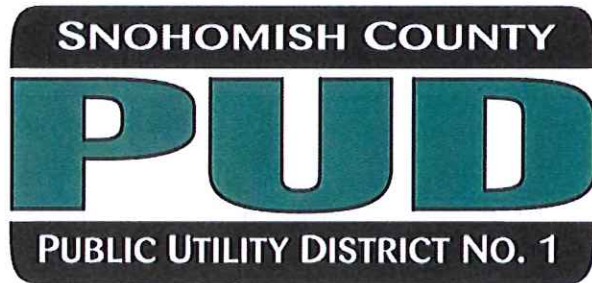


FULL DRAINAGE REPORT

FOR:
JENNINGS PARK SUBSTATION



PREPARED BY:
SNOHOMISH COUNTY P.U.D. NO. 1
February 13, 2023

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EXECUTIVE SUMMARY

The proposed development activity is to construct an electrical substation to improve system reliability and local capacity. The station is not manned and, post construction, is infrequently visited for maintenance.

The station along with distribution and transmission facilities will be constructed on District owned properties located at 7728 and 7708 47th ave NE Marysville, WA. The 7728 address corresponds to parcel number 3005210041450 (2.4 acres +/-) and the 7708 address corresponds to parcel number 30052100412500 (0.96 acres +/-).

In its existing state of development the parcels contain a building (0.17 acres), associated parking lot (0.17 acres), a gravel access road (0.27 acres) and a cell phone site (0.01 acres). The remainder of the site (2.76 acres) is an undeveloped pasture.

The existing building, parking lot and cell phone site will be removed and restored to a grass surface. The existing gravel access road be restored to a new gravel surface.

In its existing configuration of the 3.38 acre properties, 2.76 acres (81%) are pasture and 0.62 acres (19%) are impervious surfaces.

In its proposed configuration 0.51 acres (15%) will remain impervious surfaces, 0.86 acres will be converted to substation yard, 0.08 acres within the substation yard will be concrete surfacing, 0.24 acres will become a paved driveway, 0.27 acres will remain gravel access and the remaining 2.01 acres will be converted to a combination of grass, biocells and landscaping. The substation yard is not an effective impervious surface as this report demonstrates; thus there will be slight reduction of 0.11 acres of impervious surface.

An on-site soils investigation performed by Zipper Geo Associates, LLC (ZGA) revealed the soils at the site to generally consist of fill material (sand with silt, gravel and cobbles) underlain by recessional outwash (dense silty sand with low gravel content).

Limited frontage improvements are proposed as there has already been sidewalk, curb and gutter installed along 47th ave ne. The proposed frontage improvements include replacement of the 5-ft sidewalk with a 6-ft sidewalk and new curb and gutter limited to areas where removal of an entrance.

The project results in more than 5,000 sq-ft of new hard surfaces, therefore per SMMWW Figure I-3.1, all minimum requirements apply to the new and replaced hard surfaces and converted vegetation areas.

Temporary erosion and sediment control measures will be implemented during construction in accordance with the approved SWPP Plan prepared per Ecology Stormwater Management Manual for Western Washington (SMMWW) requirements. All on-site soils disturbed by construction activities will be stabilized with grass and or landscaping prior to the removal of any temporary erosion and sediment control measures.

The station will ultimately contain two 28 mva 115kv-12.5kv power transformers along with small voltage transformers (VTs) used for metering. The 28 mva power transformers include roughly 8,200 gallons of mineral oil each. The VTs contain 60 gallons of mineral oil each. In the ultimate build out, on site total oil volume is expected to be roughly 17,000 gallons. Oil pollution prevention is regulated under Federal Regulation 40 CFR

Part 112. At a threshold of 1,320 gallons or more a spill control and countermeasure (SPCC) plan is required; thus a site specific SPCC plan will be developed for this station as part of the Clean Water Act section 401 compliance. The response measures outlined in the SPCC plan and the proposed secondary containment system described within this report are intended to prevent any oil from leaving the site.

Precipitation falling within the station and facility will infiltrate through the crushed rock surface, be stored within the voids of the crushed surfacing base course (CSBC) then slowly infiltrate into the structural fill and native soils below.

Rainfall within landscaped and naturally vegetated areas will remain dispersed and infiltrate naturally. Runoff generated by the access driveway will be conveyed to a biocells between the driveways.

The station is not a staffed facility; visits post construction are infrequent occurring roughly twice monthly. The fenced area of the substation itself along with the the maintenance access driveway will only be subjected to infrequent vehicular traffic; therefore, in accordance with SWMMWW Glossary page 1090 (definition of vehicular use) and SWMMWW Glossary page 1072/1073 (definition of PGIS/PGPS) the access driveway is not considered subject to regular vehicle use; the same being true of the substation at the end of the driveway and thus both exempt from treatment requirements.

1.0 PROJECT SUMMARY

1.1 PROPERTY DESCRIPTION

The parcels include a portion of the southwest quarter of the southwest quarter of section 21, township 30 north, range 5 east, W.M. Snohomish County, Washington; TPN 30052100414500 and 30052100412500. More specifically, the site is located at addresses 7728 and 7708 47th Ave NE Marysville, WA.



Figure 1: Vicinity map, not to scale.

1.2 EXISTING CONDITIONS

The project site consists of (2) parcels parcel number 30052100414500 (A) and parcel number 30052100421500 (B). Parcel A is currently vacant land. There is a graveled driveway incorporated into parcel A used for access to that parcel. Parcel B includes an existing building and graveled parking lot.

North of parcel B is a landscaping materials supply company, south of parcel B is a lumber supply company. North of parcel A are 4 properties, including two residential and two zoned as miscellaneous manufacturing. South of parcel A is vacant land (parcel number 30052100422900) owned by the City of Marysville. West of parcel A is a storage business.

The site has no drainage facilities or features such as infiltration trenches or detention ponds, other than a small swale on the west portion of parcel A. In the current configuration the runoff that accumulates gathers in some locations in puddles in the gravel parking lot and the gravel access until infiltration occurs. In the undeveloped and grassed areas of the lot runoff accumulates and infiltrates into the below soils.

Runoff generated from City owned parcel to the south of Districts parcel A flows to the north and pools upon Parcel A. In 2015 the District desired to improve the drainage in this area and applied to the City for a grading permit and received GC14-0025. The work included removal of poorly draining soils and the installation of soils with a higher permeability rate; increasing the infiltration rate in that area of the runoff into the native soils.

Site topography is mostly flat. The drainage swale on the west portion of parcel A has no outlet, it serves to retain runoff from the City's site to supply additional storage capacity for infiltration to occur. The District has supplied a topographical survey by ASPI, LLC for review, the swale can be seen upon, please reference S-131-K2A.

Frontage improvements have been previously installed including City street drainage along 47th ave NE and appears to be functioning.

The USDA Natural Resources Conservation Service Soil Map identifies the on-site soils as 100% Ragnar fine sandy loam, zero to eight percent slopes. These soils are defined as well drained soils with a capacity to transmit water at 1.98 to 5.95 inches per hour.

The site-specific geotechnical evaluation and report identifies the surface soil layer to consist of organics and topsoil; limited fill material; sub-subsurface of the fill layer is a recessional outwash layer.

1.3 DEVELOPED CONDITIONS

The proposal is to construct an electrical substation (station) to improve system reliability and capacity. The station is not manned and is infrequently visited for maintenance.

The station will generally consist of transmission line termination (dead-end) structures, 115kV switches, 115kV circuit switchers, 115kV-12kV transformers, small transformers, electrical enclosures, 12kv switches, underground conduits for power cables and control wires. Related site work for the station includes a stormwater management system, security fence, high voltage warning signs, grounding system, a maintenance access driveway and landscaping.

Sod and topsoil will be stripped for the station and driveway construction. Stripped soils will be reused in the landscaping areas to the extent practicable.

Native soil excavated from the site will be reused as structural fill to the extent practicable. Granular fill material will be imported to provide a suitable base for the station, access roads and driveway. The station yard will be surfaced with coarse crushed rock. Where access is shared via easement, the maintenance access driveway will continue as its existing graveled surfacing; where access is not shared the driveway will be paved with asphalt.

Temporary erosion and sediment control measures will be implemented during construction in accordance with city stormwater management requirements. All on-site soils disturbed by construction activities will be stabilized with grass and or landscaping prior to the removal of any temporary erosion and sediment control measures.

The site will be landscaped with a combination of trees, shrubs, and other plant materials. The station yard will be secured by a 7-ft security fence.

Precipitation falling within the station yard will infiltrate through the imported crushed rock fill. Stormwater will be temporarily stored within the voids of the CSBC and imported structural fill layers while it slowly infiltrates into the structural fill and native soil. Refer to the site specific geotechnical report, page 25 for a detailed description and testing of the storage considerations.

The existing graveled shared maintenance access driveway will be re-surfaced with gravel and the crown re-established. Resurfacing with gravel within an existing prism and is an activity exempt from from minimum requirements; refer to SWMMWW Volume I – Chapter 3 – page 85.

Water runoff from landscaped and naturally vegetated areas will surface infiltrate naturally.

The station is not a staffed facility; visits post construction are infrequent occurring roughly twice monthly. The fenced area of the substation itself along with the the maintenance access driveway will only be subjected to infrequent vehicular traffic; therefore, in accordance with SWMMWW Glossary page 1090 (definition of vehicular use) and SWMMWW Glossary page 1072/1073 (definition of PGIS/PGPS) the access driveway is not considered subject to regular vehicle use; the same being true of the substation at the end of the driveway and thus both exempt from treatment requirements.

The station and facility yards are a drivable surface; however, use is infrequent and only used for maintenance by District utility vehicles after construction. Therefore, the station yard is not considered a pollution generating surface.

Also note, District vehicles are serviced and maintained regularly by the District’s Transportation Department, thus providing further pollution prevention.

2.0 MINIMUM REQUIREMENTS

According to the SMMWW Figure I-3.1, this project is subject to all Minimum Requirements (MR's) for new and replaced hard surfaces and converted vegetation areas. SMMWW Figure I-3.1 is provided for reference in Appendix C.

The following bullets provide a narrative for each step of the flow chart.

- The existing site does not have 35% or more of impervious coverage.
- The proposed project will result in greater than 5,000 square feet of new hard surface.
- The impervious surfaces will be a combination of gravel surfacing and asphalt pavement for the maintenance access driveway; electrical enclosures, and concrete foundations for electrical equipment. The station does not function as an impervious surface as described below.
 - The station yard will be surfaced with station rock (crushed rock). The rock surface provides a layer of electrical resistance to help reduce the risk of step and touch potential; minimize weed growth; provide a clean and reasonably dry surface during wet periods; and dissipates erosions effect from rain. Station rock is a poorly graded mix of crushed rock ranging from 1 inch to 3/8 inch with fines content of less than 1.5%. Station rock is placed 4 inches deep across the surface of the station yard and 3-ft perimeter. In place, station rock has a minimum void ratio of 0.30.
 - The station rock will be underlain with a minimum of 8 inches of Crushed Surfacing Base Course (CSBC) meeting the gradation and quality criteria in WSDOT Standard Specification 9-09.9(3). The District's geotechnical consultant, Zipper Geo Associates (ZGA), has tested multiple samples of CSBC for permeability and void ratio at 95% of the modified Proctor maximum dry density. Void ratio has been approximately 0.4 and permeability ranged from 30.8 (Iron Mtn.) to 130 in/hr . Refer to page 25 of the site specific geotechnical report for additional data.
 - Before CSBC is placed, the station yard will be stripped of unsuitable soils and topsoil during excavation to subgrade. The geotechnical report shows the borings and test pits investigated by ZGA's field work starting on page 35. ZGA estimates the factored design infiltration rate to be 18-inch/hour for the native soils, see page 25 of the site specific geotechnical report.
 - In conclusion, the station yard will not function as an impervious surface. Rainfall landing on the crushed rock surface will infiltrate through station rock and CSBC layers then infiltrate into the underlying native soil. The WWHM 12 software was used to model the station site with the drainage characteristics described above. The results of the model demonstrate that 100% of the total rainfall within the station and facility yards will infiltrate.

Based on SMMWW Figure I-3.1 the project is subject to minimum requirements 1-9, the District will address these requirements as follows:

2.1 MINIMUM REQUIREMENT #1 – Preparation of Stormwater Site Plans

To comply with Minimum Requirement #1, information and analysis of the existing site conditions, a site development layout, and an off-site analysis are provided in the following documents. The plans and reports are prepared in accordance with the SWMMWW Volume I, Chapter I-3.4.1 – Preparation of Stormwater Site Plans.

- **Site Plan**, prepared by Sno. Co. PUD. Supporting boundary and topographic survey provided by ASPI, LLC.
- **SWPP Plan**, prepared by Sno. Co. PUD
- **Grading and Drainage Plan**, prepared by Sno. Co. PUD
- **Full Drainage Report**, prepared by Sno. Co. PUD
- **Critical Area Report**, prepared by Wetland Resources, Inc
- **Geotechnical Engineering Report**, prepared by Zipper Geo Associates, LLC
- **Landscape Plans**, prepared by David Evans and Associates

2.2 MINIMUM REQUIREMENT #2 –Stormwater Pollution Prevention Plan (SWPPP)

A SWPPP is required for the proposed development activity. The SWPPP consists of two parts; the plan, and the narrative. The SWPP Plan will be provided in the plan set submitted with the land development permit application. The narrative portion is addressed in a separate SWPPP report.

The narrative addresses all thirteen elements described in The Drainage Manual, Volume II, Chapter 3. Site disturbance will exceed the 1.0-acre threshold however a discharge from this site we do not expect. The District is consulting with Ecology as to coverage under the Department of Ecology’s Construction Stormwater General Permit is required and will be obtained by the District.

2.3 MINIMUM REQUIREMENT #3 – Source Control of Pollution

The station will ultimately contain two 115kv-12kv Power transformers, several small voltage transformers (VT) for metering and a small station service transformer (SSVT) to provide power from the station to the control enclosure.

Device	Quantity	Insulating Oil (gallons)
115kV-12kv Power Transformer	2	16,400
Small Voltage Transformer	2	120
	Total	16,520

Total on site oil is expected to be approximately 16,520 gallons. The insulating oil is highly refined mineral oil that is essentially equivalent to food grade oil except for color. Refer to Appendix D for greater detail.

Oil pollution prevention is regulated under Federal Regulation 40 CFR Part 112. This part establishes procedures, methods, equipment, and other requirements to prevent the discharge of oil into or upon navigable waters of the United States. As required by federal law, oil storage of 1,320-gallons or more requires the owner of said facility to have a Spill Prevention Control and Countermeasure Plan (SPCC Plan).

The District has an SPCC plan for each of its station facilities. As utilized at many of the District stations, a secondary oil containment system will be construction as part of the site development. The transformers will be placed within a curbed, concrete slab lined oil containment area. Runoff is gathered within the containment area and metered out through an oil stop valve (OSV).

The OSV allows water to pass through during normal operation, during the event of an oil spill the OSV will close preventing oil from escaping the containment area. The OSV is a specialized device which contains a float which is lighter than water but heavier than oil; this difference in specific gravity is what triggers the OSV to close during an oil spill.

Downstream of the OSV is an oil trap which serves as a secondary defense against minor oil leaks escaping the containment area during closure of the OSV.

A loss of oil that exceeds the containment system capacity will spill over the containment curb and into the substation yard. The yard consists of highly permeable crushed rock placed over a highly permeable crushed rock base. Void space within the crushed rock exceeds 30%. Native subgrade soils have lower permeability, thus allowing the crushed rock to act as a reservoir, containing the oil on-site.

A loss of oil to ground and surface waters is not likely to occur prior to emergency response teams arriving at the site.

Snohomish PUD has an agency wide Spill Prevention, Control and Countermeasure (SPCC) Plan in place, and a site-specific SPCC plan will be developed for this substation project as part of the Clean Water Act section 401 compliance. The response measures outlined in the SPCC Plan are intended to prevent any oil from leaving the site. Remote sensing devices will alert dispatchers to an oil leak or equipment failure, and emergency personnel will be directed to the station.

In the event of an oil spill, the District will notify authorities, recover, and cleanup an oil discharge in accordance with Washington Administrative Code (WAC), Chapter 173-303 – Dangerous Waste Regulations, Section 173-303-145 – Spills and Discharges to the Environment.

2.4 MINIMUM REQUIREMENT #4 – Preservation of Natural Drainage Systems and Outfalls

The proposed development activity will not alter the existing drainage patterns.

As the site and outfalls exist today, there is no constructed drainage system. The runoff generated on site infiltrates on site. The proposal does not alter that pattern. Post construction, runoff generated on site will infiltrate on site.

2.5 MINIMUM REQUIREMENT #5 – On-site Stormwater Management

The project will trigger minimum requirements 1-9, is not a site greater than 5 acres and is not utilizing the LID performance standard. The project falls under the “list approach” compliance method; specifically it best fits under list #2 as identified upon table I-3.2.

The project is not identified as exempt from flow control requirements; infiltration is the methodology utilized on site to demonstrate flow control compliance. This matter is further discussed under section 2.7 in following pages.

The proposed on-site stormwater management system consists of on-site infiltration within the station yard and a biofiltration facility to service the area of the paved driveways.

As described in detail in Section 2.0, the proposed station footprint is underlain by native permeable soils. Utilizing the footprint of the yard to infiltrate stormwater makes infiltration an effective means for disposing of stormwater.

Runoff from the new asphalt driveways will be gathered in depression between the driveways east of the substation fence. The “List #2” approach specifies biofiltration as a valid method for complying with minimum requirement #5. This depression is designed as a bio retention cell (BMP T7.30 – Volume V – Chapter 5 – page 774) and has been modeled in the WWHM model for infiltration compliance.

Within the station yard, to achieve 100% infiltration within the native soils the stormwater needs to be stored in the voids of the CSBC above. The CSTC defined drivepath within the substation will be crowned; allowing any runoff generated to infiltrate through the substation rock and into the CSBC layer below. The WWHM model demonstrates that the 8-inch CSBC layer is adequate to retain stormwater within the voids. The CSBC void ratio will be a minimum of 0.4.

Stage storage discharge tables were developed and utilized to model the infiltration characteristics of the station yard. The yard and gravel perimeter were modeled as impervious surfaces to mimic rainfall landing within the yard passing directly to the underlying native soil.

The WWHM output and a drainage narrative describing the model is provided for review within Appendix E.

2.6 MINIMUM REQUIREMENT #6 – Runoff Treatment

The existing shared access graveled access driveway in the panhandle of the property will be resurfaced with gravel (in kind material) within its existing prism. This area is exempt from minimum requirements; refer to SWMMWW Volume I – Chapter 3 – page 87.

A secured drive gate will be installed at the end of the panhandle to limit drive to the substation access to District personnel.

The station yard and access driveway beyond the joint panhandle access driveway are not pollution generating surfaces. Neither item meets the definition of pollution-generating hard or pervious surfaces as defined by the SWMMWW. The station is not a staffed facility; visits post construction are infrequent occurring roughly twice monthly. The fenced area of the substation itself along with the the maintenance access driveway will only be subjected to infrequent vehicular traffic; therefore, in accordance with SWMMWW Glossary page 1090 (definition of vehicular use) and SWMMWW Glossary page 1072/1073 (definition of PGIS/PGPS) the access driveway is not considered subject to regular vehicle use; the same being true of the substation at the end of the driveway. The use of these access points is infrequent and thus both are exempt from treatment requirements.

2.7 MINIMUM REQUIREMENT #7 – Flow Control

As addressed under MR #5, the on-site stormwater management system proposed for the station and the site is designed to retain and infiltrate stormwater without causing flooding or erosion impacts.

The new impervious surfaces are fully infiltrated and therefore ineffective.

The groundwater elevations were found to be approximately at elevation 40 during the initial site investigation. A monitoring well was installed and the highest observed groundwater level was at elevation 41.5. Refer to the geotechnical report pages 41-56.

The substation will be constructed upon raised grade; final grade will be roughly 46.0. District standard substation construction includes a 4-inch layer of highly permeable substation rock; below the substation rock is a layer of crushed surfacing base course (CSBC). As discussed below a 8-inch thick layer of CSBC provides enough void storage to retain and allow the precipitation landing upon the facility to slowly infiltrate in the structural fill layer below. The bottom of the infiltration facility is effectively the bottom of the CSBC layer will be roughly 45.0; above the 3-ft separation of the observed groundwater level specified by the SMMWW Volume V – Chapter 5 – page 743.

A mounding analysis has been completed by Zipper Geo Associates and is available for review upon page 28.

The proposed system consists of on-site infiltration within the station yard where 100% of the rainfall will infiltrate.

Surface water runoff generated from the paved maintenance access driveways, will sheet flow from the driveways into a bioretention cell landscaped area and slowly infiltrate. The bottom of the bioretention cells (bio-cells) including a 1'-6" layer of the standard bioretention mix will be 43.25; thus providing a 1-ft separation between the groundwater level and the bottom of the facility in compliance with the 1-ft separation specified within SMMWW Volume V – Chapter 5 – page 782. The impervious area of the paved surface is approximately 10,300 square feet in total; a water bar will be installed which will limit the functional drainage area to the biofiltration facilities to approximately 9,900 square feet (refer to S-135-K8). The design proposes (2) bio-cells between the driveways limiting the impervious area to approximately 4,950 square feet per bio-cell. The paved portion of the maintenance access driveway is infrequently used as explained previously; so there is no pollution to remove however the District is electing to install bio-cells in this area as the area will be planted.

The bio-cells (BMP T7.30 – Volume V – Chapter 5 – page 774) and have been modeled in WWHM for infiltration compliance. After application of the safety factor of 2 to of initial Ksat 12 in/hr an infiltration rate of 6 inches per hour for the WDOE standard bioretention mix was used for infiltration design of the cell. Refer to Volume 5 – Chapter 5 – page 787.

All other disturbed areas of the site will be landscaped where rainfall will disperse and infiltrate.

The WWHM software was used to demonstrate compliance with the flow control requirements. In accordance with SWMMWW Volume I – Chapter 3 – Page 127, when comparing scenarios for evaluation of the 0.15 cfs TDA threshold; the predeveloped condition need not be modeled as forest, but rather as exiting conditions. Refer to the WWHM model report in Appendix E.

2.8 MINIMUM REQUIREMENT #8 – Wetlands Protection

The project does not propose to use a wetland or wetland buffer for detention or treatment of stormwater. There are no wetlands on site as evaluated by Wetland Resources Inc. Refer to Appendix B for the Wetland Resources Critical Areas Report.

2.9 MINIMUM REQUIREMENT #9 – Operation and Maintenance

Stormwater facilities within the security fence will only be accessible to PUD personnel who are electrically qualified to enter; these facilities will be inspected and maintained by the PUD’s substation construction and maintenance department. Stormwater facilities located outside the security fence will be inspected and maintained by the PUD’s facilities maintenance department.

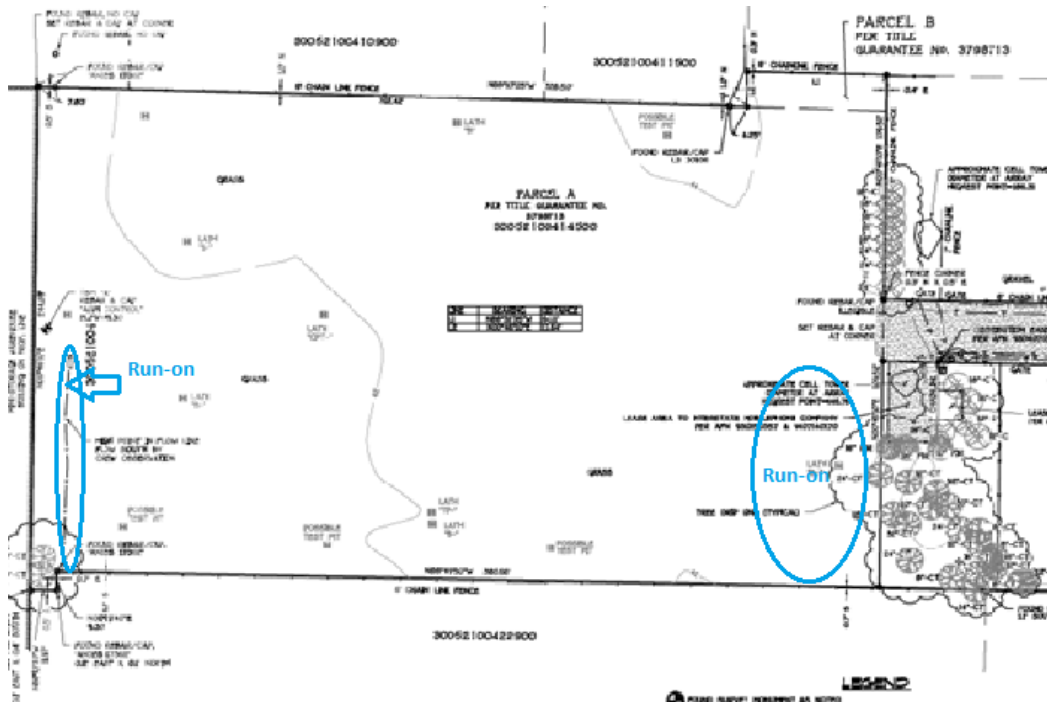
The operation and maintenance manual for the stormwater facilities is provided in Appendix F.

3.0 UPSTREAM & DOWNSTREAM ANALYSIS

3.1 OFF-SITE (UPSTREAM AND DOWNSTREAM) ANALYSIS

In its existing condition, during sustained rain events there is some run-on from City owned parcel 30052100422900 to District owned parcel 30052100414500.

The run-on sheet flows onto District property in the southeast quadrant of the parcel 30052100414500 and into the the swale located upon the west portion of the same parcel per the sketch below.



The run-on is retained on site and over time infiltrates into the native soils on site.

The precipitation generated from rainfall events on site gathers and percolates into the native soils.

Precipitation and run-on which enters the parcel infiltrates upon the parcel – therefore there is no downstream runoff to consider.

The proposed drainage design utilizes on site infiltration as the primary mitigation method. This is little different than the current site conditions. We do not anticipate the proposed project to cause any drainage problems.

REFERENCES

Department of Ecology 2019 Stormwater Management Manual for Western Washington (SMMWW)

ZipperGeo *Geotechnical Engineering Report Jennings Park Substation dated 2/10/2023.*

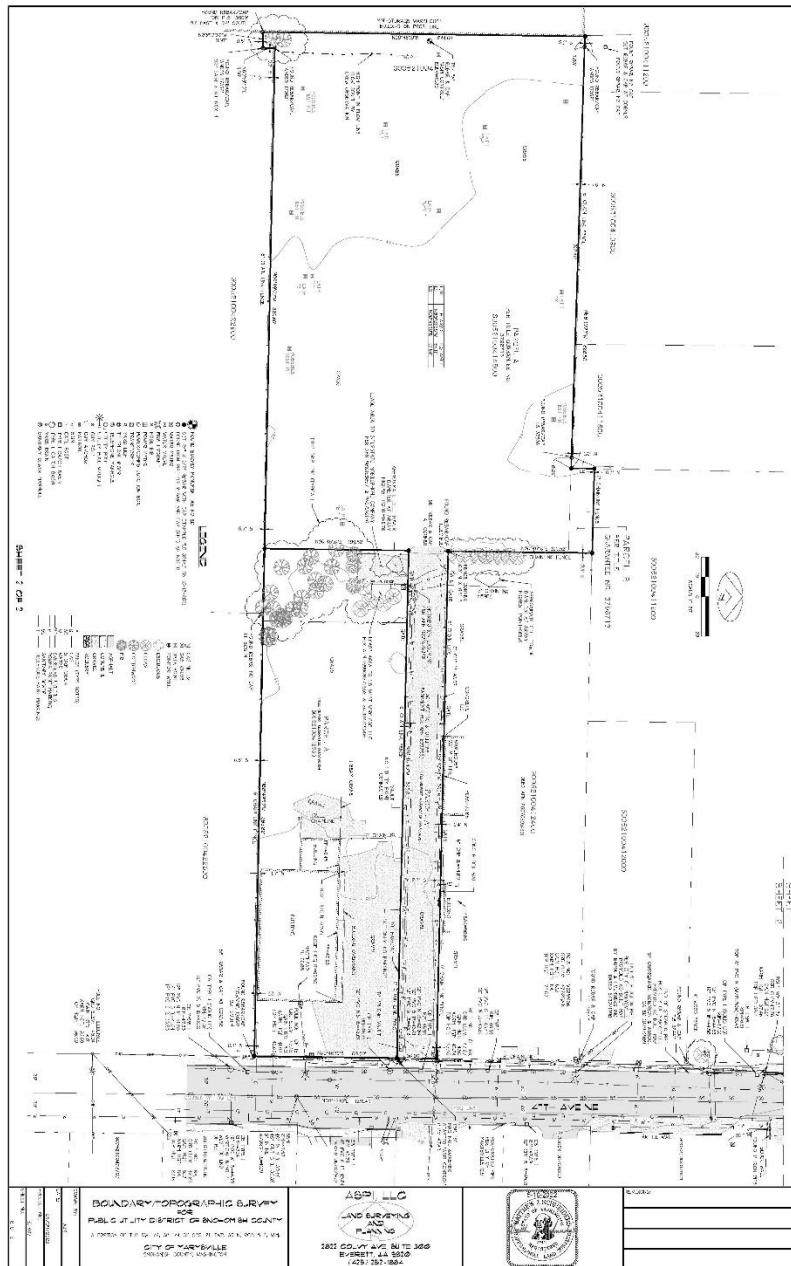
U.S.D.A. Natural Resources Conservation Service. (n.d.). *Web Soil Survey*. Retrieved June 2022, from <http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx>

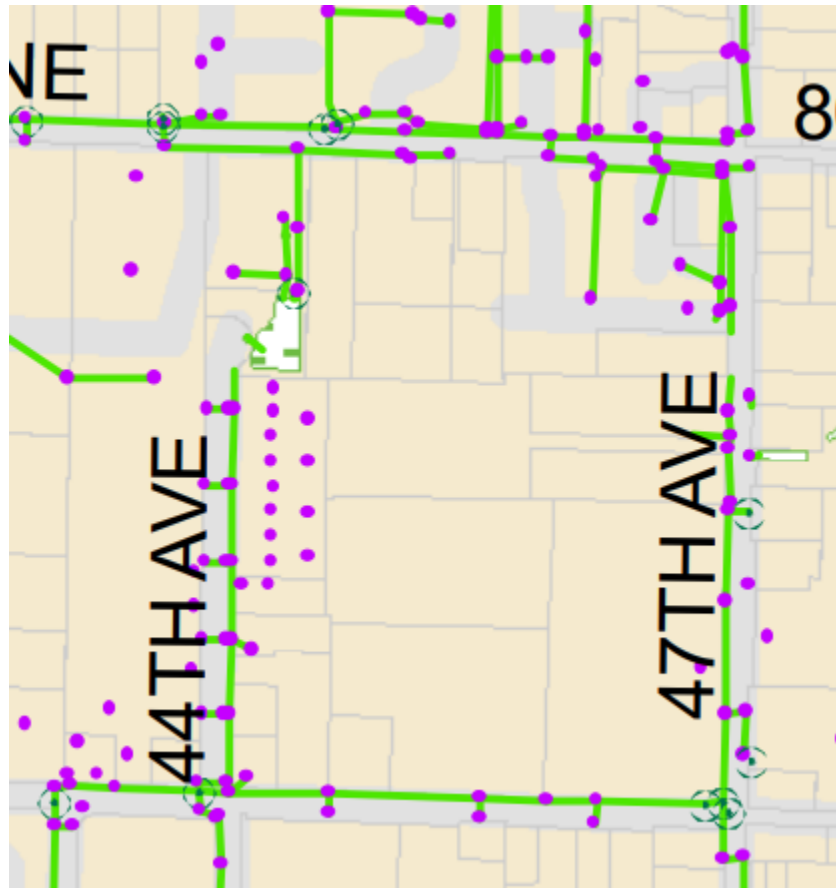
Wetland Resources, Inc. Critical areas report for Jennings Substation dated November 11,2022.

APPENDIX A

Maps

- Exhibit 1 – Existing Conditions (survey)
- Exhibit 2 – Proposed Conditions (grading and drainage plan)
- Exhibit 3 – City of Marysville Storm System Map









City of Marysville

Storm System

Legend

- | | | | |
|---|-------------|---|------------------------|
| • | Catchbasins |  | Storm Facilities |
| ◦ | Manholes |  | Marysville City Limits |
|  | Lines |  | Tulalip Reservation |
|  | Culverts |  | Parks |

APPENDIX B

ZipperGeo Geotechnical Engineering Report Jennings Park Substation

USDA Natural Resources Conservation Service, Web Soil Survey

Wetland Resources Critical Areas Report

GEOTECHNICAL ENGINEERING REPORT

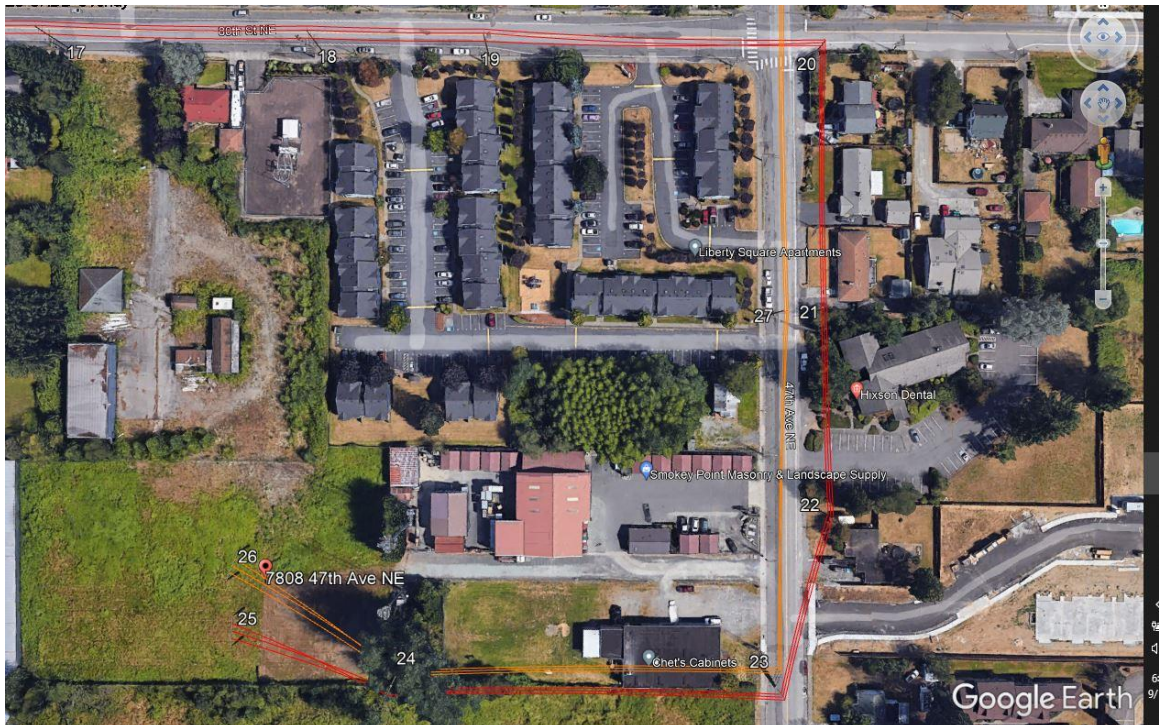
JENNINGS PARK SUBSTATION

7728 & 7808 – 47th Avenue NE

Marysville, Washington

Project No. 2494.01
10 February 2023

Prepared for:
Snohomish County PUD No. 1



Prepared by:

ZipperGeo

Zipper Geo Associates, LLC
19019 36th Avenue W., Suite E
Lynnwood, WA 98036

Project No. 2494.01

10 February 2023

Snohomish County PUD No. 1
Distribution & Engineering Services Division, PO Box 1107
Everett, Washington 98206-1107

Attention: Mr. Will Blanchard, PE, Professional Engineer

Subject: Geotechnical Engineering Report
Jennings Park Substation
7728 & 7808 – 47th Avenue NE
Marysville, Washington



Dear Mr. Blanchard:

In accordance with your request, Zipper Geo Associates, LLC (ZGA) has completed the subsurface exploration and geotechnical engineering evaluation for the proposed Jennings Park Substation. This report presents the findings of the subsurface exploration and geotechnical recommendations for the project. Our work was completed in general accordance with the scope of services described in Contract No. CW2245207. Written authorization to proceed was provided by the District on 23 August 2021. We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further assistance, please contact us.

Sincerely,
Zipper Geo Associates LLC



Martin Cross, GIT
Staff Geologist



DAVID C. WILLIAMS

David C. Williams, LG, LEG
Principal Engineering Geologist

Signed 2.10.23



Robert A. Ross, P.E.
Managing Principal

Signed 2.10.23

Distribution: Addressee (1 electronic)
Cover photo courtesy Google Earth

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FIGURES

Figure 1 – Site and Exploration Plan (Substation and driveway)

Figure 2 – Site and Exploration Plan (47TH Avenue NE)

APPENDICES

Appendix A – Subsurface Exploration Procedures and Logs

Appendix B – Laboratory Testing Procedures and Results

Appendix C – Liquefaction Analysis Output Plot

Appendix D – Groundwater Mounding Analysis Data Sheets

GEOTECHNICAL ENGINEERING REPORT
JENNINGS PARK SUBSTATION
7728 & 7808 – 47th AVENUE NE
MARYSVILLE, WASHINGTON
Project No. 2494.01
10 February 2023

INTRODUCTION

This report summarizes the geotechnical engineering exploration and analysis completed for the proposed Jennings Park Substation project in Marysville, Washington. Seven borings (B-1 through B-7), six test pits (TP-1 through TP-6), and one cone penetrometer (CPT-1) were completed by ZGA to depths ranging from approximately 4.5 to 51.5 feet below the existing ground surface to evaluate subsurface conditions. Descriptive logs of the explorations are included in Appendix A while Appendix B contains a summary of laboratory testing procedures and results.

PROJECT INFORMATION

Site Location

The project property consists of two adjoining parcels located to the west of 47th Avenue NE. The new substation is proposed for construction on the undeveloped parcel at 7808 – 47th Avenue NE. This parcel, historically known as the Goetz parcel, has approximate dimensions of 385 feet east-west and 235 to 240 feet north-south (roughly 2.2 acres). The substation parcel is about 390 feet west of 47th Avenue NE and is accessed via a gravel-surfaced driveway in the north portion of an adjoining property known as the Jensen parcel at 7728 – 47th Avenue NE. Developed commercial and multi-family residential properties adjoin the parcels except to the south of the substation site which is currently undeveloped. The business Chet's Cabinets occupies about the southern half of the Jensen parcel. The primary site and the west portion of the driveway are illustrated on the *Site and Exploration Plan*, Figure 1. The eastern portion of the driveway and a portion of 47th Avenue NE to the north are illustrated on the Site and Exploration Plan, Figure 2.

Project Description

A new double bank substation is proposed for construction on the site. At the time this report was prepared, the proposed substation construction would not include the southern portion of the Jensen parcel. Site improvements on the Goetz parcel at the west are expected to include:

- Dead end towers (termination structures) in the eastern portion of the yard.
- Circuit switchers, disconnect switches, neutral reactors, termination structures, and bus supports.
- Two slab-supported switchgear enclosures.

- Two slab-supported transformers.
- Below-grade conduits and pre-cast concrete vaults in the yard and driveway.
- Structural fill placement to achieve a yard finished grade of 46 feet.
- New transmission poles are planned for construction at the southeast corner of the yard and along 47th Avenue NE.

SITE HISTORY

According to a Phase I Environmental Site Assessment report, dated 7 September 2012 and prepared by Terracon Consultants, Inc. (TCI), the Goetz parcel has been undeveloped since at least 1941. The Chet's Cabinets business was constructed on the Jensen parcel in 1973, and the other nearby commercial properties were developed starting in the 1980s. Two cellular communication compounds were constructed at the west end of the driveway circa the 1990s.

SITE CONDITIONS

Surface Conditions

The substation site is a relatively level area with ground surface elevations ranging from a low of 40 feet at the west to 44 feet at the east according to a topographic survey of the site provided for our review and our site observations. The slight elevation variation is likely due to limited historical grading as we observed fill material at some of the boring and test pit locations. The site is predominantly mantled with grasses and weeds, although trees are present along the east boundary. We did not observe standing or flowing surface water on site during our visits in September and October 2021, but we did observe several puddles on the substation site in November shortly following several days of significant rain.

The gravel driveway extending east of the substation site to 47th Avenue NE is approximately 30 feet wide and rises very gently toward the street with ground surface elevations of approximately 44 to 46 feet from the west to east, respectively. The driveway is surfaced with fine gravel-size crushed rock and contains underground electrical and communication utilities based on utility locate marks that we observed.

The east side of 47th Avenue NE, where the new transmission poles will be located, includes both paved and unpaved shoulder areas commonly used for parking. The shoulder area where we advanced boring B-7 near a proposed transmission pole location included underground storm sewer, natural gas, and water utilities according to locate marks that we observed.

Local Geologic Conditions

We assessed the geologic setting of site and the surrounding vicinity by reviewing the *Geologic Map of the Marysville Quadrangle, Snohomish County, Washington* (US Geological Survey, Map MF-1743, 1985). The published geologic mapping indicates the site is underlain by Vashon Recessional Outwash, Marysville Sand Member. The Marysville Sand is described as mostly well-drained, stratified to massive outwash sand, some fine gravel, and some areas of silt and clay. The sediments were deposited by melt water flowing south from the stagnating and receding Vashon glacier. The outwash is reported to have a maximum thickness of about 140 feet. Subsurface conditions disclosed by the explorations advanced by ZGA and others are consistent with the published mapping. Some of the borings and test pits disclosed undocumented fill material above the native soils.

Soil Conditions

The soil descriptions presented below have been generalized for ease of report interpretation. Please refer to the exploration logs for detailed soil descriptions at the exploration locations. Variations in subsurface conditions may exist between the exploration locations and the nature and extent of variations between the explorations may not become evident until additional explorations are completed or until construction. Undocumented fill material is present and it should be recognized that the nature of undocumented fill material is such that its composition and depth may vary over relatively short distances. Subsurface conditions at specific locations are summarized below.

Subsurface conditions were evaluated using a combination of six test pits, seven borings, and one cone penetrometer test (CPT). Borings B-1 through B-5 were advanced in the future substation yard. Boring B-6 was advanced through the driveway connecting the project site to 47th Avenue NE, and boring B-7 was advanced in 47th Avenue NE, located to the west of the existing dental office at 7825 - 47th Ave NE. The six test pits were excavated in the substation yard and cone CPT-1 was advanced approximately near the center of the yard. Approximate exploration locations, as well as pertinent surface features, are shown on Figures 1 and 2. Observed soil conditions are summarized below.

Surficial Organic Topsoil

The explorations disclosed about 2 to 10 inches of topsoil consisting of dark brown, silty sand with fine roots and fine organic matter. Fine roots were observed extending to about 1 foot below grade. The topsoil thickness should be expected to vary across the site.

Fill

We observed undocumented fill material consisting of brown to dark brown, silty sand with some gravel and trace cobbles to gravelly sand with some silt, and trace cobbles, extending to depths of approximately

1.75 to 2.25 feet at the test pit TP-5 and TP-6 locations, respectively. The coarse sand to cobble size material consisted of crushed rock. We observed undocumented fill material consisting of dark brown, brown and orange-brown, silty sand to sand with some silt, and a varying gravel content, extending to depths of approximately 2.5 to 3.3 feet at the boring B-1, B-2, B-4, and B-5 locations, respectively. The coarse sand and gravel size material observed in the upper 3.3 feet of boring B-5 consisted of crushed rock. We observed a thin relic topsoil horizon at approximately 2.5 feet in boring B-4. We observed undocumented fill material consisting of orange-brown to brown sand with some silt and a varying gravel content, extending to a depth of approximately 2.5 feet at boring B-6 in the crushed gravel driveway. We observed undocumented fill material consisting of crushed gravel over orange-brown sand with gravel and some silt, extending to a depth of approximately 2.5 feet at boring B-7.

Please note that the nature of undocumented fill is such that its composition and thickness can vary over relatively short distances. We submitted five samples of the fill material to an analytical laboratory in order to test for the presence of asbestos-containing material. The test results were negative.

Recessional Outwash

The test pits disclosed that the shallow native recessional outwash soils consisted of very loose to medium dense sand with a low silt and gravel content. The soils above the water table were generally in a moist condition. The test pits were terminated at relatively shallow depths of approximately 6.5 to 8.5 feet due to caving associated with the relatively low density and low fines content of the material in combination with shallow groundwater conditions.

The deeper recessional deposits as disclosed by CPT-1 consist of medium dense sand with a variable silt content to approximately 30 feet with dense sand, silty sand, and sandy silt to about 45 feet. Between about 45 and 50 feet (the CPT-1 termination depth), the density dropped off to medium dense and included a thin horizon of stiff sandy silt to clayey silt. Boring B-1 disclosed somewhat similar conditions, with medium dense sand with a variable silt content and discrete silt horizons to about 42 feet with very stiff sandy silt to the boring's approximately 51.5 foot termination depth.

Groundwater

We observed groundwater seepage at depths of approximately 4 to 6 feet while excavating the test pits and at approximately 3 feet while advancing boring B-1. We observed groundwater at depths of approximately 4.5 to 6 feet while advancing borings B-2 through B-5, and at approximately 6.5 feet while advancing boring B-7 along the east side of 47th Avenue NE, near the proposed location of a new transmission pole. We did not encounter groundwater while advancing boring B-6 in the driveway.

We installed a groundwater observation well at the boring B-3 location following completion of drilling and sampling. Groundwater measurements in the well subsequent to drilling and the well installation are summarized in the table below. It should be noted that groundwater conditions will likely vary seasonally and in response to precipitation events, land use, and other factors.

Table 1: Boring B-3 Groundwater Monitoring Well Observations			
Date	10.27.21	11.11.21	11.17.21
Groundwater Depth/Elevation (feet)	4.5 / 37.5	1.7 / 40.3	0.5 / 41.5
Date	4.1.22	6.16.22	9.27.22
Groundwater Depth/Elevation (feet)	1.8 / 40.2	1.86 / 40.14	4.3 / 37.7
*Groundwater depth measured relative to the rim of the flush-mount well monument.			
*Monument ground surface elevation approximately 42 feet			

CONCLUSIONS AND RECOMMENDATIONS

General Geotechnical Considerations

Based on information gathered during the field exploration, laboratory testing, and analysis, we conclude that construction of the proposed improvements is feasible from the geotechnical perspective provided that the recommendations presented herein are followed during design and construction. Selected aspects of the site conditions that should be considered during design and construction are summarized below.

- The native recessional outwash soils are generally favorable from the site grading and shallow foundation support perspectives. Selective removal of the existing undocumented fill material and underlying relic topsoil from below foundations, slabs, and vaults is recommended.
- Re-use of the existing non-organic native soil during grading will be feasible provided that the soil moisture content can be adequately controlled prior to compaction. The native soil has a low gravel content, and applications requiring a higher gravel content than typifies the native soils will necessitate selective import of aggregates.
- We anticipate that most excavations for foundations, vaults, and conduits will encounter groundwater, most likely necessitating dewatering during construction. Raising site grade to the extent feasible will help to reduce groundwater intrusion into the excavations and the dewatering magnitude.
- The granular nature of the shallow recessional outwash soils is favorable from the stormwater infiltration perspective.
- Our analysis indicates that the site soils between approximately 10 and 30 feet, and below about 45 feet, will likely liquefy during the IBC-defined seismic event. This may yield between about 3-1/2 and 4-1/2 inches of total settlement with differential settlement over 40 feet approximating half the total settlement. Based on our analysis, it appears that settlement associated with typical

substation foundations due to liquefaction accompanying the design seismic event will likely be considered acceptable without the need for deep foundations or extensive ground improvement.

Geotechnical engineering recommendations for site grading, drainage, foundations, and other geotechnically-related aspects of the project are presented in the following sections. The recommendations contained in this report are based upon the results of and the field exploration, laboratory testing, engineering analyses, review of historical documents, and our current understanding of the proposed project design. ASTM and WSDOT specification codes cited herein refer to the current manual published by the American Society for Testing & Materials and the current edition of the WSDOT *Standard Specifications for Road, Bridge, and Municipal Construction* (Publication M41-10).

Geologic Hazard Areas

Article IV of Chapter 22E of the Marysville Municipal Code (MMC) regulated geologic hazard areas as defined in Chapter 22A.020:

“Geologic hazard areas” means lands or areas characterized by geologic, hydrologic and topographic conditions that render them susceptible to potentially significant or severe risk of landslides, erosion, or seismic activity. It should be noted that the project site is not mapped as within, or near, any designated geologic hazard areas on the City of Marysville *Geologic Hazards* map, dated May 2014.

Erosion Hazard Areas

“Erosion hazard areas” means lands or areas that, based on a combination of slope inclination and the characteristics of the underlying soils, are susceptible to varying degrees of risk of erosion. Erosion hazard areas are classified as low hazard, moderate hazard and high hazard, based on the following criteria:

(1) Low Hazard. Areas sloping less than 15 percent.

(2) Moderate Hazard. Areas sloping between 15 and 40 percent and underlain by soils that consist predominantly of silt, clay, bedrock or glacial till.

(3) High Hazard. Areas sloping between 15 and 40 percent that are underlain by soils consisting largely of sand and gravel, and all areas sloping more steeply than 40 percent.

The project site is essentially level and lacks significant slopes, certainly lacking slopes 15 percent or steeper. It is our opinion that the site presents a low erosion hazard per the MMC definition.

Landslide Hazard Areas

“Landslide hazard areas” means areas that, due to a combination of slope inclination and relative soil permeability, are susceptible to varying degrees of risk of landsliding. Landslide hazard areas are classified as Classes I through IV based on the degree of risk as follows:

(1) Low Hazard. Areas with slopes of less than 15 percent.

(2) Moderate Hazard. Areas with slopes of between 15 and 40 percent and that are underlain by soils that consist largely of sand, gravel, bedrock or glacial till.

(3) High Hazard. Areas with slopes between 15 percent and 40 percent that are underlain by soils consisting largely of silt and clay, and all areas sloping more steeply than 40 percent.

(4) Very High Hazard. Areas with slopes over 40 percent and areas of known mappable landslide deposits.

As described above, the project site is essentially level and lacks significant slopes, including slopes 15 percent or steeper. It is our opinion that the site presents a low landslide hazard per the MMC definition.

Seismic Hazard Areas

“Seismic hazard areas” means areas that, due to a combination of soil and ground water conditions, are subject to severe risk of ground shaking, subsidence or liquefaction of soils during earthquakes. These areas are typically underlain by soft or loose saturated soils (such as alluvium), have a shallow ground water table and are typically located on the floors of river valleys. Seismic hazard areas are classified as follows:

(1) Low Hazard. Areas underlain by dense soils or bedrock.

(2) High Hazard. Areas underlain by soft or loose saturated soils.

Based upon our analysis, it appears that the site meets the MMC criteria for a High Hazard area due to the potential for liquefaction-induced settlement, as described in the following sections. We evaluated the seismic performance of the site relative to hazards resulting from ground shaking associated with a design seismic event with a 2,475-year return period determined in accordance with the 2018 International Building Code (IBC) and the American Society of Civil Engineers Standard 7-16 (ASCE 7-16). Conformance to the above criteria for seismic excitation does not constitute any kind of guarantee or assurance that significant structural damage will not occur if a maximum level earthquake occurs. The primary goal of the IBC seismic design procedure is to protect life and not to avoid all damage, since such design may be economically prohibitive. Following a major earthquake, a building or structure may be damaged beyond repair, yet not collapse.

Ground Fault Rupture: The USGS Quaternary Fault Web Mapping Application indicates that the site is about 12 miles northeast of the South Whidbey Island Fault Zone and about 21 miles southeast of the Utsalady Point Fault. Based on the location of the mapped fault zones relative to the project site, it is our opinion that the risk of ground surface rupture at the site is low and does not require mitigation.

Landsliding: Based on the relatively level topography of the site and surrounding vicinity, it is our opinion that the risk of earthquake-induced landsliding is low and does not require mitigation.

Liquefaction: Liquefaction is a phenomenon wherein saturated cohesionless soils build up excess pore water pressures during earthquake loading. Liquefaction typically occurs in loose soils, but may occur in denser soils if the ground shaking is sufficiently strong. ZGA completed a liquefaction analysis in general accordance with Section 1803.5.12 of the 2018 IBC and Section 11.8.3 of ASCE 7-16. Specifically, our analysis used the following primary seismic ground motion parameters.

- A Maximum Considered Earthquake Geometric Mean (MCE_G) Peak Ground Acceleration of 0.472g, based on Figure 22-9 of ASCE 7-16.
- A Site Modified Peak Ground Acceleration (PGA_M) of 0.532g based on Site Class D, per Section 11.8.3 of ASCE7-16 (Site Class modification to MCE_G without regard to liquefaction in accordance with Sections 11.4.8 and 20.3.1 of ASCE 7-16).
- A Geometric Mean Magnitude of 7.08 based on 2014 USGS National Seismic Hazard Mapping Project deaggregation data for a seismic event with a 2% probability of exceedance in 50 years (2,475 year return period).

Our liquefaction analysis was completed using the computer program LiquefyPro Version 5.8 using the modified Robertson method for CPT data. Our analysis was based on CPT-1 completed to a depth of about 50 feet below existing grade. The approximate exploration location is shown on the enclosed *Site and Exploration Plan, Figure 1*. Our analysis indicates the potential for liquefaction at depths ranging from about 10 to 30 feet and greater than about 45 feet below grade.

Liquefaction Settlement: Based on our analyses, we estimate a total seismic settlement of approximately 3½ to 4½ inches. We estimate a differential seismic settlement of approximately 1¾ to 2¼ inches over a horizontal distance of 40 feet.

Lateral Spread: Lateral spreading is a phenomenon in which soil deposits which underlie a site can experience significant lateral displacements associated with the reduction in soil strength caused by soil liquefaction. This phenomenon tends to occur most commonly at sites where the soil deposits can flow toward a “free-face”, such as a water body. Our evaluation did not identify a nearby free face condition. We also evaluated the potential for lateral spread using the Liquefaction Severity Index (LSI) method developed by Youd and Perkins (1987). This method evaluates earthquake magnitude and the horizontal distance from the surface projective of the energy source to generate an LSI index value of 1 to 100, with 1 being a very low risk and 100 being a very high risk of lateral spread. Our evaluation indicates a site LSI value of about 1. Given the site LSI value and the lack of a free face condition, it is our opinion that the potential for lateral spread is low and does not require mitigation.

Earthwork

The following sections present recommendations for site preparation, subgrade preparation, and placement of engineered fills on the project. The recommendations presented in this report for design and construction of foundations and slabs are contingent upon following the recommendations outlined in this section.

Earthwork on the project should be observed and evaluated by a ZGA representative. Evaluation of earthwork should include observation and testing of structural fill, subgrade preparation, foundation bearing soils, deep foundations, and subsurface drainage installations.

Site Preparation

Stripping: In preparation for grading we recommend removal of all existing surficial vegetation and deleterious debris such as trash, small amounts of which we observed. These materials should be wasted away from the substation and access road areas.

Existing Fill Removal: Site preparation is recommended to include selective removal of existing undocumented fill material containing substantial organics or deleterious debris and any relic organic topsoil from within the yard below structure and conduit run locations.

Variation in the fill depth and composition, and the depth of relic topsoil below the fill, should be expected. These materials should be evaluated during construction and removed as necessary under the observation of a ZGA representative. Our representative will identify unsuitable materials that should be removed and possibly some that may be re-used as structural fill. The existing undocumented fill in the open areas of the yard (not below foundations, slabs, or conduit runs) and with no more than about 3 percent organic material and lacking deleterious material may be left in place.

The resultant excavations should be backfilled in accordance with the subsequent recommendations for structural fill placement and compaction. Specific recommendations regarding removal of existing fill material at foundation and slab locations are provided subsequently in association with foundation design and construction recommendations.

Site Preparation and Grading Scheduling: Most of the native soils likely to be exposed during grading consist of sand with a relatively low fines content. It will be feasible from the geotechnical perspective to grade these soils under a relatively wide weather band, although even with favorable granular soils it may be difficult or impossible to grade the site during very wet weather. If this is a concern with the District, we recommend that site preparation and grading take place in the drier summer and early fall months if possible. Completion of site preparation and grading under drier site and weather conditions will reduce the potential for disturbance of some of the moisture-sensitive soils and the need to replace disturbed soils with imported fill material. Completing the work during the drier summer and early fall months will also allow the grading to coincide with the seasonal low groundwater condition and this would reduce the extent of construction dewatering.

Structural Fill Placement and Compaction

Establishing a yard elevation of 46 feet will require placing about 3 to 5 feet structural fill. Structural fill will also be placed for conduit and vault installations, storm drainage piping and structures, and adjacent to new slabs and shallow foundations. All fill material should be placed in accordance with the recommendations herein for structural fill. Prior to placement, the surfaces to receive structural fill should be observed by a ZGA representative in order to verify that at least medium dense properly prepared fill or native soil is present. In the event that soft or loose soils are present at the subgrade elevation, and we expect that this will locally be the case given the nature of the native recessional outwash soils, the soils below foundation, slab, vault, and entry drive locations should be compacted to a firm and non-yielding condition and to at least 95 percent of the modified Proctor maximum dry density (ASTM D 1557) prior to placing structural fill. In the event that the soils cannot be adequately compacted, they should be moisture condition as necessary or removed as necessary and replaced with other granular fill material at a moisture content that allows its compaction to the recommended density.

The suitability of soils for use as structural fill depends primarily on the gradation and moisture content of the soil when it is placed. As the amount of fines (that soil fraction passing the US No. 200 sieve) increases, soil becomes increasingly sensitive to small changes in moisture content and adequate compaction becomes more difficult, or impossible, to achieve. Generally, soils containing more than about 5 percent fines by weight (based on that soil fraction passing the US No. 4 sieve) cannot be compacted to a firm, non-yielding condition when the moisture content is more than a few percent from optimum. The optimum moisture content is that which yields the greatest soil density under a given compactive effort.

Re-use of On-site Soils: Soil expected to be encountered in excavations include predominantly native soil typically consisting of sand with a variable silt content and some undocumented fill consisting of sand and gravelly sand with some cobbles and variable silt content with some organics. We collected seven native soils samples from depths of about 3 to 7 feet. Six of those samples had a fines content of less than 2 percent while the seventh has a fines content of about 9 percent. Overall, the native recessional outwash is well-suited for use as structural fill. Please note that some of the fill material contains a relatively high silt content. Using these materials as structural fill could be difficult due to the high fines content and moisture sensitivity.

Imported Structural Fill: We recommend that structural fill consist of a well-graded sand and gravel with a low fines content, such as the District's standard substation fill, the gradation of which is presented in the table below.

Table 2: Snohomish County PUD No. 1 Substation Import Granular Fill Gradation	
US Standard Sieve Size	Percent Passing by Dry Weight Basis
2 inch	100
½ inch	56 - 100

Table 2: Snohomish County PUD No. 1 Substation Import Granular Fill Gradation	
US Standard Sieve Size	Percent Passing by Dry Weight Basis
¼ inch	40 - 78
No. 10	22 - 57
No. 40	8 - 32
No. 200	< 5

This material may be considered slightly to moderately moisture-sensitive relative to placement and compaction. A means of reducing the moisture sensitivity of the imported fill would be to base the fines content to less than 5 percent based on the soil fraction passing the ½ inch sieve. It would be feasible to use other granular soils with a higher fines content as structural fill, but it should be recognized that soils with a higher fines content will be more moisture-sensitive and this may limit their use during wet weather or wet site conditions. Another advantage of using granular fill with a relatively low fines content is that it will drain better than fill with a higher fines content. The use of other fill types should be reviewed and approved by ZGA prior to their use on site.

It has been our experience that the District may specify the use of Crushed Surfacing, Base Course Gradation (CSBC) [WSDOT Specification 9-03.9(3)] as structural fill. It should be noted that the gradational criteria for crushed surfacing base course allows up to 7.5 percent fines for 1.5-inch minus material. Crushed surfacing base course with a fines content near the permissible upper limit should not be considered select all-weather fill. Imported fill that is less moisture-sensitive could be achieved by specifying that the material have no more than 5 percent fines based on the soil fraction passing the 1/2-inch sieve. We recommend the use of 100 percent crushed CSBC with a low fines content at the base of fills in the yard and yard entry to facilitate successful stormwater infiltration.

Compaction Recommendations: Structural fill should be placed in horizontal lifts and compacted to a firm and non-yielding condition using equipment and procedures that will produce the recommended moisture content and densities throughout the fill. Fill lifts should generally not exceed 10 inches in loose thickness, although the nature of the compaction equipment in use and its effectiveness will influence functional fill lift thicknesses. Recommended compaction criteria for structural fill materials, including trench backfill, are as follows:

Table 3: Recommended Soil Compaction Levels	
Location	Minimum Percent Compaction*
Below foundations and slabs	95
Yard area and extending 5 feet beyond the fence	95
Under driveways, roadways, and sidewalks	95
Fill sections and berms in other areas of the site	90 – 95 (refer to report text)
Trenches, foundation, and slab backfill	95
All other areas	90

* ASTM D 1557 Modified Proctor Maximum Dry Density

Earthwork may be difficult or impossible during periods of elevated soil moisture and wet weather. If soils are stockpiled for future use and wet weather is anticipated, the stockpile should be protected with plastic sheeting that is securely anchored.

Subgrade soils that become disturbed due to elevated moisture conditions should be overexcavated to expose firm, non-yielding, non-organic soils and backfilled with compacted structural fill. We recommend that the earthwork portion of this project be completed during extended periods of dry weather if possible. If earthwork is completed during the wet season (typically November through June) it will be necessary to take extra precautionary measures to protect subgrade soils. Wet season earthwork may require additional mitigative measures beyond that which would be expected during the drier summer and fall months. This could include diversion of surface runoff around exposed soils and draining of ponded water. Once subgrades are established, it will be necessary to protect the exposed subgrade soils from construction traffic during wet weather. Placing quarry spalls or crushed recycled concrete over these areas would further protect the soils from construction traffic.

If earthwork takes place during freezing conditions, we recommend allowing the exposed subgrade to thaw and then recompacting the subgrade prior to placing subsequent lifts of engineered fill. Frozen soil should not be used as structural fill.

We recommend that a ZGA representative be present during the construction phase of the project to observe earthwork operations and to perform necessary tests and observations during subgrade preparation, placement and compaction of structural fill, backfilling of excavations, and prior to construction of foundations and slabs.

Drainage: Positive drainage should be provided during construction and maintained throughout the life of the project. Uncontrolled movement of water into trenches or foundation and slab excavations during construction should be prevented.

Additional Considerations: It is anticipated that excavations for the proposed improvements can be accomplished with conventional earthmoving equipment.

Excavation Quantities: It has been our experience that grading calculations need to accommodate a “shrink or swell” factor when comparing in-place soil volumes to truck volumes. We recommend considering that the in-place volume of soil removed from excavations will increase by approximately 25 to 40 percent when measured on a loose cubic yards basis (truck yards). Likewise, loose truck yards delivered to the site will shrink on the order of 25 to 30 percent when compared to the in-place compacted volume of the soil. Truck yards are also subject to other discrepancies when correlating to bank yards, including “rounding errors” that can be significant.

Utility Installation Recommendations

Below-grade utilities are expected to include conduits and storm drain piping and structures. We recommend that utility trenching conform to all applicable federal, state, and local regulations, such as OSHA and WISHA, for open excavations. The existing shallow native and fill soils in the substation footprint are generally expected to be adequate for support of utilities.

All trenches should be wide enough to allow for compaction around the haunches of the pipe. If water is encountered in the excavations, it should be removed prior to fill placement. Materials, placement and compaction of utility trench backfill exclusive of CDF should be in accordance with the recommendations presented in the *Structural Fill* section of this report. In our opinion, the initial lift thickness should not exceed 1 foot unless recommended by the manufacturer to protect utilities from damage by compacting equipment. Light, hand operated compaction equipment may be utilized directly above utilities if damage resulting from heavier compaction equipment is of concern.

Dewatering: Depending upon the time of year that the work takes place and the depth of the utilities, groundwater seepage should be expected in excavations and certainly during the wetter time of year. Seepage could be heavy enough to require temporary dewatering measures and flattening the sidewalls of excavations to reduce the risk of caving. The contractor should be prepared to pump water from excavations into either a nearby storm or sanitary sewer or Baker tank. Dewatering water discharged from the site will likely need to comply with permit requirements issued by the City of Marysville. We recommend that dewatering effectively lower the water table at least 2 feet below the bottoms of excavations until they are backfilled.

Temporary Excavation Slopes: We recommend that utility trenching, installation, and backfilling conform to all applicable Federal, State, and local regulations such as WISHA and OSHA regulations for open excavations. In order to maintain the function of any existing utilities that may be located near excavations, we recommend that temporary excavations not encroach upon the bearing splay of existing utilities, foundations, or slabs. The bearing splay of structures and utilities should be considered to begin at the edge of the utility, foundation, or slab and extend downward at a 1.5H:1V (Horizontal:Vertical) slope under fully drained conditions. Much shallower temporary slope inclinations will be required under saturated soil conditions. If, due to space constraints, an open excavation cannot be completed without encroaching on a utility, we recommend shoring the new utility excavation with a slip box or other suitable means that provide for protection of workers and that maintain excavation sidewall integrity to the depth of the excavation.

Temporary slope stability is a function of many factors, including the following:

- The presence and abundance of groundwater;
- The type and density of the various soil strata;

- The depth of cut;
- Surcharge loadings adjacent to the excavation;
- The length of time the excavation remains open.

It is difficult to pre-establish a safe and “maintenance-free” temporary cut slope angle. Therefore, it should be the responsibility of the contractor to maintain safe slope configurations since the contractor is continuously at the job site, able to observe the nature and condition of the cut slopes, and able to monitor the subsurface materials and groundwater conditions encountered. It may be necessary to drape temporary slopes with plastic or to otherwise protect the slopes from the elements and minimize sloughing and erosion. We do not recommend vertical slopes or cuts deeper than 4 feet if worker access is necessary. The cuts should be adequately sloped or supported to prevent injury to personnel from local sloughing and spalling. The excavation should conform to applicable Federal, State, and local regulations.

Based upon our review of WAC Chapter 296-155-66401 (Appendix A – Soil Classification), we have interpreted the soils disclosed by the explorations and likely to be present in most excavations as consistent with the Type C definition. The contractor should be responsible for determining soil types in all excavations at the time of construction and should be prepared to adequately shore or slope all excavations. Please note that the shallow granular soils have a low fines content and that unsupported excavation sidewalls in these soils may slough or cave readily.

Below-grade Vault Recommendations

Bearing Conditions: Below-grade conduit vaults will be installed as part of the project. Based upon our experience with other District substations, and depending on the orientation of the new conduit sweeps, the vault bases may be up to approximately 8 feet below grade, although due to the site’s shallow groundwater conditions, we recommend that consideration be given to using shallower vaults. Based upon conditions disclosed by the explorations, we anticipate that vault subgrades will consist of loose native sand with a low fines and gravel content.

The vaults will exert a relatively low bearing pressure on the existing soils, and we estimate that up to approximately 1 inch of settlement may take place soon after the vaults are installed and backfilled. Some subgrade improvement is recommended to reduce the potential for differential settlement. Placing a minimum 6-inch compacted thickness of crushed rock below the vaults will help to reduce the magnitude of differential settlement. The crushed rock should conform to the quality and gradation requirements for WSDOT CSBC. Moderate to rapid groundwater seepage should be expected for excavations that extend into groundwater. The contractor should be prepared to dewater excavations to the extent necessary to allow for installation of vaults, conduits, and bedding and backfill materials in accordance with the District’s requirements.

Buoyancy Considerations: The vaults will be subject to buoyant forces if they are water-tight. Potential buoyant forces acting on the vaults may be calculated by multiplying the volume of the portion of the vault below the water table (in cubic feet) by 62.4 pcf. Buoyant forces may be resisted by the weight of a vault and its contents. Additional resistance to buoyant forces may be achieved by installing flanges on the vault base. The weight of the soil backfill placed above the flanges will assist in counteracting buoyant forces. We recommend using a soil density of 125 pcf for backfill above the water table, and 60 pcf for backfill below the water table. Based on our observations, we recommend considering a seasonal high groundwater elevation of 41.5 feet.

IBC Seismic Design Parameters

Per the 2018 IBC seismic design procedures and ASCE 7-16, the presence of liquefiable soils requires a Site Class definition of F. However, through reference to Sections 11.4.8 and 20.3.1 of ASCE 7-16, the 2018 IBC allows site coefficients F_a and F_v to be determined assuming that liquefaction does not occur for structures with fundamental periods of vibration less than 0.5 seconds. Provided the buildings fundamental period of vibration is less than 0.5 seconds, Site Class D may be used to determine the values of F_a and F_v in accordance with Sections 11.4.8 and 20.3.1 of ASCE 7-16. If exceptions for Site Class D presented in Section 11.4.8 and 20.3.1 of ASCE 7-16 do not apply, a ground motion hazard analysis may be required.

Table 4: Recommended Seismic Parameters	
Code Used	Site Classification
2018 International Building Code (IBC) ¹	F ^{2,3}
Site Latitude/Longitude	48.0668/-122.1701
Peak Ground Acceleration, PGA	0.472g
Site Modified Peak Ground Acceleration, PGA_M	0.532g
S_s Spectral Acceleration for a Short Period	1.110g
S_1 Spectral Acceleration for a 1-Second Period	0.395g
F_a Site Coefficient for a Short Period	1.056 (Site Class D)
F_v Site Coefficient for a 1-Second Period	Null-See ASCE 7-16 Section 11.4.8
<ol style="list-style-type: none"> IBC Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile. The explorations completed for this study extended to a maximum depth of approximately 50 feet below grade. ZGA therefore determined the Site Class assuming that medium dense normally consolidated soils extend to 100 feet as suggested by published geologic maps for the project area. Per ASCE 7-16, Chapter 20, any profile containing soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils shall be classified as Site Class F. 	

Foundations

We anticipate that some of the new structures will be supported by drilled pier foundations, while others may be supported by slabs or conventional shallow foundations. The foundation net vertical bearing pressures are expected to be relatively low, and the slabs and foundations are typically about 2 to 5 feet deep, respectively, based upon our experience with other District facilities. The native granular soils and properly compacted structural fill are adequate for support of shallow foundations.

Based on conditions observed at the locations of borings and test pits completed at or near the proposed slab locations, we anticipate that foundation subgrade soils will largely consist of loose to medium dense sand with a low silt and gravel content. In order to reduce post-construction settlement, we recommend excavating 1 foot below the design foundation or slab subgrade elevation and replacing the existing soils with CSBC compacted to at least 95 percent per ASTM D 1557. In the event that loose soils or soils containing organics material or deleterious debris are encountered at the CSBC subgrade elevation, we recommend removing the organics and deleterious debris and compacting loose soils to a firm and non-yielding condition and to at least 95 percent density. The excavations made prior to CSBC placement and overexcavation of inadequate soils below footings should extend laterally beyond all edges of the footings a distance of 2 feet per 3 feet of overexcavation depth below footing base elevation. We recommend backfilling excavations made to remove unsuitable soils with CSBC placed in lifts of 10 inches or less in loose thickness and compacted to at least 95 percent density (ASTM D 1557). It would also be feasible to backfill the excavations with lean mix concrete or Controlled Density Fill (CDF). If excavations are backfilled with lean mix concrete or CDF, we recommend the material have a minimum compressive strength of 100 psi. When using CDF, the overexcavation need only be 1 foot wider than the foundation on all sides.

Recommended criteria for shallow foundations are summarized below.

Net allowable bearing pressure: 2,000 psf. This value incorporates a factor of safety of 3. A one-third increase may be applied for short-term wind or seismic loading.

Minimum base dimension: 4 feet

Minimum embedment for frost protection: 18 inches

Approximate total settlement: 1 inch

Estimate differential settlement: One half of total settlement over 40 feet

Ultimate passive resistance: 235 pcf. This value assumes that foundations are backfilled with native sand compacted to 95 percent density and does not include a factor of safety. Neglect the upper 18 inches of embedment when calculating passive resistance.

Ultimate coefficient of base friction: 0.55. This value assumes the foundations are formed above compacted CSBC.

Shallow Foundation Construction Considerations

The base of all foundation excavations should be free of water, loose soil, or debris prior to placing concrete, and should be compacted as recommended in this report. Concrete should be placed soon after excavating and compaction of subgrade CSBC to reduce bearing soil disturbance. Should the bearing subgrade become excessively disturbed or frozen, the affected material should be removed prior to placing concrete. We recommend that a ZGA representative observe foundation subgrade conditions prior to form and reinforcing steel placement.

Drilled Pier Foundation / Direct Burial Recommendations

We anticipate that some of the structures in the substation, including the dead end (termination) structures, will be supported by drilled pier foundations, although the dead end structures may be installed via direct burial. Transmission poles are also proposed for construction in the southeastern portion of the substation and along 47th Avenue NE. Based upon conditions observed at the locations of the explorations, site conditions are generally favorable for support of drilled pier foundations or direct burial although the shallow groundwater condition will necessitate the use of casing during installation.

We understand that the District will complete the foundation designs in house. The tables below provide recommended soil values for incorporation into the District's *Caisson* design program. We have not incorporated factors of safety into the listed values. **The depth intervals referenced in the tables are relative to the existing ground surface elevation at the specific boring locations.** Non-cohesive soils were observed at the exploration locations, so soil cohesion values are not provided. The pressuremeter elastic modulus values are based upon correlations with Standard Penetration Test values (N) published in "Estimating Foundation Settlements in Residual Soils", Journal of the Geotechnical Engineering Division, Vol. 103, No. 3, March 1977.

We recommend incorporating the values listed in Table 5A and 5B for structures or poles at the substation site.

Table 5A: Recommended Soil Parameters Based on boring B-1

Depth interval in feet below existing grade	Soil Condition	Averaged Standard Penetration Resistance (N)	Correlated Pressuremeter Elastic Modulus (kips/in ²) ¹	Soil Wet Density (pcf)	Internal Friction Angle (∅, in degrees)
0 – 3	Med. dense Sand and silty Sand, variable gravel, wood debris (Fill)	13	1.65	105 ²	31
3 – 9.5	Loose Sand, trace silt and gravel	10	1.39	100 ²	30
9.5 – 14.5	Med. Dense Sand and silty Sand	16	1.89	105 ²	32
14.5 – 42.5	Med. Dense Sand and silty Sand	25	2.52	107 ²	35
42.5 – 51.5	Very stiff sandy Silt	24	2.45	107 ²	34

1. The pressuremeter modulus values are based upon published correlations between Standard Penetration Test values (N) and the pressuremeter modulus; a factor of safety does not apply.
2. Soil Wet Density does not reflect buoyant unit density below the observed groundwater. Subtract 62.4 pcf for buoyant unit density.

Table 5B: Recommended Soil Parameters Based on boring B-1

Depth interval in feet below existing grade	Soil Condition	Relative Density (D _r as percent)	Ultimate Friction Factor ¹	Ultimate Friction Factor ²	Moisture Content (percent by dry weight basis) ³	Rankine Coefficient Passive ⁴ / Active
0 – 3	Med. dense Sand and silty Sand, variable gravel, wood debris (Fill)	40	0.4	0.25	15	3.12 / 0.32
3 – 9.5	Loose Sand, trace silt and gravel	35	0.5	0.3	21 ³	3.0 / 0.33
9.5 – 14.5	Med. Dense Sand and silty Sand	45	0.5	0.3	23 ³	3.25 / 0.31
14.5 – 42.5	Med. Dense Sand and silty Sand	57	0.5	0.3	25 ³	3.69 / 0.27
42.5 – 51.5	Very stiff sandy Silt	57	0.35	0.2	26 ³	3.54 / 0.28

1. The ultimate friction factors are based upon published values for adhesion between concrete and the applicable soil type.
2. The ultimate friction factors are based upon published values for adhesion between steel and the applicable soil type.
3. Moisture contents are for saturated sand samples retrieved from below groundwater.
4. Passive resistance in the upper 1.5 feet should be neglected entirely.

We recommend incorporating the values listed in Table 6A and 6B for design of the proposed transmission poles along 47th Avenue NE.

Table 6A: Recommended Soil Parameters Based on boring B-7

Depth interval in feet below existing grade	Soil Condition	Averaged Standard Penetration Resistance (N)	Correlated Pressuremeter Elastic Modulus (kips/in ²) ¹	Soil Wet Density (pcf) ²	Internal Friction Angle (∅, in degrees)
0 – 4.5	Loose Sand with some gravel, trace silt	5	0.89	105 ²	28
4.5 – 17.5	Med. dense Sand, variable silt and gravel	19	2.11	106 ²	33
17.5 – 29	Loose Sand, trace silt	9	1.3	100 ²	29
29 – 36.5	Stiff to very stiff sandy Silt	16	1.89	105 ²	32

1. The pressuremeter modulus values are based upon published correlations between Standard Penetration Test values (N) and the pressuremeter modulus; a factor of safety does not apply.
2. Soil Wet Density does not reflect buoyant unit density below the observed groundwater. Subtract 62.4 pcf for buoyant unit density.

Table 6B: Recommended Soil Parameters Based on boring B-7

Depth interval in feet below existing grade	Soil Condition	Relative Density (D _r as percent)	Ultimate Friction Factor ¹	Ultimate Friction Factor ²	Moisture Content (percent by dry weight basis) ³	Rankine Coefficient Passive ⁴ / Active
0 – 4.5	Loose Sand with some gravel, trace silt	17	0.4	0.25	11	2.77 / 0.36
4.5 – 17.5	Med. dense Sand, variable silt and gravel	52	0.5	0.3	26 ³	3.39 / 0.29
17.5 – 29	Loose Sand, trace silt	30	0.4	0.3	30 ³	2.88 / 0.35
29 – 36.5	Stiff to very stiff sandy Silt	45	0.35	0.2	26 ³	3.25 / 0.31

1. The ultimate friction factors are based upon published values for adhesion between concrete and the applicable soil type.
2. The ultimate friction factors are based upon published values for adhesion between steel and the applicable soil type.
3. Moisture contents are for saturated sand samples retrieved from below groundwater.
4. Passive resistance in the upper 1.5 feet should be neglected entirely.

Drilled Shaft End Bearing Considerations

When calculating drilled pier end bearing values, it will be necessary to consider the density of the soils to a depth below the shaft that is a function of the shaft diameter. We can provide specific end bearing capacity recommendations once preliminary design efforts for the drilled pier foundations have identified likely drilled pier diameters and depths.

Open Shaft Construction Considerations

Given the soil conditions encountered at the exploration locations, we anticipate that construction of the shafts can be accomplished with standard drilling equipment. Although the exploratory drilling and probing processes did not suggest the presence of cobbles and potentially boulders or other possible drilling obstructions within the deposits encountered within our explorations, the contractor should be prepared to deal with the presence of oversize material and obstructions over the installation depth interval.

Casing / Sleeve Cleanout

We anticipate that the granular soils encountered over the drilled interval will cave in an open borehole condition. The contractor should be prepared to install full-depth casing or a sleeve through caving soil zones. The drilling contractor should be prepared to clean out the bottom of the shaft if loose soil is observed or suspected prior to placing the buried portion of the pole and surrounding concrete/crushed

rock or prior to installing drilled pier reinforcing and concrete. We recommend that the drilling contractor have a cleanout bucket on site to remove loose soils and/or mud from the bottom of the drilled shafts.

Groundwater and Bore Hole Stability

The site is characterized by a groundwater table aquifer and groundwater will be encountered while drilling. We estimate that successful completion of drilled shafts may require dewatering or the use of drilling fluids. The contractor should develop means and methods such as dewatering, the use of casing, and the use of drilling fluids or combinations thereof to maintain bore hole stability during construction. The contractor should be prepared to maintain an adequate head of drilling fluid in order to avoid bottom heave of the drilled shaft. Where drilling fluids are used, the slurry level used to maintain a stable bore hole should be maintained to obtain hydrostatic equilibrium throughout the construction operation at a height required to provide and maintain a stable bore hole.

Concrete Placement

Concrete for drilled piers should normally be placed via the free fall method. However, per the *Drilled Shaft Manual* published by the Federal Highway Administration, we recommend placing concrete by the tremie method if more than 3 inches of water has accumulated in the excavation as a means of displacing water and to reduce the risk of contaminating or segregating the concrete mix. A minimum 5-foot head of concrete should be maintained above the tremie.

IBC Non-constrained Pole Design Recommendations

Section 1805.7.2.1 of the 2003 the *International Building Code* (IBC) describes the methodology for determining a drilled pier foundation or pole depth of embedment in cases where no constraint is provided at the surface to resist lateral forces. We have evaluated the equivalent passive soil pressure per foot of depth for use in the IBC method. Recommended lateral bearing pressures as a function of pole depth are listed below in Table 7. We recommend neglecting resistance in the upper 1.5 feet of embedment. Please note that the values listed below are relative to the ground surface elevation at the boring locations.

Table 7: IBC Non-constrained Pole Lateral Bearing Pressure	
ZGA Boring	Recommended Lateral Bearing Pressure (lbs/ft²/ft) of Embedment Depth^{1,2,3}
B-1	1.5 to 3 feet: 130 3 to 9.5 feet: 120 9.5 to 14.5 feet: 135 14.5 to 42.5 feet: 158 42.5 to 51.5 feet: 150
B-7	1.5 to 4.5 feet: 115 4.5 to 17.5 feet: 145 17.5 to 29 feet: 115 29 to 36.5 feet: 135
1. Values incorporate a factor of safety = 2.5 2. Neglect upper 1.5 feet 3. Subtract 62.5 to determine effective value below groundwater	

In the event that structural fill compacted to 95 percent density per ASTM D 1557 is placed to raise grade at drilled pier locations, we recommend using a lateral bearing pressure of 200 lbs/ft²/ft of embedment depth for compacted fill that extends below a depth of 1.5 feet. This value incorporates a factor of safety of 2.5. The upper 1.5 feet of embedment should be neglected.

Concrete Slab Subgrade Preparation Recommendations

The transformers and switchgear enclosures will be supported by reinforced concrete slabs, and oil containment slabs will surround the transformer slabs. Our previous recommendations regarding selective excavation and compaction of existing loose fill soils, and removal of organic materials and deleterious debris, should they be observed at the time of construction, are applicable to slab subgrades. Based on conditions observed at the locations of explorations completed at or near the proposed slab locations, we anticipate that slab subgrade soils will largely consist of loose to medium dense sand with a variable silt content. We recommend compacting the slab subgrades to a firm and non-yielding condition and to at least 95 percent of the modified Proctor maximum dry density prior to placing a 12-inch thick CSBC leveling course for the slabs. Provided that the slab subgrades are prepared as described herein, we anticipate that total settlement will be less than ½ inch.

Stormwater Management Analysis Considerations

The site is largely mantled by some uncontrolled fill material underlain by permeable native granular soil and is characterized by a relatively shallow seasonal groundwater condition. Conclusions regarding stormwater infiltration feasibility can be drawn from subsurface conditions disclosed by the subsurface explorations, groundwater observations, and laboratory testing completed to date.

We understand that stormwater management improvements will be designed in accordance with the Washington State Department of Ecology 2019 *Stormwater Management Manual for Western*

Washington (Manual). We collected representative samples of shallow soils and completed mechanical grain size tests as part of assessing the soils' saturated hydraulic conductivity, as summarized below.

Saturated Hydraulic Conductivity

The *Manual* allows a determination of soil saturated hydraulic conductivity to be estimated based on grain size distribution characteristics in accordance with the following formula:

$$\text{Log}_{10} (K_{\text{sat, initial}}) = -1.57 + 1.9D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{\text{fines}} \text{ where:}$$

$K_{\text{sat, initial}}$ = initial saturated hydraulic conductivity in centimeters/second prior to the application of correction factors

D_{10} = grain size diameter (mm) for which 10 percent of the sample by weight is finer

D_{60} = grain size diameter (mm) for which 60 percent of the sample by weight is finer

D_{90} = grain size diameter (mm) for which 90 percent of the sample by weight is finer

f_{fines} = fraction of the sample by weight that passes the US No. 200 sieve.

The calculated hydraulic conductivity values for representative soils that we tested are listed in the table below. Grain size distribution curves for the samples are presented in Appendix B.

Table 8: Saturated Hydraulic Conductivity Summary		
Exploration / Sample	Approximate sample depth (feet)	Unfactored Saturated Hydraulic Conductivity (inches per hour)
TP-1 / S-3	5.5	83.9
TP-1 / S-4	7	59.6
TP-2 / S-2	3.5	67.3
TP-3 / S-2	3	83.9
TP-4 / S-3	3	77.4
TP-5 / S-3	4.5	78.1
TP-6 / S-3	3.3	28.7

Design Saturated Hydraulic Conductivity Rate

The *Manual* requires applying correction factors to the baseline saturated hydraulic conductivity rate. Table 3.3.1 *Correction Factors to be Used with In-Situ Saturated Hydraulic Conductivity Measurements to Estimate Design Rates* of the *Manual* calls for 40 percent reduction of the baseline rate. Table 3.3.1 also

requires applying correction factors for site variability and number of locations tested (CF_M) and the degree of influent control to prevent siltation and bio-buildup (CF_V). Based upon the site conditions, testing, and our experience with projects of a similar nature, we applied values of 0.4, 0.4, and 0.9 for CF_V , CF_I , and $CF_{M,I}$, respectively. We recommend using a factored rate (K_{sat}) of 18 inches/hour for the *in situ* native outwash sand for purposes of stormwater infiltration analysis.

Construction of the substation will include selective removal of existing uncontrolled fill material prior to placing imported granular fill to foundation and slab subgrade elevations as necessary. This densification will reduce the site soil's infiltration rate compared to the underlying less dense *in situ* soils. However, this process is only recommended for below foundations and slabs; it is not recommended for the balance of the yard in order to promote stormwater infiltration.

Groundwater Considerations

We measured the depth to groundwater at approximately 5 feet while advancing boring B-3, and at 0.5 feet (approximately elevation 41.5 feet) on 17 November 2021 after several days of significant rain. This is the highest elevation at which we have measured groundwater, and we recommend considering elevation 41.5 feet as the seasonal high condition. This condition will yield approximately 4.5 feet of vertical separation between the seasonal high groundwater and the substation yard finished grade of elevation 46 feet. The yard will be constructed as an embankment of highly permeable granular fill and crushed rock and as described below it will essentially function as a permeable surface.

Storage Considerations

Project plans indicate that the substation yard will be mantled with a 4-inch compacted thickness of "substation rock" underlain by WSDOT CSBC per Specification 9-03.9(3). The substation rock is used for safety purposes as it has a very high void ratio and electrical resistivity and its use reduces the likelihood of step potentials developing. The high void ratio of the substation rock and the CSBC are also beneficial from the stormwater management perspective because over the course of design and construction of numerous substations and switching stations it has been shown that these materials provide useful storage capacity.

As part of previous District substation projects, ZGA and others have tested CSBC sourced from the Iron Mountain Quarry in Granite Falls, Washington. Samples of this material, when compacted to approximately 95 percent density per ASTM D 1557, have been shown to have a permeability of 130 inches/hour and void ratio of over 40 percent. In contrast to some other locally available CSBC, the Iron Mountain Quarry products are 100 percent crushed rock and no naturally occurring bank run sand is blended with the crushed rock to produce the finished product. Based on the testing, the crushed products from Iron Mountain Quarry tend to have a high permeability and void ratio compared to some other locally available products that combine crushed rock and bank run sand and this is a function of the overall low fine to medium sand content and the fines content (the fraction of soil particles finer than the US No. 200 sieve) and angularity of the products. Below we have excerpted a section from the 30

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We collected a sample of material meeting the criteria for WSDOT Specification 9-03.9(3) *Crushed Surfacing* (base course gradation). The sample was compacted to 95 percent of the modified Proctor maximum dry density (ASTM D 1557) and the permeability determined. Test results are summarized below.

Summary of Crushed Surfacing Laboratory Testing					
Supplier / Location	Dry Density (ASTM D 1557)	Compaction (percent)	Specific Gravity (data provided by WSDOT)	Void Ratio	Permeability (inches/hour)
Iron Mountain Quarry / Granite Falls	120.6	95.0	2.75	0.424	130

It should be noted that the testing was completed on the sample fraction passing the US No. ¾-inch sieve for compliance with ASTM D 1557. Actually field values will vary slightly from the reported values due to the presence of aggregate larger than ¾-inch and also due to variations in loads. Material placement procedures can also result in aggregate segregation which can produce variable void ratio and permeability values.

It has been our experience that the crushed rock base course that is produced completely from crushed rock and not including any bank-run material is generally "clean" (lacking finer particles) and this is reflected in the test results.

In 2013, ZGA tested what Iron Mountain Quarry was selling as "substation rock" at the time. This was a 1.5-inch minus product, all crushed, and just slightly coarser than the 1.25-inch minus CSBC. The tested material had a void ratio of 45 percent. A photograph of this substation rock is shown below as a means to illustrate its angularity and obvious functional high void ratio even when compacted.



Iron Mountain Quarry “substation rock” used at the Fitzgerald Substation (Bothell, Washington)

It is our understanding that the District will specify the use of CSBC in the substation yard that is composed of 100 percent crushed rock and not a product produced by blending crushed bank run rounded gravel with sand. The use of substation rock and CSBC as specified by the District and consistent with the gradation characteristics of these materials used over the past several years on multiple District substations will meet the performance standards described in the drainage report, in our opinion.

We recommend that imported crushed rock used for both structural fill in the yard and stormwater management purposes have the gradation show in the table below.

Table 9: Recommended Crushed Rock Fill Gradation	
US Standard Sieve Size	Percent Passing by Dry Weight Basis
1.25 inch	100
1 inch	80 - 100
5/8 inch	50 - 80
No. 4	25 - 45
No. 40	3 - 18
No. 200	< 3

Groundwater Mounding Analysis

Plans available at the time this report was prepared indicate that the substation entry will include two bioretention features for stormwater management; their locations are illustrated on Figure 1. The bioretention features are proposed to have a bottom elevation of 43.25 feet (1.75 feet above the seasonal high groundwater elevation) and a design high water elevation of 45.5 feet. Stormwater management in the yard will rely upon the very high infiltration rate of the clear crushed rock and select granular fill materials that will be used to raise grade to the proposed elevation 46 feet. For modelling purposes, the base of the yard rock, elevation 45.7 feet, was considered the infiltration surface elevation.

The use of on-site infiltration depends on sizing the infiltration system such that the receptor soils below the system can accept the water without water backing up into the system to an unacceptable degree. The development of a groundwater mound, or a localized rise in the local groundwater table, can adversely affect an infiltration system if the mound rises too high. A groundwater mounding analysis was completed for the proposed storm water infiltration system per the requirements of the *Manual*.

The purpose of the mounding analysis was to evaluate if groundwater mounding below the proposed bioretention cells would adversely affect performance of the system, and in the case of the yard, adversely affect functional of the substation. We used the MODRET computer software program to model groundwater mounding at the yard entry and the yard itself.

The simulations incorporated long-term surface water runoff data provided by the District, subsurface conditions as disclosed by the test pits, boring, and CPT, the results of laboratory testing, and measured aquifer properties described in the USGS report: *The Ground-Water System and Ground-Water Quality in Western Snohomish County, Washington* (USGS Water-Resources Investigations Report 96-4312, 1997), and ZGA site observations of other sites in the vicinity of the proposed substation. The groundwater mounding analyses for the entry and the yard incorporated the parameters listed on the data sheets included in Appendix D. Both models considered that at least 1 foot of select, clean, 100 percent crushed CSBC is placed above the existing ground surface.

The mounding analysis for the entry indicates that the high water elevation will extend to the bioretention cells' bottom elevation of 43.25 feet. Based upon our analysis, it is our opinion that the bioretention cells will function adequately relative to the groundwater conditions and the design inflow event.

The mounding analysis for the yard indicates that the high water elevation will extend to elevation 42.38 feet, or slightly less than 1 foot above the seasonal high groundwater elevation and 3.62 feet below the yard finished grade of 46 feet. Based upon our analysis, it is our opinion that the modeled design event will not adversely affect the substation functionality.

Driveway Flexible Pavement Section Recommendations

It is our understanding that the existing gravel and crushed rock surfacing of the access driveway will remain. However, we have provided the recommendations below in the event that the District elects to pave the entry drives. The District typically requires that the pavement section be able to accommodate H20 loading.

Pavement Life and Maintenance: It should be realized that asphaltic pavements such as hot mix asphalt (HMA) are not maintenance-free. The following pavement sections represent our minimum recommendations for an average level of performance during a 20-year design life; therefore, an average level of maintenance will likely be required. Thicker asphalt, base, and subbase courses would offer better long-term performance, but would cost more initially. Conversely, thinner courses would be more susceptible to “alligator” cracking and other failure modes. As such, pavement design can be considered a compromise between a high initial cost and low maintenance costs versus a low initial cost and higher maintenance costs.

Soil Design Values: Pavement subgrade soils are anticipated to consist well-compacted gravelly sand and/or CSBC with a relatively low silt content. Our analysis assumes the pavement section subgrade will have a minimum California Bearing Ratio (CBR) value of 10.

Recommended Pavement Section: We recommend that the pavement section, at a minimum, consist of 3 inches of asphalt concrete over 2 inches (compacted thickness) of crushed surfacing top course over 8 inches of crushed surfacing base course.

We recommend the following regarding flexible pavement materials and pavement construction.

Subgrade Preparation and Compaction: The pavement subgrade will consist of structural fill and should be prepared in accordance with the recommendations presented in the *Subgrade Preparation* section of this report, and all fill should be compacted in accordance with the recommendations presented in the *Structural Fill* section of this report.

HMA: We recommend that the HMA conform to Section 9-02.1(4) for PG 58-22 or PG 64-22 Performance Graded Asphalt Binder as presented in the WSDOT *Standard Specifications*. We also recommend that the gradation of the HMA aggregate conform to the aggregate gradation control points for ½-inch mixes as presented in Section 9-03.8(6), HMA Proportions of Materials.

Base Course: We recommend that the CSBC conform to Section 9-03.9(3) of the WSDOT *Standard Specifications*.

Compaction and Paving: We recommend compacting the HMA to a minimum of 92 percent of the Rice (theoretical maximum) density per the 2021 WSDOT *Standard Specifications* is in effect. Placement and compaction of HMA should conform to requirements of Section 5-04 of the *Standard Specifications*.

Erosion Control

Construction phase erosion control activities are recommended to include measures intended to reduce erosion and subsequent sediment transport. We recommend that the project incorporate the following erosion and sedimentation control measures during construction:

- Capturing water from low permeability surfaces and directing it away from bare soil exposures.
- Erosion control BMP inspection and maintenance: The contractor should be aware that inspection and maintenance of erosion control BMPs is critical toward their satisfactory performance. Repair and/or replacement of dysfunctional erosion control elements should be anticipated.
- Undertake site preparation, excavation, and filling during periods of little or no rainfall.
- Cover excavation surfaces with anchored plastic sheeting if surfaces will be left exposed during wet weather.
- Cover soil stockpiles with anchored plastic sheeting.
- Provide an all-weather quarry spall construction site entrance.
- Provide for street cleaning on an as-needed basis.
- Protect exposed soil surfaces that will be subject to vehicle traffic with crushed rock or crushed recycled concrete to reduce the likelihood of subgrade disturbance and sediment generation during wet weather or wet site conditions.
- Install siltation control fencing on the lower perimeter of work areas.
- If grounding wells are installed, containment of the cuttings produced during the drilling process will reduce the likelihood of off-site sediment migration. Cuttings with a high fines content should be removed from the site following completion of drilling.

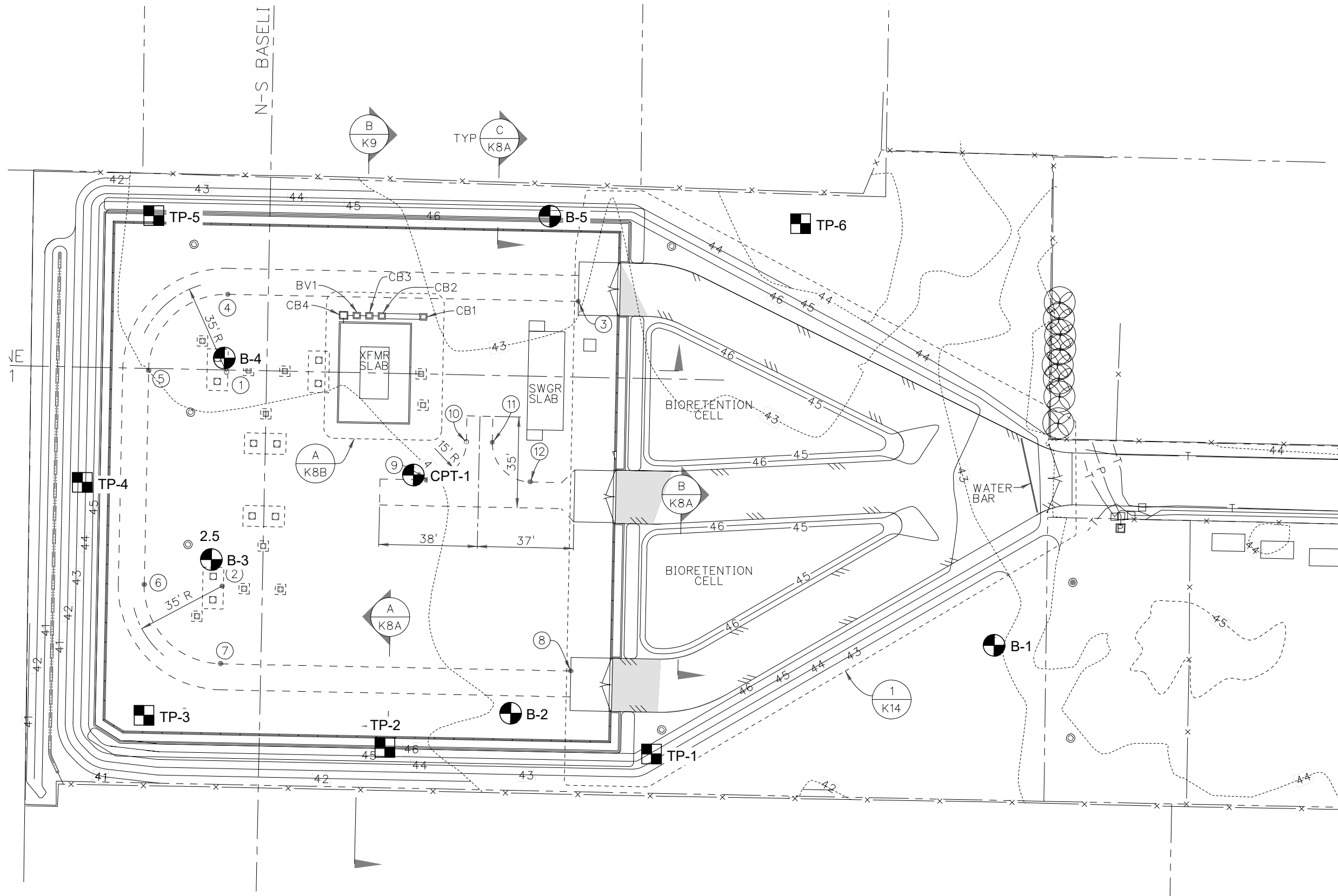
CLOSURE

The analysis and recommendations presented in this report are based, in part, on the explorations completed for this study. The number, location, and depth of the explorations were completed within the constraints of budget and site access so as to yield the information to formulate our recommendations. Project plans were in the preliminary stage at the time this report was prepared. We therefore recommend we be provided an opportunity to review the final plans and specifications when

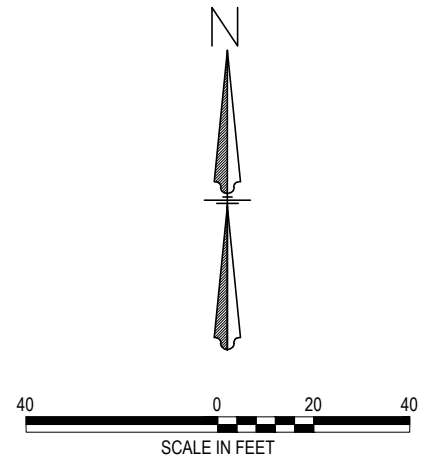
they become available in order to assess that the recommendations and design considerations presented in this report have been properly interpreted and implemented into the project design.

The performance of earthwork, structural fill, foundations, and slabs depends greatly on proper site preparation and construction procedures. We recommend that Zipper Geo Associates, LLC be retained to provide geotechnical engineering services during the earthwork-related construction phases of the project. If variations in subsurface conditions are observed at that time, a qualified geotechnical engineer could provide additional geotechnical recommendations to the contractor and design team in a timely manner as the project construction progresses.

This report has been prepared for the exclusive use of Snohomish County PUD No. 1, and its agents, for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless ZGA reviews the changes and either verifies or modifies the conclusions of this report in writing.



- LEGEND**
- B-1 SOIL BORING NUMBER AND APPROXIMATE LOCATION
 - CPT-1 CPT NUMBER AND APPROXIMATE LOCATION
 - TP-1 TEST PIT NUMBER AND APPROXIMATE LOCATION



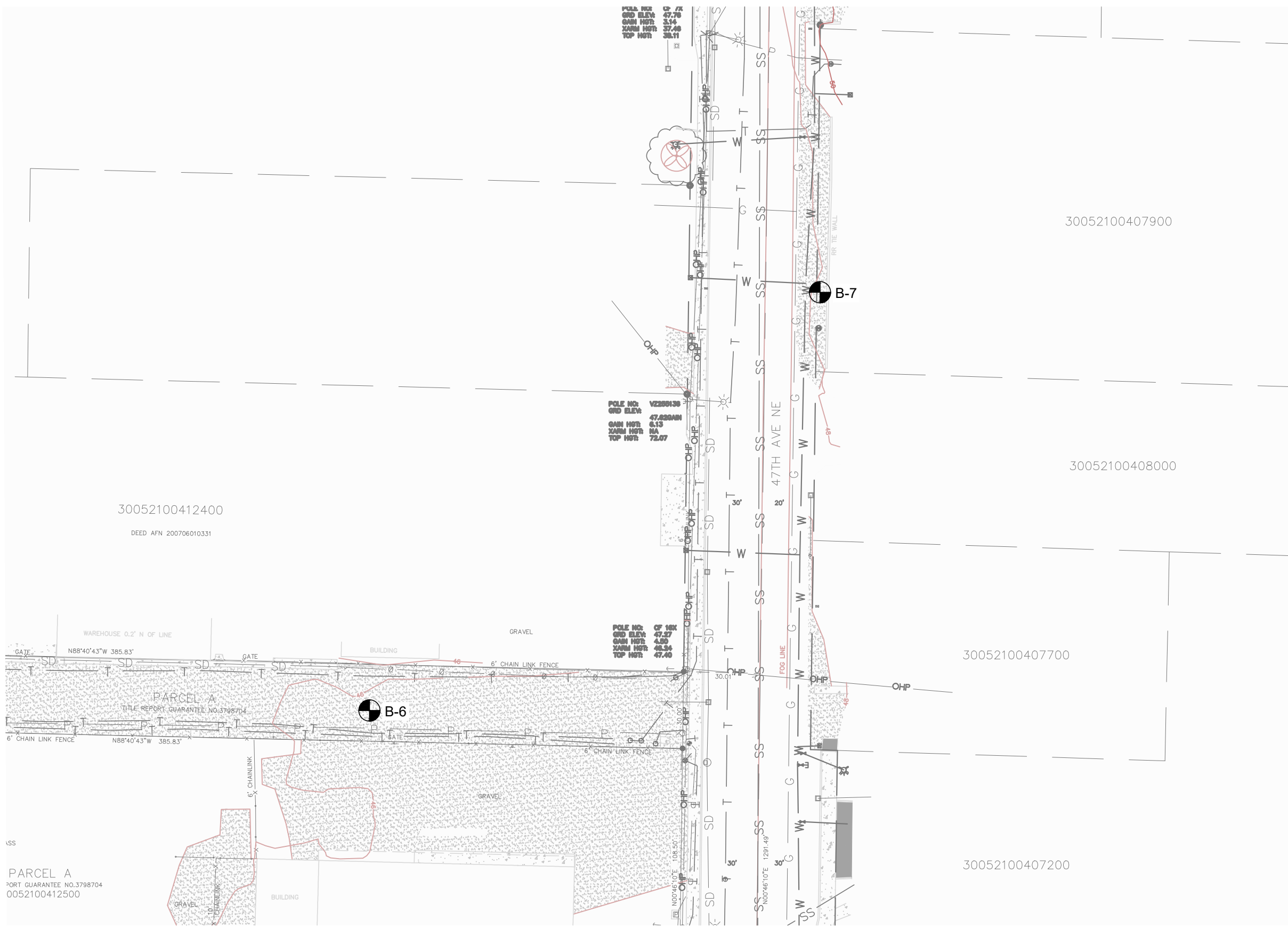
JENNINGS PARK SUBSTATION 7808 47TH AVE NE Marysville, Washington	
SITE AND EXPLORATION PLAN	
DATE: FEBRUARY 2023	Job No. 2494.01
Zipper Geo Associates, LLC 19019 36th Ave. W., Suite E Lynnwood, WA	FIGURE SHT. 1 of 1

REFERENCE: JENNINGS PARK SUBSTATION GRADING AND DRAINAGE PLAN, DRAWING S-135-K8, SNOHOMISH COUNTY PUD

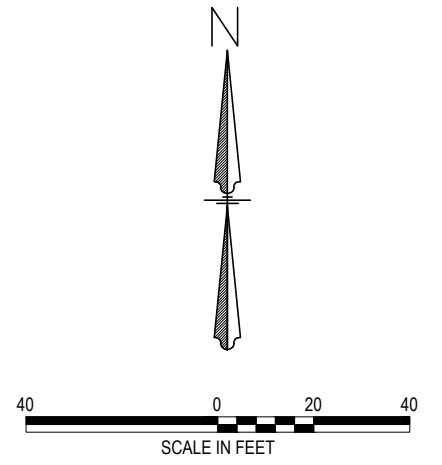
POLE NO: 09 7A
 GRD ELEV: 47.78
 GAIN HGT: 3.14
 XARM HGT: 37.48
 TOP HGT: 38.11

POLE NO: V2280438
 GRD ELEV: 47.828MM
 GAIN HGT: 6.13
 XARM HGT: NA
 TOP HGT: 72.07

POLE NO: 09 18K
 GRD ELEV: 47.27
 GAIN HGT: 4.89
 XARM HGT: 48.34
 TOP HGT: 47.40



LEGEND
 B-1 SOIL BORING NUMBER AND APPROXIMATE LOCATION



JENNINGS SUBSTATION 7808 47TH AVE NE Marysville, Washington	
SITE AND EXPLORATION PLAN	
DATE: NOVEMBER 2021	Job No. 2494.01
Zipper Geo Associates, LLC 19019 36th Ave. W., Suite E Lynnwood, WA	FIGURE SHT. 2 of 2

APPENDIX A
FIELD EXPLORATION PROCEDURES AND LOGS

FIELD EXPLORATION AND TESTING PROCEDURES AND LOGS

Our field exploration program for this project included completing a visual reconnaissance of the site, advancing seven borings (B-1 through B-7), advancing one cone penetrometer test (CPT-1), and excavating six test pits (TP-1 through TP-6). The approximate exploration locations are presented on Figures 1 and 2, the *Site and Exploration Plans*. Exploration locations were determined in the field using steel and fiberglass tapes by measuring distances from existing site features shown on the *Central Marysville Rebuild Concept A* plan, dated 26 August 2021, provided by the District. The ground surface elevation at each exploration location was interpolated from the topography shown on an undated topographic survey prepared by ASPI, LLC and provided for our review. As such, the exploration locations and elevations should be considered accurate to the degree implied by the measurement method. The following sections describe our procedures associated with the explorations. Descriptive logs of the explorations are enclosed in this appendix.

Boring Procedures

The borings were advanced using a truck-mounted drill rig operated by an independent drilling company (Environmental Drilling) working under subcontract to ZGA. The borings were advanced using hollow stem auger drilling methods. An engineering geologist from our firm continuously observed the borings, logged the subsurface conditions encountered, and obtained representative soil samples. All samples were stored in moisture-tight containers and transported to our laboratory for further evaluation and testing. Samples were generally obtained by means of the Standard Penetration Test at 2.5-foot to 5-foot intervals throughout the drilling operation.

The Standard Penetration Test (ASTM D 1586) procedure consists of driving a standard 2-inch outside diameter steel split spoon sampler 18 inches into the soil with a 140-pound hammer free falling 30 inches. The number of blows required to drive the sampler through each 6-inch interval is recorded, and the total number of blows struck during the final 12 inches is recorded as the Standard Penetration Resistance, or “blow count” (N value). If a total of 50 blows are struck within any 6-inch interval, the driving is stopped and the blow count is recorded as 50 blows for the actual penetration distance. The resulting Standard Penetration Resistance values indicate the relative density of granular soils and the relative consistency of cohesive soils.

A groundwater observation well was installed at the boring B-3 location following completion of drilling and sampling. The well consists of a 10-foot long section of 2-inch inside-diameter PVC screen section with machined 0.020-inch wide slots. Washed silica sand was placed in the annular space between the screen and the borehole. A non-machined riser was installed to the ground surface, and bentonite clay was placed around the riser. The well as finished with a flush-mount metal monument set in concrete.

The enclosed boring logs describe the vertical sequence of soils and materials encountered in each boring, based primarily upon our field classifications. Where a soil contact was observed to be gradational, our logs indicate the average contact depth. Where a soil type changed between sample intervals, we inferred the contact depth. Our logs also graphically indicate the blow count, sample type, sample number, and

approximate depth of each soil sample obtained from the boring. If groundwater was encountered in a borehole, the approximate groundwater depth and date of observation are depicted on the log.

Test Pit Procedures

An independent contractor (Northwest Excavation & Trucking) working under subcontract to ZGA excavated the test pits through the use of a tracked excavator. An engineering geologist from ZGA continuously observed the test pit excavations, logged the subsurface conditions, and obtained representative soil samples. The samples were stored in moisture tight containers and transported to our laboratory for further visual classification and testing.

The enclosed test pit logs indicate the vertical sequence of soils and materials encountered in each test pit, based primarily on our field classifications and supported by our subsequent laboratory testing. Where a soil contact was observed to be gradational or undulating, our logs indicate the average contact depth. We estimated the relative density and consistency of *in situ* soils by means of the excavation characteristics and by the sidewall stability. Our logs also indicate the approximate depths of any sidewall caving or groundwater seepage observed in the test pits, as well as all sample numbers and sampling locations.

Cone Penetrometer Testing

The cone penetrometer test was completed by a ZGA subcontractor (In Situ Engineering) using a truck-mounted rig. The testing was completed in general accordance with ASTM D 5778-12 procedures. The cone penetrometer testing involves advancing 35.7-millimeter diameter rods equipped with a friction sleeve, standard area cone, load cell, and pressure transducer. The apparatus is advanced via hydraulic pressure and the tip resistance and friction are recorded continuously. Pore pressure measurements and shear wave and compression wave testing may be taken at selected intervals.

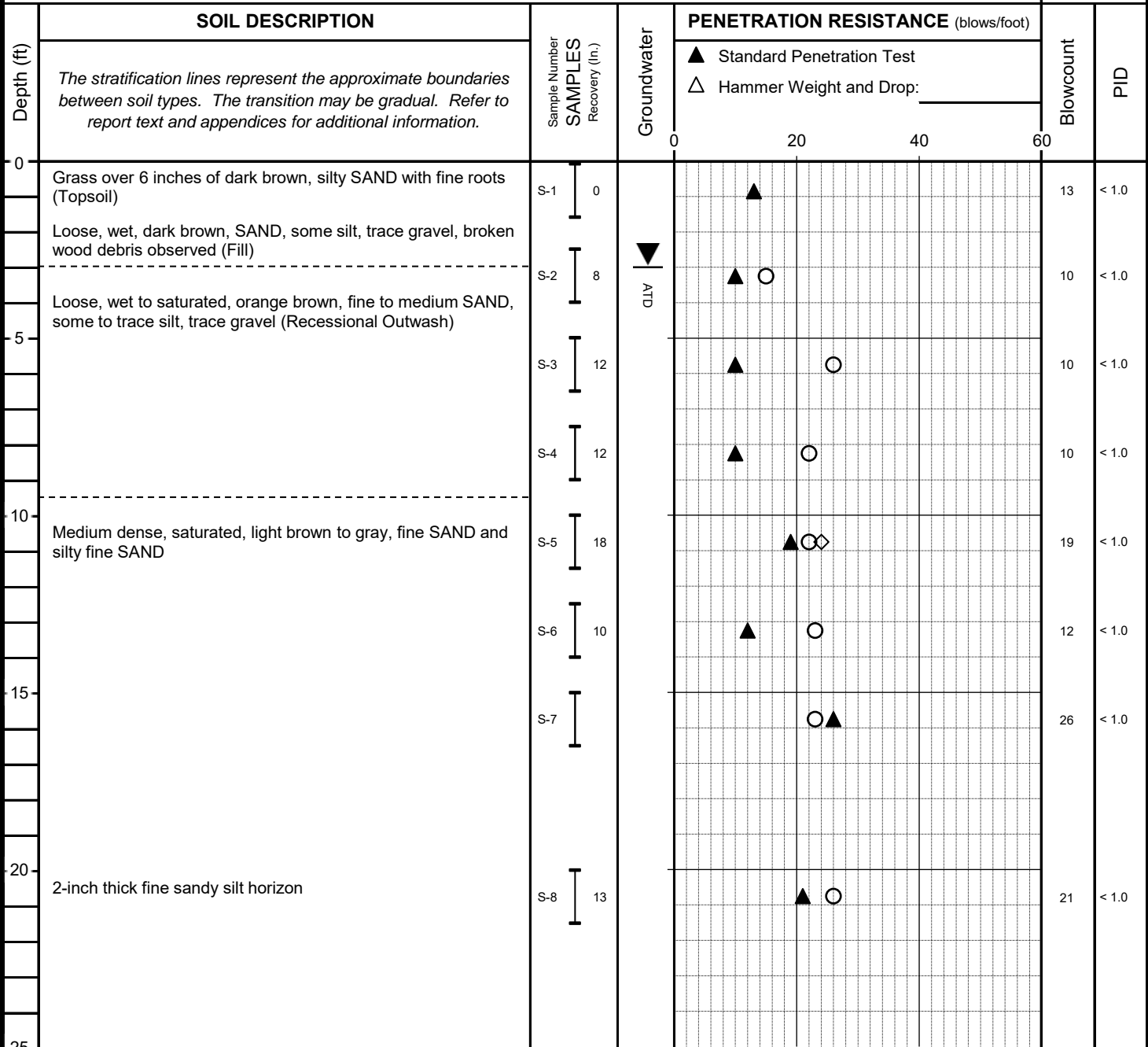
The enclosed cone penetrometer test log indicate the recorded tip resistance, friction, friction ratio, pore pressure, correlation to the Standard Penetration Test, and a graphic representation of the soil type.

Sample Screening

The boring and test pit logs also include the results of sample container headspace measurements taken with a RAE Systems photoionization detector (PID). The measurements indicate the relative concentration of petroleum hydrocarbons in the headspace air, but do not identify the type of hydrocarbon. The sample headspace readings, recorded as hydrocarbon concentration in parts per million (ppm) are presented on the logs in this appendix. The sample screening did not detect hydrocarbon levels of concern.

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 43 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/27/2021 **Drill Rig:** B-61 **Logged by:** MRC

B-1



SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ———— ○ ———— Liquid Limit

Natural Water Content

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

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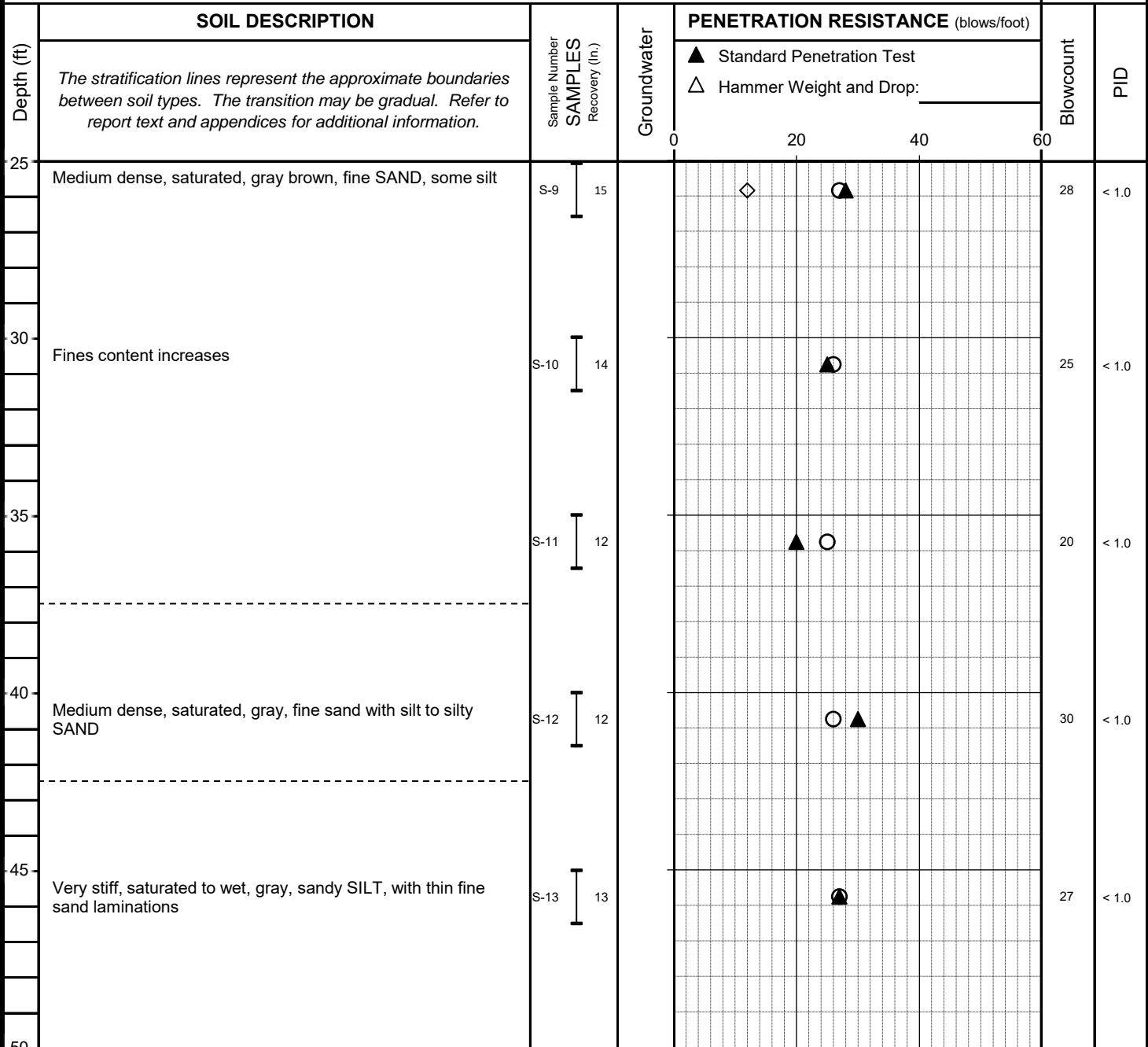
Project No.: 2494.01

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BORING LOG: B-1

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 43 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/27/2021 **Drill Rig:** B-61 **Logged by:** MRC

B-1



SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ———○——— Liquid Limit

Natural Water Content

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BORING LOG: B-1



Page 2 of 3

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 43 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/27/2021 **Drill Rig:** B-61 **Logged by:** MRC







B-1

Depth (ft)	SOIL DESCRIPTION	Sample Number SAMPLES Recovery (in.)	Groundwater	PENETRATION RESISTANCE (blows/foot)				Blowcount	PID
				▲ Standard Penetration Test △ Hammer Weight and Drop: _____					
50	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information. Very stiff, saturated to wet, gray, sandy SILT, with thin fine sand laminations Boring completed at approximately 51.5 feet. Groundwater observed at approximately 3 feet ATD.	S-14		0	20	40	60	22	< 1.0
55									
60									
65									
70									
75									

SAMPLE LEGEND


-  2-inch O.D. split spoon sample
-  3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

-  Clean Sand
-  Bentonite
-  Grout/Concrete
-  Screened Casing
-  Blank Casing
-  Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit  Liquid Limit

Natural Water Content

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

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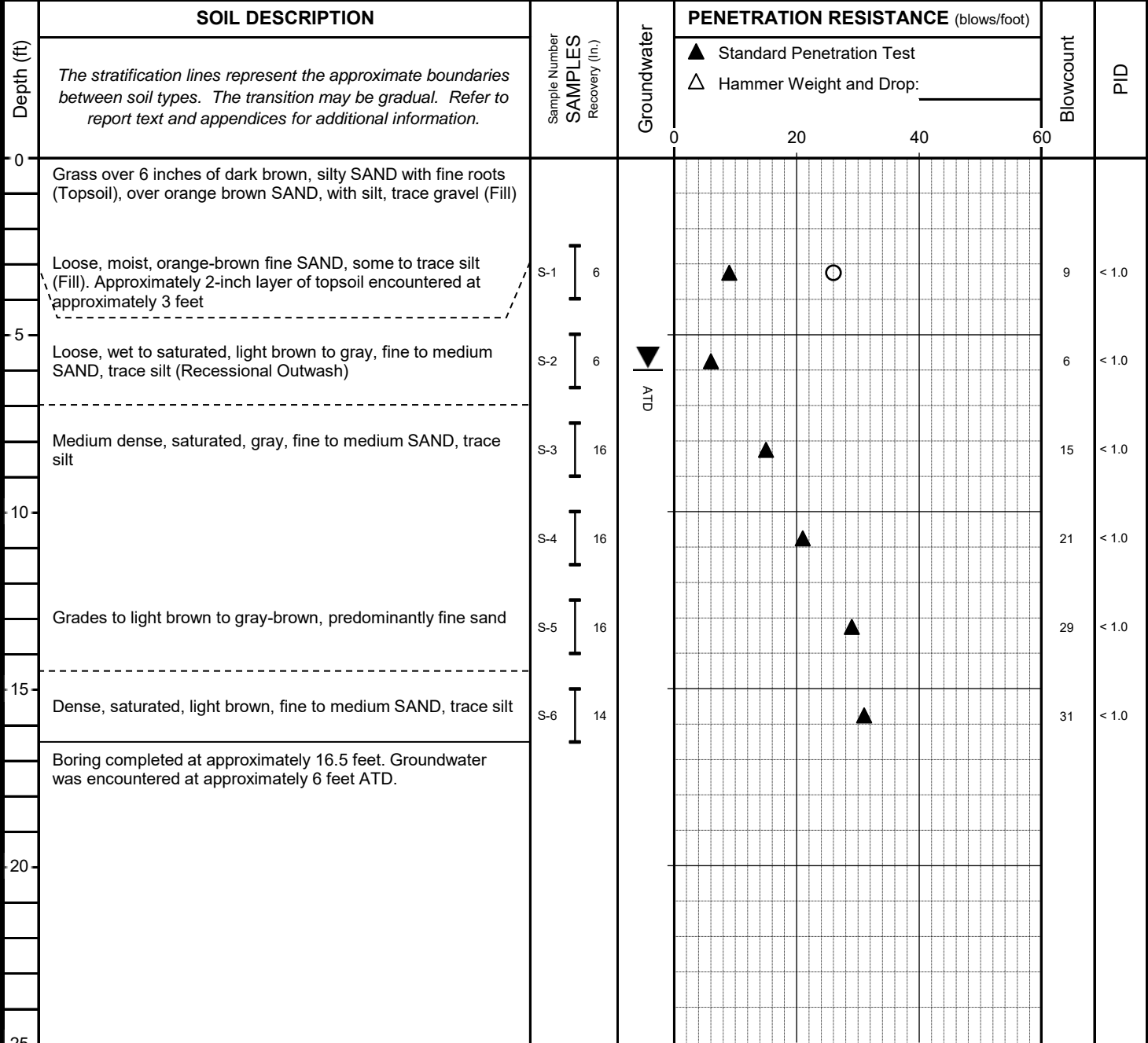
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BORING LOG: B-1

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 42 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/27/2021 **Drill Rig:** Truck Rig **Logged by:** MRC

B-2



SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit Liquid Limit

Natural Water Content

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 Marysville, Washington

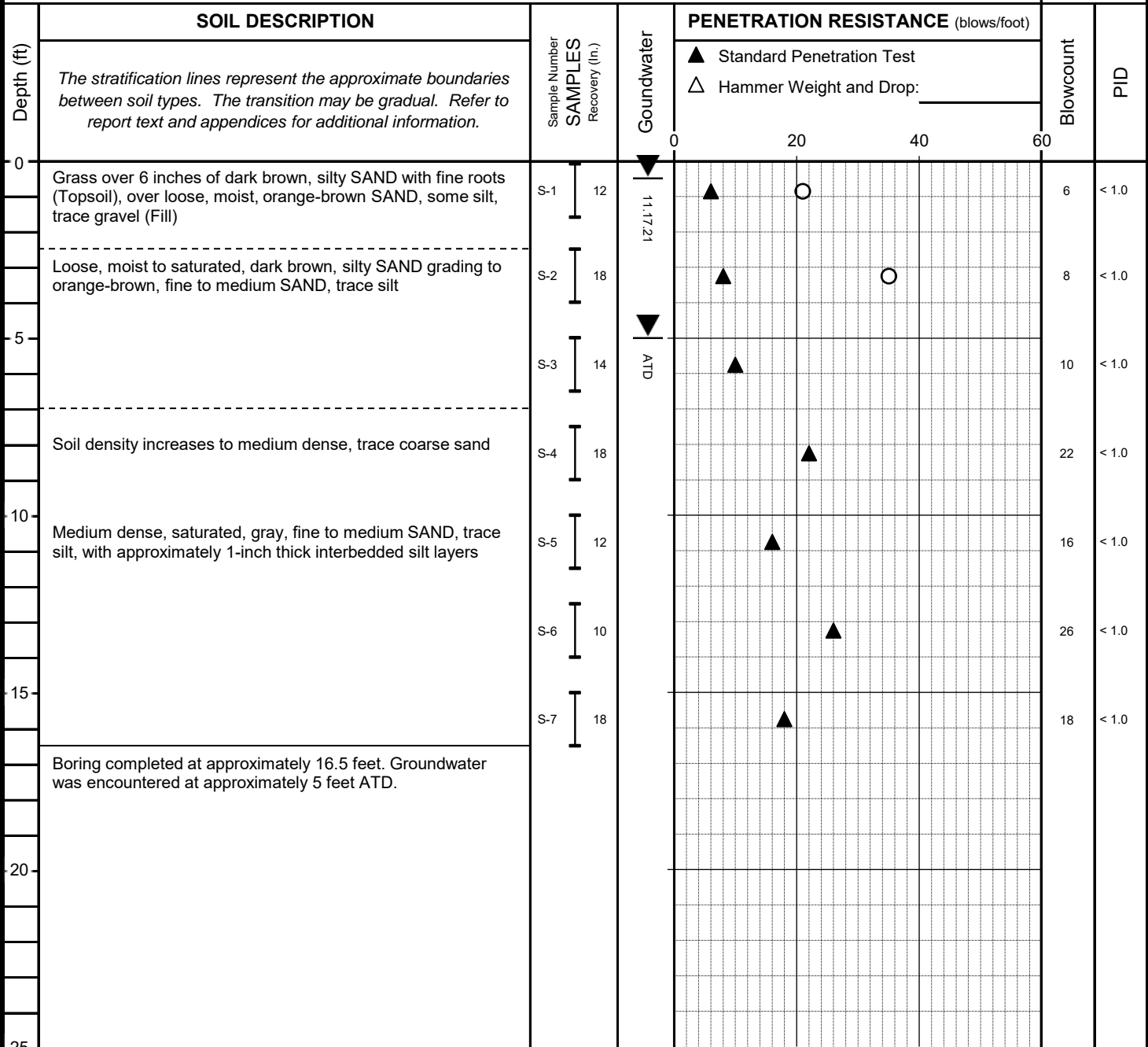
Project No.: 2494.01

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BORING LOG: B-2
 Page 1 of 1

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 42 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/27/2021 **Drill Rig:** Truck Rig **Logged by:** MRC

B-3



SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ———— ○ ———— Liquid Limit
 Natural Water Content

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

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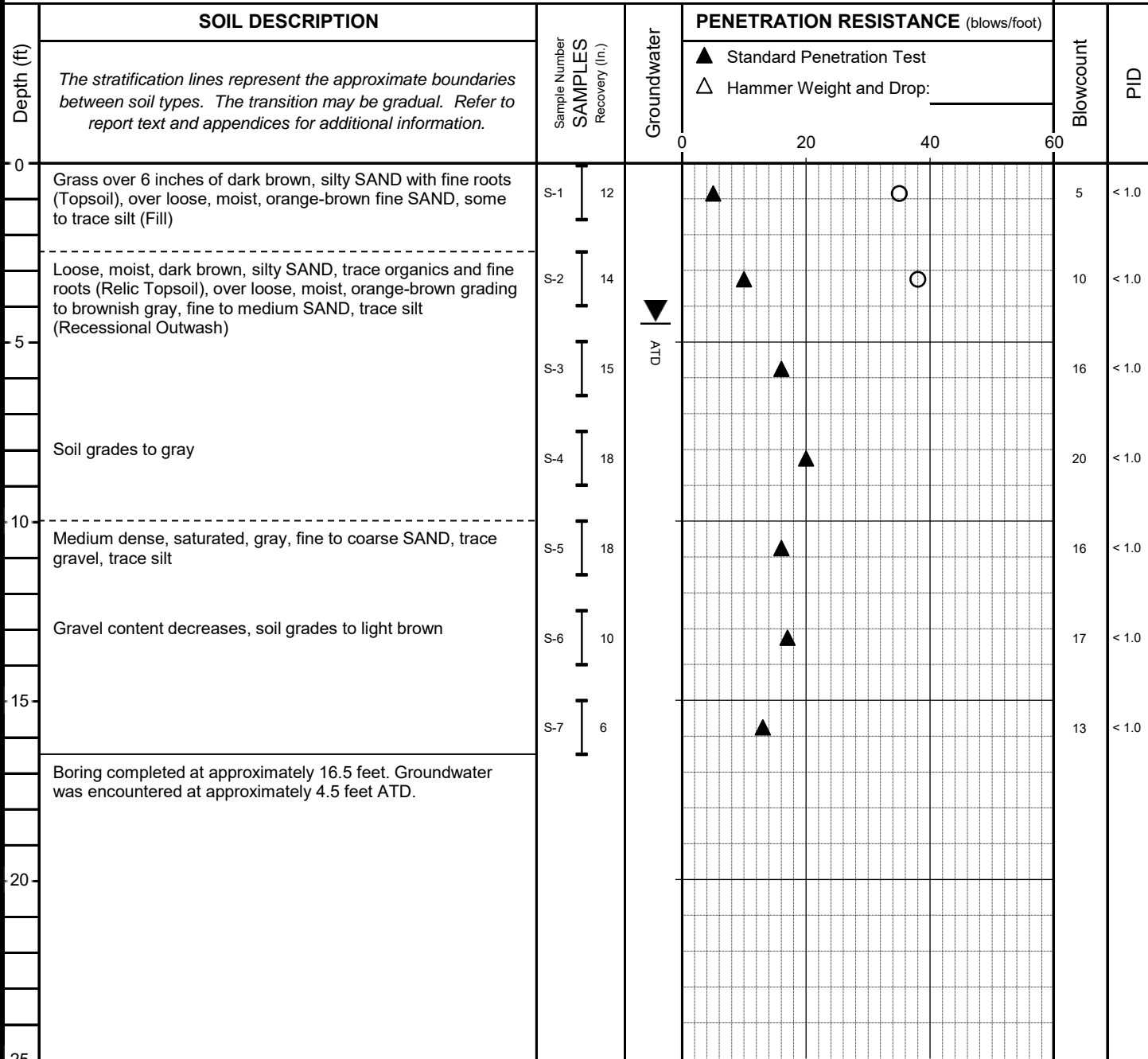
Project No.: 2494.01

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BORING LOG: B-3
 Page 1 of 1

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 42 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/27/2021 **Drill Rig:** Truck Rig **Logged by:** MRC

B-4



SAMPLE LEGEND

- ┆ 2-inch O.D. split spoon sample
- ┆ 3-inch I.D. Shelby tube sample

GROUNDWATER LEGEND

- ▨ Clean Sand
- ▨ Bentonite
- Grout/Concrete
- ▨ Screened Casing
- Blank Casing
- ▼ Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ———○——— Liquid Limit
 Natural Water Content

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

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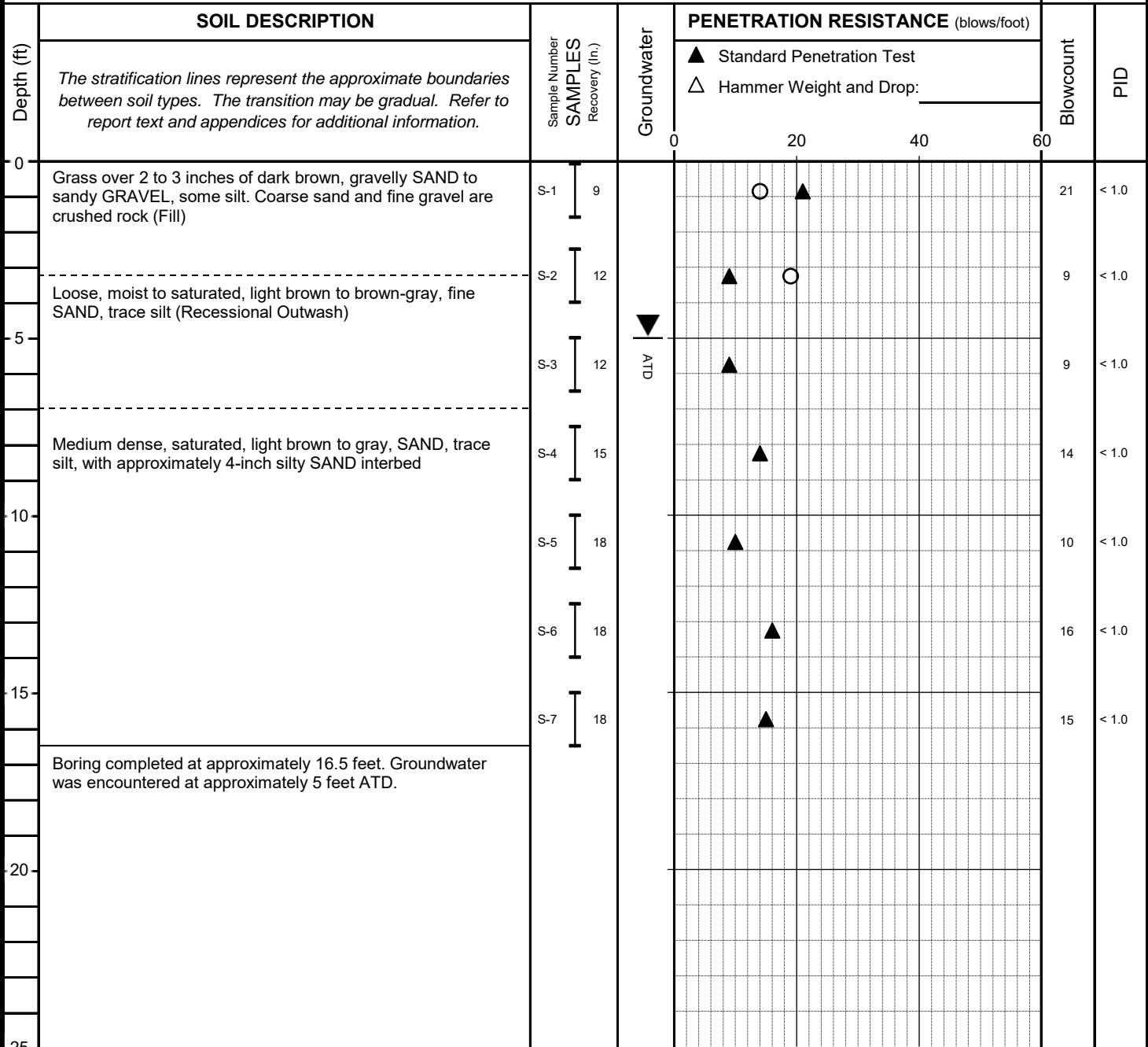
Project No.: 2494.01

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BORING LOG: B-4

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 43 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/27/2021 **Drill Rig:** Truck Rig **Logged by:** MRC

B-5



SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ————○——— Liquid Limit

Natural Water Content

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Project No.: 2494.01

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BORING LOG: B-5

Page 1 of 1

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 46 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/28/2021 **Drill Rig:** Truck Rig **Logged by:** MRC

B-6

Depth (ft)	SOIL DESCRIPTION	Sample Number SAMPLES Recovery (In.)	Groundwater	PENETRATION RESISTANCE (blows/foot)				Blowcount	PID
				▲ Standard Penetration Test △ Hammer Weight and Drop: _____					
0	<i>The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.</i>			0	20	40	60		
0 - 0.5	Approximately 6 inches of crushed rock over brown gravelly SAND (Fill) above loose, moist, orange-brown, SAND, some to trace silt, trace wood debris	S-1 9		▲ ○				9	< 1.0
0.5 - 4.5	Medium dense, moist, brown, gravelly SAND, some silt, wood debris observed in SPT tip	S-2 3		▲ ○				12	< 1.0
4.5 - 25	Boring completed at approximately 4.5 feet. Groundwater was not encountered ATD.								

SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ———— ⊖ ———— Liquid Limit

Natural Water Content

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 Marysville, Washington

Project No.: 2494.01

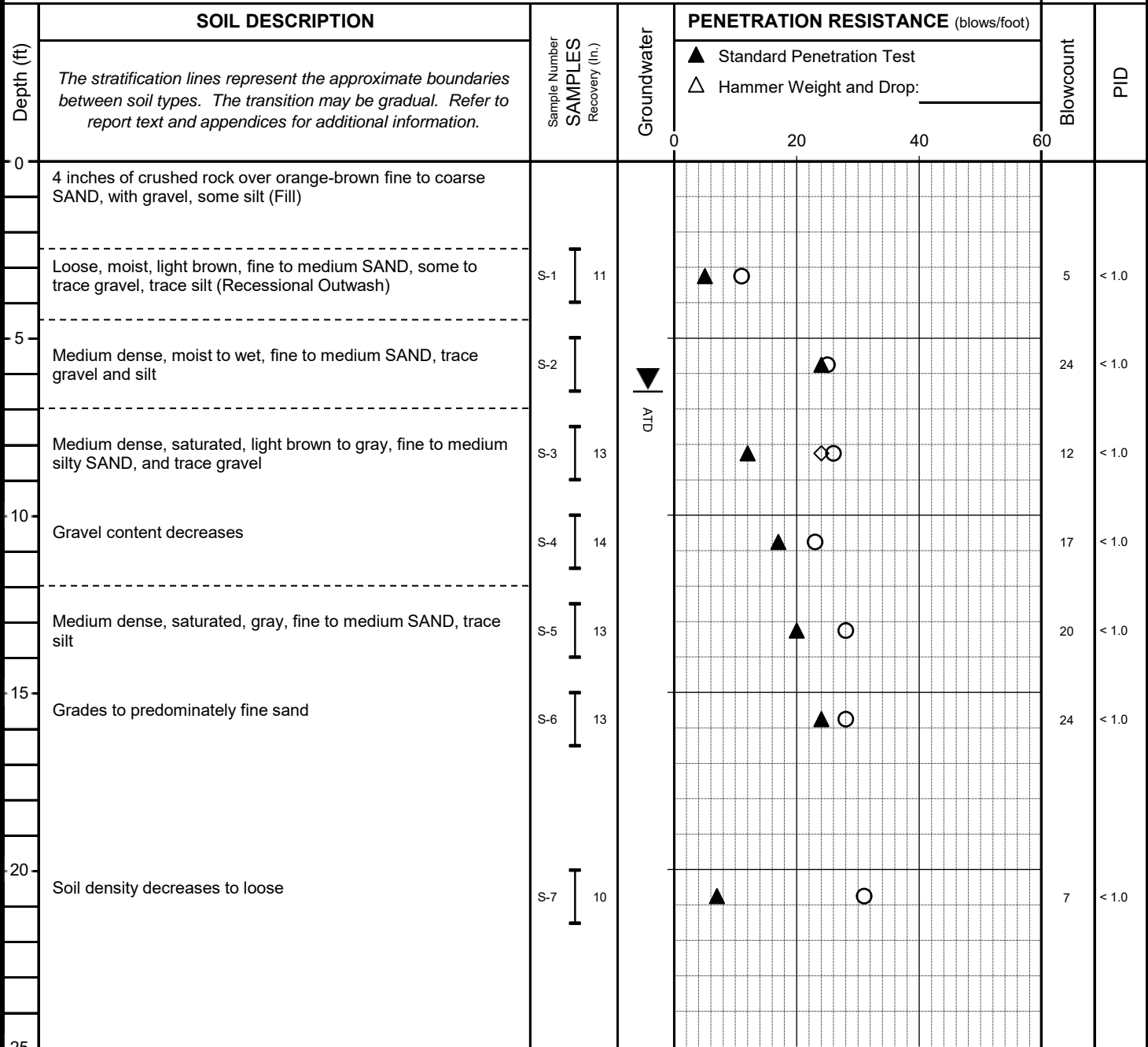
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BORING LOG: B-6

Page 1 of 1

Boring Location: See Figure 1, Site and Exploration Plan **Drilling Company:** Environmental **Bore Hole Dia.:** 8-inch
Top Elevation: Approximately 48 Feet **Drilling Method:** Hollow Stem Auger **Hammer Type:** Auto
Date Drilled: 10/28/2021 **Drill Rig:** Truck Rig **Logged by:** MRC

B-7



SAMPLE LEGEND

- ┆ 2-inch O.D. split spoon sample
- ┆ 3-inch I.D. Shelby tube sample

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

GROUNDWATER LEGEND

- ▨ Clean Sand
- ▨ Bentonite
- Grout/Concrete
- ▨ Screened Casing
- Blank Casing
- ▼ Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ———○——— Liquid Limit

Natural Water Content

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BORING LOG: B-7

Page 1 of 2

Boring Location: See Figure 1, Site and Exploration Plan
Drilling Company: Environmental
Bore Hole Dia.: 8-inch
Top Elevation: Approximately 48 Feet
Drilling Method: Hollow Stem Auger
Hammer Type: Auto
Date Drilled: 10/28/2021
Drill Rig: Truck Rig
Logged by: MRC

B-7

Depth (ft)	SOIL DESCRIPTION	Sample Number SAMPLES Recovery (In.)	Groundwater	PENETRATION RESISTANCE (blows/foot)		Blowcount	PID
				▲ Standard Penetration Test	△ Hammer Weight and Drop:		
25	Loose, saturated, brown to gray, SAND, some to trace silt, with silt interbeds approximately 1 inch thick	S-8 12		▲	○	10	< 1.0
30	Stiff to very stiff, saturated to wet, gray, sandy SILT	S-9 18		▲	○	15	1.3
35		S-10 12		▲	○	16	1.1
Boring completed at approximately 36.5 feet. Groundwater was encountered at approximately 6.5 feet ATD.							

SAMPLE LEGEND

- 2-inch O.D. split spoon sample
- 3-inch I.D. Shelby tube sample

TESTING KEY

- GSA = Grain Size Analysis
- 200W = 200 Wash Analysis
- Consol. = Consolidation Test
- Att. = Atterberg Limits

GROUNDWATER LEGEND

- Clean Sand
- Bentonite
- Grout/Concrete
- Screened Casing
- Blank Casing
- Groundwater level at time of drilling (ATD) or on date of measurement.

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit Liquid Limit

Natural Water Content

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BORING LOG: B-7

Page 2 of 2

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<u>Test Pit TP-1</u>					
Location: See Site and Exploration Plan, Figure 1 Approx. Ground Surface Elevation: Approximately 42 Feet		Project: Jennings Substation Project No: 2494.01 Date Excavated: September 21, 2021			
Depth (ft)	Material Description	Sample	PID	%M	Testing
	Grass over 6 to 8 inches of dark brown, silty sand, some organics, with fine roots (Topsoil)				
1	Fine roots extend to approximately 1 foot Loose, moist, orange-brown, SAND, some silt, trace gravel	S-1 @ 1.3 feet	<1		
2	..... Loose, moist, gray-brown, fine to medium SAND, trace gravel and silt	S-2 @ 2 feet	<1	8	
3					
4					
5					
6	Soil density increases to medium dense	S-3 @ 5.5 feet	<1	18	GSA
7	Moderate to strong seepage observed at approximately 6 feet				
7		S-4 @ 7 feet	<1	29	GSA
8	Test pit TP-1 completed at approximately 7.5 feet. Groundwater observed at approximately 6 feet.				
	Test pit was terminated due to severe caving from approximately 6 to 7.5 feet				

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<u>Test Pit TP-2</u>					
Location: See Site and Exploration Plan, Figure 1 Approx. Ground Surface Elevation: Approximately 42 Feet		Project: Jennings Substation Project No: 2494.01 Date Excavated: September 21, 2021			
Depth (ft)	Material Description	Sample	PID	%M	Testing
1	Grass over 6 to 8 inches of dark brown, silty sand, some organics, with fine roots (Topsoil) Fine roots extend to approximately 1 foot				
2	Loose, moist, orange-brown, SAND, trace silt, trace gravel				
3		S-1 @ 2 feet	<1	12	
4	Loose, wet, gray to gray-brown, fine SAND, trace gravel, trace silt Moderate seepage observed at approximately 4.3 feet.	S-2 @ 3.5 feet	<1	25	GSA
5					
6	Soil density increases to medium dense. Grades to medium sand	S-3 @ 5.3 feet	<1		
7	Test pit TP-2 completed at approximately 6.5 feet. Groundwater observed at approximately 4.3 feet. Test pit was terminated due to severe caving from approximately 5 to 6.5 feet.				
8					

ZIPPER GEO ASSOCIATES, LLC

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	<u>Test Pit TP-3</u>				
	Location: See Site and Exploration Plan, Figure 1 Approx. Ground Surface Elevation: Approximately 41 Feet	Project: Jennings Substation Project No: 2494.01 Date Excavated: September 21, 2021			
Depth (ft)	Material Description	Sample	PID	%M	Testing
	Grass over 8 to 10 inches of dark brown, silty sand, some organics, with fine roots (Topsoil)				
1	Fine roots extend to approximately 1 foot				
	Loose, moist, orange-brown, SAND, trace gravel				
2		S-1 @ 1.5 feet	<1	8	
3	Loose, moist, light brown to gray-brown, fine to medium SAND, trace gravel, trace silt				
		S-2 @ 3 feet	<1	19	GSA
4	Grades to gray at approximately 3.5 feet				
5	Moderate seepage observed at approximately 5 feet				
6	Medium dense, saturated, gray, medium SAND, trace gravel	S-3 @ 5.5 feet	<1		
7	Test pit TP-3 completed at approximately 6.8 feet. Groundwater observed at approximately 5 feet.				
	Test pit was terminated due to severe caving from approximately 5.5 to 6.8 feet.				
8					

ZIPPER GEO ASSOCIATES, LLC

19019 36th Avenue West, Suite E, Lynnwood, Washington 98036

<u>Test Pit TP-4</u>					
Location: See Site and Exploration Plan, Figure 1 Approx. Ground Surface Elevation: Approximately 41 Feet		Project: Jennings Substation Project No: 2494.01 Date Excavated: September 21, 2021			
Depth (ft)	Material Description	Sample	PID	%M	Testing
	Grass and blackberries over 6 to 10 inches of dark brown, silty sand, some organics, with fine roots (Topsoil)				
1	Fine roots extend to approximately 1 foot				
	Loose, moist, orange-brown, SAND, trace silt, trace gravel				
2					
		S-1 @ 2 feet	<1	20	
3	.....			
	Loose, wet, gray-brown to gray, fine to medium SAND, trace gravel				
4	Grades to gray at approximately 3.8 feet Moderate seepage observed at approximately 4.3 feet	S-2 @ 3.5 feet	<1	19	
5					
6	Loose, wet, gray-brown to gray, gravelly SAND, trace silt Seepage rate increases at approximately 6 feet	S-3 @ 5.8 feet	<1	24	GSA
7	Mild caving soil conditions observed				
8		S-4 @ 7.5 feet	<1		
	Test pit TP-4 completed at approximately 8 feet. Groundwater observed at approximately 4.3 feet.				

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<u>Test Pit TP-5</u>					
Location: See Site and Exploration Plan, Figure 1 Approx. Ground Surface Elevation: Approximately 42 Feet		Project: Jennings Substation Project No: 2494.01 Date Excavated: September 21, 2021			
Depth (ft)	Material Description	Sample	PID	%M	Testing
1	Grass over 2 to 3 inches of dark brown, silty sand, some organics, with fine roots (Topsoil), over loose, moist, dark brown, silty sand, some gravel, trace cobbles, trace organics. Cobbles consist of quarry spalls (Fill)	S-1 @ 0.5 feet	<1		ACM
2	..... Loose, moist, orange-brown, SAND, trace silt, trace gravel				
3					
4	..... Loose, moist, light brown to gray, fine SAND, trace silt, trace gravel	S-2 @ 3.3 feet	<1	10	
5		S-3 @ 4.5 feet	<1	23	GSA
6	Moderate seepage observed at approximately 5.8 feet				
7	Mild caving soil conditions observed at approximately 6.8 feet				
8	..... Medium dense, saturated, gray, fine to coarse SAND, trace gravel	S-4 @ 7.5 feet	<1		
	Test pit TP-5 completed at approximately 8 feet. Groundwater was encountered at approximately 5.8 feet.				

ZIPPER GEO ASSOCIATES, LLC

19019 36th Avenue West, Suite E, Lynnwood, Washington 98036

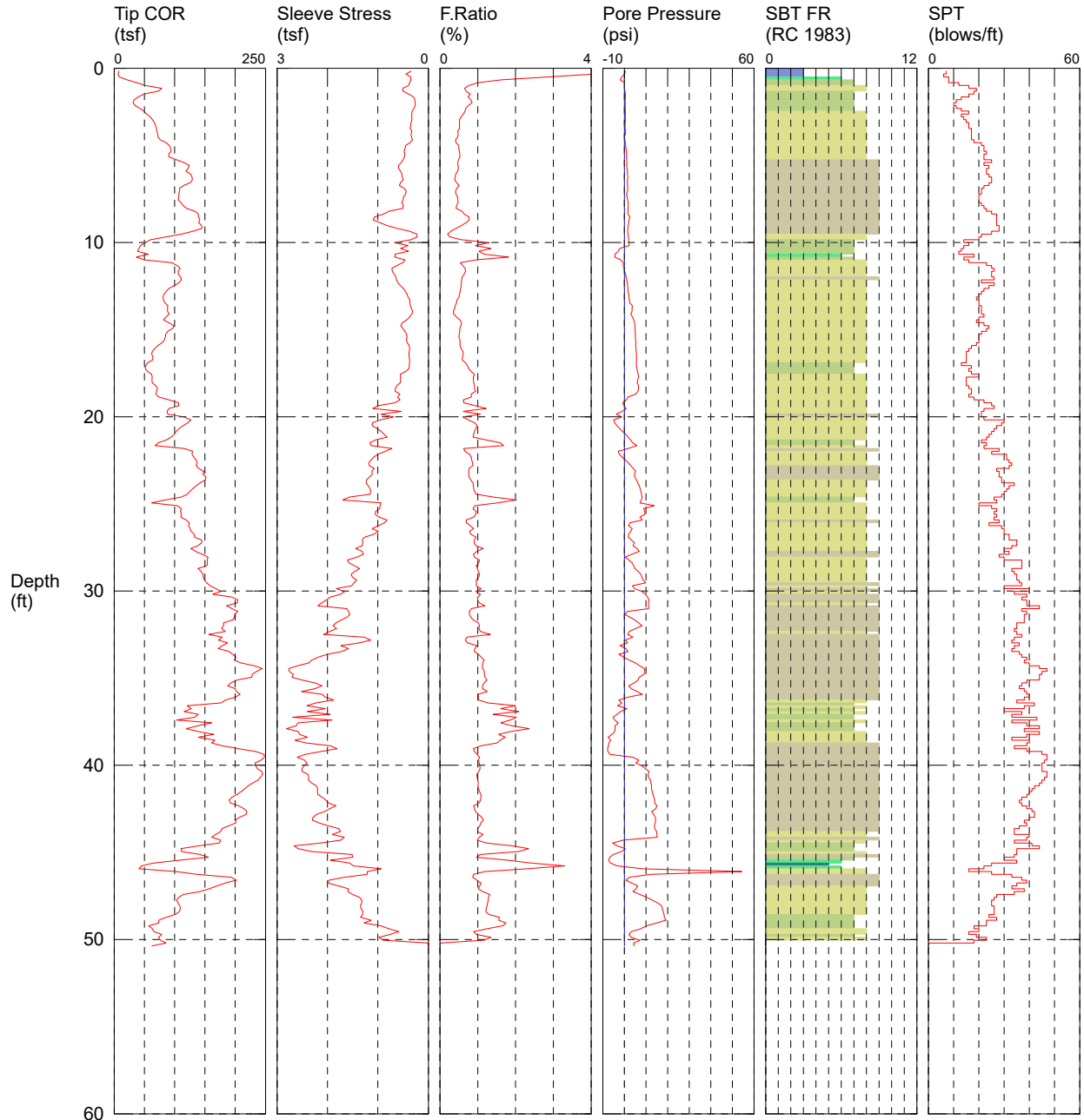
<u>Test Pit TP-6</u>		Project: Jennings Substation Project No: 2494.01 Date Excavated: September 21, 2021			
Location: See Site and Exploration Plan, Figure 1 Approx. Ground Surface Elevation: Approximately 44 Feet					
Depth (ft)	Material Description	Sample	PID	%M	Testing
1	Grass, over 2 inches of dark brown, silty sand, some organics, with fine roots (Topsoil), over medium dense, moist, brown, gravelly SAND, some silt. Coarse sand and fine gravel are crushed rock (Fill)	S-1 @ 0.5 feet	<1	6	ACM
2	Several pieces of plastic observed at approximately 1.5 feet	S-2 @ 1.8 feet	<1	8	ACM
3	..... Loose to medium dense, moist, orange-brown, SAND, some silt, trace gravel	S-3 @ 3.3 feet	<1	20	GSA
4	..... Loose to medium dense, moist, gray, fine to medium SAND, trace gravel				
5					
6	Moderate seepage observed at approximately 6 feet.	S-4 @ 5.5 feet	<1	20	
7					
8	Grades to medium to coarse sand	S-5 @ 7.5 feet	<1		
	Test pit TP-6 completed at approximately 8.3 feet.				
	Groundwater observed at approximately 6 feet.				



CPT-01

CPT CONTRACTOR: In Situ Engineering
 CUSTOMER: ZipperGeo
 LOCATION: Marysville
 JOB NUMBER: 000
 COMMENT: Snohomish PUD
 COMMENT:

OPERATOR: Okbay
 CONE ID: DDG1369
 TEST DATE: 9/22/2021 9:09:50 AM
 PREDRILL: None
 BACK FILL: 20% Grout + Bentonite Chips
 SURFACE PATCH: None



TOTAL DEPTH: 50.361 ft

- | | | | |
|---|---|--|--|
| <ul style="list-style-type: none"> ■ 1 sensitive fine grained ■ 2 organic material ■ 3 clay | <ul style="list-style-type: none"> ■ 4 silty clay to clay ■ 5 clayey silt to silty clay ■ 6 sandy silt to clayey silt | <ul style="list-style-type: none"> ■ 7 silty sand to sandy silt ■ 8 sand to silty sand ■ 9 sand | <ul style="list-style-type: none"> ■ 10 gravelly sand to sand ■ 11 very stiff fine grained (*) ■ 12 sand to clayey sand (*) |
|---|---|--|--|

*SBT/SPT CORRELATION: UBC-1983

APPENDIX B
LABORATORY TESTING PROCEDURES AND RESULTS

LABORATORY PROCEDURES AND RESULTS

A series of laboratory tests were performed during the course of this study to evaluate the index and geotechnical engineering properties of the subsurface soils. Descriptions of the types of tests performed are given below.

Visual Classification

Samples recovered from the exploration locations were visually classified in the field during the exploration program. Representative portions of the samples were carefully packaged in moisture tight containers and transported to our laboratory where the field classifications were verified or modified as required. Visual classification was generally done in accordance with ASTM D 2488. Visual soil classification includes evaluation of color, relative moisture content, soil type based upon grain size, and accessory soil types included in the sample. Soil classifications are presented on the exploration logs in Appendix A.

Moisture Content Determinations

Moisture content determinations were performed on representative samples obtained from the explorations in order to aid in identification and correlation of soil types. The determinations were made in general accordance with the test procedures described in ASTM D 2216. The results are shown on the exploration logs in Appendix A.

Grain Size Analysis

A grain size analysis indicates the range in diameter of soil particles included in a particular sample. Grain size analyses were performed on representative samples in general accordance with ASTM D 6913. The results of the grain size determinations for the samples were used in classification of the soils, and are presented in this appendix.

Atterberg Limits

Atterberg limits are used primarily for classification and indexing of cohesive soils. The liquid and plastic limits are two of the five Atterberg limits and are defined as the moisture content of a cohesive soil at arbitrarily established limits for liquid and plastic behavior, respectively. Liquid and plastic limits were established for selected samples in general accordance with ASTM D 423 and ASTM D 424, respectively. The results of the Atterberg limits are presented on a plasticity chart in this appendix where the plasticity index (liquid limit minus plastic limit) is related to the liquid limit. The plastic limits and liquid limits are also presented adjacent to appropriate samples on the exploration logs in Appendix A.

Asbestos Containing Material (ACM)

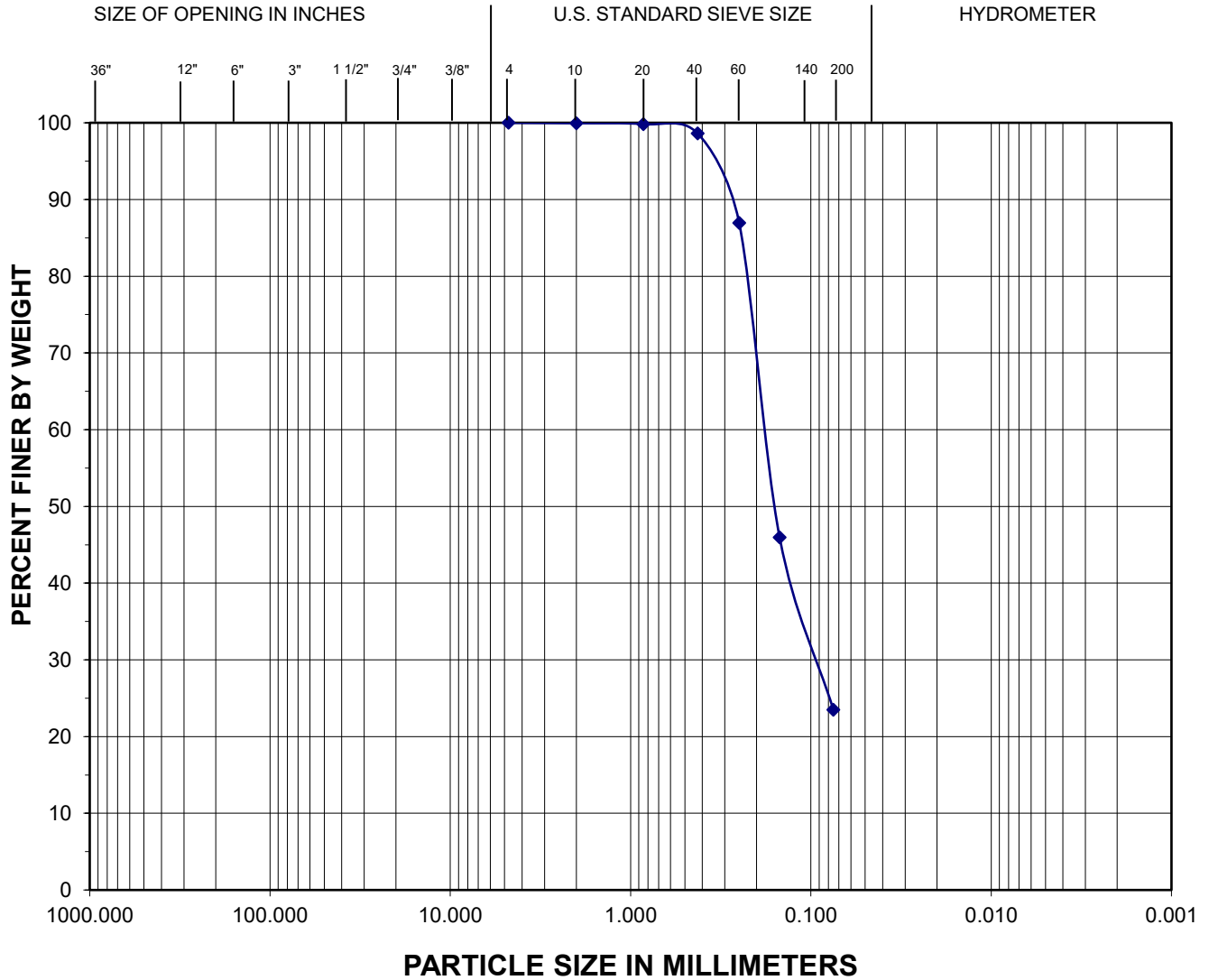
Five samples of existing fill material were collected from the test pits and borings in order to test for the presence of ACM. Examination of these samples was conducted for the presence of identifiable asbestos fibers using polarized light microscopy (PLM) with dispersion staining in accordance with both EPA 600/M4-82-020, Interim Method for the Determination of Asbestos in Bulk Insulation Samples and EPA 600/R-93/116 Method for the Determination of Asbestos in Bulk Building Materials. Results of the tests

are presented in the attached NVL report in this appendix. The ACM was not detected in any of the samples.

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

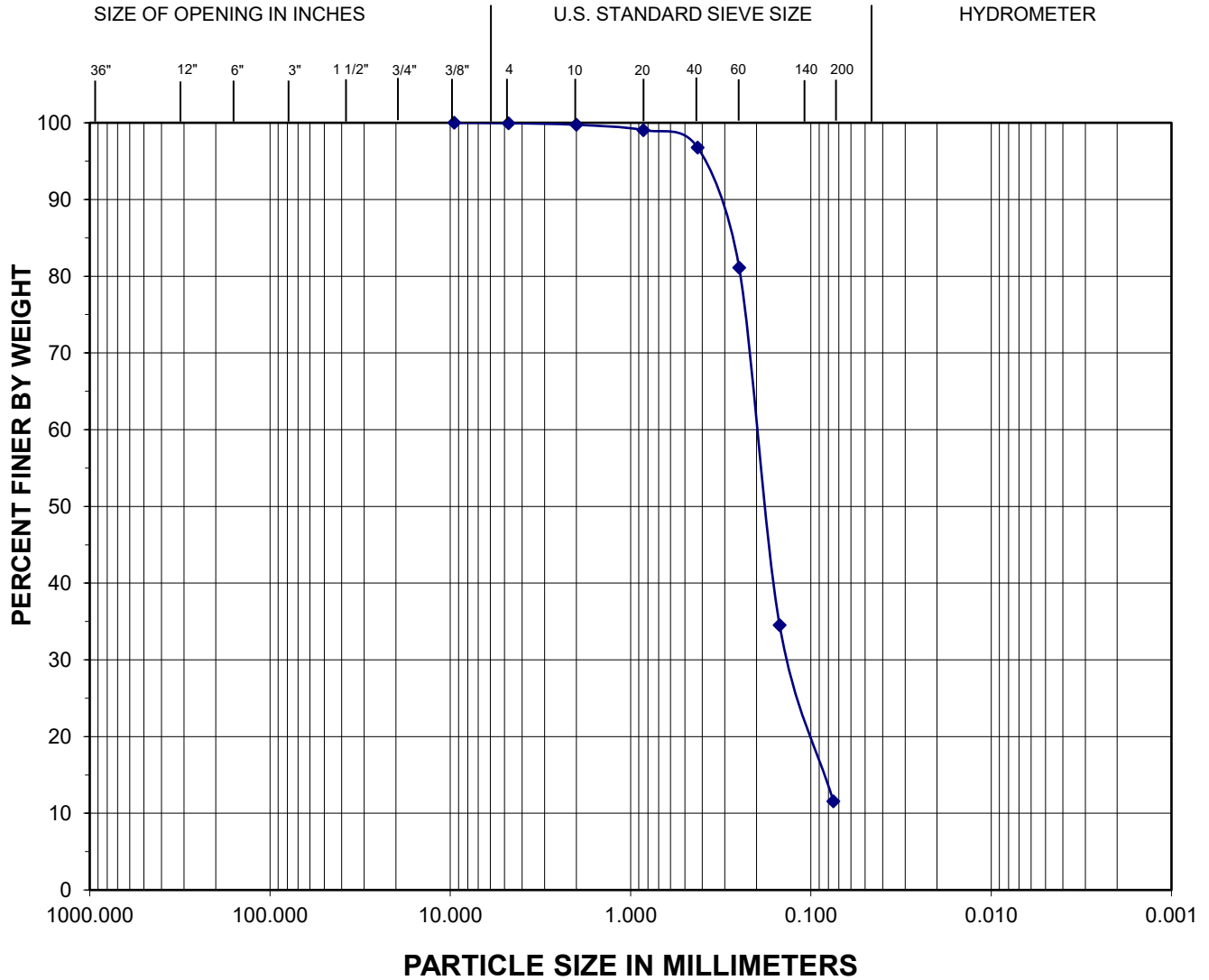
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-5	10-11.5	22.1	23.5	Silty SAND

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 11/4/2021	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

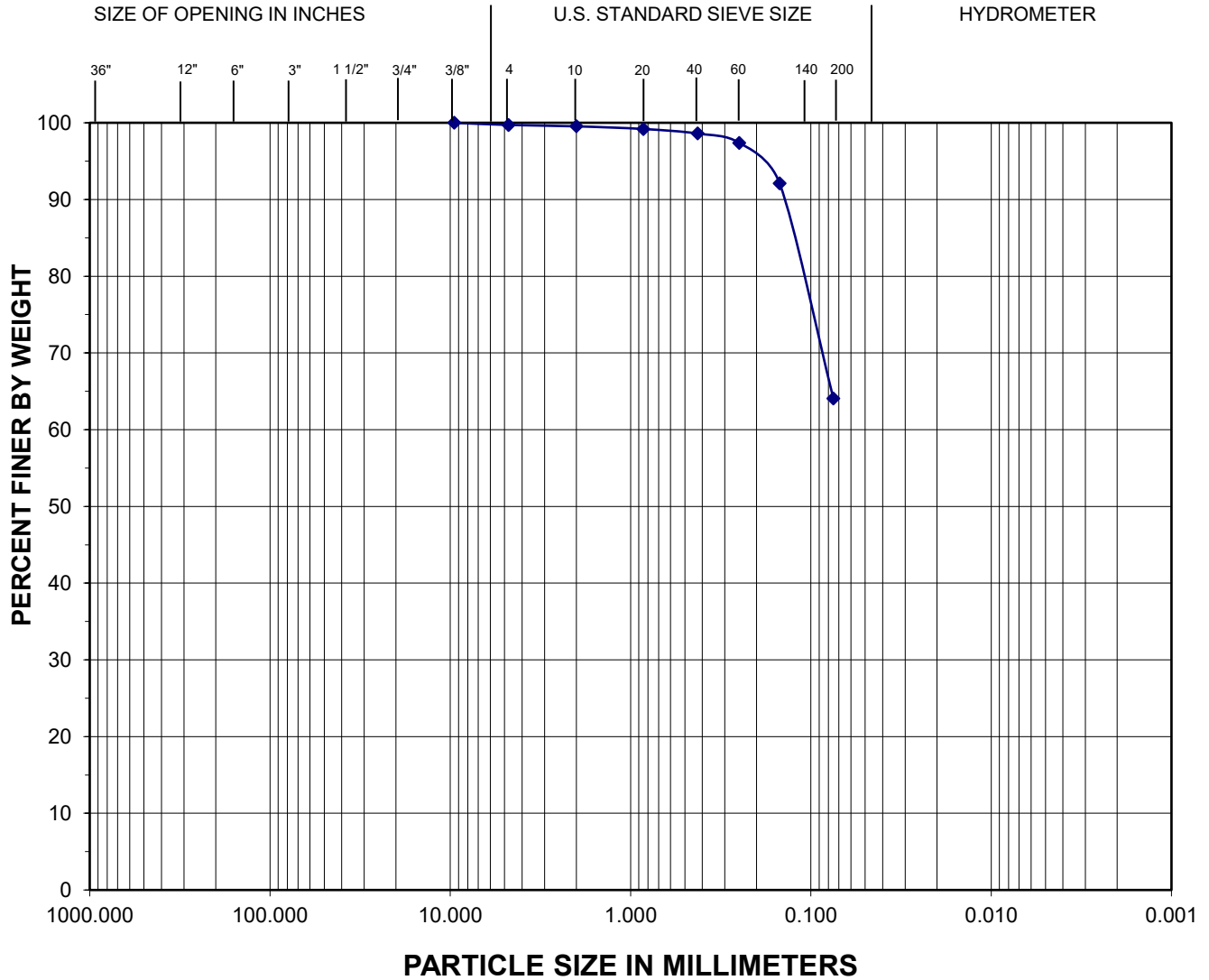
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-9	25-26.5	26.6	11.6	SAND, some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 11/4/2021	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

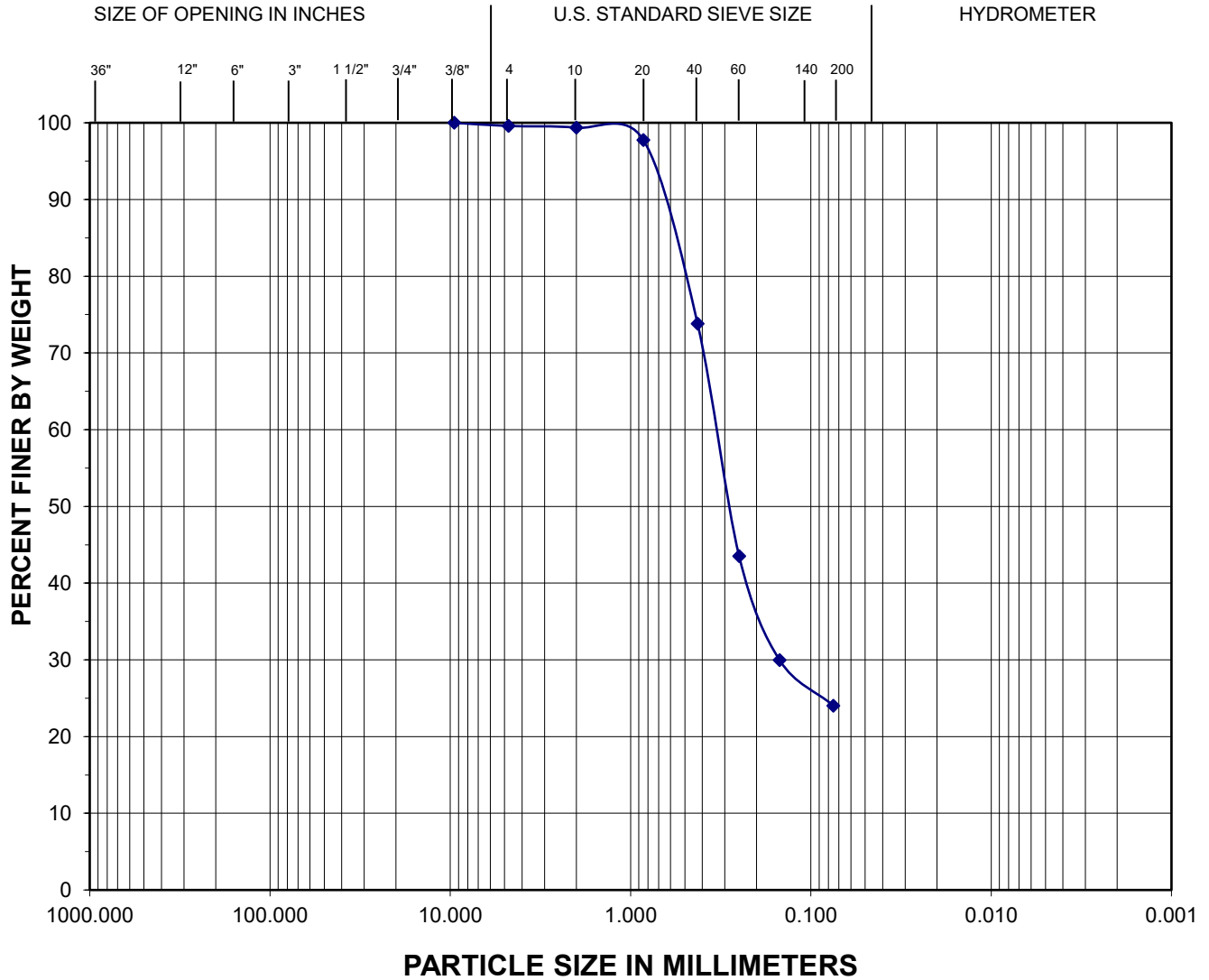
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-13	45-46.5	26.6	64.1	Sandy SILT, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 11/4/2021	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

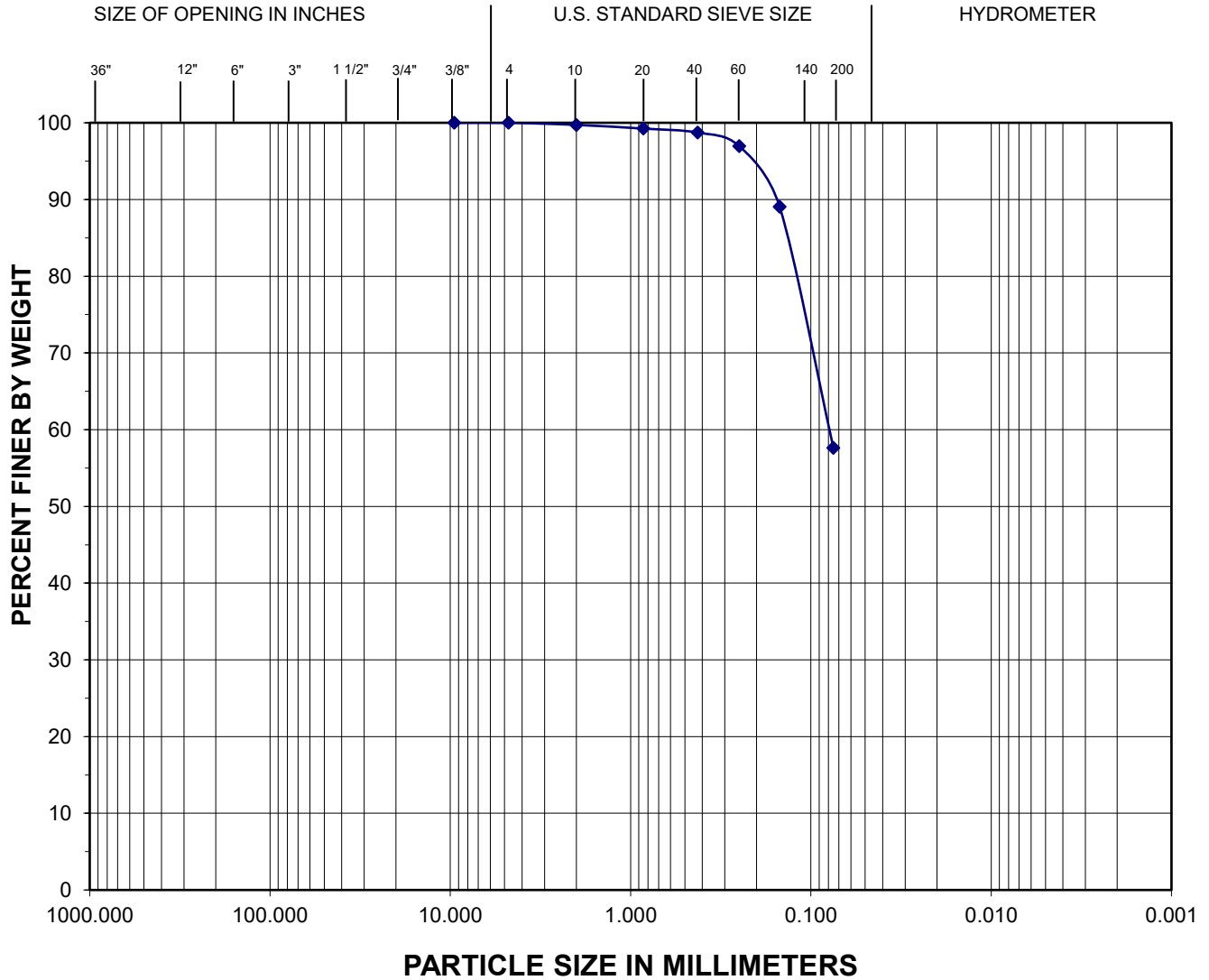
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-7	S-3	7.5-9	26.2	24.0	Silty SAND

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 11/4/2021	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

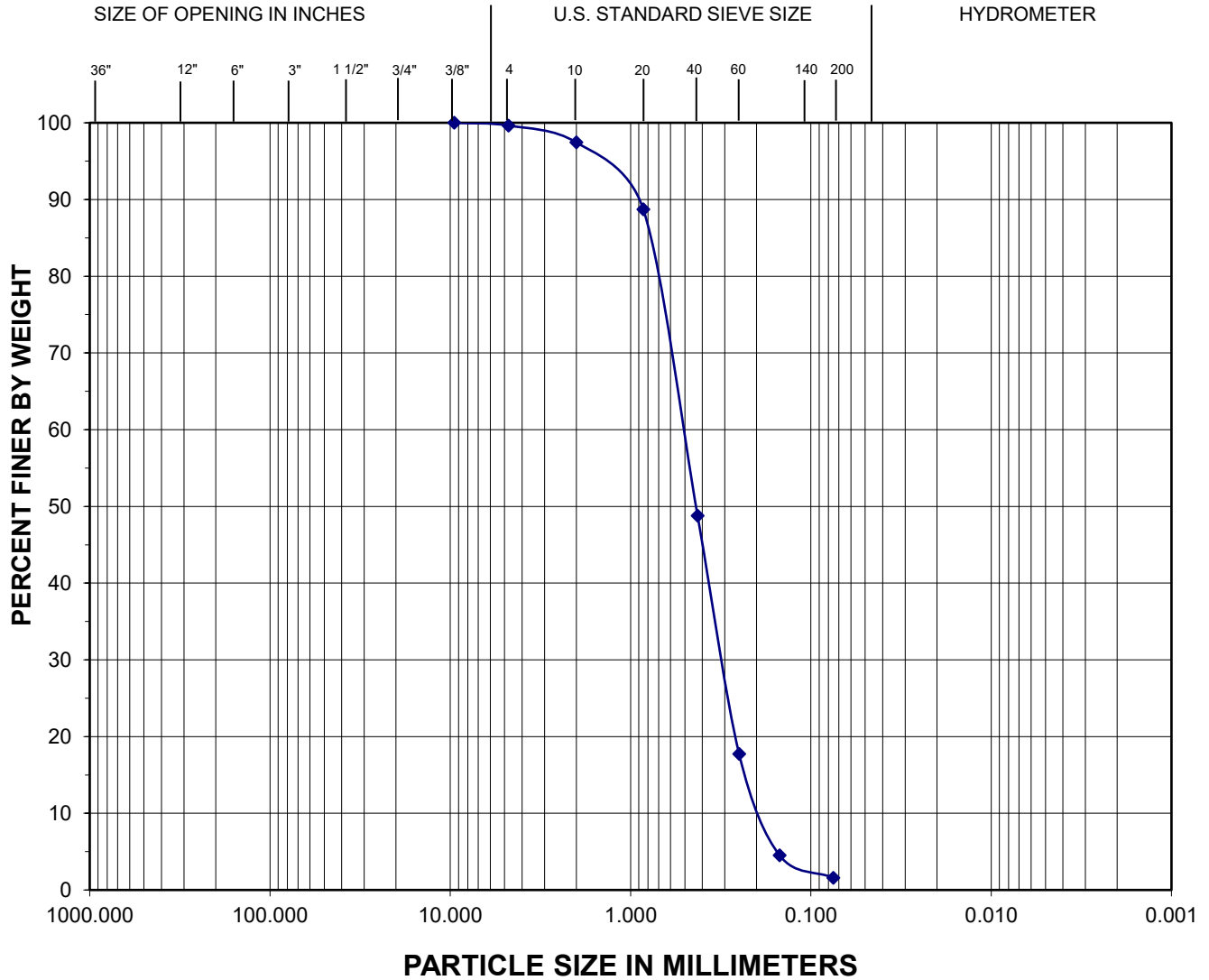
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-7	S-9	30-31.5	28.4	57.6	Sandy SILT

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 11/4/2021	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

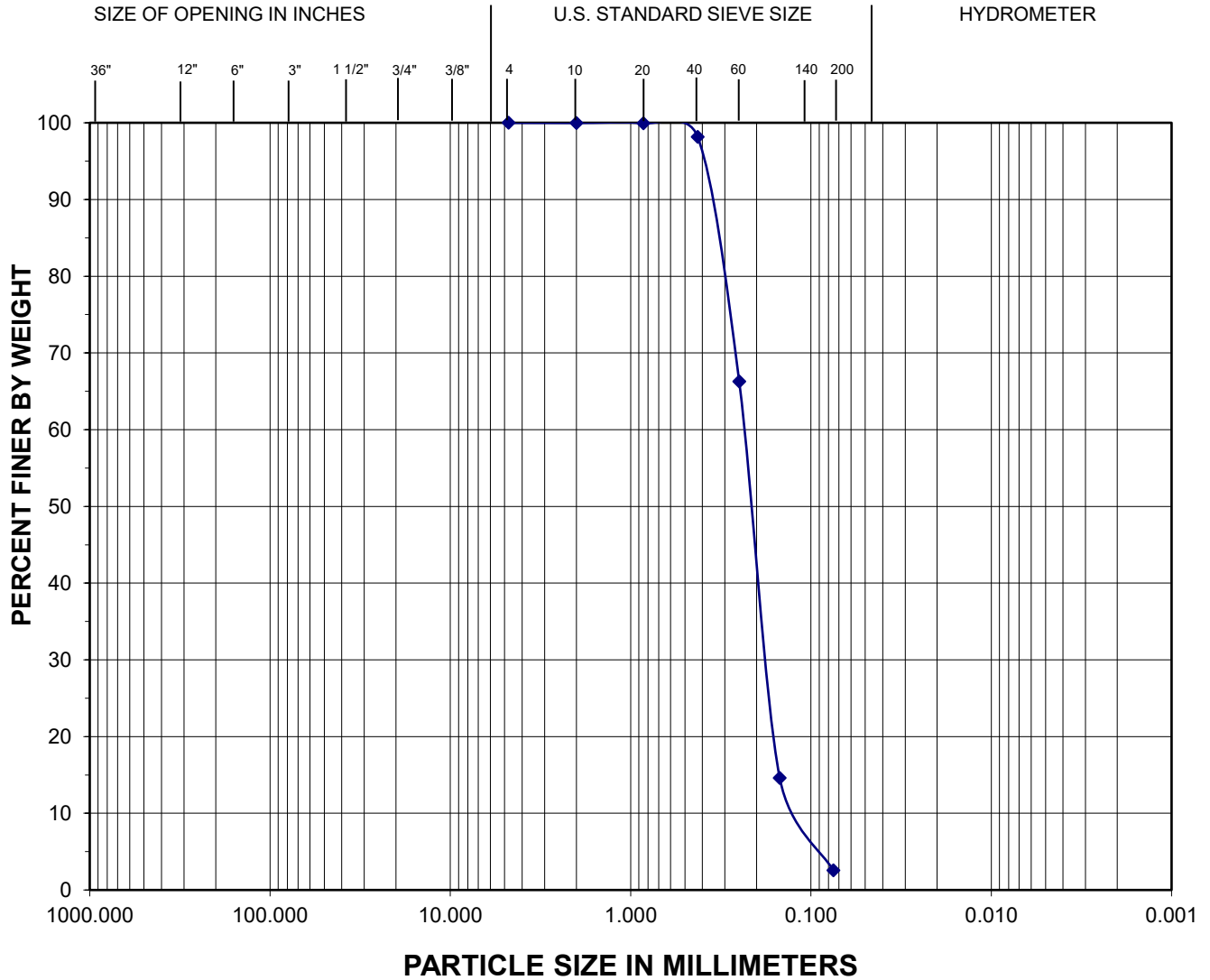
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-3	5.5	17.5	1.6	SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 9/28-9/30	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

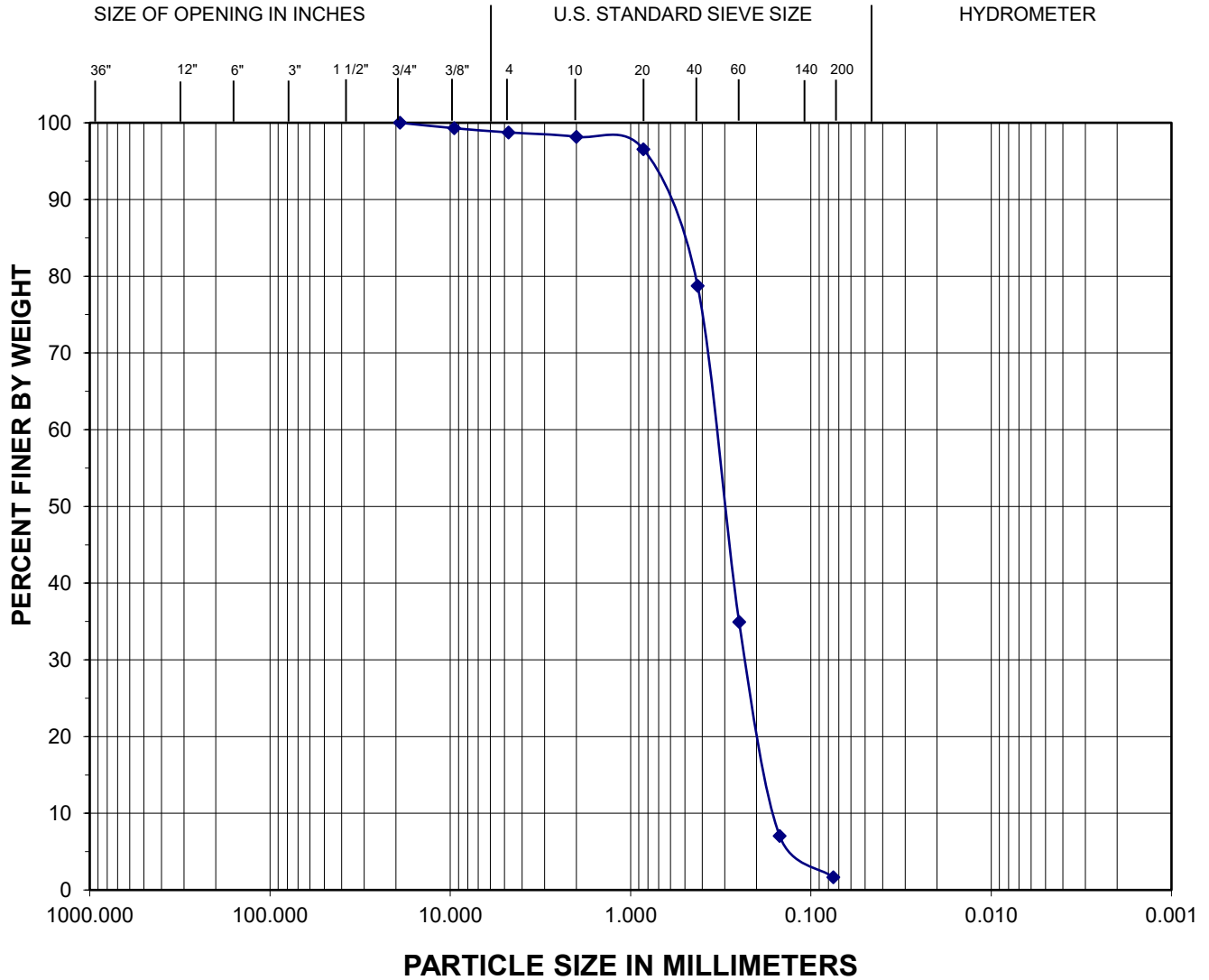
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-4	7	29.4	2.5	SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 9/28-9/30	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

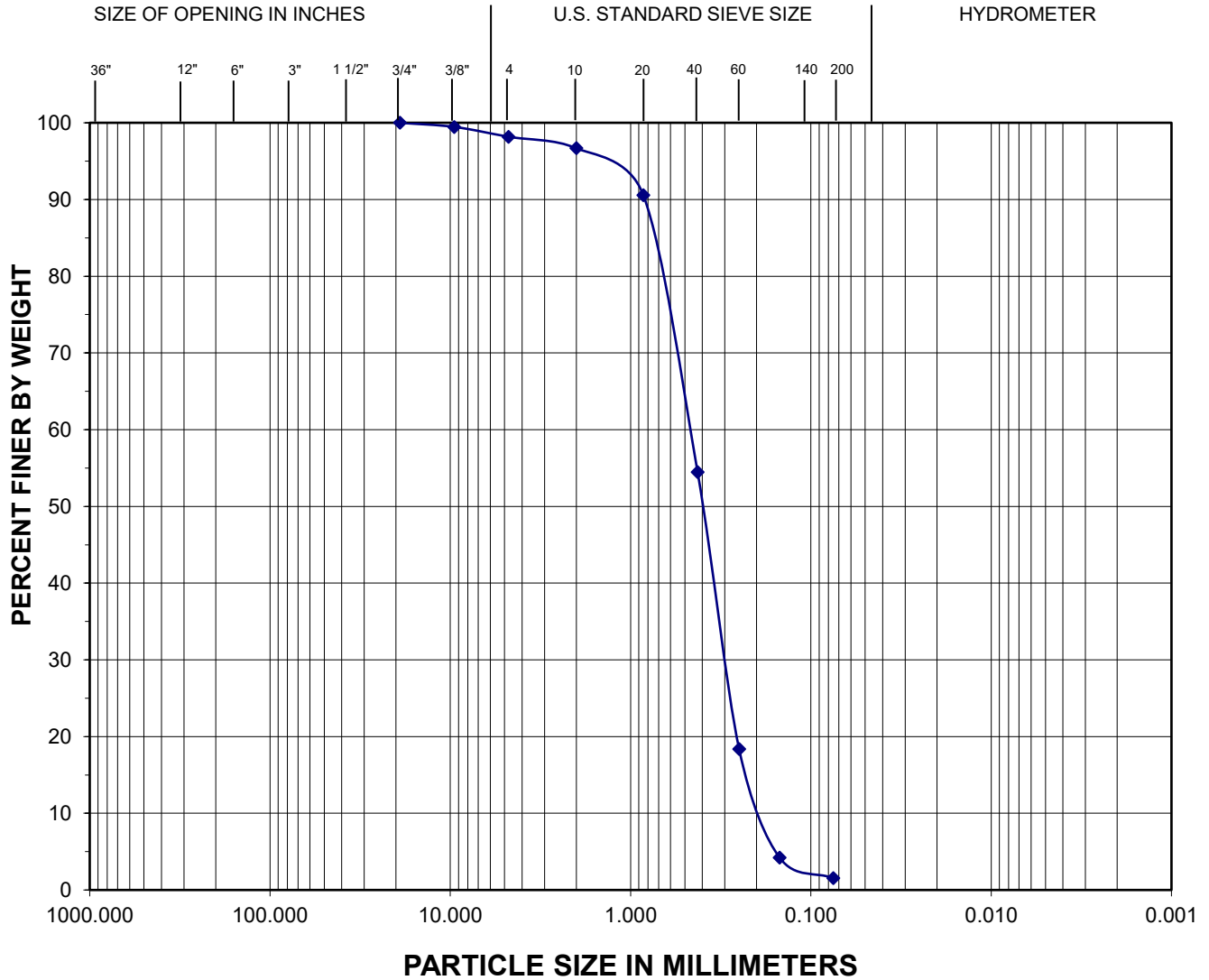
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-2	S-2	3.5	25.1	1.7	SAND, trace silt and gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 9/28-9/30	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

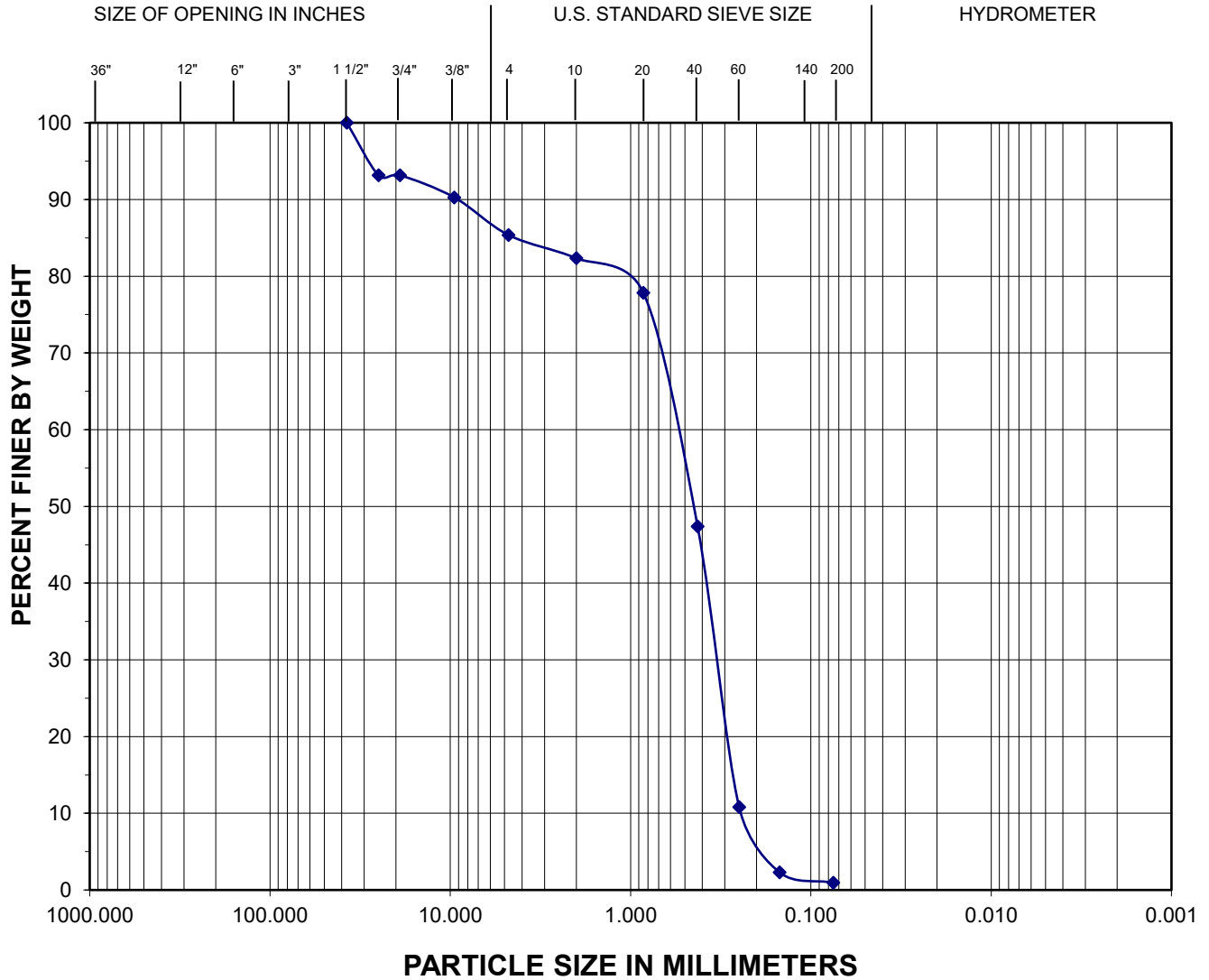
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-3	S-2	3	19.0	1.6	SAND, trace gravel and silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 9/28-9/30	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

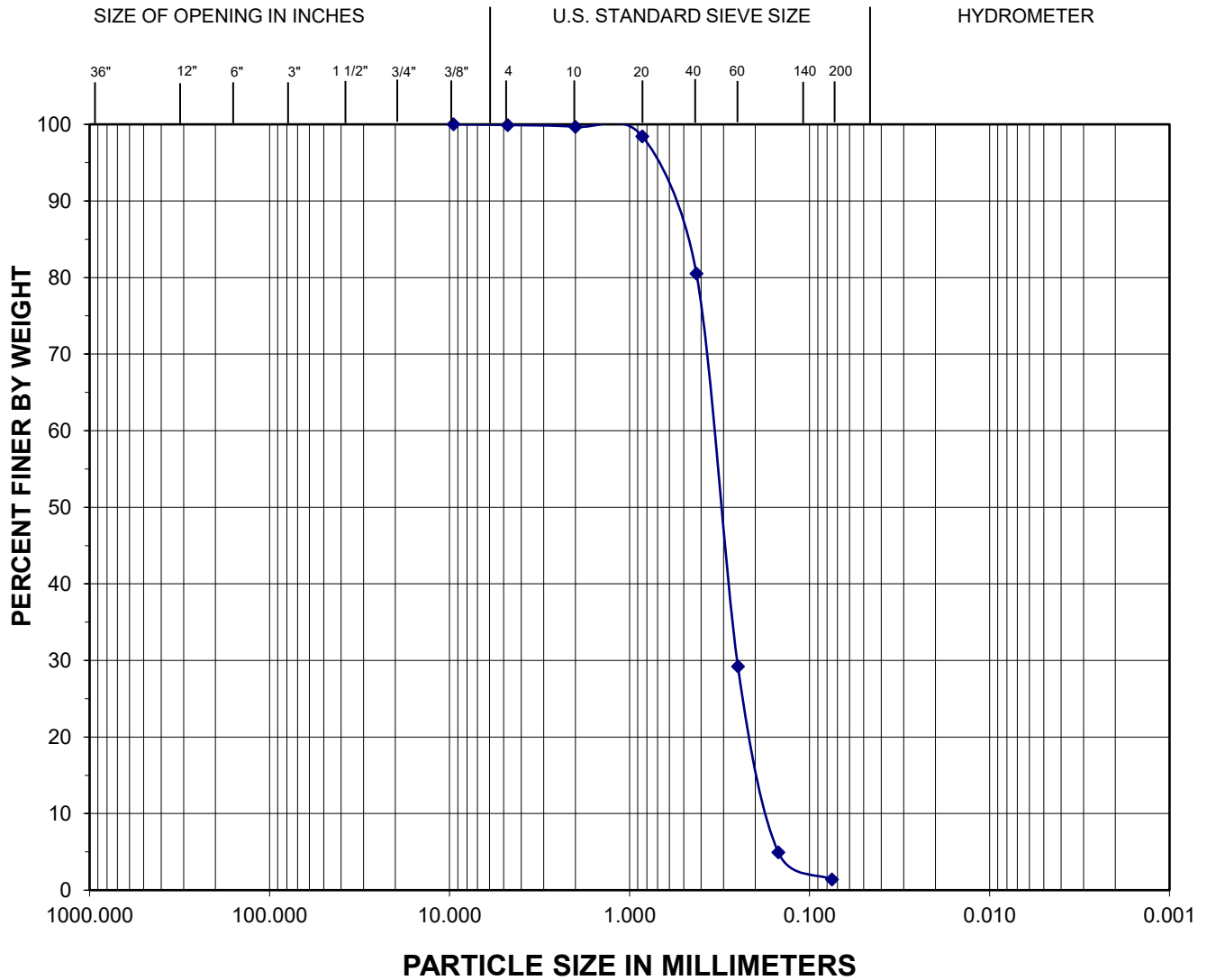
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-4	S-3	3	24.3	1.0	Gravelly SAND

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 9/28-9/30	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

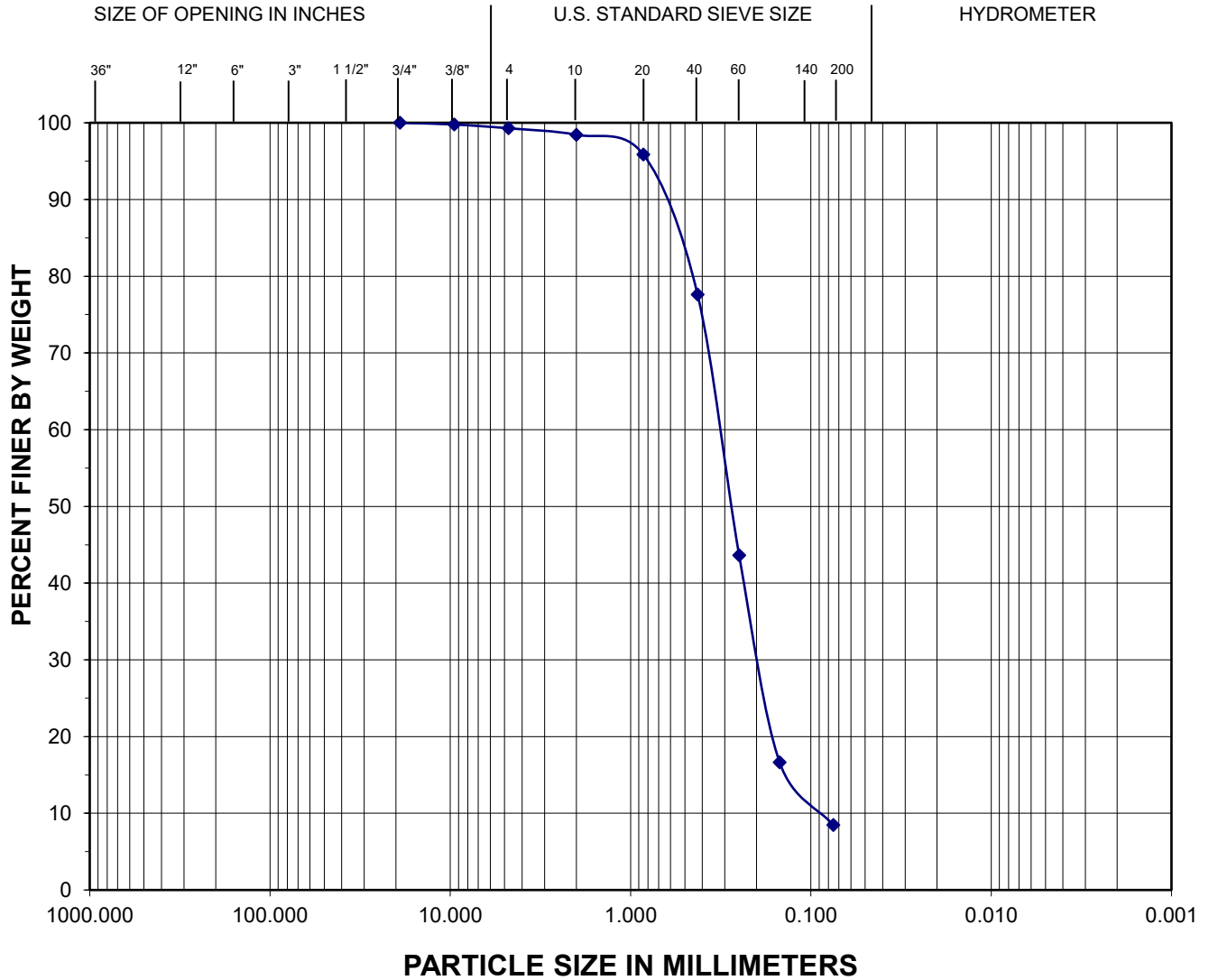
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-5	S-3	4.5	22.7	1.4	SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 9/28-9/30	Jennings Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



BOULDERS	COBBLES	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
		GRAVEL		SAND			FINE GRAINED	

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-6	S-3	3.3	19.8	8.5	SAND, some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2494.01	PROJECT NAME:
	DATE OF TESTING: 9/28-9/30	Jennings Substation

November 8, 2021



Dave Williams
Zipper Geo Associates, LLC
19019 36th Avenue West, Suite E
Lynnwood, WA 98036

RE: Bulk Asbestos Fiber Analysis; NVL Batch # 2119161.00

Client Project: Jennings Substation 2494.01
Location: Marysville, WA

Dear Mr. Williams,

Enclosed please find test results for the 5 sample(s) submitted to our laboratory for analysis on 11/2/2021.

Examination of these samples was conducted for the presence of identifiable asbestos fibers using polarized light microscopy (PLM) with dispersion staining in accordance with **U. S. EPA 40 CFR Appendix E to Subpart E of Part 763**, Interim Method for the Determination of Asbestos in Bulk Insulation Samples and **EPA 600/R-93/116**, Method for the Determination of Asbestos in Bulk Building Materials.

For samples containing more than one separable layer of materials, the report will include findings for each layer (labeled Layer 1 and Layer 2, etc. for each individual layer). The asbestos concentration in the sample is determined by calibrated visual estimation.

For those samples with asbestos concentrations between 1 and 10 percent based on visual estimation, the EPA recommends a procedure known as point counting (NESHAPS, 40 CFR Part 61). Point counting is a statistically more accurate means of quantification for samples with low concentrations of asbestos.

The detection limit for the calibrated visual estimation is <1%, 400 point counts is 0.25% and 1000 point counts is 0.1%

Samples are archived for two weeks following analysis. Samples that are not retrieved by the client are discarded after two weeks.

Thank you for using our laboratory services. Please do not hesitate to call if there is anything further we can assist you with.

Sincerely,

A handwritten signature in black ink, appearing to read "Nick Ly".

Nick Ly, Technical Director

The logo for NVL LABS, featuring the letters "NVL" in a large, outlined, sans-serif font, followed by "LABS" in a smaller, outlined, sans-serif font.

Lab Code: 102063-0

Enc.: Sample Results

Phone: 206 547.0100 | Fax: 206 634.1936 | Toll Free: 1.888.NVL.LABS (685.5227)
4708 Aurora Avenue North | Seattle, WA 98103-6516



Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Zipper Geo Associates, LLC
Address: 19019 36th Avenue West, Suite E
Lynnwood, WA 98036

Batch #: 2119161.00
Client Project #: Jennings Substation 2494.01
Date Received: 11/2/2021
Samples Received: 5
Samples Analyzed: 5
Method: EPA/600/R-93/116

Attention: Mr. Dave Williams
Project Location: Marysville, WA

Lab ID: 21126580 Client Sample #: TP-5, S-1

Location: Marysville, WA

Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1 Description: Brown loose crumbly material with debris

Non-Fibrous Materials:	Other Fibrous Materials:%	Asbestos Type: % None Detected ND
Binder/Filler, Fine grains, Fine particles	Cellulose	
Mineral grains, Organic debris		

Lab ID: 21126581 Client Sample #: TP-6, S-1

Location: Marysville, WA

Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1 Description: Light brown loose crumbly material with debris

Non-Fibrous Materials:	Other Fibrous Materials:%	Asbestos Type: % None Detected ND
Binder/Filler, Fine grains, Fine particles	Cellulose	
Mineral grains, Granules, Debris		

Lab ID: 21126582 Client Sample #: TP-6, S-2

Location: Marysville, WA

Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1 Description: Gray/brown loose crumbly material with debris


Non-Fibrous Materials:	Other Fibrous Materials:%	Asbestos Type: % None Detected ND
Binder/Filler, Fine grains, Granules	Cellulose	
Fine particles, Mineral grains, Sand		

Debris

Lab ID: 21126583 Client Sample #: B-2, S-1

Location: Marysville, WA

Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Sampled by: Client		
Analyzed by: Hilary Crumley	Date: 11/05/2021	
Reviewed by: Nick Ly	Date: 11/08/2021	_____ Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government



Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

Client: Zipper Geo Associates, LLC
 Address: 19019 36th Avenue West, Suite E
 Lynnwood, WA 98036

Batch #: 2119161.00
 Client Project #: Jennings Substation 2494.01
 Date Received: 11/2/2021
 Samples Received: 5
 Samples Analyzed: 5
 Method: EPA/600/R-93/116

Attention: Mr. Dave Williams
 Project Location: Marysville, WA

Layer 1 of 1 **Description:** Brown loose crumbly material with debris

Non-Fibrous Materials:	Other Fibrous Materials: %	Asbestos Type: % None Detected ND
Binder/Filler, Fine grains, Mineral grains	Cellulose	
Fine particles, Organic debris		


Lab ID: 21126584 **Client Sample #: B-3, S-1**

Location: Marysville, WA

Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1 **Description:** Tan loose crumbly material with debris

Non-Fibrous Materials:	Other Fibrous Materials: %	Asbestos Type: % None Detected ND
Binder/Filler, Mineral grains, Fine grains	Cellulose	
Sand, Fine particles, Debris		

Sampled by: Client		
Analyzed by: Hilary Crumley	Date: 11/05/2021	
Reviewed by: Nick Ly	Date: 11/08/2021	_____ Nick Ly, Technical Director

Note: If samples are not homogeneous, then subsamples of the components were analyzed separately. All bulk samples are analyzed using both EPA 600/R-93/116 and 600/M4-82-020 Methods with the following measurement uncertainties for the reported % Asbestos (1%=0-3%, 5%=1-9%, 10%=5-15%, 20%=10-30%, 50%=40-60%). This report relates only to the items tested. If sample was not collected by NVL personnel, then the accuracy of the results is limited by the methodology and acuity of the sample collector. This report shall not be reproduced except in full, without written approval of NVL Laboratories, Inc. It shall not be used to claim product endorsement by NVLAP or any other agency of the US Government

ASBESTOS LABORATORY SERVICES



Company Zipper Geo Associates, LLC	NVL Batch Number 2119161.00
Address 19019 36th Avenue West, Suite E Lynnwood, WA 98036	TAT 5 Days AH No
Project Manager Mr. Dave Williams	Rush TAT
Phone (425) 582-9928	Due Date 11/9/2021 Time 10:35 AM
Cell (425) 218-4619	Email dwilliams@zippergeo.com
	Fax (425) 582-9930

Project Name/Number: Jennings Substation
2494.01 **Project Location:** Marysville, WA

Subcategory PLM Bulk
Item Code ASB-02 EPA 600/R-93-116 Asbestos by PLM <bulk>

Total Number of Samples 5 **Rush Samples** _____

Lab ID	Sample ID	Description	A/R
1	21126580	TP-5, S-1	A
2	21126581	TP-6, S-1	A
3	21126582	TP-6, S-2	A
4	21126583	B-2, S-1	A
5	21126584	B-3, S-1	A

	Print Name	Signature	Company	Date	Time
Sampled by	Client				
Relinquished by	Drop Box				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Hieu Ta		NVL	11/2/21	1035
Analyzed by	Hilary Crumley		NVL	11/5/21	
Results Called by					
<input type="checkbox"/> Faxed <input type="checkbox"/> Emailed					

Special Samples were dried prior to analysis.
Instructions: _____

Date: 11/2/2021
Time: 3:24 PM
Entered By: Fatima Khan



WALK-IN SAMPLE SUBMITTAL FORM

 Asbestos

2119161

First DAVE Last WILLIAMS Company ZIPPER GEO ASSOC., LLC
 Address 19019-36TH AVE. WEST, S.E Cell (425) 218-4619
LYNNWOOD, WA 98036 Email dwilliams@zippergeo.com
 Phone 425-218-4619

Project Name/Number JENNINGS SUBSTATION Project Location MARYSVILLE, WA
2494.01

Pricing	Turn Around Time				
	1-Hr	2-Hr	4-Hr	1-Day	
Asbestos	75.00	70.00	65.00	50.00	<input type="checkbox"/> 1 Hour (Asbestos only)
Lead	N/A	75.00	70.00	50.00	<input type="checkbox"/> 2 Hours (Lead only)
Mold	N/A	N/A	105.00	82.50	<input type="checkbox"/> 4 Hours (Asbestos, Lead, & Mold)
					<input type="checkbox"/> 24 Hours (Asbestos, Lead, & Mold)

Total Number of Samples 5 5-DAY TURNAROUND

Sample ID	Description	A/R
1	TR-5, S-1	EPA 600/R-93-116 ASBESTOS BY PLM
2	TR-6, S-1	
3	TR-6, S-2	
4	B-2, S-1	
5	B-3, S-1	
6		
7		
8		
9		
10		

	Print Name	Signature	Company	Date	Time
Sampled by	<u>DAVE WILLIAMS</u>	<u>Dave Williams</u>	<u>ZGA</u>	<u>11.2.21</u>	
Relinquish by					

Office Use Only

	Print Name	Signature	Company	Date	Time
Received by	<u>Hien Ta</u>	<u>Hien Ta</u>	<u>NVL Labs</u>	<u>11/2/21</u>	<u>10:35</u> DB
Analyzed by					
Called by					
Faxed/Email by					

Kelly Au Vu

From: Dave Williams <dwilliams@zippergeo.com>
Sent: Tuesday, November 2, 2021 12:47 PM
To: Client Services
Subject: RE: Jennings Substation - On Hold

Sorry about that. "I relinquish my samples to NVL Labs."

Regards,

David C. Williams, LG, LEG, Principal



19019 - 36th Avenue West, Suite E
Lynnwood, Washington 98036
Office: 425-582-9928
Mobile: 425-218-4619
www.zippergeo.com

From: Client Services <ClientServices@nvllabs.com>
Sent: Tuesday, November 2, 2021 12:46 PM
To: Dave Williams <dwilliams@zippergeo.com>
Cc: Client Services <ClientServices@nvllabs.com>; Hilary Crumley <Hilary.C@nvllabs.com>; Hieu Ta <hieu.t@nvllabs.com>
Subject: Jennings Substation - On Hold
Importance: High

Hi Dave,

Please see the attached COC.

We are missing the relinquished by signature at the bottom of the page, please sign and return at your earliest convenience. If you are unable to digitally sign, please respond to this email stating, "I relinquish my samples to NVL Labs."

We will be placing this batch on hold.

Thanks & Regards,

Client Services



www.nvllabs.com

Your feedback is very important to us!

ph: 206.547.0100 | fax: 206.634.1936

APPENDIX C

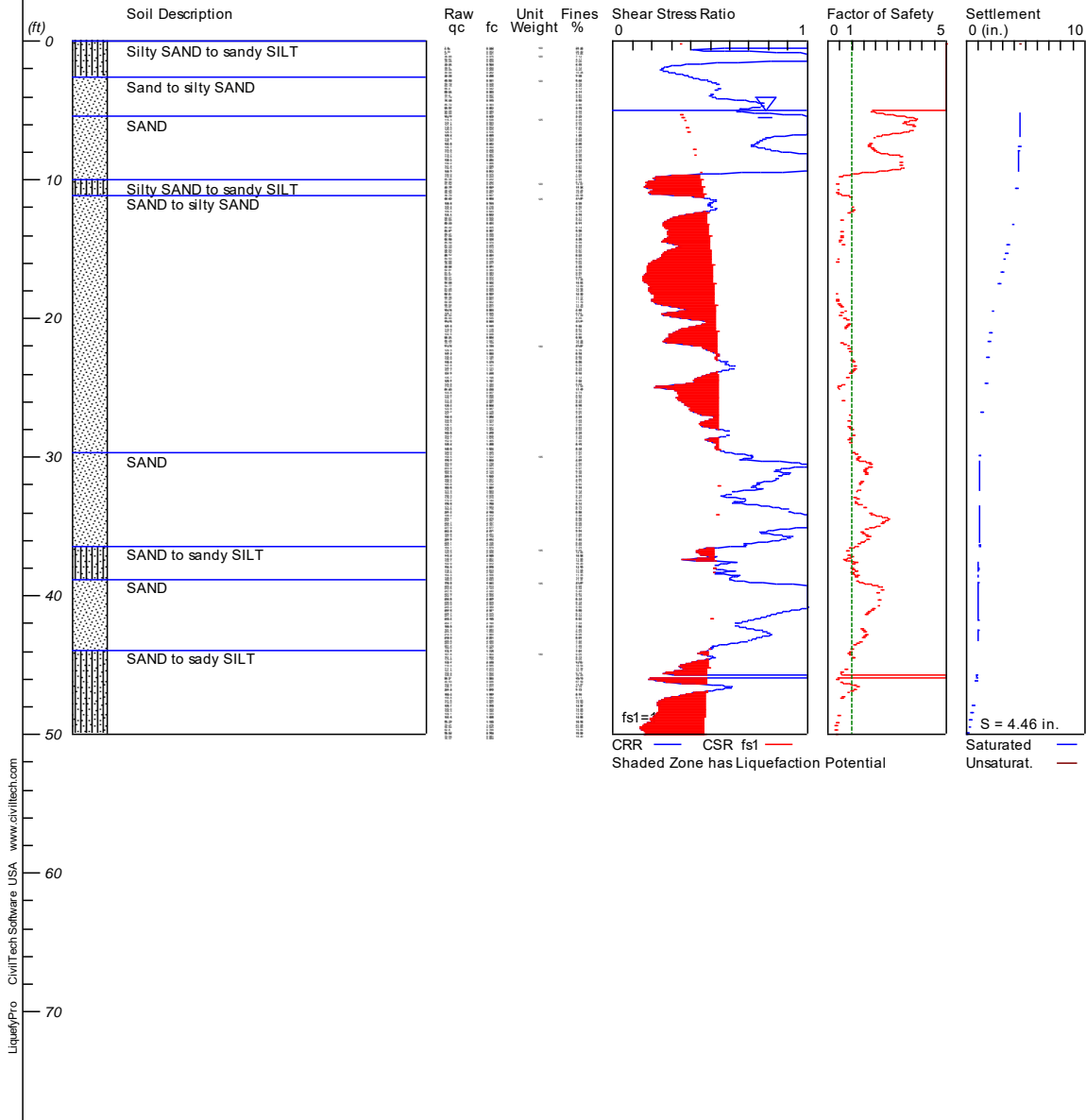
LIQUEFACTION ANALYSIS OUTPUT PLOT

LIQUEFACTION ANALYSIS

Jennings Substation, Proj. No. 2494.01

Hole No.=CPT-01 Water Depth=5 ft Surface Elev.=Approx. 42 ft.

Magnitude=7.08
Acceleration=0.532g



APPENDIX D
GROUNDWATER MOUNDING ANALYSIS DATA SHEETS

Saturated and Unsaturated Data Input

Project Name: 2494.01, Entry, MS and CSBC Trial, 2.8.23
 Unsaturation Analysis: Yes No
 Runoff Data: **MANUAL** Overflow: **NONE**
 Design High Water Elevation: 45.50

Area at Starting Water Level (ft²):	6400.00
Volume Between Starting Water Level & Estimated High Water Level (ft³):	6280.00
Pond Length to Width Ratio (L/W):	2.80
Elevation of Effective Aquifer Base (ft):	17.82
Elevation of Seasonal High Groundwater Table (ft):	41.50
Elevation of Starting Water Level (ft):	41.50
Elevation of Pond Bottom (ft):	43.25
Average Effective Storage Coefficient of Soil for Unsaturation Analysis:	0.30
Unsaturation Vertical Hydraulic Conductivity (ft/d):	24.00
Factor of Safety for Kvu (typically 2.0):	1.00
Saturated Horizontal Hydraulic Conductivity (ft/d):	520.00
Average Effective Storage Coefficient of Soil for Saturated Analysis:	0.30
Average Effective Storage Coefficient of Pond (typically 1.0):	1.00

Specify Hydraulic Control Features

Groundwater Control: Top Bottom Left Right

Distance to Edge of Pond: Top Bottom Left Right

Elevation of Water Level: Top Bottom Left Right

Impervious Barrier: Top Bottom Left Right

Elevation of Barrier Bottom: Top Bottom Left Right

Runoff Data: Manual

Stress Period Number	Increment of Time (hrs)	Volume of Runoff (ft³)	Stress Period Number	Increment of Time (hrs)	Volume of Runoff (ft³)
Unsat	0.00	0.00	15	15.00	101.93
1	1.00	5.23	16	16.00	60.11
2	2.00	1,664.88	17	17.00	39.20
3	3.00	577.62	18	18.00	28.75
4	4.00	229.98	19	19.00	20.91
5	5.00	117.60	20	20.00	15.68
6	6.00	67.98	21		
7	7.00	182.95	22		
8	8.00	1,889.64	23		
9	9.00	1,735.44	24		
10	10.00	10,015.32	25		
11	11.00	14,764.20	26		
12	12.00	1,591.68	27		
13	13.00	4,390.85	28		
14	14.00	188.18	29		

Saturated and Unsaturated Data Input

Project Name: 2494.01, Yard MS and CSBC, 2.8.23

Unsaturation Analysis: Yes No

Runoff Data: MANUAL Overflow: NONE

Design High Water Elevation: 45.67

Area at Starting Water Level (ft²):	41270.00
Volume Between Starting Water Level & Estimated High Water Level (ft³):	185715.00
Pond Length to Width Ratio (L/W):	1.00
Elevation of Effective Aquifer Base (ft):	17.82
Elevation of Seasonal High Groundwater Table (ft):	41.50
Elevation of Starting Water Level (ft):	41.50
Elevation of Pond Bottom (ft):	42.00
Average Effective Storage Coefficient of Soil for Unsaturation Analysis:	0.30
Unsaturation Vertical Hydraulic Conductivity (ft/d):	24.00
Factor of Safety for K _{vu} (typically 2.0):	1.00
Saturated Horizontal Hydraulic Conductivity (ft/d):	520.00
Average Effective Storage Coefficient of Soil for Saturated Analysis:	0.30
Average Effective Storage Coefficient of Pond (typically 1.0):	0.40

Specify Hydraulic Control Features

Groundwater Control: Top Bottom Left Right

Distance to Edge of Pond: Top Bottom Left Right

Elevation of Water Level: Top Bottom Left Right

Impervious Barrier: Top Bottom Left Right

Elevation of Barrier Bottom: Top Bottom Left Right

Runoff Data: Manual








































Stress Period Number	Increment of Time (hrs)	Volume of Runoff (ft³)	Stress Period Number	Increment of Time (hrs)	Volume of Runoff (ft³)
Unsat	0.00	0.00	15	15.00	366.43
1	1.00	14.38	16	16.00	219.54
2	2.00	5,896.80	17	17.00	143.23
3	3.00	2,111.27	18	18.00	99.32
4	4.00	834.52	19	19.00	72.14
5	5.00	421.57	20	20.00	54.36
6	6.00	245.94	21		
7	7.00	614.46	22		
8	8.00	6,701.80	23		
9	9.00	6,278.39	24		
10	10.00	35,425.50	25		
11	11.00	53,090.60	26		
12	12.00	5,885.04	27		
13	13.00	1,637.16	28		
14	14.00	696.26	29		

OK Cancel



Soil Map—Snohomish County Area, Washington

MAP LEGEND

 Area of Interest (AOI)	 Area of Interest (AOI)	 Spoil Area
Soils	 Soil Map Unit Polygons	 Stony Spot
 Soil Map Unit Lines	 Soil Map Unit Points	 Very Stony Spot
 Soil Map Unit Points	Special Point Features	 Wet Spot
 Blowout	 Borrow Pit	 Other
 Clay Spot	 Closed Depression	 Special Line Features
 Gravel Pit	 Gravelly Spot	Water Features
 Landfill	 Lava Flow	 Streams and Canals
 Marsh or swamp	 Mine or Quarry	Transportation
 Miscellaneous Water	 Perennial Water	 Interstate Highways
 Rock Outcrop	 Saline Spot	 Rails
 Sandy Spot	 Severely Eroded Spot	 US Routes
 Sinkhole	 Slide or Slip	 Major Roads
 Soft Spot		 Local Roads
		 Background
		 Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
 Web Soil Survey URL: <http://www.nrcs.usda.gov/wss>
 Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distances and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Snohomish County Area, Washington
 Survey Area Data: Version 23, Aug 31, 2021
 Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.
 Date(s) aerial images were photographed: Aug 16, 2020—Aug 19, 2020

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
57	Ragnar fine sandy loam, 0 to 8 percent slopes	5.6	100.0%
Totals for Area of Interest		5.6	100.0%



**CRITICAL AREA
DETERMINATION REPORT**

FOR

JENNINGS SUBSTATION

7728 & 7808 47TH AVE NE

MARYSVILLE, WA

Wetland Resources, Inc. Project #21261

Prepared By

Wetland Resources, Inc.
9505 19th Avenue SE, Suite 106
Everett, WA 98208
(425) 337-3174

Prepared For

PUD No. 1 of Snohomish County
Attn: Will Blanchard
PO Box H
Everett, Washington 98206-0055

November 22, 2021

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FIGURE 2 – PHOTO OF SUBJECT PROPERTY (FACING EAST).....2

ATTACHMENT

US ARMY CORPS WETLAND DETERMINATION DATA FORM

1.0 INTRODUCTION

Wetland Resources, Inc. (WRI) performed field inspections in January and February, 2012, and September, 2021, on the site located at 7728 & 7808 47th Avenue NE. The 3.21-acre property is composed of two tax parcels (Parcel A=30052100412500; Parcel B=30052100414500) and is located within the city limits of Marysville Washington (Section 21, Township 30N, Range 5E, W.M.). Access to the site is from the east via 47th Avenue NE.



Figure 1 – Aerial View of the Subject Property

1.1 SITE DESCRIPTION

Parcel A fronts along 47th Avenue NE and contains an existing cabinet shop in the eastern portion, with maintained grasses and a small patch of trees in the western portion. Parcel B is accessed from 47th Avenue NE via a narrow panhandle. The larger portion of Parcel B sits to the west. This parcel is undeveloped and is currently covered with maintained grasses and shrubs. A cellular telephone tower is located near the western end of the panhandle to Parcel B. Surrounding land use is a combination of residential and commercial to the north and east, with commercial development to the south and west.

The vegetated portions of the site contain mostly maintained grasses and forbs. A small patch of forest is located in the western portion of Parcel A, containing black cottonwood (*Populus balsamifera*; FAC) and Douglas fir (*Pseudotsuga menziesii*; FACU) with Himalayan blackberry (*Rubus armeniacus*) and Japanese knotweed (*Polygonum cuspidatum*) in the understory.

Soils underlying the site from the surface to ten inches below are generally very dark grayish brown (10YR 3/2) sandy loam. From ten to at least sixteen inches below the surface, soils are typically dark yellowish brown (10YR 3/4) sandy loam. Soils were dry during all of our site inspections.



Figure 2 – Photo of Subject Property (facing east)

2.0 REVIEW OF EXISTING INFORMATION

Prior to conducting the site investigations, publicly available resources were reviewed to gather background information. These sources include the USFWS National Wetlands Inventory (NWI), USDA/NRCS Web Soil Survey, Snohomish County PDS Map Portal, WDFW SalmonScape mapping tool, WDFW Priority Habitat and Species (PHS) Interactive Map, the DNR Forest Practices Application Mapping Tool (DNR-FPAMT), and the City of Marysville’s Online Critical Areas Map.

- United States Fish and Wildlife Service (USFWS) National Wetlands Inventory: NWI mapper displays the property being in between two riverine features. Quilceda Creek and associated wetlands along its corridor are mapped approximately 2,300 feet west of the property. Allen Creek with associated wetlands is mapped approximately 2,300 feet to the east.
- USDA/NRCS Web Soil Survey: The Web Soil Survey maps soils on the subject property as Ragnar fine sandy loam, 0 to 8 percent slopes (57), which is not listed a hydric soil. Observed soils were generally consistent with the mapped soil type.
- WDFW Priority Habitat and Species (PHS) Interactive Map: The PHS interactive map depicts the same features as NWI. Allen Creek is mapped well off-site to the east and is documented to contain Bull Trout (*Salvelinus confluentus*), Resident Cutthroat Trout

(*Oncorhynchus clarkii*), Coho (*O. kisutch*), and Chinook (*O. tshawytscha*). Quilceda Creek and a matrix of freshwater wetlands are mapped well off-site to the west. Quilceda Creek is documented to contain the same species as Allen Creek with the addition of Steelhead (*O. mykiss*) and Chum (*O. keta*).

- Washington Department of Fish and Wildlife (WDFW) SalmonScape Interactive Mapping System: SalmonScape depicts the same salmonid species described by PHS within the off-site streams, with the addition of being gradient accessible to odd-year Pink salmon (*Oncorhynchus gorbuscha*).
- Snohomish County PDS Map Portal: The PDS map portal does not show any documented critical areas on or near the subject property. A remote sensing-based wetland is shown on the western parcel, extending to 76th Street NE. This wetland polygon is derived from a predictive model and is not indicative actual wetlands. This feature was not found during our site inspections.
- Marysville WA Critical Areas Interactive Map: This source does not map any wetlands or streams on or near the site. Quilceda Creek and Allen Creek are located 2,300 feet off-site to the west and east, respectively.
- Washington Department of Natural Resources Forest Practices Application Mapping Tool (FPAMT): No wetlands or streams are mapped on or near the site by this source. Quilceda Creek is mapped as a Type S feature and Allen Creek is mapped as a Type F feature.

3.0 CRITICAL AREAS DELINEATION REPORT

3.1 WETLAND DELINEATION METHODOLOGY

Wetland conditions were identified using the methodologies described in the *Corps of Engineers Wetlands Delineation Manual (Final Report; January 1987)*, except where superseded by the *2010 Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0, referred to as 2010 Regional Supplement)*. Our findings are consistent with these manuals. The following criteria descriptions were used in the wetland boundary determination:

- 1.) Examination of the site for hydrophytic vegetation (species present and percent cover);
- 2.) Examination of the site for hydric soils;
- 3.) Determining the presence of wetland hydrology

3.1.1 Hydrophytic Vegetation Criteria

The manuals define hydrophytic vegetation as the sum total of macrophytic plant life that occurs in areas where the frequency and duration of inundation or soil saturation produce permanently or periodically saturated soils of sufficient duration to exert a controlling influence on the plant species present. One of the most common indicators for hydrophytic vegetation is when more than

50 percent of a plant community consists of species rated “Facultative” and wetter on lists of plant species that occur in wetlands.

3.1.2 Soils Criteria and Mapped Description

The manuals define hydric soils as those that formed under conditions of saturation, flooding, or ponding long enough during the growing season to develop anaerobic conditions in the upper part. Field indicators are used for determining whether a given soil meets the definition for hydric soils.

The soils underlying the site are mapped in the Soil Survey of Snohomish County Area Washington as Ragnar fine sandy loam, 0 to 8 percent slopes. Soils sampled on-site appear to match the description for these soils.

The Ragnar series is described as moderately well drained on outwash plains. The surface layer is typically a dark brown fine sandy loam about two inches thick. The upper part of the subsoil is dark brown and brown sandy loam about 22 inches thick. Included in this unit are areas of Everett, Indianola, Pastik and Wilson soils on terraces and outwash plains.

3.1.3 Hydrology Criteria

The 2010 Regional Supplement defines wetland hydrology as “areas that are inundated (flooded or ponded) or the water table is less than or equal to 12 inches below the soil surface for 14 or more consecutive days during the growing season at a minimum frequency of 5 years in 10.” During the early growing season, wetland hydrology determinations are made based on physical observation of surface water, a high water table, or saturation in the upper 12 inches. Outside of the early growing season, wetland hydrology determinations are made based on physical evidence of recent inundation or saturation (i.e. water marks, surface soil cracks, water-stained leaves).

3.2 STREAM DELINEATION METHODOLOGY

The ordinary high water marks (OHWM) of streams and waterbodies were identified using the methodology described in *Determining the Ordinary High Water Mark for Shoreline Management Act Compliance in Washington State* (Anderson et al. 2016).

3.3 CRITICAL AREA BOUNDARY DETERMINATION FINDINGS

No wetlands, streams, or buffers are located on or near the subject property. Wetlands require a dominance of hydrophytic vegetation, hydric soils, and wetland hydrology to meet wetland criteria. Wetland hydrology and hydric soil indicators are not present anywhere on this site. Undeveloped areas off-site to the south appear to have the same characteristics.

4.0 CONCLUSION

No wetlands, streams, or buffers are located on or near the subject property. Wetlands require a dominance of hydrophytic vegetation, hydric soils, and wetland hydrology to meet wetland criteria. Wetland hydrology and hydric soil indicators are not present anywhere on this site. Undeveloped areas off-site to the south appear to have the same characteristics. The closest documented critical areas to the subject property are Quilceda Creek and Allen Creek, both of which are located more than 2,000 feet away from the subject property.

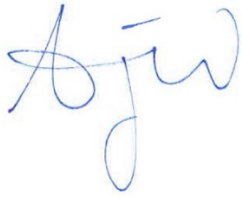
5.0 USE OF THIS REPORT

This Critical Area Determination Report is supplied to PUD No. 1 of Snohomish County as a means of determining the presence of on-site and nearby critical areas, as required by City of Marysville. This report is based largely on readily observable conditions and, to a lesser extent, on readily ascertainable conditions. No attempt has been made to determine hidden or concealed conditions.

The laws applicable to critical areas are subject to varying interpretations and may be changed at any time by the courts or legislative bodies. This report is intended to provide information deemed relevant in the applicant's attempt to comply with the laws now in effect.

This report conforms to the standard of care employed by wetland ecologists. No other representation or warranty is made concerning the work or this report and any implied representation or warranty is disclaimed.

Wetland Resources, Inc.



Alex Wachter
Associate Ecologist



John Laufenberg
Principal Ecologist
Professional Wetland Scientist

6.0 REFERENCES

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WETLAND DETERMINATION DATA FORM – Western Mountains, Valleys, and Coast Region

Project/Site: Jennings Substation City/County: Marysville, WA Sampling Date: 9/30/2021
 Applicant/Owner: Snohomish County PUD No. 1 State: WA Sampling Point: S1
 Investigator(s): JL / SB Section, Township, Range: Sec 21, Twp 30N, Rge 05E, W.M.
 Landform (hillslope, terrace, etc.): terrace Local relief (concave, convex, none): None Slope (%): ~1%
 Subregion (LRR): LRR A Lat: 48.066832° Long: -122.170140° Datum: WGS84
 Soil Map Unit Name: _____ NWI classification: N/A

Are climatic / hydrologic conditions on the site typical for this time of year? Yes No (If no, explain in Remarks.)
 Are Vegetation , Soil , or Hydrology significantly disturbed? Are "Normal Circumstances" present? Yes No
 Are Vegetation , Soil , or Hydrology naturally problematic? (If needed, explain any answers in Remarks.)

SUMMARY OF FINDINGS – Attach site map showing sampling point locations, transects, important features, etc.

Hydrophytic Vegetation Present? Yes <input checked="" type="checkbox"/> No <input type="checkbox"/> Hydric Soil Present? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> Wetland Hydrology Present? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>	Is the Sampled Area within a Wetland? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/>
Remarks: Maintained lawn	

VEGETATION – Use scientific names of plants.

	Absolute % Cover	Dominant Species?	Indicator Status		
Tree Stratum (Plot size: <u>5m²</u>)					
1. <u>Populus balsamifera</u>	<u>5</u>	<u>Y</u>	<u>FAC</u>	Dominance Test worksheet: Number of Dominant Species That Are OBL, FACW, or FAC: <u>3</u> (A) Total Number of Dominant Species Across All Strata: <u>5</u> (B) Percent of Dominant Species That Are OBL, FACW, or FAC: <u>60</u> (A/B)	
2. _____	_____	_____	_____		
3. _____	_____	_____	_____		
4. _____	_____	_____	_____		
<u>5</u> = Total Cover					
Sapling/Shrub Stratum (Plot size: <u>3m²</u>)					
1. <u>Rubus armeniacus</u>	<u>15</u>	<u>Y</u>	<u>FAC</u>	Prevalence Index worksheet: Total % Cover of: _____ Multiply by: OBL species _____ x 1 = <u>0</u> FACW species _____ x 2 = <u>0</u> FAC species _____ x 3 = <u>0</u> FACU species _____ x 4 = <u>0</u> UPL species _____ x 5 = <u>0</u> Column Totals: <u>0</u> (A) <u>0</u> (B) Prevalence Index = B/A = _____	
2. <u>Polygonum cuspidatum</u>	<u>5</u>	<u>Y</u>	<u>FACU</u>		
3. _____	_____	_____	_____		
4. _____	_____	_____	_____		
5. _____	_____	_____	_____		
<u>20</u> = Total Cover					
Herb Stratum (Plot size: <u>1m²</u>)					
1. <u>Phalaris arundinacea</u>	<u>40</u>	<u>Y</u>	<u>FACW</u>		
2. <u>Trifolium pratense</u>	<u>15</u>	<u>Y</u>	<u>FACU</u>		
3. <u>Cirsium scariosum</u>	<u>10</u>	<u>N</u>	<u>FAC</u>		
4. <u>Plantago lanceolata</u>	<u>5</u>	<u>N</u>	<u>FACU</u>		
5. _____	_____	_____	_____		
6. _____	_____	_____	_____		
7. _____	_____	_____	_____		
8. _____	_____	_____	_____		
9. _____	_____	_____	_____		
10. _____	_____	_____	_____		
11. _____	_____	_____	_____		
<u>70</u> = Total Cover					
Woody Vine Stratum (Plot size: <u>3m²</u>)					
1. <u>None</u>	_____	_____	_____		
2. _____	_____	_____	_____		
<u>0</u> = Total Cover					
% Bare Ground in Herb Stratum <u>30</u>					

Remarks:

SOIL

Sampling Point: S1

Profile Description: (Describe to the depth needed to document the indicator or confirm the absence of indicators.)

Depth (inches)	Matrix		Redox Features			Loc ²	Texture	Remarks
	Color (moist)	%	Color (moist)	%	Type ¹			
0-10	10YR 3/2	100					sandy loam	dry
10-16	10YR 3/4	100					sandy loam	dry

¹Type: C=Concentration, D=Depletion, RM=Reduced Matrix, CS=Covered or Coated Sand Grains. ²Location: PL=Pore Lining, M=Matrix.

Hydric Soil Indicators: (Applicable to all LRRs, unless otherwise noted.)

<input type="checkbox"/> Histosol (A1)	<input type="checkbox"/> Sandy Redox (S5)	Indicators for Problematic Hydric Soils³:
<input type="checkbox"/> Histic Epipedon (A2)	<input type="checkbox"/> Stripped Matrix (S6)	
<input type="checkbox"/> Black Histic (A3)	<input type="checkbox"/> Loamy Mucky Mineral (F1) (except MLRA 1)	
<input type="checkbox"/> Hydrogen Sulfide (A4)	<input type="checkbox"/> Loamy Gleyed Matrix (F2)	
<input type="checkbox"/> Depleted Below Dark Surface (A11)	<input type="checkbox"/> Depleted Matrix (F3)	
<input type="checkbox"/> Thick Dark Surface (A12)	<input type="checkbox"/> Redox Dark Surface (F6)	
<input type="checkbox"/> Sandy Mucky Mineral (S1)	<input type="checkbox"/> Depleted Dark Surface (F7)	
<input type="checkbox"/> Sandy Gleyed Matrix (S4)	<input type="checkbox"/> Redox Depressions (F8)	

2 cm Muck (A10)

Red Parent Material (TF2)

Very Shallow Dark Surface (TF12)

Other (Explain in Remarks)

³Indicators of hydrophytic vegetation and wetland hydrology must be present, unless disturbed or problematic.

Restrictive Layer (if present):

Type: _____

Depth (inches): _____

Hydric Soil Present? Yes No

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)	Secondary Indicators (2 or more required)
<input type="checkbox"/> Surface Water (A1) <input type="checkbox"/> High Water Table (A2) <input type="checkbox"/> Saturation (A3) <input type="checkbox"/> Water Marks (B1) <input type="checkbox"/> Sediment Deposits (B2) <input type="checkbox"/> Drift Deposits (B3) <input type="checkbox"/> Algal Mat or Crust (B4) <input type="checkbox"/> Iron Deposits (B5) <input type="checkbox"/> Surface Soil Cracks (B6) <input type="checkbox"/> Inundation Visible on Aerial Imagery (B7) <input type="checkbox"/> Sparsely Vegetated Concave Surface (B8)	<input type="checkbox"/> Water-Stained Leaves (B9) (except MLRA 1, 2, 4A, and 4B) <input type="checkbox"/> Salt Crust (B11) <input type="checkbox"/> Aquatic Invertebrates (B13) <input type="checkbox"/> Hydrogen Sulfide Odor (C1) <input type="checkbox"/> Oxidized Rhizospheres along Living Roots (C3) <input type="checkbox"/> Presence of Reduced Iron (C4) <input type="checkbox"/> Recent Iron Reduction in Tilled Soils (C6) <input type="checkbox"/> Stunted or Stressed Plants (D1) (LRR A) <input type="checkbox"/> Other (Explain in Remarks)
	<input type="checkbox"/> Water-Stained Leaves (B9) (MLRA 1, 2, 4A, and 4B) <input type="checkbox"/> Drainage Patterns (B10) <input type="checkbox"/> Dry-Season Water Table (C2) <input type="checkbox"/> Saturation Visible on Aerial Imagery (C9) <input type="checkbox"/> Geomorphic Position (D2) <input type="checkbox"/> Shallow Aquitard (D3) <input type="checkbox"/> FAC-Neutral Test (D5) <input type="checkbox"/> Raised Ant Mounds (D6) (LRR A) <input type="checkbox"/> Frost-Heave Hummocks (D7)

Field Observations:

Surface Water Present? Yes No Depth (inches): _____

Water Table Present? Yes No Depth (inches): _____

Saturation Present? Yes No Depth (inches): _____
 (includes capillary fringe)

Wetland Hydrology Present? Yes No

Describe Recorded Data (stream gauge, monitoring well, aerial photos, previous inspections), if available:

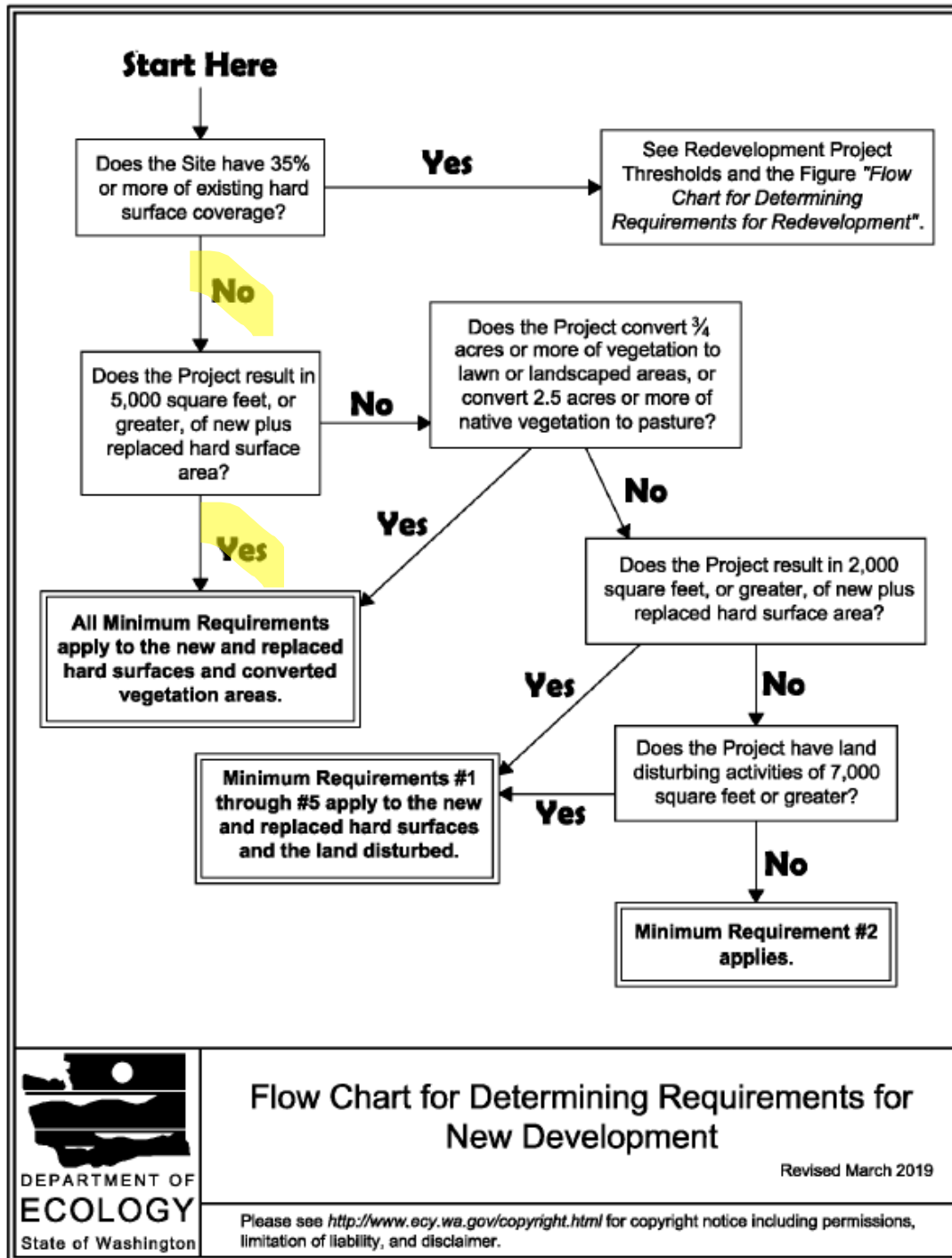
Remarks:

APPENDIX C

2019 Stormwater Management Manual for Western Washington - Figure I-3.1

Flow Chart for Determining Requirements for New Development

Figure I-3.1: Flow Chart for Determining Requirements for New Development



APPENDIX D

Department of Ecology Fact Sheet #95-157-TCP – Mineral Insulating Oil Cleanup Standard



Mineral Insulating Oil Cleanup Standard

Recommended Approach to the Cleanup of Mineral Insulating Oil Contaminated Sites

Based on the unique characteristics of mineral insulating oil and of substation and distribution stations, Ecology is recommending that cleanup actions be conducted for historical releases of non-PCB mineral insulating oil (ASTM D-3487) at sites where contamination levels exceed 2000 mg/kg (ppm).

Ecology does not recommend the completion of risk-based evaluations at Washington electric utility substations and distribution stations due to the unique site characteristics of these facilities and the low toxicity and environmental behavior of mineral insulating oil. Mineral insulating oil is acknowledged as very different in its physical/chemical nature as compared to other petroleum hydrocarbon products. For current and historical mineral insulating oil spills that are small and well defined, electric utility resources should be dedicated to the cleanup of the site and not to extensive risk-based evaluations. Historical mineral insulating oil spills refers to those spills that have remained beneath heavy transformers in high-voltage substation or distribution stations and switchyards for longer than six months.

Technical Utility Industry Issues

Electric utility site characteristics. Electric utility sites where mineral insulating oil is used are unique because of the standards associated with the generation and storage of energy, electric voltage loads, and transmission of electric energy. The utility industry also maintains unique requirements for safety, land use, and environmental resource protection. For sites where historical release residues remaining onsite exceed the 2000 mg/kg (ppm), monitoring shall be conducted as an institutional control. Future land use must also remain in an industrial setting and within the

ownership of the Washington electric utility industry or Bonneville Power Administration, where institutional controls are in place, given the industrial setting. If property is transferred for uses other than industrial utility use, residential standards may apply. The historical contamination should be addressed in accordance with the intended land use.

These types of sites include high-voltage substation or distribution stations or switchyards as defined by the Bonneville Power Administration Definitions, DOE/BP-2279, April 1994. Pad- and pole-mounted electrical transformers are not considered in this fact sheet. The Toxics Cleanup Program, Department of Ecology, will consider additional data as it becomes available. High-voltage substations or distribution stations and switchyards are carefully controlled, fenced areas with special working surface areas (crushed gravel, compacted soils and clays) to eliminate static electricity or electrical arcs.

Chemical characteristics of mineral insulating oil. Mineral insulating oil used in electrical equipment is a highly refined petroleum distillate. Mineral insulating oil is used as an insulating and cooling medium in electrical equipment. Physical/chemical properties of mineral oil are strictly controlled by federal regulation and product specifications. Synonyms for mineral insulating oil include mineral oil, liquid petroleum, liquid paraffin, paraffin oil, medicinal oil and medicinal white oil, white oil and white mineral oil, good grade oil and good grade white oil, and technical white oil.

Biological Effects and Environmental Issues

ASTM D-3487 Toxicity. Mineral insulating oil poses a low potential for toxicity, and is similar to mineral

(Over)

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oil used for food packaging and processing (21 CFR 178.3620). Known information from acute, subchronic and chronic toxicity tests shows little evidence of adverse health effects. Animal toxicity tests using mineral oils shows no evidence of carcinogenicity, nor adverse reproductive or developmental effects. Mineral insulating oil is similar to mineral oil used for cosmetics and pharmaceuticals (USP XXII, CIIA), in that it is non-irritating to the skin and eyes, is non-sensitizing and non-allergenic, and exhibits minimal systemic toxicity via multiple routes of exposure. The 2000 mg/kg (ppm) cleanup level for mineral insulating oil was selected because of low acute ($LD_{50} > 5000$ mg/kg), subchronic (no observed effect level $> 1500 - 4350$ mg/kg-day) and chronic toxicities (no observed effect level $> 1200 - 6000$ mg/kg-day) using different animal species and routes of exposure. There is no data showing mineral oil to be mobile or to present a threat to groundwater at soil concentrations at less than 2000 mg/kg.

Behavior in the environment. Based on the physical/chemical properties of mineral insulating oil, the threat of cross-media contamination of groundwater from release of mineral insulating oil from electrical equipment is minimal. Mineral insulating oil (ASEM D-3487) is non-volatile, insoluble (hydrophobic), and highly adsorbs to organic particles in soil.

Conclusion and Recommendation. Ecology recommends a clear distinction in the Model Toxics Control Act (MCA) cleanup standards between electric utility mineral insulating oil and other types of petroleum hydrocarbons. Design characteristics of electric substations or distribution stations preclude direct human exposure and environmental releases of historic mineral insulating oil. Cleanup standards for (non-PCB contaminated) electric utility industry mineral insulating oil must acknowledge the difference in mineral insulating oil chemical composition, toxicity, and behavior in the environment.

APPENDIX E

WWHM12 Project Narrative, Report and Stage Storage-Discharge Tables

Drainage Narrative

The project site contains one drainage basin and targeted discharge area (point of compliance (POC)).

Predeveloped threshold discharge areas include:

- Predeveloped Basin 1 -The low point existing the property we expect is the northwest corner of the property adjacent to parcel 30052100411200
 - In order to exit this direction shared flow between the PUD's property 30052100414500/30052100412500 would have to pool at the property line and accumulate enough to overtop the capacity of the swale depicted upon S-135-K2A.

Developed threshold discharge areas include

- Developed Basin 1 – The same low point mentioned in the predeveloped conditions is also the point of compliance for the developed conditions.

The stormwater management method is infiltration. The nature of the construction of the station is such that these areas act function as infiltration beds as described in greater detail within this report under the flow control section. Runoff from the paved portion of driveways will be directed to a biofiltration cell – which has also been modeled as an infiltration facility within WWHM.

The impervious areas identify are fully infiltrated on site – thus are ineffective.

WWHM input

Predeveloped input

Existing impervious surface include a concrete masonry unit building along with associated graveled parking area and a panhandle driveway. Combined these surfaces are 0.62 acres; within WWHM they have been modeled as 0.62 acres driveway flat.

The remainder of the site is undeveloped consisting of grass and small brush. The soils are well draining outwash type – thus the remainder of the site has been modeled as type A/B pasture, flat; 2.76 acres. Combined total of predeveloped area 3.38 acres.

Mitigated input

The substation platform was modeled as subbasin 'station platform' an impervious (flat driveway) surface of 0.86 acres. Stage storage tables were utilized to determine the required thickness of the CSBC layer such that the model achieves 100% infiltration.

The paved driveways were modeled as subbasin 'paved driveway' 0.24 acres of impervious (flat driveway) surface and 0.13 acres of pasture included in order to represent the area of the biocells.

The remaining area was modeled as subbasin 'Landscaped, undeveloped and exempt' 1.88 acres of type a/b pasture flat to approximate landscaped areas along with existing conditions. The existing graveled driveway will remain that way and is exempt from flow control however the 0.27 acres was included in the impervious area to demonstrate site wide compliance.

WWHM2012
PROJECT REPORT

General Model Information

Project Name: Jennings Park
Site Name: Jennings Park Sub
Site Address: 7808 47th ave ne
City: Marysville
Report Date: 2/13/2023
Gage: Everett
Data Start: 1948/10/01
Data End: 2009/09/30
Timestep: 15 Minute
Precip Scale: 0.00 (adjusted)
Version Date: 2016/02/25
Version: 4.2.12

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 A B, Pasture, Flat	acre 2.76
Pervious Total	2.76
Impervious Land Use DRIVEWAYS FLAT	acre 0.62
Impervious Total	0.62
Basin Total	3.38

Element Flows To:		
Surface	Interflow	Groundwater

Mitigated Land Use

Station Platform

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
Pervious Total	0
Impervious Land Use	acre
DRIVEWAYS FLAT	0.86
Impervious Total	0.86
Basin Total	0.86

Element Flows To:		
Surface	Interflow	Groundwater
CSBC	CSBC	

Landscaped, undeveloped and exempt

Bypass: Yes

GroundWater: No

Pervious Land Use acre
A B, Pasture, Flat 1.88

Pervious Total 1.88

Impervious Land Use acre
DRIVEWAYS FLAT 0.27

Impervious Total 0.27

Basin Total 2.15

Element Flows To:
Surface Interflow Groundwater

Paved Driveway

Bypass:	No
GroundWater:	No
Pervious Land Use A B, Pasture, Flat	acre 0.13
Pervious Total	0.13
Impervious Land Use DRIVEWAYS FLAT	acre 0.24
Impervious Total	0.24
Basin Total	0.37

Element Flows To:

Surface	Interflow	Groundwater
Biocell between driveways	Biocell between driveways	

Routing Elements
Predeveloped Routing

Mitigated Routing

CSBC

Depth: 44.6 ft.
Element Flows To:
Outlet 1 Outlet 2

SSD Table Hydraulic Table

Stage (feet)	Area (ac.)	Volume (ac-ft.)	Manual	Manual	NotUsed	NotUsed	NotUsed
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
44.10	1.100	0.039	0.000	19.97	0.000	0.000	0.000
44.20	1.100	0.077	0.000	19.97	0.000	0.000	0.000
44.30	1.100	0.116	0.000	19.97	0.000	0.000	0.000
44.40	1.100	0.154	0.000	19.97	0.000	0.000	0.000
44.50	1.100	0.193	0.000	19.97	0.000	0.000	0.000
44.60	1.100	0.231	0.000	19.97	0.000	0.000	0.000

Biocell between driveways

Bottom Length: 70.00 ft.
 Bottom Width: 70.00 ft.
 Depth: 0.5 ft.
 Volume at riser head: 0.0569 acre-feet.
 Infiltration On
 Infiltration rate: 6
 Infiltration safety factor: 1
 Wetted surface area On
 Total Volume Infiltrated (ac-ft.): 36.807
 Total Volume Through Riser (ac-ft.): 0
 Total Volume Through Facility (ac-ft.): 36.807
 Percent Infiltrated: 100
 Total Precip Applied to Facility: 0
 Total Evap From Facility: 0
 Side slope 1: 0 To 1
 Side slope 2: 0 To 1
 Side slope 3: 0 To 1
 Side slope 4: 0 To 1
 Discharge Structure
 Riser Height: 0.5 ft.
 Riser Diameter: 24 in.
 Element Flows To:
 Outlet 1 Outlet 2

Pond Hydraulic Table

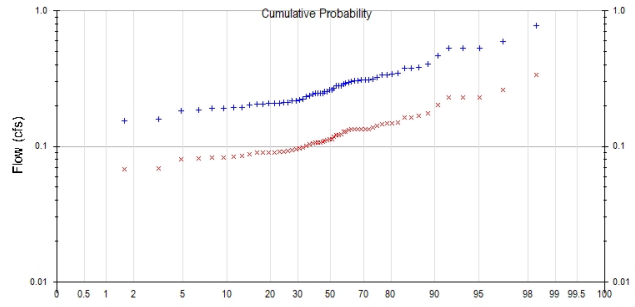
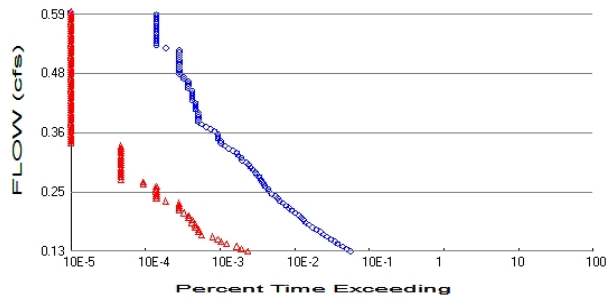
Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.112	0.000	0.000	0.000
0.0056	0.112	0.000	0.000	0.680
0.0111	0.112	0.001	0.000	0.680
0.0167	0.112	0.001	0.000	0.680
0.0222	0.112	0.002	0.000	0.680
0.0278	0.112	0.003	0.000	0.680
0.0333	0.112	0.003	0.000	0.680
0.0389	0.112	0.004	0.000	0.680
0.0444	0.112	0.005	0.000	0.680
0.0500	0.112	0.005	0.000	0.680
0.0556	0.112	0.006	0.000	0.680
0.0611	0.112	0.006	0.000	0.680
0.0667	0.112	0.007	0.000	0.680
0.0722	0.112	0.008	0.000	0.680
0.0778	0.112	0.008	0.000	0.680
0.0833	0.112	0.009	0.000	0.680
0.0889	0.112	0.010	0.000	0.680
0.0944	0.112	0.010	0.000	0.680
0.1000	0.112	0.011	0.000	0.680
0.1056	0.112	0.011	0.000	0.680
0.1111	0.112	0.012	0.000	0.680
0.1167	0.112	0.013	0.000	0.680
0.1222	0.112	0.013	0.000	0.680
0.1278	0.112	0.014	0.000	0.680
0.1333	0.112	0.015	0.000	0.680
0.1389	0.112	0.015	0.000	0.680
0.1444	0.112	0.016	0.000	0.680
0.1500	0.112	0.016	0.000	0.680

0.1556	0.112	0.017	0.000	0.680
0.1611	0.112	0.018	0.000	0.680
0.1667	0.112	0.018	0.000	0.680
0.1722	0.112	0.019	0.000	0.680
0.1778	0.112	0.020	0.000	0.680
0.1833	0.112	0.020	0.000	0.680
0.1889	0.112	0.021	0.000	0.680
0.1944	0.112	0.021	0.000	0.680
0.2000	0.112	0.022	0.000	0.680
0.2056	0.112	0.023	0.000	0.680
0.2111	0.112	0.023	0.000	0.680
0.2167	0.112	0.024	0.000	0.680
0.2222	0.112	0.025	0.000	0.680
0.2278	0.112	0.025	0.000	0.680
0.2333	0.112	0.026	0.000	0.680
0.2389	0.112	0.026	0.000	0.680
0.2444	0.112	0.027	0.000	0.680
0.2500	0.112	0.028	0.000	0.680
0.2556	0.112	0.028	0.000	0.680
0.2611	0.112	0.029	0.000	0.680
0.2667	0.112	0.030	0.000	0.680
0.2722	0.112	0.030	0.000	0.680
0.2778	0.112	0.031	0.000	0.680
0.2833	0.112	0.031	0.000	0.680
0.2889	0.112	0.032	0.000	0.680
0.2944	0.112	0.033	0.000	0.680
0.3000	0.112	0.033	0.000	0.680
0.3056	0.112	0.034	0.000	0.680
0.3111	0.112	0.035	0.000	0.680
0.3167	0.112	0.035	0.000	0.680
0.3222	0.112	0.036	0.000	0.680
0.3278	0.112	0.036	0.000	0.680
0.3333	0.112	0.037	0.000	0.680
0.3389	0.112	0.038	0.000	0.680
0.3444	0.112	0.038	0.000	0.680
0.3500	0.112	0.039	0.000	0.680
0.3556	0.112	0.040	0.000	0.680
0.3611	0.112	0.040	0.000	0.680
0.3667	0.112	0.041	0.000	0.680
0.3722	0.112	0.041	0.000	0.680
0.3778	0.112	0.042	0.000	0.680
0.3833	0.112	0.043	0.000	0.680
0.3889	0.112	0.043	0.000	0.680
0.3944	0.112	0.044	0.000	0.680
0.4000	0.112	0.045	0.000	0.680
0.4056	0.112	0.045	0.000	0.680
0.4111	0.112	0.046	0.000	0.680
0.4167	0.112	0.046	0.000	0.680
0.4222	0.112	0.047	0.000	0.680
0.4278	0.112	0.048	0.000	0.680
0.4333	0.112	0.048	0.000	0.680
0.4389	0.112	0.049	0.000	0.680
0.4444	0.112	0.050	0.000	0.680
0.4500	0.112	0.050	0.000	0.680
0.4556	0.112	0.051	0.000	0.680
0.4611	0.112	0.051	0.000	0.680
0.4667	0.112	0.052	0.000	0.680
0.4722	0.112	0.053	0.000	0.680

0.4778	0.112	0.053	0.000	0.680
0.4833	0.112	0.054	0.000	0.680
0.4889	0.112	0.055	0.000	0.680
0.4944	0.112	0.055	0.000	0.680
0.5000	0.112	0.056	0.000	0.680
0.5056	0.112	0.056	0.008	0.680

Analysis Results

POC 1



+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1

Total Pervious Area: 2.76
Total Impervious Area: 0.62

Mitigated Landuse Totals for POC #1

Total Pervious Area: 2.01
Total Impervious Area: 1.37

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.264179
5 year	0.357254
10 year	0.42529
25 year	0.518836
50 year	0.594219
100 year	0.674648

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.115291
5 year	0.155903
10 year	0.185589
25 year	0.226404
50 year	0.259294
100 year	0.294384

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.270	0.117
1950	0.314	0.137
1951	0.309	0.135
1952	0.247	0.108
1953	0.324	0.141
1954	0.403	0.176
1955	0.307	0.134
1956	0.140	0.061
1957	0.237	0.103
1958	0.596	0.260

1959	0.246	0.107
1960	0.232	0.101
1961	0.775	0.338
1962	0.301	0.132
1963	0.339	0.148
1964	0.187	0.082
1965	0.217	0.095
1966	0.217	0.095
1967	0.529	0.231
1968	0.281	0.122
1969	0.528	0.230
1970	0.209	0.091
1971	0.294	0.128
1972	0.375	0.163
1973	0.309	0.134
1974	0.383	0.167
1975	0.294	0.128
1976	0.205	0.089
1977	0.210	0.092
1978	0.158	0.069
1979	0.346	0.151
1980	0.202	0.088
1981	0.208	0.091
1982	0.210	0.092
1983	0.278	0.121
1984	0.259	0.113
1985	0.375	0.164
1986	0.342	0.149
1987	0.306	0.133
1988	0.246	0.107
1989	0.254	0.111
1990	0.193	0.084
1991	0.253	0.110
1992	0.242	0.105
1993	0.190	0.083
1994	0.207	0.090
1995	0.195	0.085
1996	0.279	0.121
1997	0.305	0.135
1998	0.336	0.146
1999	0.155	0.068
2000	0.527	0.229
2001	0.190	0.083
2002	0.183	0.080
2003	0.245	0.107
2004	0.466	0.203
2005	0.220	0.096
2006	0.288	0.134
2007	0.261	0.114
2008	0.206	0.090
2009	0.224	0.098

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.7753	0.3377
2	0.5958	0.2597
3	0.5291	0.2308

4	0.5278	0.2299
5	0.5266	0.2294
6	0.4659	0.2029
7	0.4031	0.1756
8	0.3827	0.1672
9	0.3752	0.1638
10	0.3747	0.1632
11	0.3462	0.1508
12	0.3417	0.1489
13	0.3387	0.1475
14	0.3362	0.1464
15	0.3242	0.1412
16	0.3141	0.1368
17	0.3087	0.1346
18	0.3087	0.1346
19	0.3073	0.1345
20	0.3059	0.1338
21	0.3049	0.1336
22	0.3014	0.1332
23	0.2944	0.1315
24	0.2940	0.1282
25	0.2882	0.1281
26	0.2808	0.1223
27	0.2790	0.1215
28	0.2780	0.1211
29	0.2696	0.1174
30	0.2610	0.1137
31	0.2594	0.1130
32	0.2545	0.1108
33	0.2531	0.1104
34	0.2470	0.1076
35	0.2460	0.1072
36	0.2455	0.1069
37	0.2448	0.1066
38	0.2419	0.1054
39	0.2367	0.1031
40	0.2322	0.1012
41	0.2239	0.0980
42	0.2203	0.0964
43	0.2170	0.0947
44	0.2166	0.0945
45	0.2104	0.0921
46	0.2103	0.0916
47	0.2090	0.0910
48	0.2079	0.0905
49	0.2073	0.0904
50	0.2059	0.0897
51	0.2052	0.0893
52	0.2020	0.0880
53	0.1946	0.0848
54	0.1934	0.0842
55	0.1905	0.0831
56	0.1898	0.0827
57	0.1866	0.0818
58	0.1827	0.0798
59	0.1584	0.0691
60	0.1552	0.0676
61	0.1400	0.0612

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.1321	1190	50	4	Pass
0.1368	1062	41	3	Pass
0.1414	931	36	3	Pass
0.1461	807	26	3	Pass
0.1508	740	22	2	Pass
0.1554	657	20	3	Pass
0.1601	573	17	2	Pass
0.1648	517	12	2	Pass
0.1694	466	11	2	Pass
0.1741	415	11	2	Pass
0.1788	371	10	2	Pass
0.1834	335	10	2	Pass
0.1881	303	9	2	Pass
0.1928	278	9	3	Pass
0.1974	264	8	3	Pass
0.2021	243	8	3	Pass
0.2068	217	7	3	Pass
0.2114	196	6	3	Pass
0.2161	178	6	3	Pass
0.2208	165	6	3	Pass
0.2254	149	6	4	Pass
0.2301	134	4	2	Pass
0.2348	127	3	2	Pass
0.2395	117	3	2	Pass
0.2441	105	3	2	Pass
0.2488	97	3	3	Pass
0.2535	94	3	3	Pass
0.2581	85	3	3	Pass
0.2628	82	2	2	Pass
0.2675	78	2	2	Pass
0.2721	75	1	1	Pass
0.2768	72	1	1	Pass
0.2815	65	1	1	Pass
0.2861	63	1	1	Pass
0.2908	59	1	1	Pass
0.2955	55	1	1	Pass
0.3001	52	1	1	Pass
0.3048	48	1	2	Pass
0.3095	42	1	2	Pass
0.3141	41	1	2	Pass
0.3188	38	1	2	Pass
0.3235	36	1	2	Pass
0.3281	32	1	3	Pass
0.3328	28	1	3	Pass
0.3375	25	1	4	Pass
0.3421	22	0	0	Pass
0.3468	22	0	0	Pass
0.3515	20	0	0	Pass
0.3562	20	0	0	Pass
0.3608	20	0	0	Pass
0.3655	18	0	0	Pass
0.3702	16	0	0	Pass
0.3748	14	0	0	Pass

0.3795	12	0	0	Pass
0.3842	11	0	0	Pass
0.3888	11	0	0	Pass
0.3935	11	0	0	Pass
0.3982	11	0	0	Pass
0.4028	11	0	0	Pass
0.4075	10	0	0	Pass
0.4122	10	0	0	Pass
0.4168	10	0	0	Pass
0.4215	10	0	0	Pass
0.4262	9	0	0	Pass
0.4308	9	0	0	Pass
0.4355	9	0	0	Pass
0.4402	9	0	0	Pass
0.4448	9	0	0	Pass
0.4495	8	0	0	Pass
0.4542	8	0	0	Pass
0.4588	8	0	0	Pass
0.4635	8	0	0	Pass
0.4682	7	0	0	Pass
0.4729	7	0	0	Pass
0.4775	6	0	0	Pass
0.4822	6	0	0	Pass
0.4869	6	0	0	Pass
0.4915	6	0	0	Pass
0.4962	6	0	0	Pass
0.5009	6	0	0	Pass
0.5055	6	0	0	Pass
0.5102	6	0	0	Pass
0.5149	6	0	0	Pass
0.5195	6	0	0	Pass
0.5242	6	0	0	Pass
0.5289	4	0	0	Pass
0.5335	3	0	0	Pass
0.5382	3	0	0	Pass
0.5429	3	0	0	Pass
0.5475	3	0	0	Pass
0.5522	3	0	0	Pass
0.5569	3	0	0	Pass
0.5615	3	0	0	Pass
0.5662	3	0	0	Pass
0.5709	3	0	0	Pass
0.5755	3	0	0	Pass
0.5802	3	0	0	Pass
0.5849	3	0	0	Pass
0.5896	3	0	0	Pass
0.5942	3	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume: 0 acre-feet

On-line facility target flow: 0 cfs.

Adjusted for 15 min: 0 cfs.

Off-line facility target flow: 0 cfs.

Adjusted for 15 min: 0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
CSBC POC	<input type="checkbox"/>	121.84			<input type="checkbox"/>	99.74			
Biocell between driveways	<input type="checkbox"/>	34.02			<input type="checkbox"/>	98.45			
Total Volume Infiltrated		155.86	0.00	0.00		99.46	0.00	0%	No Treat Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Passed

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

		<p>Paved Driveway 0.37ac</p>		<p>Landscaped, undeveloped and exempt 2.15ac</p>			
<p>SI</p>	<p>SI</p>						
		<p>Biocell between driveways</p>					

Predeveloped UCI File

RUN

GLOBAL

```
WVHM4 model simulation
START      1948 10 01      END      2009 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      Jennings Park.wdm
MESSU    25      PreJennings Park.MES
          27      PreJennings Park.L61
          28      PreJennings Park.L62
          30      POCJennings Park1.dat
```

END FILES

OPN SEQUENCE

```
INGRP          INDELT 00:15
  PERLND        4
  IMPLND        5
  COPY          501
  DISPLY        1
```

END INGRP

END OPN SEQUENCE

DISPLY

DISPLY-INFO1

```
# - #<-----Title----->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
1      Basin 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 ***
```

END OPCODE

PARM

```
# # K ***
```

END PARM

END GENER

PERLND

GEN-INFO

```
<PLS ><-----Name----->NBLKS Unit-systems Printer ***
# - # User t-series Engl Metr ***
          in out ***
```

```
4      A/B, Pasture, 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 ***
4      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 *****
4      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 ***
4 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
4 0 5 1.5 400 0.05 0.3 0.996
END PWAT-PARM2

PWAT-PARM3
<PLS > PWATER input info: Part 3 ***
# - # ***PETMAX PETMIN INFEXP INFILD DEEPFR BASETP AGWETP
4 0 0 2 2 0 0 0
END PWAT-PARM3

PWAT-PARM4
<PLS > PWATER input info: Part 4 ***
# - # CEPSC UZSN NSUR INTFW IRC LZETP ***
4 0.15 0.5 0.3 0 0.7 0.4
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
4 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 ***
5 DRIVEWAYS/FLAT 1 1 1 27 0
END GEN-INFO
*** Section IWATER***

ACTIVITY
<PLS > ***** Active Sections *****
# - # ATMP SNOW IWAT SLD IWG IQAL ***
5 0 0 1 0 0 0
END ACTIVITY

PRINT-INFO
<ILS > ***** Print-flags ***** PIVL PYR
# - # ATMP SNOW IWAT SLD IWG IQAL *****
5 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 ***
5 0 0 0 0 0
END IWAT-PARM1

IWAT-PARM2
<PLS > IWATER input info: Part 2 ***
# - # *** LSUR SLSUR NSUR RETSC
5 400 0.01 0.1 0.1
END IWAT-PARM2

IWAT-PARM3
<PLS > IWATER input info: Part 3 ***
# - # ***PETMAX PETMIN
5 0 0

```

```

END IWAT-PARM3

IWAT-STATE1
  <PLS > *** Initial conditions at start of simulation
  # - # *** RETS      SURS
  5   0       0
END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->          <--Area-->      <-Target->      MBLK      ***
<Name> #          <-factor->      <Name> #      Tbl#      ***
Basin 1***
PERLND  4              2.76      COPY  501      12
PERLND  4              2.76      COPY  501      13
IMPLND  5              0.62      COPY  501      15

*****Routing*****
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

<-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>	#	#	***
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***
COPY	501	OUTPUT	MEAN	1 1	48.4	WDM	501	FLOW	ENGL	REPL

END EXT TARGETS

MASS-LINK

<Volume>	<-Grp>	<-Member->	<--Mult-->	<Target>	<-Grp>	<-Member->	***		
<Name>	#	<Name>	#	#<-factor->	<Name>	<Name>	#	#	***
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			15						
IMPLND	IWATER	SURO		0.083333	COPY	INPUT	MEAN		
END MASS-LINK			15						

END MASS-LINK

END RUN

Mitigated UCI File

RUN

GLOBAL

```
WVHM4 model simulation
START      1948 10 01      END      2009 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      Jennings Park.wdm
MESSU    25      MitJennings Park.MES
          27      MitJennings Park.L61
          28      MitJennings Park.L62
          30      POCJennings Park1.dat
```

END FILES

OPN SEQUENCE

```
INGRP          INDELT 00:15
  IMPLND        5
  PERLND        4
  RCHRES        1
  RCHRES        2
  COPY          1
  COPY          501
  COPY          601
  DISPLY        1
```

END INGRP

END OPN SEQUENCE

DISPLY

DISPLY-INFO1

```
# - #<-----Title----->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
1      CSBC          MAX          1      2      30      9
```

END DISPLY-INFO1

END DISPLY

COPY

TIMESERIES

```
# - # NPT NMN ***
1      1      1
501    1      1
601    1      1
```

END TIMESERIES

END COPY

GENER

OPCODE

```
#      # OPCODE ***
```

END OPCODE

PARAM

```
#      #          K ***
```

END PARAM

END GENER

PERLND

GEN-INFO

```
<PLS ><-----Name----->NBLKS  Unit-systems  Printer ***
# - #          User  t-series  Engr Metr ***
          in  out          ***
4      A/B, Pasture, 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 ***
4      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  *****
4   0   0   4   0   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 ***
4   0   0   0   0   0   0   0   0   0   0   0   0
END PWAT-PARM1

```

```

PWAT-PARM2
<PLS > PWATER input info: Part 2          ***
# - # ***FOREST  LZSN  INFILF  LSUR  SLSUR  KVARY  AGWRC
4   0   5   1.5  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
4   0   0   2   2   0   0   0
END PWAT-PARM3

```

```

PWAT-PARM4
<PLS > PWATER input info: Part 4          ***
# - # CEPSC  UZSN  NSUR  INTFW  IRC  LZETP ***
4   0.15  0.5  0.3  0   0.7  0.4
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
4   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 ***
5   DRIVENWAYS/FLAT  1  1  1  27  0
END GEN-INFO
*** Section IWATER***

```

```

ACTIVITY
<PLS > ***** Active Sections *****
# - # ATMP SNOW IWAT  SLD  IWG IQAL  ***
5   0   0   1   0   0   0
END ACTIVITY

```

```

PRINT-INFO
<ILS > ***** Print-flags ***** PIVL  PYR
# - # ATMP SNOW IWAT  SLD  IWG IQAL  *****
5   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  ***
5   0   0   0   0   0
END IWAT-PARM1

```

```

IWAT-PARM2
<PLS > IWATER input info: Part 2          ***
# - # *** LSUR  SLSUR  NSUR  RETSC
5   400  0.01  0.1  0.1
END IWAT-PARM2

```

```

IWAT-PARM3
  <PLS >          IWATER input info: Part 3          ***
  # - # ***PETMAX    PETMIN
  5      0          0
END IWAT-PARM3

```

```

IWAT-STATE1
  <PLS > *** Initial conditions at start of simulation
  # - # ***  RETS      SURS
  5      0          0
END IWAT-STATE1

```

END IMPLND

```

SCHEMATIC
<-Source->          <--Area-->          <-Target->      MBLK      ***
<Name> #           <-factor->          <Name> #      Tbl#      ***
Station Platform***
IMPLND  5              0.86          RCHRES  1      5
Paved Driveway***
PERLND  4              0.13          RCHRES  2      2
PERLND  4              0.13          RCHRES  2      3
IMPLND  5              0.24          RCHRES  2      5
Landscaped, undeveloped and exempt***
PERLND  4              1.88          COPY    501     12
PERLND  4              1.88          COPY    601     12
PERLND  4              1.88          COPY    501     13
PERLND  4              1.88          COPY    601     13
IMPLND  5              0.27          COPY    501     15
IMPLND  5              0.27          COPY    601     15

```

```

*****Routing*****
IMPLND  5              0.86          COPY    1      15
PERLND  4              0.13          COPY    1      12
IMPLND  5              0.24          COPY    1      15
PERLND  4              0.13          COPY    1      13
RCHRES  1              1            COPY    501     17
RCHRES  2              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

```

```

<-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  Engr Metr LKFG  ***
      in  out
1      CSBC          2      1      1      1      28      0      1
2      Biocell between -013  2      1      1      1      28      0      1
END GEN-INFO
*** Section RCHRES***

```

```

ACTIVITY
  <PLS > ***** Active Sections *****
  # - # HYFG ADFG CNFG HTFG SDFG GQFG OXFG NUFQ PKFG PHFG ***
  1      1      0      0      0      0      0      0      0      0
  2      1      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
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
2      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          0.5          0.0          ***
2      2          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
END HYDR-INIT

```

END RCHRES

```

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES

```

```

FTABLE 1
7      5
Depth          Area          Volume          Outflow1          Outflow2          Velocity          Travel Time***
(ft)          (acres) (acre-ft)          (cfs)          (cfs)          (ft/sec)          (Minutes)***
0.000000  0.000000  0.000000  0.000000  0.000000
44.10000  1.100000  0.038500  0.000000  19.96500
44.20000  1.100000  0.077000  0.000000  19.96500
44.30000  1.100000  0.115500  0.000000  19.96500
44.40000  1.100000  0.154000  0.000000  19.96500
44.50000  1.100000  0.192500  0.000000  19.96500
44.60000  1.100000  0.231000  0.000000  19.96500
END FTABLE 1

```

```

FTABLE 2
91     5
Depth          Area          Volume          Outflow1          Outflow2          Velocity          Travel Time***
(ft)          (acres) (acre-ft)          (cfs)          (cfs)          (ft/sec)          (Minutes)***
0.000000  0.112489  0.000000  0.000000  0.000000
0.005556  0.112489  0.000625  0.000000  0.680556
0.011111  0.112489  0.001250  0.000000  0.680556
0.016667  0.112489  0.001875  0.000000  0.680556
0.022222  0.112489  0.002500  0.000000  0.680556
0.027778  0.112489  0.003125  0.000000  0.680556
0.033333  0.112489  0.003750  0.000000  0.680556
0.038889  0.112489  0.004375  0.000000  0.680556
0.044444  0.112489  0.004999  0.000000  0.680556
0.050000  0.112489  0.005624  0.000000  0.680556
0.055556  0.112489  0.006249  0.000000  0.680556
0.061111  0.112489  0.006874  0.000000  0.680556
0.066667  0.112489  0.007499  0.000000  0.680556
0.072222  0.112489  0.008124  0.000000  0.680556
0.077778  0.112489  0.008749  0.000000  0.680556
0.083333  0.112489  0.009374  0.000000  0.680556
0.088889  0.112489  0.009999  0.000000  0.680556
0.094444  0.112489  0.010624  0.000000  0.680556
0.100000  0.112489  0.011249  0.000000  0.680556
0.105556  0.112489  0.011874  0.000000  0.680556

```

0.111111	0.112489	0.012499	0.000000	0.680556
0.116667	0.112489	0.013124	0.000000	0.680556
0.122222	0.112489	0.013749	0.000000	0.680556
0.127778	0.112489	0.014374	0.000000	0.680556
0.133333	0.112489	0.014998	0.000000	0.680556
0.138889	0.112489	0.015623	0.000000	0.680556
0.144444	0.112489	0.016248	0.000000	0.680556
0.150000	0.112489	0.016873	0.000000	0.680556
0.155556	0.112489	0.017498	0.000000	0.680556
0.161111	0.112489	0.018123	0.000000	0.680556
0.166667	0.112489	0.018748	0.000000	0.680556
0.172222	0.112489	0.019373	0.000000	0.680556
0.177778	0.112489	0.019998	0.000000	0.680556
0.183333	0.112489	0.020623	0.000000	0.680556
0.188889	0.112489	0.021248	0.000000	0.680556
0.194444	0.112489	0.021873	0.000000	0.680556
0.200000	0.112489	0.022498	0.000000	0.680556
0.205556	0.112489	0.023123	0.000000	0.680556
0.211111	0.112489	0.023748	0.000000	0.680556
0.216667	0.112489	0.024373	0.000000	0.680556
0.222222	0.112489	0.024997	0.000000	0.680556
0.227778	0.112489	0.025622	0.000000	0.680556
0.233333	0.112489	0.026247	0.000000	0.680556
0.238889	0.112489	0.026872	0.000000	0.680556
0.244444	0.112489	0.027497	0.000000	0.680556
0.250000	0.112489	0.028122	0.000000	0.680556
0.255556	0.112489	0.028747	0.000000	0.680556
0.261111	0.112489	0.029372	0.000000	0.680556
0.266667	0.112489	0.029997	0.000000	0.680556
0.272222	0.112489	0.030622	0.000000	0.680556
0.277778	0.112489	0.031247	0.000000	0.680556
0.283333	0.112489	0.031872	0.000000	0.680556
0.288889	0.112489	0.032497	0.000000	0.680556
0.294444	0.112489	0.033122	0.000000	0.680556
0.300000	0.112489	0.033747	0.000000	0.680556
0.305556	0.112489	0.034371	0.000000	0.680556
0.311111	0.112489	0.034996	0.000000	0.680556
0.316667	0.112489	0.035621	0.000000	0.680556
0.322222	0.112489	0.036246	0.000000	0.680556
0.327778	0.112489	0.036871	0.000000	0.680556
0.333333	0.112489	0.037496	0.000000	0.680556
0.338889	0.112489	0.038121	0.000000	0.680556
0.344444	0.112489	0.038746	0.000000	0.680556
0.350000	0.112489	0.039371	0.000000	0.680556
0.355556	0.112489	0.039996	0.000000	0.680556
0.361111	0.112489	0.040621	0.000000	0.680556
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0.372222	0.112489	0.041871	0.000000	0.680556
0.377778	0.112489	0.042496	0.000000	0.680556
0.383333	0.112489	0.043121	0.000000	0.680556
0.388889	0.112489	0.043746	0.000000	0.680556
0.394444	0.112489	0.044370	0.000000	0.680556
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0.405556	0.112489	0.045620	0.000000	0.680556
0.411111	0.112489	0.046245	0.000000	0.680556
0.416667	0.112489	0.046870	0.000000	0.680556
0.422222	0.112489	0.047495	0.000000	0.680556
0.427778	0.112489	0.048120	0.000000	0.680556
0.433333	0.112489	0.048745	0.000000	0.680556
0.438889	0.112489	0.049370	0.000000	0.680556
0.444444	0.112489	0.049995	0.000000	0.680556
0.450000	0.112489	0.050620	0.000000	0.680556
0.455556	0.112489	0.051245	0.000000	0.680556
0.461111	0.112489	0.051870	0.000000	0.680556
0.466667	0.112489	0.052495	0.000000	0.680556
0.472222	0.112489	0.053120	0.000000	0.680556
0.477778	0.112489	0.053745	0.000000	0.680556
0.483333	0.112489	0.054369	0.000000	0.680556
0.488889	0.112489	0.054994	0.000000	0.680556
0.494444	0.112489	0.055619	0.000000	0.680556

0.500000 0.112489 0.056244 0.000000 0.680556
 END FTABLE 2
 END FTABLES

EXT SOURCES

<-Volume->	<Member>	SsysSgap	<--Mult-->	Tran	<-Target vols>	<-Grp>	<-Member->	***
<Name>	#	<Name>	#	tem strg	<-factor-->	strg	<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>	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
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
COPY	601	OUTPUT	MEAN	1	1	48.4	WDM	901	FLOW	ENGL	REPL
RCHRES	2	HYDR	RO	1	1	1	WDM	1008	FLOW	ENGL	REPL
RCHRES	2	HYDR	O	1	1	1	WDM	1009	FLOW	ENGL	REPL
RCHRES	2	HYDR	O	2	1	1	WDM	1010	FLOW	ENGL	REPL
RCHRES	2	HYDR	STAGE	1	1	1	WDM	1011	STAG	ENGL	REPL

END EXT TARGETS

MASS-LINK

<Volume>	<-Grp>	<-Member->	<--Mult-->	<Target>	<-Grp>	<-Member->	***
<Name>	#	<Name>	#	<-factor-->	<Name>	#	#
PERLND	2	PWATER	SURO	0.083333	RCHRES	INFLOW	IVOL
END MASS-LINK	2						
PERLND	3	PWATER	IFWO	0.083333	RCHRES	INFLOW	IVOL
END MASS-LINK	3						
IMPLND	5	IWATER	SURO	0.083333	RCHRES	INFLOW	IVOL
END MASS-LINK	5						
PERLND	12	PWATER	SURO	0.083333	COPY	INPUT	MEAN
END MASS-LINK	12						
PERLND	13	PWATER	IFWO	0.083333	COPY	INPUT	MEAN
END MASS-LINK	13						
IMPLND	15	IWATER	SURO	0.083333	COPY	INPUT	MEAN
END MASS-LINK	15						
RCHRES	17	OFLOW	OVOL	1	COPY	INPUT	MEAN
END MASS-LINK	17						

END MASS-LINK

END RUN

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

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Clear Creek Solutions, Inc.
6200 Capitol Blvd. Ste F
Olympia, WA. 98501
Toll Free 1(866)943-0304
Local (360)943-0304

www.clearcreeksolutions.com

APPENDIX F

Operations and Maintenance Manual

The substation fenced area is maintained by the substation construction department. The top 4-inches of rock “substation rock” is necessary for electrical resistivity measures; refer to IEEE 80 for more information. The substation rock layer is changed out as needed with like for like material by the substation construction maintenance crews as leaves, sticks, grass or other debris makes it into the station. This maintenance is done for electrical safety but also serves to preserve the infiltration capability of the fenced substation area.

The remainder of the drainage related maintenance conforms to the typical items identified within the SMMWW and are listed below:

Per 2019 SMMWW – Volume V – Appendix A

Table V-A.3: Maintenance Standards - Closed Detention Systems (Tanks/Vaults) (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins	See Table V-A.5: Maintenance Standards - Catch Basins

Table V-A.5: Maintenance Standards - Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch. (Intent is to make sure no material is running into basin). Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Top slab is free of holes and cracks. Frame is sitting flush on the riser/rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound. Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Basin replaced or repaired to design standards. Pipe is routed and secure at basin wall.
	Settlement/ Mis-alignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
Catch Basin Cover	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening. Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation blocking opening to basin. No vegetation or root growth present.
	Contamination and Pollution	See Table V-A.1: Maintenance Standards - Detention Ponds	No pollution present.
	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Cover/grate is in place, meets design standards, and is secured
Ladder	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Metal Grates (If Applicable)	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
	Grate operating Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
Trash and Debris	Grate missing or broken member(s) of the grate.	Grate missing or broken member(s) of the grate.	Grate is in place, meets the design standards, and is installed and aligned with the flow path.
	Grate missing or broken member(s) of the grate.	Grate missing or broken member(s) of the grate.	Grate is in place, meets the design standards, and is installed and aligned with the flow path.