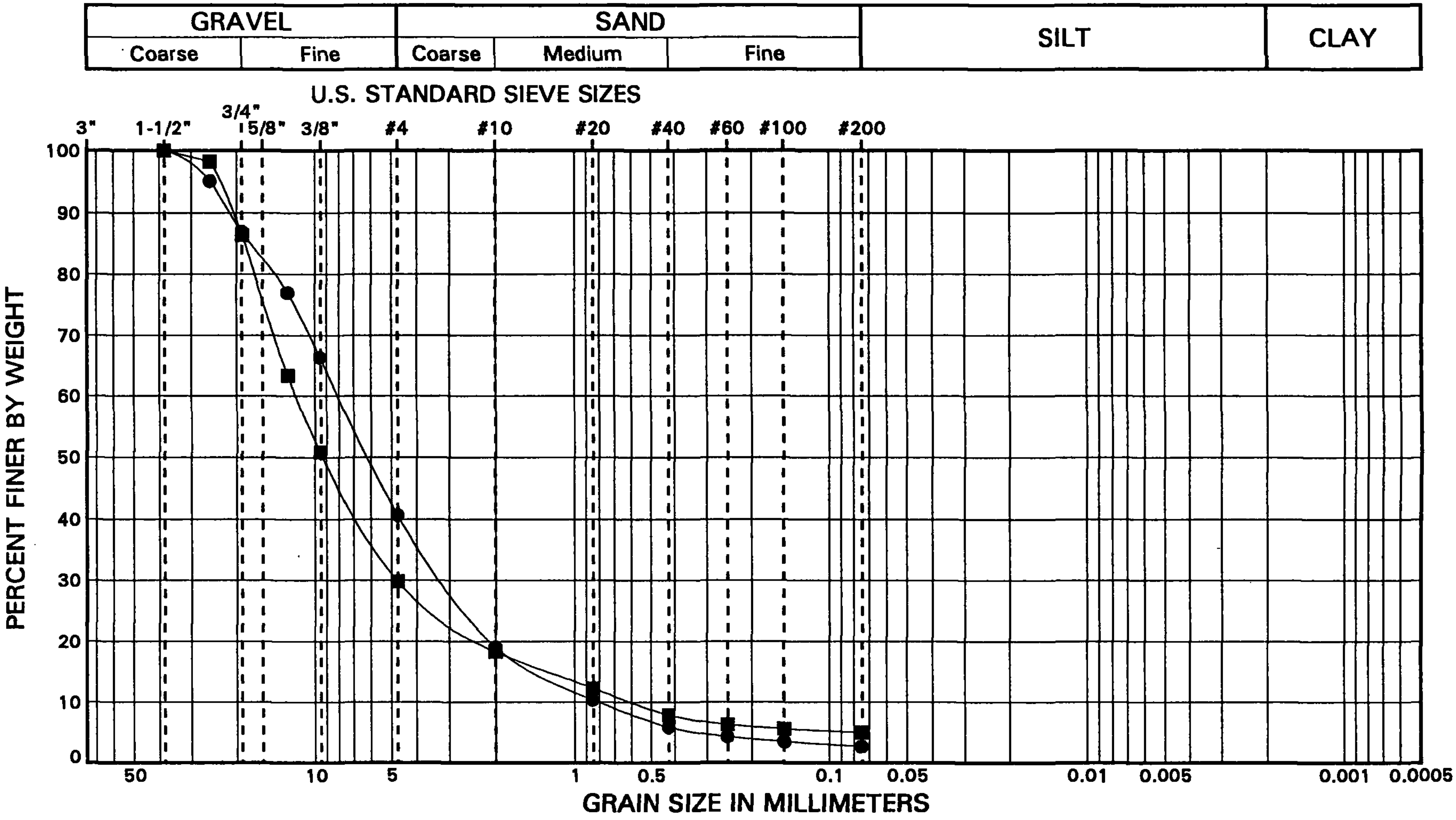
HONGWEST
& ASSOCIATES, INC.

State Route 510
Lacey, WA

GRAIN SIZE DISTRIBUTION TEST RESULTS

PROJECT NO.: 96178 FIGURE: B-4

HWAGRSZM 96178 6/18/97



SYMBOL	SAMPLE		DEPTH (m)	CLASSIFICATION	% MC	LL	PL	PI	% Gravel	% Sand	% Fines
●	BH-5	S-2	0.9 - 1.2	(GW) Dark brown, well graded GRAVEL with sand.					59.3	38.0	2.7
■	BH-5	S-4	3.1 - 3.4	(GP-GM) Dark grayish brown, poorly graded GRAVEL w/silt and sand.					70.2	24.8	5.0

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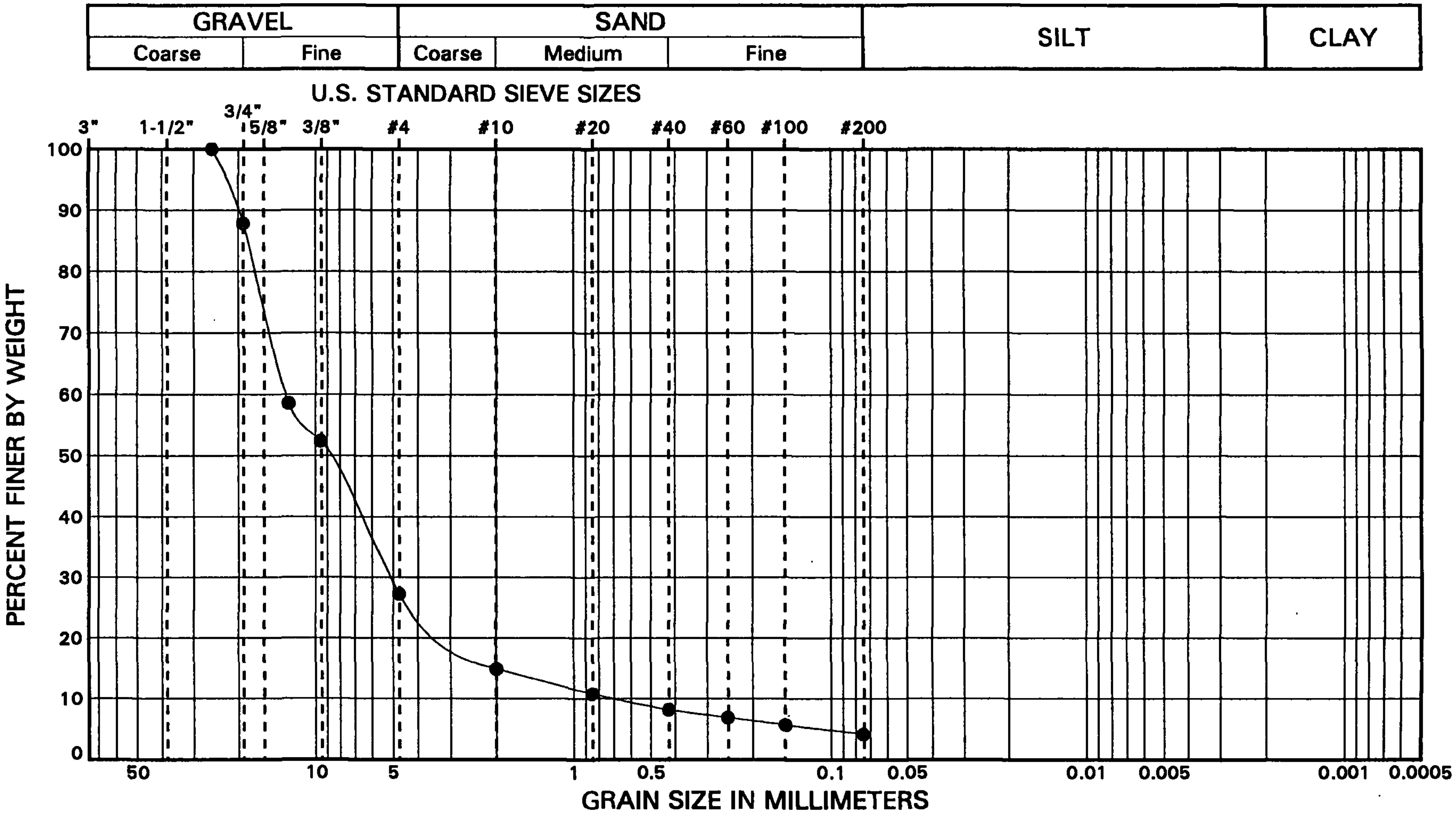
State Route 510
Lacey, WA

GRAIN SIZE DISTRIBUTION TEST RESULTS

PROJECT NO.: 96178

FIGURE: B-5

HWAGRSZM 96178 6/18/97



SYMBOL	SAMPLE		DEPTH (m)	CLASSIFICATION	% MC	LL	PL	PI	% Gravel	% Sand	% Fines
●	BH-6	S-1	0.2 - 0.5	(GW) Olive brown, well graded GRAVEL with sand.					72.7	23.1	4.2

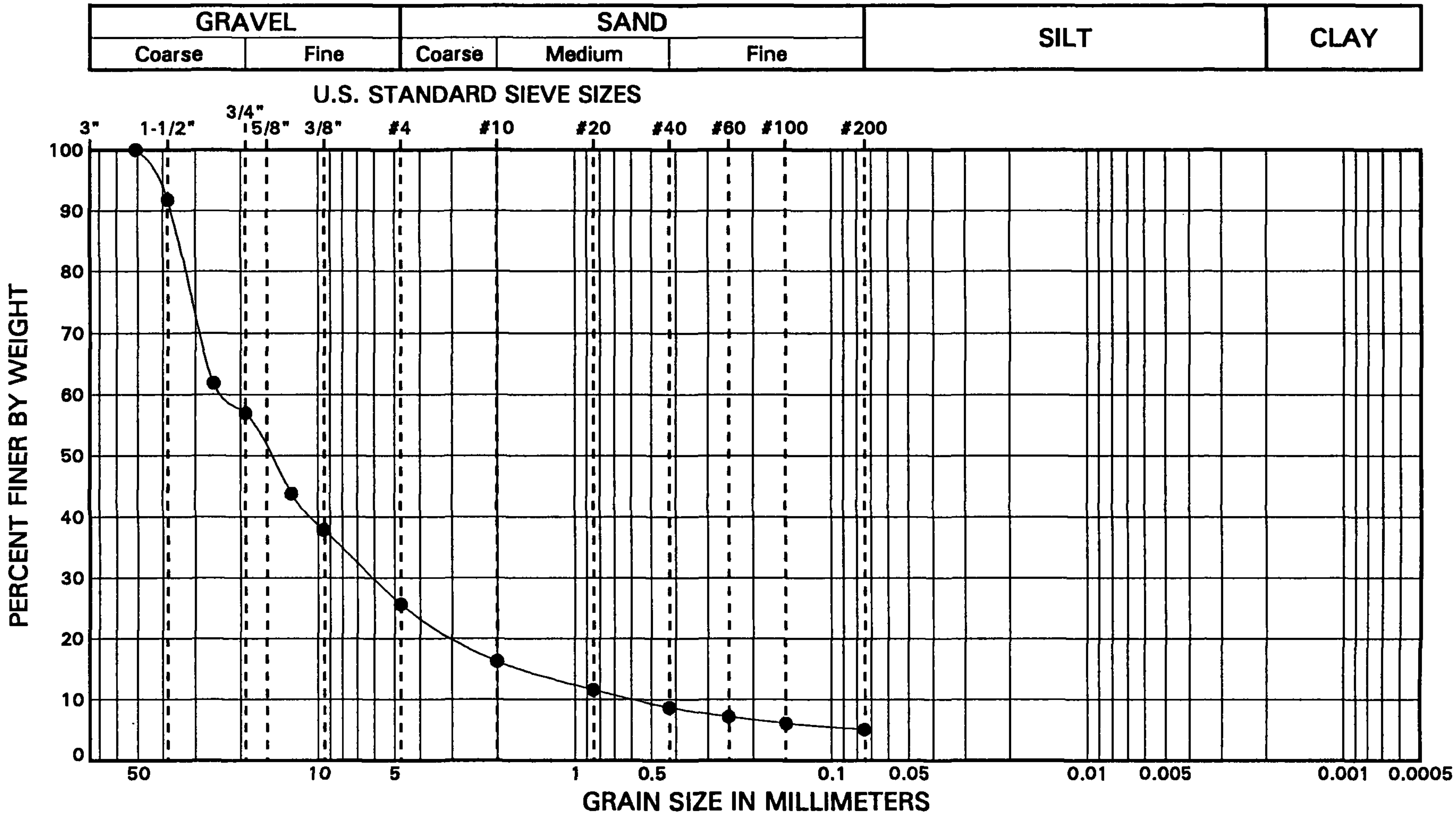
HONGWEST & ASSOCIATES, INC.

State Route 510
Lacey, WA

GRAIN SIZE DISTRIBUTION TEST RESULTS

PROJECT NO.: 96178 FIGURE: B-6

HWAGRSZM 96178 6/18/97



SYMBOL	SAMPLE		DEPTH (m)	CLASSIFICATION	% MC	LL	PL	PI	% Gravel	% Sand	% Fines
●	BH-7	S-1	0.2 - 0.5	(GW-GM) Olive brown, well graded GRAVEL with silt and sand.					74.3	20.6	5.1

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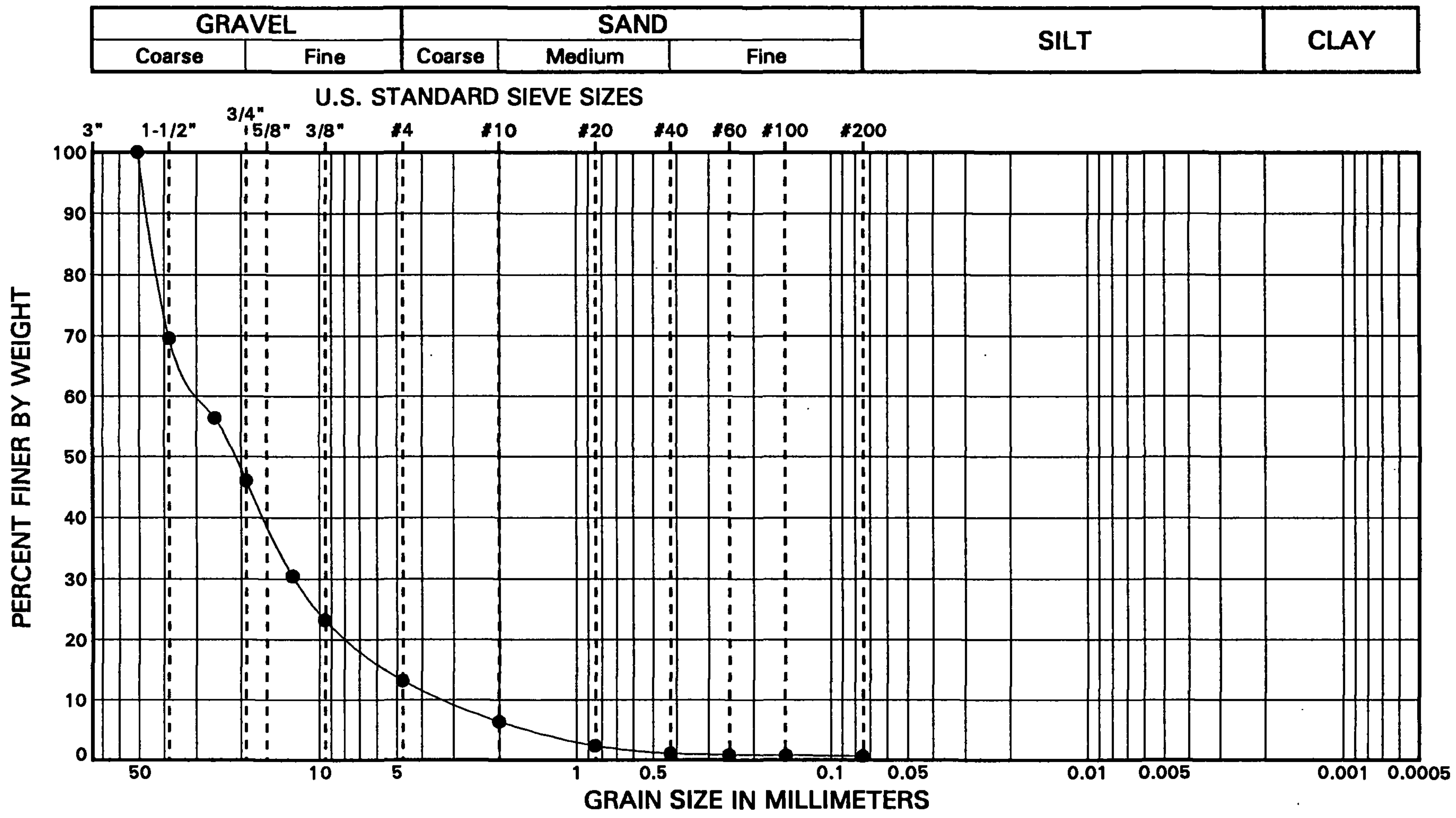
State Route 510
Lacey, WA

GRAIN SIZE DISTRIBUTION TEST RESULTS

PROJECT NO.: 96178 FIGURE: B-7

HWAGRSZM 96178 6/27/97



SYMBOL	SAMPLE		DEPTH (m)	CLASSIFICATION	% MC	LL	PL	PI	% Gravel	% Sand	% Fines
●	TP-1	S-2	1.5 - 1.8	(GW) Light olive brown, well graded GRAVEL.					86.8	12.5	0.7

HONGWEST
& ASSOCIATES, INC.

State Route 510
Lacey, WA

GRAIN SIZE DISTRIBUTION TEST RESULTS

PROJECT NO.: 96178 FIGURE: B-8

HWAGRSZM 96178 6/27/97

Northern, Inc.
Kirkland, Yakima, Kennewick, Hermiston (OR)

Project No.: 298-811
SR-510
SR-5 to Martin Way
Lacey, Washington

PARTICLE SIZE ANALYSIS

(ASTM C-136-93; D-1140-92)

Test Boring/ Test Pit Number: TH-1
Sample Identification: S5
Sample Depth (ft. BGS): 15.0
Date Sampled: 04/15/99

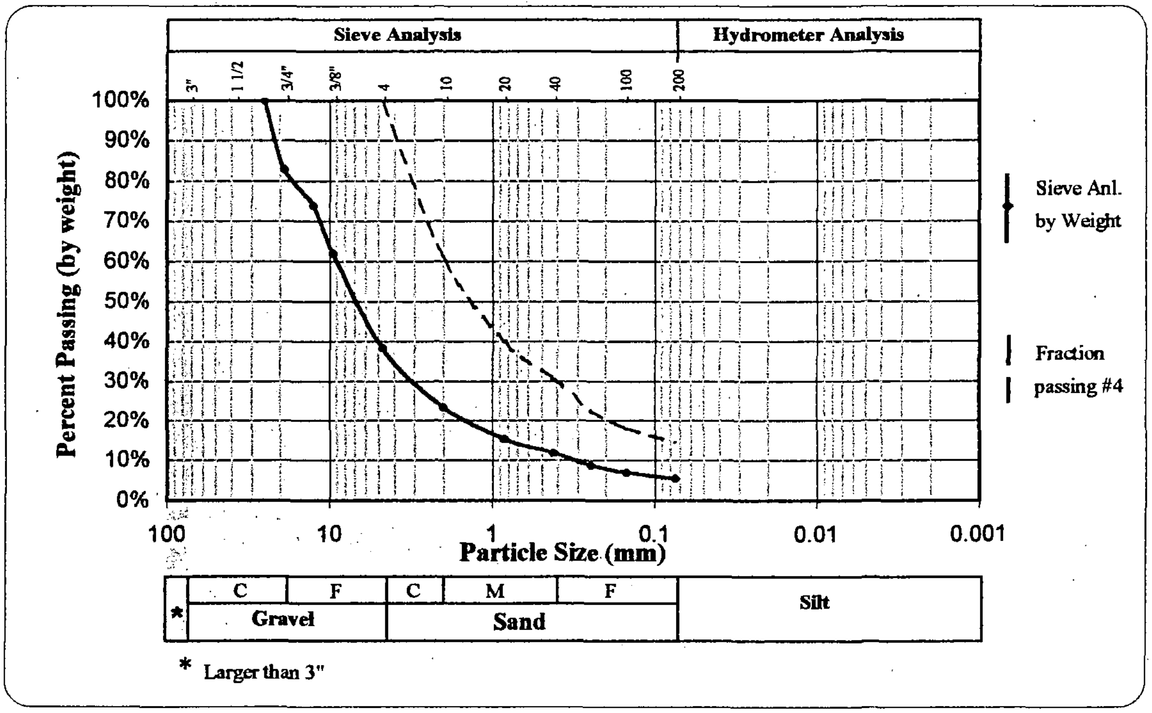
Atterberg Limits (ASTM D 4318)

Liquid Limit: N/A
Plastic Limit: N/A
Plasticity Index: N/A

Specific Gravity (ASTM C 127): N/A
Moisture Content (ASTM D 2216): N/A

Soil Classification (ASTM D 2487): GW-GM
Description: Well Graded Gravel with Silt and Sand

Major Divisions	Sieve Designation	% Passing by Weight	Fraction Passing #4
	3"		
	2"		
	1.5"		
Gravel	1"	100	
62%	3/4"	83	
	1/2"	74	
	3/8"	62	
	No. 4	38	100%
	No. 10	23	61%
Sand	No. 20	15	40%
33%	No. 40	12	31%
	No. 80	9	23%
	No. 100	7	18%
Fines	No. 200	6	15%



Reviewed by: Joseph Hard

Date: May 25, 1999

WASHINGTON
STATE HIGHWAY COMMISSION
DEPARTMENT OF HIGHWAYS
Materials Laboratory
Olympia

SOIL TEST DATA

Job No. L-2055 PS.H. No. 1 Section Gleason - Carney Road - Channelization

Field Sample No.	2	4	5			
Laboratory No.	5-6161	5-6162	5-6163			
Sample from Station	191+15	196+05	200+50			
Offset	25' Rt.	25' Rt.	29' Rt.			
Depth	7"-36"	8"-11"	2"-16"			
Textural Classification	Gravel	Silty Sandy Gravel	Silty Sandy Gravel			
Liquid Limit	33	—	—			
Plasticity Index	14	N.P.	N.P.			
Grading - Maximum Size	2"	3"	2½			
% Passing 1½"	99	83	87			
1"	93	74	74			
3/4"	85	63	66			
3/8"	46	40	46			
#4	15	26	32			
10	8	22	26			
40	5	17	18			
200	3	11	11			
HRB Class. & Group Index	A-2-6 (0)	A-1-a (0)	A-1-a (0)			
Proctor (ASTM D698-42T): Opt. Moist. Cont.						
Max. Density						
Density in Place						
% of Max. Density						
Moist. Cont. in Place						
Hveem Stabilometer Test: Resistance Value "R"	To coarse	75	71			
Equilibrium Swell Pressure (psi)						
Theoretical Total Surfacing ~~and Bituminous Mat~~, Design ~~Curve~~ T.I. 6.6		7"	8"			

DISTRIBUTION:
Materials Files X
General Files ✓
District Engineer (3) 3
Dist. Soils Engr. (3) X
Plan. & Contracts X
Hdq.Loc.Engr. X
Bureau Pub. Roads
Soils Lab. X

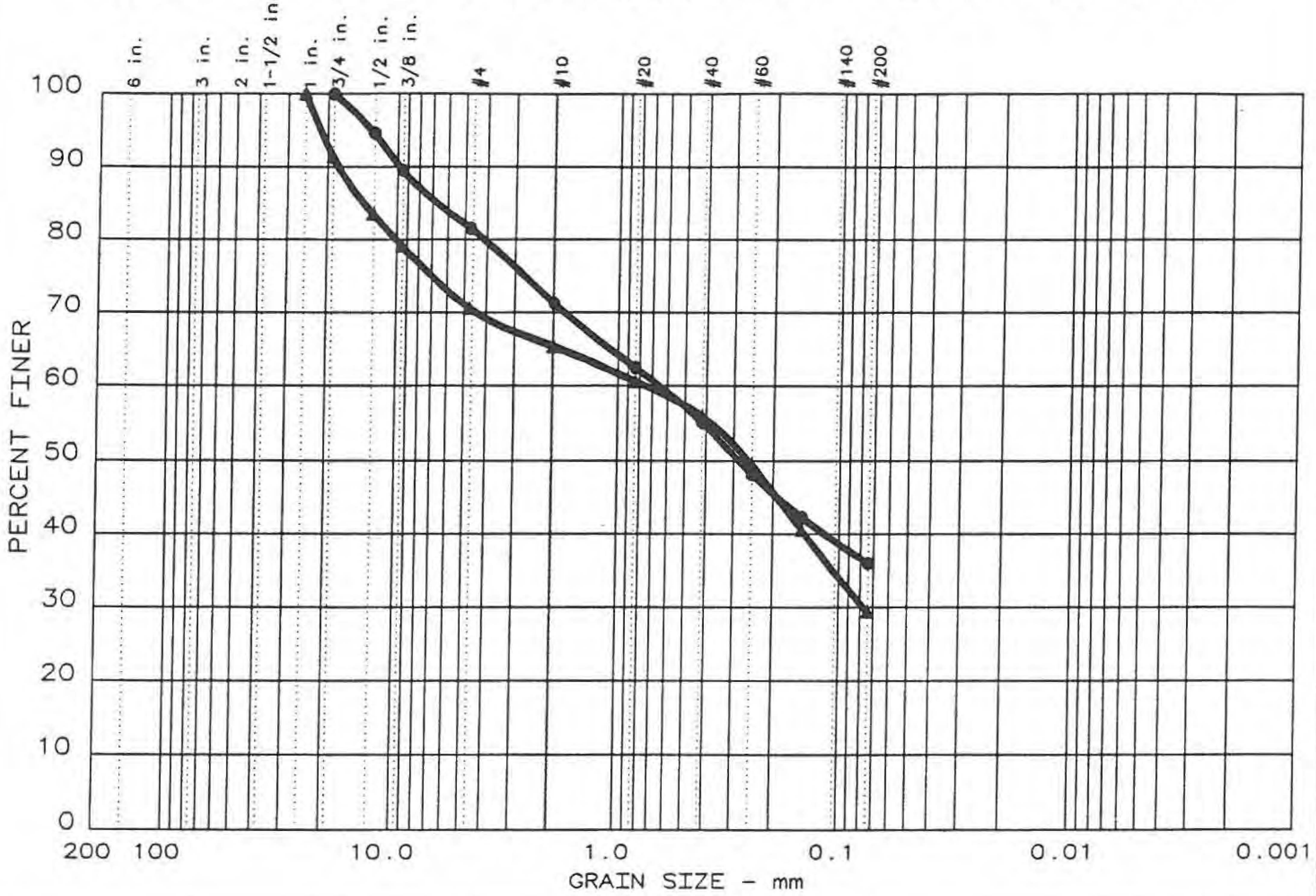
CARL E. MINOR
Principal Materials Engineer

By

Date 4-21-58

H.F. 26.02 (Rev.)

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	18.5	45.6	35.9	
▲	0.0	29.4	41.2	29.4	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			6.68	0.65	0.29					
▲			13.80	0.74	0.26	0.077				

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Gravelly, very silty SAND	SM	18%
▲ Gravelly, Silty SAND	SM	9%

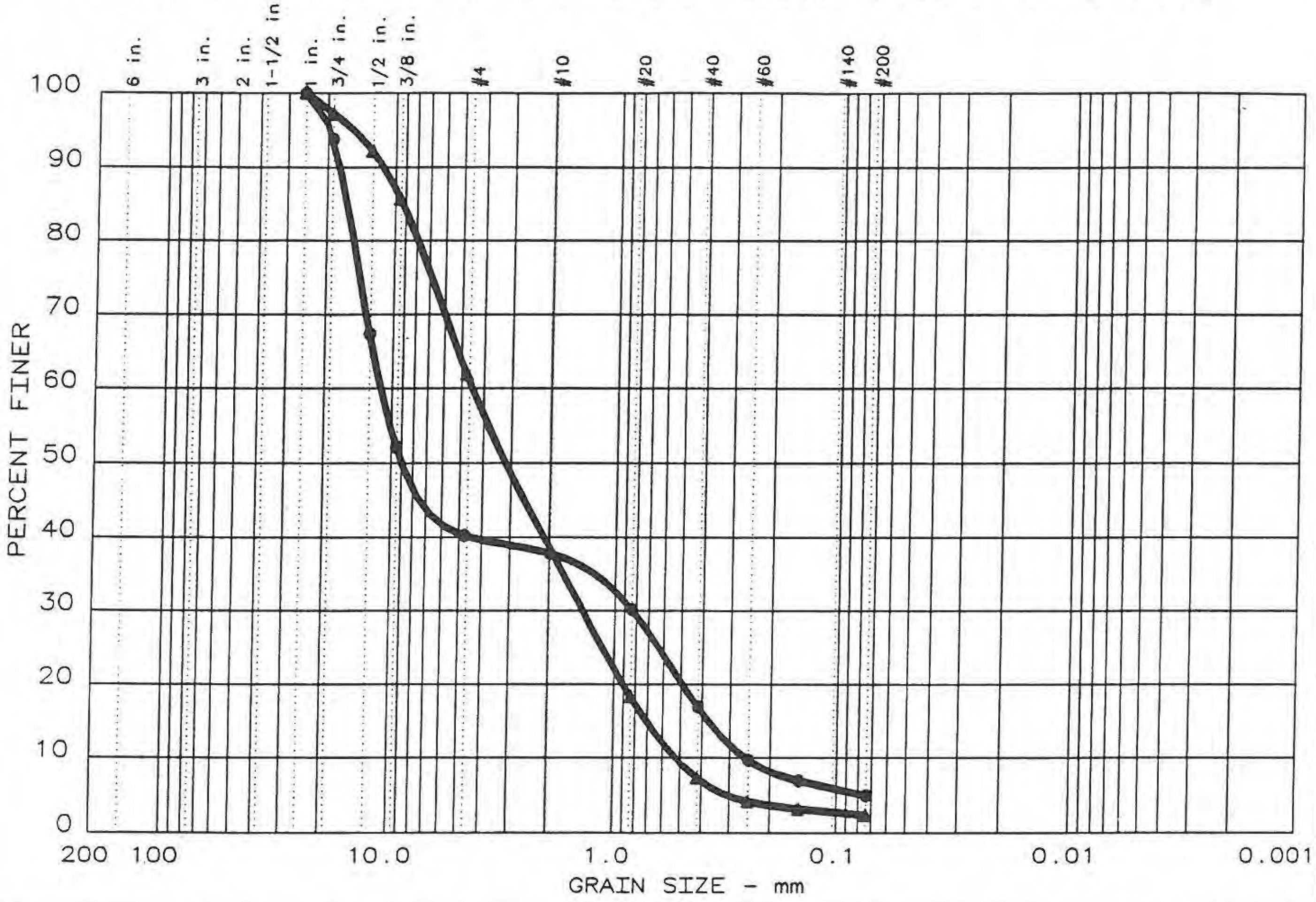
Remarks:

Project: Lacey L.I.D.
● Location: TP-1, S-2
▲ Location: TP-2, S-3

HART CROWSER

J-4668 12/9/96
Figure B-2

GRAIN SIZE DISTRIBUTION TEST REPORT



	%+75mm	% GRAVEL	% SAND	% SILT	% CLAY
●	0.0	59.8	35.3	4.9	
▲	0.0	38.1	59.6	2.3	

	LL	PI	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
●			16.27	11.23	8.98	0.829	0.3745	0.2562	0.24	43.9
▲			9.23	4.47	3.16	1.396	0.7071	0.5182	0.84	8.6

MATERIAL DESCRIPTION	USCS	NAT. MOIST.
● Very sandy GRAVEL	GP	6%
▲ Very gravelly SAND	SP	16%

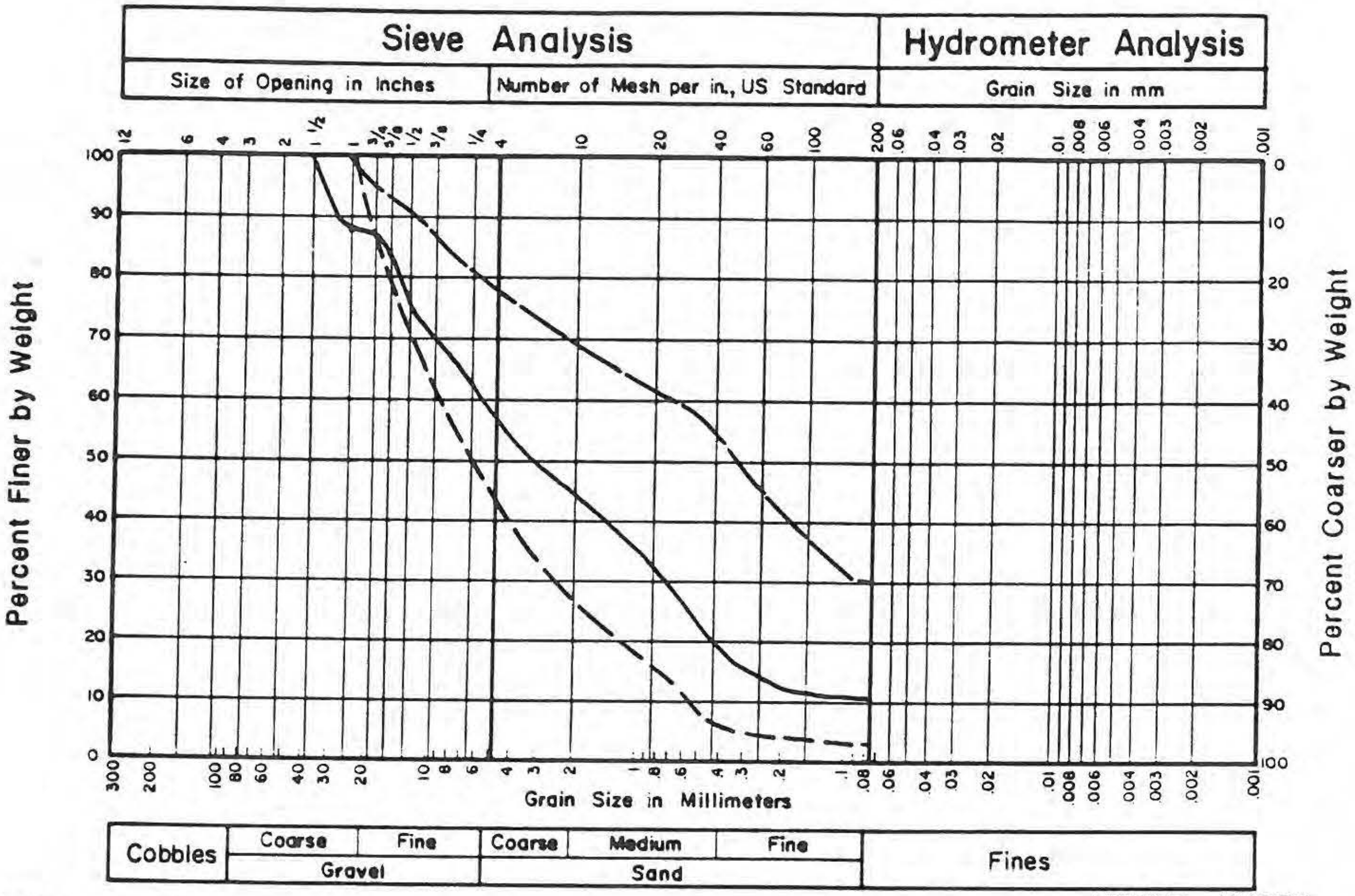
Remarks:

Project: Lacey L.I.D.
● Location: TP-7, S-2
▲ Location: TP-7, S-3

HARTCROWSER

J-4668 12/9/96
Figure B-3

Grain Size Classification



LINE SYMBOL	BORING NUMBER	SAMPLE NUMBER	DEPTH IN FEET	CLASSIFICATION	UNIFIED SOIL CLASS.	WATER CONTENT PERCENT
———	HC-2	S-5	22.5-23.2	Slightly silty, very gravelly, SAND	SM-SW	8
— —	HC-4	S-3	12.5-13.5	Gravelly, silty SAND	SM	8
- - - -	HC-6	S-3	12.5-14.0	Very sandy GRAVEL	GW	3

HARTCROWSER
J-2276 8/89
Figure B-2

Appendix F

Catchment #	Total Area Forested (AC)
C101	22.59
C102	22.97
C103	18.53
C104	32.50
C105	8.60
C106	28.45
C107	6.50
C108	24.91
C109	8.95
Total:	**174.00**

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CLIENT:

ACORN ENVIROMENTAL
5170 GOLDEN FOOTHILL PARKWAY
EL DORADO HILLS, CA 95762

PH: 916-235-8224
FX:
CONTACT: RYAN SAWYER
EMAIL: rsawyer@acorn-env.com

PRE-DEVELOPED CATCHMENT PLAN FOR:

QUIEMUTH VILLAGE

OLSON LAND SURVEYORS
ENGINEERS
ENGINEERING INC. 222 E. EVERGREEN, VANCOUVER, WA 98660
360-695-1385

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PETER A. TUCK
31517

6/01/2023

CHANGES / REVISIONS

DESCRIPTION:	DATE:

DESIGNED: GCO

DRAWN: GCO/TAS

CHECKED: PAT

DATE: NOVEMBER 2020

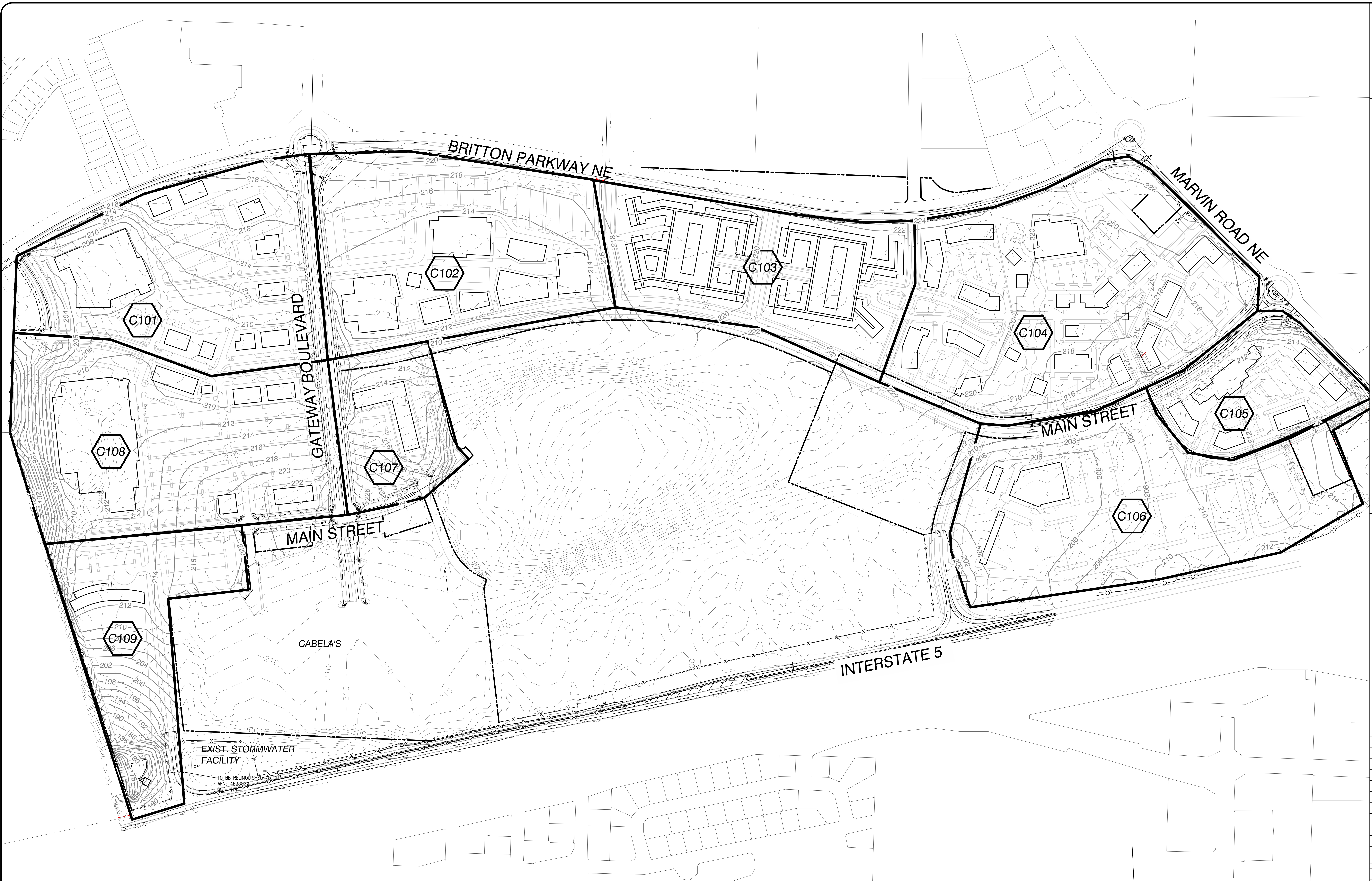
SCALE: H: 1"= XX'
V: N/A

QUIEMUTH VILLAGE

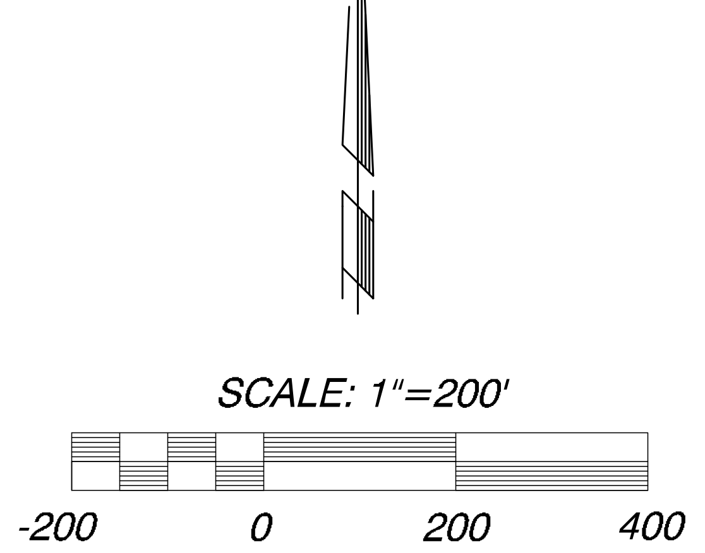
JOB NO.: 1234.01.01

SHEET

CP-1.0



Catchment #	Total Area (AC)	Impervious Total Area (AC)	Paved Area (PGIS) (AC)	Roof Area (AC)	Landscape Area (AC)
C101	22.59	19.20	15.36	3.84	3.39
C102	22.97	19.52	15.62	3.90	3.45
C103	18.53	15.75	12.60	3.15	2.78
C104	32.50	27.64	22.09	5.55	4.86
C105	8.60	7.31	5.85	1.46	1.29
C106	28.45	24.18	19.35	4.83	4.27
C107	6.50	5.52	4.42	1.10	0.98
C108	24.91	21.17	16.94	4.23	3.74
C109	8.96	7.61	6.09	1.52	1.34
Total:	**174.00**	**147.90**	**118.32**	**29.58**	**26.10**



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CLIENT:

ACORN ENVIROMENTAL
5170 GOLDEN FOOTHILL PARKWAY
EL DORADO HILLS, CA 95762

PH: 916-235-8224
FX:
CONTACT: RYAN SAWYER
EMAIL: rsawyer@acorn-env.com

DEVLOPED CATCHMENT PLAN - ALTERNATIVE 1 FOR:

QUIEMUTH VILLAGE

OLSON LAND SURVEYORS
ENGINEERS
ENGINEERING INC. 222 E. EVERGREEN, VANCOUVER, WA 98660
360-695-1385

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CHANGES / REVISIONS

DESCRIPTION:	DATE:

DESIGNED: GCO

DRAWN: GCO/TAS

CHECKED: PAT

DATE: NOVEMBER 2020

SCALE: H: 1"= XX'
V: N/A

QUIEMUTH VILLAGE

JOB NO.:1234.01.01

SHEET

CP-2.0

Catchment #	Total Area (AC)	Impervious Total Area (AC)	Paved Area (PGIS) (AC)	Roof Area (AC)	Landscape Area (AC)
C201	22.59	5.19	4.35	0.84	17.40
C202	22.97	19.52	15.62	3.90	3.45
C203	18.53	3.71	3.71	0.00	14.82
C204	32.50	27.64	22.09	5.55	4.86
C205	8.60	7.31	5.85	1.46	1.29
C206	28.45	24.18	19.35	4.83	4.27
C207	6.50	5.52	4.42	1.10	0.98
C208	24.91	4.98	4.98	0.00	19.93
C209	8.95	7.61	6.09	1.52	1.34
Total:	**174.00**	**105.66**	**86.46**	**19.20**	**68.34**

J:\data\A10000\A10300\A10360\A10367\Engineering\Conceptual\4-SHEETS\Sheet Set\A10367 e MixedUse CATCHMENTS.dwg

CLIENT:

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FX:
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DEVELOPED CATCHMENT PLAN - ALTERNATIVE 2 FOR:

QUIEMUTH VILLAGE

OLSON LAND SURVEYORS
ENGINEERS
ENGINEERING INC. 222 E. EVERGREEN, VANCOUVER, WA 98660
360-695-1385

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CHANGES / REVISIONS

DESCRIPTION:	DATE:

DESIGNED: GCO

DRAWN: GCO/TAS

CHECKED: PAT

DATE: NOVEMBER 2020

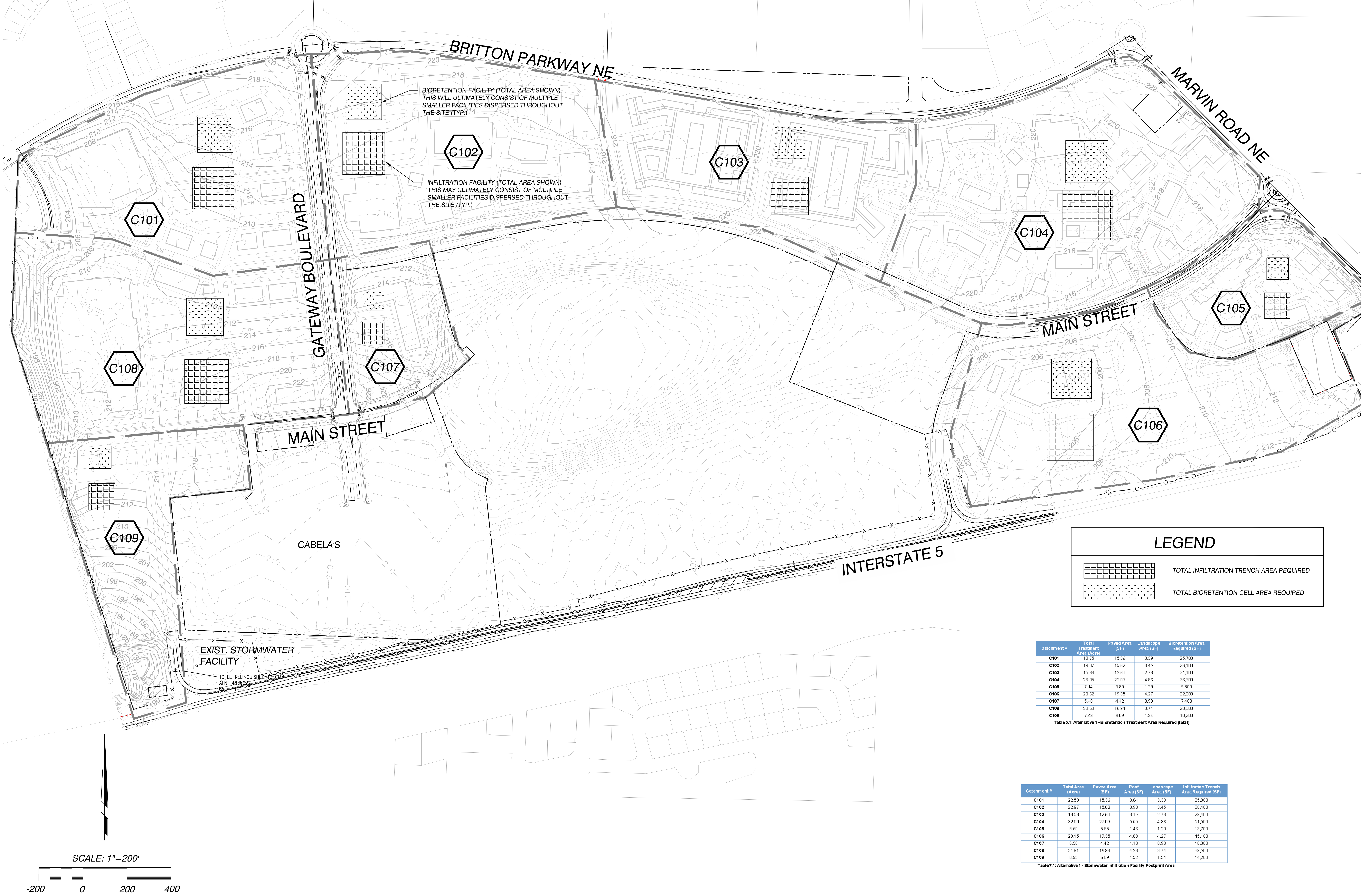
SCALE: H: 1"= XX'
V: N/A

QUIEMUTH VILLAGE

JOB NO.: 1234.01.01

SHEET

CP-3.0



LEGEND

▦	TOTAL INFILTRATION TRENCH AREA REQUIRED
⁘	TOTAL BIORETENTION CELL AREA REQUIRED

Catchment #	Total Treatment Area (Acre)	Paved Area (SF)	Landscape Area (SF)	Bioretention Area Required (SF)
C101	18.75	15.36	3.39	25,700
C102	19.07	15.62	3.45	26,100
C103	15.38	12.60	2.78	21,100
C104	26.95	22.09	4.86	36,900
C105	7.14	5.85	1.29	9,800
C106	23.62	19.35	4.27	32,300
C107	5.40	4.42	0.98	7,400
C108	20.68	16.94	3.74	28,300
C109	7.43	6.09	1.34	10,200

Table5.1: Alternative 1 - Bioretention Treatment Area Required (total)

Catchment #	Total Area (Acre)	Paved Area (SF)	Roof Area (SF)	Landscape Area (SF)	Infiltration Trench Area Required (SF)
C101	22.59	15.36	3.84	3.39	35,800
C102	22.97	15.62	3.90	3.45	36,400
C103	18.53	12.60	3.15	2.78	29,400
C104	32.50	22.09	5.55	4.86	51,500
C105	8.60	5.85	1.46	1.29	13,700
C106	28.45	19.35	4.83	4.27	45,100
C107	6.50	4.42	1.10	0.98	10,300
C108	24.91	16.94	4.23	3.74	39,500
C109	8.95	6.09	1.52	1.34	14,200

Table7.1: Alternative 1 - Stormwater Infiltration Facility Footprint Area

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CLIENT:

ACORN ENVIROMENTAL
5170 GOLDEN FOOTHILL PARKWAY
EL DORADO HILLS, CA 95762

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FX:
CONTACT: RYAN SAWYER
EMAIL: rsawyer@acorn-env.com

CONCEPTUAL STORMWATER PLAN - ALTERNATIVE 1 FOR:

QUIEMUTH VILLAGE

OLSON LAND SURVEYORS
ENGINEERS
ENGINEERING INC. 222 E. EVERGREEN, VANCOUVER, WA 98660
360-695-1385

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31817

6/01/2023

CHANGES / REVISIONS

DESCRIPTION:	DATE:

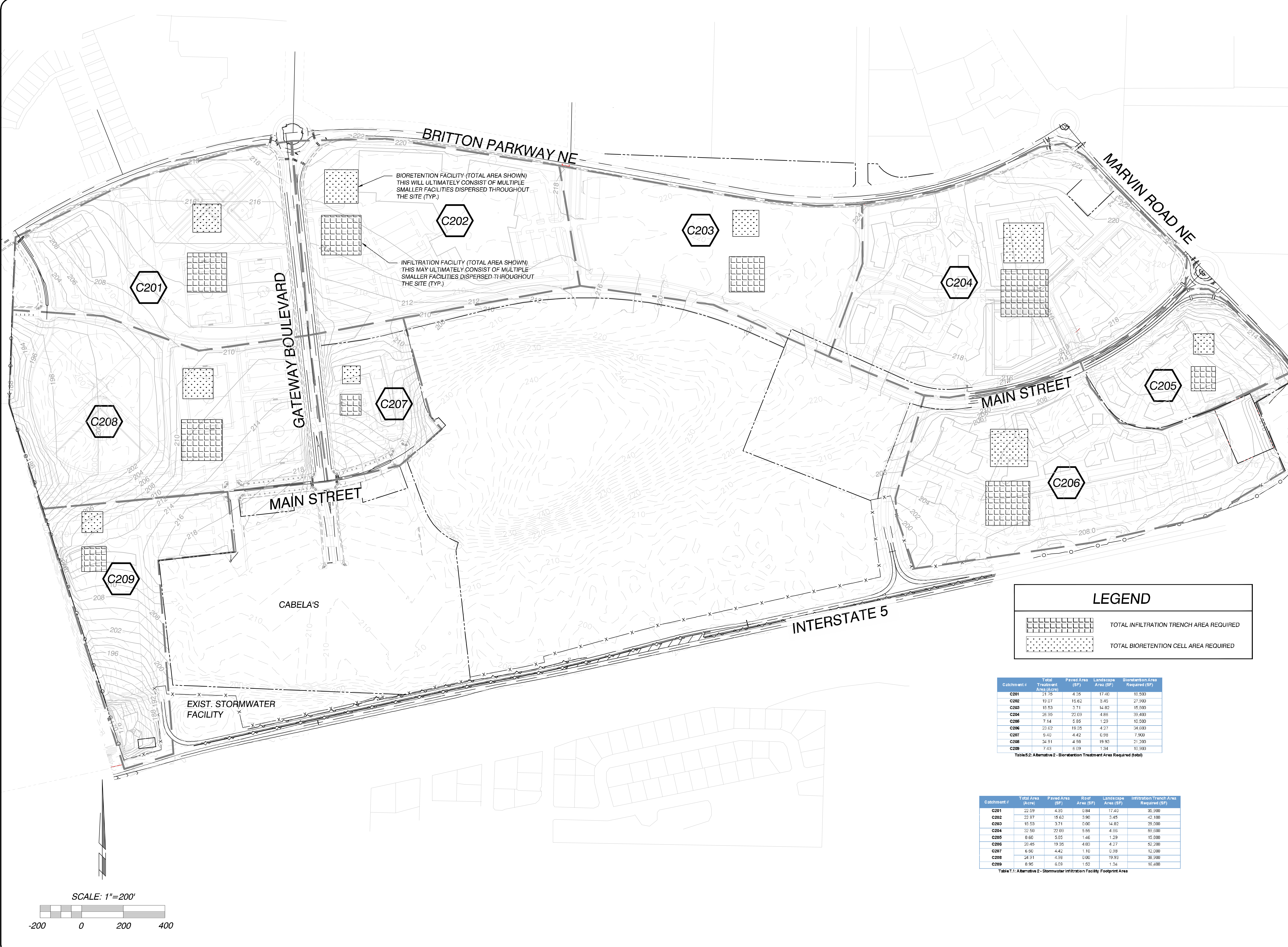
DESIGNED: GCO
DRAWN: GCO/TAS
CHECKED: PAT
DATE: NOVEMBER 2020
SCALE: H: 1"= XX'
V: N/A

QUIEMUTH VILLAGE

JOB NO.: 1234.01.01

SHEET

ST-1.0



BIORETENTION FACILITY (TOTAL AREA SHOWN) THIS WILL ULTIMATELY CONSIST OF MULTIPLE SMALLER FACILITIES DISPERSED THROUGHOUT THE SITE (TYP.)

INFILTRATION FACILITY (TOTAL AREA SHOWN) THIS MAY ULTIMATELY CONSIST OF MULTIPLE SMALLER FACILITIES DISPERSED THROUGHOUT THE SITE (TYP.)

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LEGEND

▦	TOTAL INFILTRATION TRENCH AREA REQUIRED
░	TOTAL BIORETENTION CELL AREA REQUIRED

Catchment #	Total Treatment Area (Acre)	Paved Area (SF)	Landscape Area (SF)	Bioretention Area Required (SF)
C201	21.75	4.35	17.40	18,500
C202	19.07	15.62	3.45	27,900
C203	18.53	3.71	14.82	15,800
C204	26.95	22.09	4.86	39,400
C205	7.14	5.85	1.29	10,500
C206	23.62	19.35	4.27	34,600
C207	5.40	4.42	0.98	7,900
C208	24.91	4.98	19.93	21,200
C209	7.43	6.09	1.34	10,900

Table 5.2: Alternative 2 - Bioretention Treatment Area Required (total)

Catchment #	Total Area (Acre)	Paved Area (SF)	Roof Area (SF)	Landscape Area (SF)	Infiltration Trench Area Required (SF)
C201	22.59	4.35	0.84	17.40	35,900
C202	22.97	15.62	3.90	3.45	42,100
C203	18.53	3.71	0.00	14.82	29,000
C204	32.50	22.09	5.55	4.86	59,600
C205	8.60	5.85	1.46	1.29	15,800
C206	28.45	19.35	4.83	4.27	52,200
C207	6.50	4.42	1.10	0.98	12,000
C208	24.91	4.98	0.00	19.93	38,900
C209	8.95	6.09	1.52	1.34	16,400

Table 7.1: Alternative 2 - Stormwater Infiltration Facility Footprint Area

CLIENT:

ACORN ENVIROMENTAL
5170 GOLDEN FOOTHILL PARKWAY
EL DORADO HILLS, CA 95762

PH: 916-235-8224
FX:
CONTACT: RYAN SAWYER
EMAIL: rsawyer@acorn-env.com

CONCEPTUAL STORMWATER PLAN - ALTERNATIVE 2 FOR:

QUIEMUTH VILLAGE

OLSON
LAND SURVEYORS
ENGINEERS
ENGINEERING INC. 222 E. EVERGREEN, VANCOUVER, WA 98660
360-695-1385

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31817

6/01/2023

CHANGES / REVISIONS

DESCRIPTION:	DATE:

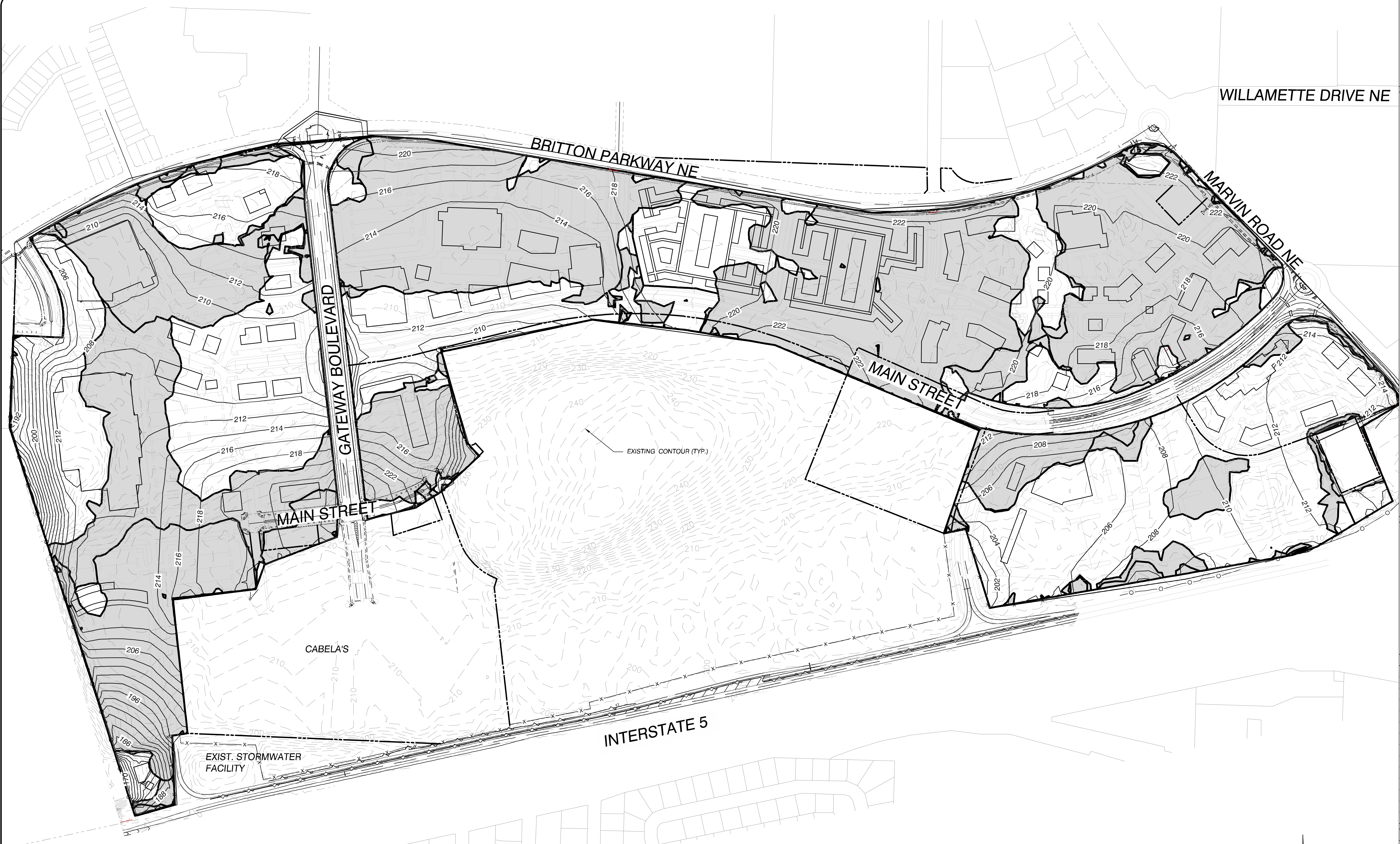
DESIGNED: GCO
DRAWN: GCO/TAS
CHECKED: PAT
DATE: NOVEMBER 2020
SCALE: H: 1"= XX'
V: N/A

QUIEMUTH VILLAGE

JOB NO.: 1234.01.01

SHEET

ST-2.0



CLIENT:

ACORN ENVIROMENTAL
5170 GOLDEN FOOTHILL PARKWAY
EL DORADO HILLS, CA 95762

PH: 916-235-8224
FX:
CONTACT: RYAN SAWYER
EMAIL: rsawyer@acorn-env.com

GRADING PLAN ALTERNATIVE 1 FOR:

QUIEMUTH VILLAGE

OLSON
LAND SURVEYORS
ENGINEERS
360-695-1385
ENGINEERING INC. 222 E. EVERGREEN, VANCOUVER, WA 98660

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6/01/2023

CHANGES / REVISIONS

DESCRIPTION:	DATE:

DESIGNED: GCO
DRAWN: GCO/TAS
CHECKED: PAT
DATE: NOVEMBER 2020
SCALE: H: 1"= XX'
V: N/A

QUIEMUTH VILLAGE

JOB NO.: 1234.01.01

SHEET

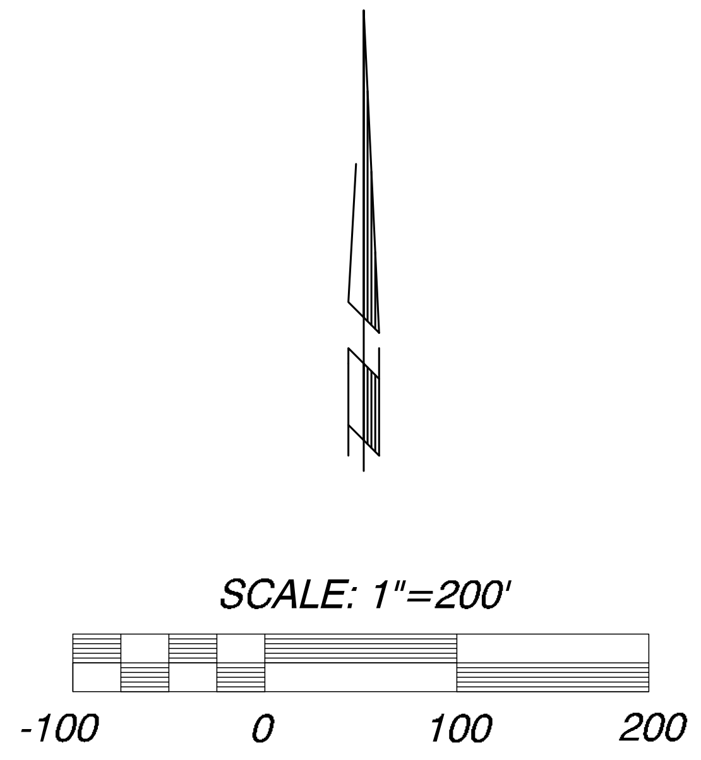
G-1.0

APPROXIMATE GRADING VOLUMES

EARTHWORK VOLUME...370,000 CY

LEGEND

—— 298 ——	FINISHED GRADE CONTOUR
— —298— —	EXISTING CONTOUR
▨	SHADING REPRESENTS AREA OF CUT
━━━	AREA OF CUT/FILL LINE



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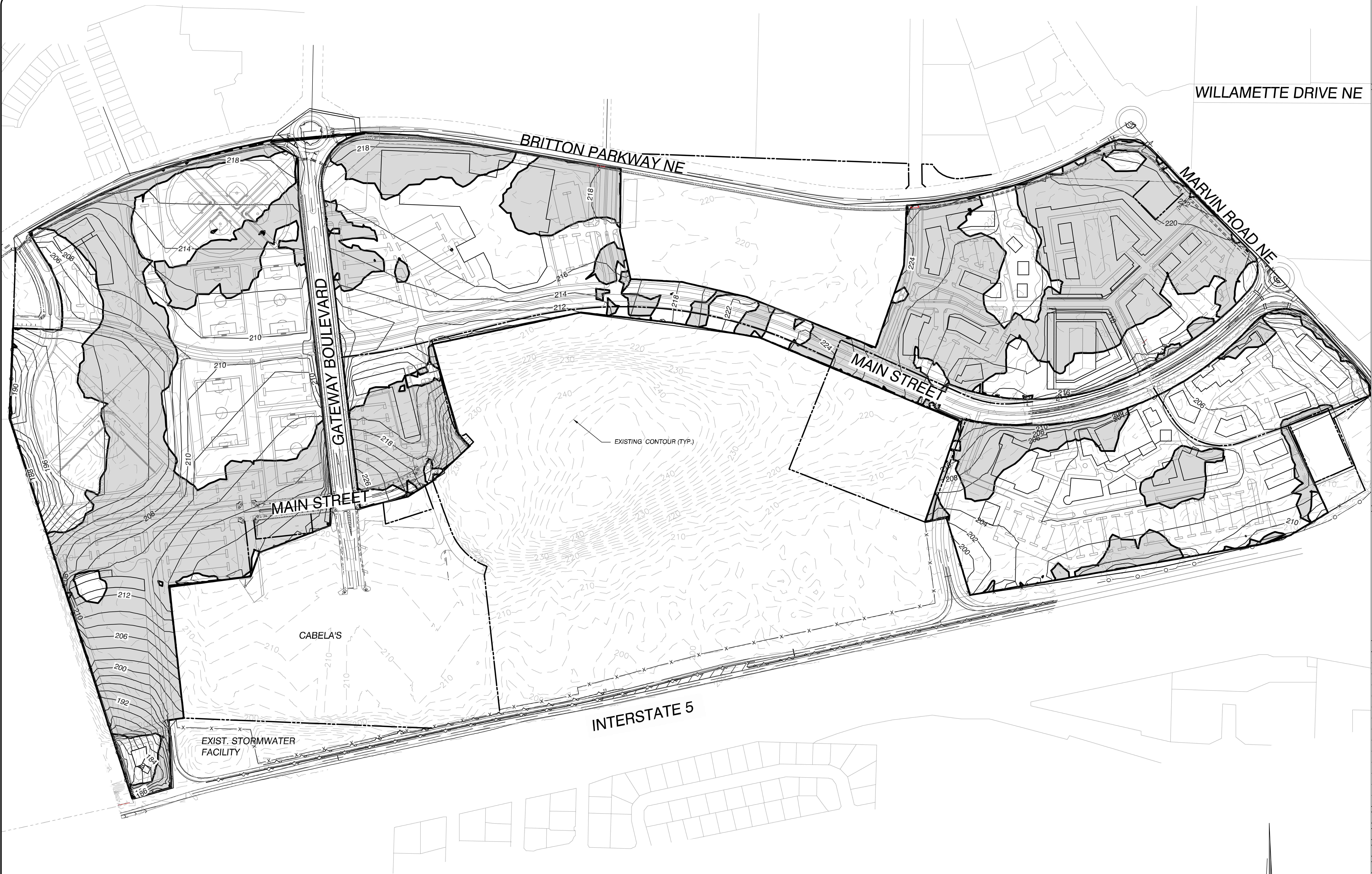
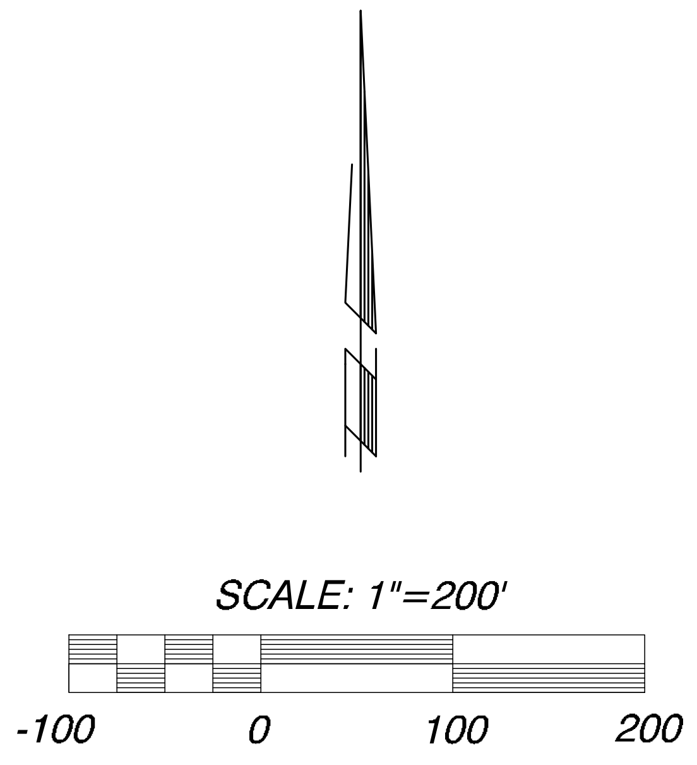


APPROXIMATE GRADING VOLUMES

EARTHWORK VOLUME .... 362,000 CY

LEGEND

—— 298 ——	FINISHED GRADE CONTOUR
— —298— —	EXISTING CONTOUR
▨	SHADING REPRESENTS AREA OF CUT
━━━━	AREA OF CUT/FILL LINE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CLIENT:

ACORN ENVIROMENTAL
5170 GOLDEN FOOTHILL PARKWAY
EL DORADO HILLS, CA 95762

PH: 916-235-8224
FX:
CONTACT: RYAN SAWYER
EMAIL: rsawyer@acorn-env.com

GRADING PLAN ALTERNATIVE 2 FOR:

QUIEMUTH VILLAGE

OLSON LAND SURVEYORS
ENGINEERS
ENGINEERING INC. 222 E. EVERGREEN, VANCOUVER, WA 98660
360-695-1385

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PETER A. TUCK
STATE OF WASHINGTON
31817

6/01/2023

CHANGES / REVISIONS	
DESCRIPTION:	DATE:

DESIGNED: GCO

DRAWN: GCO/TAS

CHECKED: PAT

DATE: NOVEMBER 2020

SCALE: H: 1"= 200'
V: N/A

QUIEMUTH VILLAGE

JOB NO.: 1234.01.01

SHEET

G-2.0