Draft Drainage Report

Submitted to
City of Arlington

November 2024

Snohomish County PUD 25MW BESS

PERTEET.COM
2707 COLBY AVENUE, SUITE 900
EVERETT, WA 98201
425.252.7700

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Better communities, by design

Draft Drainage Report

For

Snohomish County PUD 25MW BESS

Prepared For

Snohomish County PUD

Owner	Developer	Operator/Contractor
Snohomish County PUD	Ameresco	TBD

Project Site Location

Arlington, WA

Certified Erosion and Sediment Control Lead

TBD

Drainage Report Prepared By

Nathan Hahne, EIT

Drainage Report Preparation Date

November 2024

Approximate Project Construction Dates

TBD

DRAFT DRAINAGE REPORT

Project: Snohomish County PUD BESS
Arlington, WA

Date: **November 2024**

Civil Engineer: (Everett)
Perteet Inc.
2707 Colby Avenue, Suite 900
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Stormwater Lead: Clark Kunitsugu, PE
Stormwater Designer: Nathan Hahne, EIT

Name
Date

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1.0 PROJECT OVERVIEW

The proposed project is located in the City of Arlington, WA. See Figure 1 – Vicinity Map below. The site is owned and operated by Snohomish County PUD (PUD) and is currently not used. The project proposes to install a new battery system to provide PUD with more storage capacity to provide extra power when needed. The site was a solar panel array until recently when the solar panels were demolished in preparation for the battery project.

The approximately 1.5-acre project area is bounded by PUD property on all sides.

This drainage report will describe and explain the project's approach to stormwater management in accordance with the Washington State Department of Ecology 2024 Stormwater Management Manual for Western Washington (SWMMWW) as its stormwater design manual.

One Threshold Discharge Area (TDA) has been identified for this project (refer to the existing conditions map, Figure A.1 in Appendix A). A threshold analysis (found in Section 3.0 of this report) determined that flow control and water quality treatment are required for this project. Perteet has designed a water quality treatment facility upstream of an infiltration, because native soil is believed to be unsuitable for treatment.

Low impact development stormwater features have been found to be infeasible for this project. Several geotechnical reports from adjacent projects have been referenced for this project, and can be found in Appendix H. The key findings regarding infiltration feasibility have been described in Section 2.2.

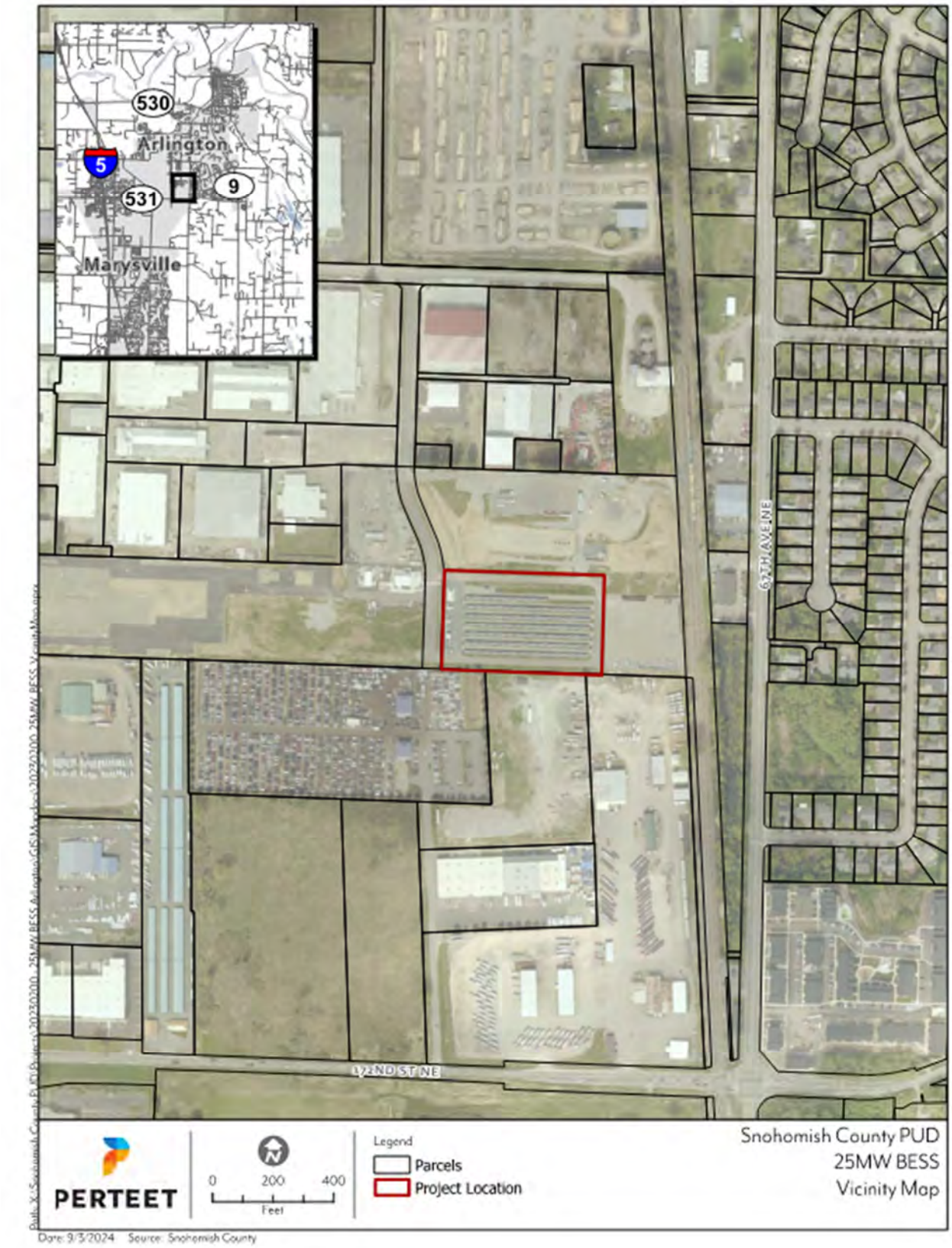


Figure 1. Vicinity Map (Not to Scale).

2.0 SITE ASSESSMENT

2.1 Existing Site Conditions

The proposed project is located on Snohomish County PUD property in Arlington, WA, at a site that was previously a solar panel array. There is no specific existing land use for the site, the solar panel array was removed and the site is now a mixture of grass and gravel. The current topographic relief across the project site is approximately 2 feet, with a high point elevation of approximately 137 feet near the northeast end of the site and a low point elevation of approximately 135 feet at the southwest end of the project site. There is no existing stormwater conveyance system at the site that transports runoff off site. There is a drywell at the northeast end of the site that is accepting runoff from the PUD facilities to the west of the project site. Refer to Figure A.1 – Existing Drainage Conditions Map for a delineation of the on-site drainage patterns.

2.2 Existing Soil Conditions

Two geotechnical reports prepared by ZipperGeo for previous projects near the site were used as reference on this project: one for the North County Special Use Permit and the other for the Crosswinds Substation. Both reports are included in Appendix H of this report. Both investigations found that the underlying soils were outwash soils consisting of loose to dense sand with gravel with a low fines content. The North County Special Use Permit report gave a factored (design) saturated hydraulic conductivity of 4.7 inches per hour for areas west of 63rd Ave, and the Crosswinds Substation report gave a factored (design) saturated hydraulic conductivity of 17 inches per hour. Most of the test pits west of 63rd from the North County report and all the test pits for the Crosswinds Substation are located on said substation which is just east of the site of the proposed battery. The North County test pits were dug primarily at 0.5-3 feet deep with one test pit going down to 8 feet. The difference between the sets of data is that the test pits for the Substation report were dug at a more even spread from 1-10 feet below ground. A saturated hydraulic conductivity of 17 inches per hour has been used for design purposes, given the characteristics of the infiltration testing from the Substation report having more robust data at the depth this project's facility will be set at. If a geotechnical analysis is done in later design stages of this project, the design hydraulic conductivity shall be adjusted per the recommendations from that investigation.

2.3 Existing Drainage System

It is understood from the lack of topographic change across the site, the site's soil properties, the lack of a nearby conveyance system, and given that the site is currently pervious, that runoff from the site is currently infiltrated. The system emanating from the PUD battery facility east of the site does not capture runoff from the project site.

2.4 Existing Utilities

The site itself does not contain any utilities but will be a utility site when developed as the site for the new PUD battery. The only underground feature at the site according to the survey is the storm line from the existing battery facility to the east.

2.5 Existing Creeks and Wetlands

The project does not contain a creek or wetland.

3.0 MINIMUM REQUIREMENTS

3.1 Design Standards

This project was designed in accordance with the 2024 Stormwater Management Manual for Western Washington (SWMMWW). As the Ecology Manual does not cover conveyance standards, this project used Chapter 3 of the City of Arlington Public Works Standards and Specifications for stormwater conveyance design. For any aspects not covered in the City's standards, the 2024 WSDOT Hydraulics Manual was used for guidance.

3.2 Threshold Analysis

3.2.1 Project Level Threshold Analysis

There are a total of nine minimum requirements listed in the SWMMWW that may apply to projects. The following step-by-step threshold analysis demonstrates which minimum requirements apply to this project. The steps for this analysis can also be followed by referring to Figures I-3.1 through I-3.2 (Minimum Requirement Applicability Flow Charts) in Volume 1 of the SWMMWW.

Tables 3.1 and 3.2 show the total existing and total new impervious surface areas both non-pollution generating (NPGIS) and pollution generating (PGIS) for the entire project site. The existing and proposed impervious surface areas listed below were derived from the area delineations shown in Figure A.2 and B.1, found in Appendices A and B of this report. NPGIS areas typically consist of sidewalks and top of curb surfaces while PGIS areas consist of surfaces designed for motor vehicle use.

Table 3.1. Existing Area Breakdown.

	Non-Pollution Generating Hard Surface (NPGHS)	Pollution Generating Hard Surface (PGHS)	Total Existing Hard Surface Area	Pervious Surface	Total Area
Project Site	29,772 SF	3,071 SF	**32,843 SF**	34,276 SF	**67,119 SF**

Table 3.2. Proposed Area Breakdown.

	New Non-Pollution Generating Hard Surface (NPGHS)	New Pollution Generating Hard Surface (PGHS)	Total New Hard Surface	Pervious Surface	Total Area
Project Site	11,972 SF	55,147 SF	**67,119 SF**	0 SF	**67,119 SF**

The following project level threshold analysis is a step-by-step procedure used to determine which minimum requirements this project must satisfy. The areas listed in Tables 3.1 through 3.2 are used to determine if the minimum requirement thresholds are exceeded.

Table 3.3. Minimum Requirements (MR) Applicability Procedure – Project Level.

Questions	Response	Action Required
Question 1: Does the site have 35% or more of existing impervious coverage?	**Yes,** hard surfaces make up 49% of the site in the existing condition.	Continue to Question 2.
Question 2: Does the project result in 2,000 square feet or more of new plus replaced hard surface area? **Or** Does the land disturbing activity total 7,000 square feet or greater?	**Yes,** the project 67,119 SF of new hard surface area.	MRs 1-5 apply to new and replaced hard surfaces and the land disturbed.
Question 3: Does the project add 5,000 square feet or more of new plus replaced hard surfaces? **Or** Convert ¾ acres or more of vegetation to lawn or landscaped area? **Or** Convert 2.5 acres or more of native vegetation to pasture?	**Yes,** the project totals 67,119 SF of new plus replaced hard surface area.	All minimum requirements apply to the new hard surfaces and converted vegetation areas.
Question 4: Is this a road-related project?	**No.**	Continue to Question 5.
Question 5: Does the project add 5,000 square feet or more of new plus replaced hard surfaces? **AND** Does the value of the proposed improvements – including interior improvements – exceed 50% of the assessed value (or replacement value) of the: • Existing project site improvements (for commercial or industrial projects) **OR** • Existing site improvements (for all other projects	**Yes,** the project totals 67,119 SF of new plus replaced hard surfaces **AND** The value of the proposed improvements will exceed the value of the existing site.	All minimum requirements Apply to the new hard surfaces and replaced hard surfaces and converted vegetation areas.

Results of Project Level Threshold Analysis

As a result of the project level threshold determination conducted by following Questions 1 through 5 above, Minimum Requirements 1 through 9 shall apply to the new and replaced hard surfaces and the land disturbed.

3.2.2 TDA Level Threshold Analysis

Once the project level threshold analysis is complete, a TDA level analysis is conducted to determine whether Minimum Requirements 6 and 7 (Runoff Treatment and Flow Control) will be required within each TDA associated with the project and to what extent. This procedure follows the requirement criteria outlined in Volume I of the SWMMWW. The areas listed in Tables 3.1 through 3.2 above were used for the following analysis.

Table 3.4 Minimum Requirements Applicability Procedure – TDA.

Questions	Response	Action Required
Question 1: Does the project add 5,000 square feet or more of pollution-generating hard surfaces in the TDA? **Or** Does the project add ¾ of an acre or more of pollution-generating pervious surface in the TDA, and from which there will be a surface discharge in a natural or man-made conveyance system?	**Yes**, there are 51,127 square feet of new pollution-generating hard surface in the TDA.	Minimum Requirement 6 **applies** to the new and replaced pollution-generating hard surfaces within the TDA. Continue to Question 2.
Question 2: Is the effective impervious surface equal to or greater than 10,000 square feet in the TDA? **Or** Does the project convert 3/4 acre or more of vegetation to lawn or landscape, and from which there is a surface water discharge into a natural or man-made conveyance system from the site? **Or** Does the project convert 2.5 acres or more of native vegetation to pasture in a TDA, and from which there is a surface water discharge into a natural or man-made conveyance system from the site? **Or** Through a combination of hard surfaces and converted vegetation areas, does the particular TDA cause a 0.15 cfs or more increase in the 100-year recurrence interval flow?	**Yes,** there are 64,003 square feet of effective impervious surface in the TDA. There are no non-effective surfaces.	Minimum Requirement 7 **applies** to the new and replaced hard surfaces in the TDA.

Table 3.6. Minimum Requirements 6 and 7 Summary Table.

TDA	Minimum Requirement 6 (Runoff Treatment)	Minimum Requirement 7 (Flow Control)
1	YES	YES

3.3 Minimum Requirement Summary

The intent of this section is to show how each of the minimum requirements, as outlined in the SWMMWW, are being addressed for this project. The minimum requirements are listed in the table below and a brief description follows each requirement.

Table 3.4. Complete Minimum Requirements Summary Table.

Requirement	Project Conformance/Method of Compliance
1. Stormwater Site Plan Preparation	A stormwater site plan (SSP) is a comprehensive report containing all of the technical information and analysis necessary for the evaluation of a proposed new development or redevelopment project for compliance with the requirements. A stormwater site plan, which includes this drainage report detailing minimum requirements, existing conditions, proposed stormwater management features. The other component of the stormwater site plan are the associated construction

Requirement		Project Conformance/Method of Compliance
		drawings. A copy of the drainage drawings has been provided in Appendix D of this report.
2.	Stormwater Pollution Prevention (SWPPP)	The objective of a construction stormwater pollution prevention plan is to ensure construction projects do not impair water quality by allowing sediment to discharge from the site or allowing pollutant spills. There are 13 elements that need to be addressed by the SWPPP. A standard Stormwater Pollution Prevention Plan (SWPPP) in accordance with Volume II, Chapter 2 of the 2024 SWMMWW will be produced as part of this project and included in the submittal as separate document.
3.	Source Control of Pollution	The intention of source control is to prevent pollutants from coming into contact and mixing with stormwater. In many cases, it is more cost-effective to apply source control than to remove pollutants after they are mixed with runoff. This is certainly the case for erosion control and spill prevention during the construction phase. Source control will be achieved during construction using the appropriate source control BMPs outlined in the Construction SWPPP.
4.	Preservation of Natural Drainage Systems and Outfalls	The intent of maintaining the natural drainage system is to 1) preserve and utilize natural drainage systems to the fullest extent because of the multiple benefits such systems provide, and 2) prevent erosion at, and downstream of, the discharge location. The project will maintain the natural drainage pattern to the maximum extent practicable as runoff will be infiltrated and join approximately the same underground flow path as it is assumed to follow in the existing condition.
5.	On-Site Stormwater Management	The purpose of on-site stormwater management is to infiltrate, disperse, and retain stormwater runoff on-site to the maximum extent feasible without causing flooding or erosion impacts, and to reduce the hydrologic disruption of developed sites. The LID performance standard will be met because the proposed infiltration trench has been designed to infiltrate 100% of runoff.
6.	Runoff Treatment	The purpose of runoff treatment is to reduce pollutant loads and concentrations in stormwater runoff using physical, biological, and chemical removal mechanisms to maintain or enhance beneficial uses of receiving waters. When site conditions are appropriate, infiltration can potentially be the most effective BMP for runoff treatment. Meeting runoff treatment requirements may also be achieved through regional stormwater facilities. Runoff treatment is required for this project based on the above threshold analysis. Runoff treatment will be accomplished through a Modular Wetland (a proprietary biofiltration BMP). It has been determined that without modification of existing soils, infiltration on the site will be too fast for the soils to provide sufficient treatment.
7.	Flow Control	The objective of flow control is to prevent increases in the stream channel erosion rates beyond natural or pre-established patterns. The intent is to prevent cumulative future impacts from increased stormwater runoff volumes and flow rates on streams. Wherever possible, infiltration is the preferred method of flow control. Meeting flow control requirements may also be achieved through regional stormwater facilities. Flow control is required for this project. An infiltration trench has been designed to fully infiltrate runoff, going beyond the standard for flow control.

Requirement	Project Conformance/Method of Compliance
8. Wetland Protection	The objective of wetlands protection is to ensure wetlands receive the same level of protection as any other waters of the state. Wetland protection is not required for this project.
9. Operations and Maintenance	The objective of operation and maintenance is to achieve appropriate preventative maintenance and performance checks to ensure stormwater control facilities are adequately maintained and properly operated. An operations and maintenance manual is included in Appendix E of this report.

Table 3.5. Minimum Requirement 5 Summary Table.

BMP	Feasible?	Location	Explanation
Full Dispersion	No	N/A	The site is not bounded by vegetated areas that would be conducive to full dispersion.
Permeable Pavement	No	N/A	Per infiltration rates listed in the Geotech reports in Appendix X, permeable pavement is feasible from a flow control standpoint. With the high native infiltration rates on site, providing sufficient water quality treatment is not practicable. In addition, this type of access road is not a typical permeable pavement application. Heavy vehicles using the access road would put high loads on the pavement, reducing efficacy as the pavement is worn down.
Bioretention	No	N/A	Siting a bioretention area is not feasible, the entire site is impervious.
Downspout Dispersion Systems	No	N/A	This solution is not practicable, a very low percentage of the site is covered by buildings, and no dispersion area exists on site.
Perforated Stub Out Connections	No	N/A	This solution is not practicable, a very low percentage of the site is covered by buildings.
Sheet Flow Dispersion	No	N/A	Sheet flow dispersion is infeasible due to lack of good vegetation surrounding the site, and the likelihood that areas around the site will be developed further in the future. It is recommended that runoff be controlled on-site.
Concentrated Flow Dispersion	No	N/A	concentrated flow dispersion is infeasible due to lack of good vegetation surrounding the site, and the likelihood that areas around the site will be developed further in the future. It is recommended that runoff be controlled on-site.
Post-Construction Soil Quality and Depth	No	N/A	Site shall be impervious, there are no landscaped areas proposed.

4.0 STORMWATER CONTROL PLAN

4.1 Off-Site Analysis

Table 4.1 below provides the applicable information sources that were consulted as part of the offsite analysis research performed for the project. These sources helped to provide an overall view of the project site, its downstream areas, and any existing and potential impacts on downstream waters and properties.

Table 4.1. Information Sources Consulted.

Item #	Source Reviewed	Findings
1	GIS Data	Project vicinity map, aerial photograph, road features, vegetation, topography, land use, etc.
2	Topography	On-site topography and utilities provided by survey.
3	FEMA Map	The project does not lie within a floodplain. See Appendix F for FEMA Flood Map.
4	Geotechnical Reports	A geotechnical investigation has been completed, and it has been determined that infiltration is infeasible on-site due to the presence of a dense glacial till layer.

4.1.1 Upstream Analysis

An upstream analysis was not performed as part of this project. The site is a local high point, there is no runoff onto the site from another source.

4.1.2 Downstream Analysis

The downstream analysis for this project included a review of resources and an investigation of possible effects due to proposed project improvements. The resource review is discussed above, and the existing hydrology, proposed hydrology, and potential impacts are discussed below.

4.1.3 TDA Downstream Analysis

Due to the infiltration characteristics of the site and the lack of point discharges, the traditional definition of a TDA is not directly applicable to this project. This entire site has been assumed as a single TDA due to its hydrologic characteristics. It is understood that runoff from the project site infiltrates in the existing condition, percolating through the sandy soils before hitting the water table. It is estimated that site water will flow downgradient underground, following the gentle topography, which generally slopes to the southwest.

4.1.4 Downstream Conveyance Impacts

There is no downstream conveyance system from the project site.

4.1.5 Mitigation of Existing Problems and Potential Impacts

The site is designed so that all runoff is directed to a treatment facility. The estimated hydraulic conductivity of 17 inches per hour is not conducive to natural treatment of runoff produced by the project site. Any impacts that could result from pollutants entering the groundwater is mitigated by treatment prior to infiltration.

4.2 Pre-Developed Site Hydrology

The project encompasses a total of approximately 1.5 acres of currently undeveloped land that was previously a solar array. Site hydrology consists of on-site infiltration due to the gentle topography and infiltrative soils. The site is mostly flat but slopes down from a high point at the northeast end of the site of 137 feet to an elevation of 136 feet throughout the site. At the southwest end, the elevation drops down to 135 feet. The elevations around the site are down to 135 feet so runoff spreads to the east, north, and west into surrounding areas if not infiltrated on site. Offsite to the south is the continuation of the old site used for the solar array, which is also at approximately 136 feet.

4.3 Developed Site Hydrology

The developed site will consist of an access road crossing the bottom of the site, Tesla batteries on the west side of the site, and several maintenance-related buildings in the center and east end of the site. The surfacing on site will consist of asphalt for the road surface, and gravel for other areas of the site. The gravel shall consist of two layers: a top layer of substation gravel as a typical non-conductive safety measure applied for energy storage sites, and a bottom layer of maximally compacted crushed surfacing top course to reduce infiltration as much as possible. The site will be graded so that runoff will sheet flow to the south to catch basins on the access road, treated in a Modular Wetland, and infiltrated with an infiltration trench.

4.4 Stormwater Flow Control Plan

Flow control is required for the project, per the threshold analysis in Section 3.0 of this report. An infiltration trench is proposed to fully infiltrate runoff from the project site. Per the SWMMWW, the following flow control standards must be met:

- Provide storage volume required to match the duration of pre-developed peak flows from 50% of the 2-year up to the 50-year storm flow.
- On-site pre-developed land-use is to be assumed as forested conditions, regardless of actual existing site conditions.

Flow control modeling for this project was performed in MGSFlood, an Ecology approved continuous simulation software. Results of the infiltration trench modeling are included in Appendix C of this report. The trench was modeled with a stage storage table, created by estimating the void space of the trench, and factoring in the storage provided by the 12" underdrain that will extend through the trench. The stage storage input for the iteration that shows infiltration of 100% of the runoff was based off a 156'x10' trench footprint, with 4 feet of depth.

The trench is proposed to be installed in three parallel 52'X10' sections, for a total length of 156'. The trench will be filled with porous gravel, except that each section of the trench will have in its center a 12" underdrain as previously mentioned to encourage even distribution of stormwater volume throughout the trench to prevent dead zones. This ensures that as much of the available storage space is used as possible to help prevent backwater into

the inlet pipe. The trench is proposed to have approximately 0.5 feet of gravel below the pipe, and approximately 2.5 feet above the pipe for a total of 4 feet of depth.

4.5 Stormwater Water Quality Treatment Plan

As determined by the threshold analysis in Section 3.0 of this report, water quality treatment will be required for the project. A Modular Wetland is proposed as the treatment structure prior to the infiltration trench. The facility was sized using the water quality flow rates obtained from MGSFlood. The methodology for obtaining these flow rates is shown in Appendix C. The key parameters from the program output are provided below in Table 4.5.1.

Table 4.5.1. Water Quality Parameters

Design Parameter	Value (CFS)
On-line Water Quality Flow Rate	0.255
Off-line Water Quality Flow Rate	0.147
100-year Flow Rate	1.650

These statistics were given to the Modular Wetland manufacturer, Contech, so that they could recommend a size for the unit. The recommended unit is an 8'x8' Modular Wetland with an internal bypass for high flows.

4.6 Conveyance Analysis

A conveyance analysis has not yet been performed for this project, but it will be performed in later stages of design if deemed necessary.

5.0 STORMWATER POLLUTION PREVENTION PLAN (SWPPP)

A SWPPP was included as a part of this project and has been prepared as a separate document.

6.0 SPECIAL REPORTS AND STUDIES

A geotechnical report has been completed and is included in Appendix H.

7.0 OTHER PERMITS

- SEPA
- NPDES Permit

8.0 OPERATIONS AND MAINTENANCE

Snohomish County PUD shall be responsible for the maintenance and operation of on-site drainage facilities.

1. Drainage facilities shall be maintained at appropriate times so that their water quantity and water quality control functions, and access are not impaired; and shall include keeping all drainage facilities and access areas free of accumulated debris, trash, or sediment.
2. Maintenance of all drainage facilities shall be conducted by the responsible party in compliance with an operation and maintenance plan for drainage facilities developed in accordance with the requirements of this title.

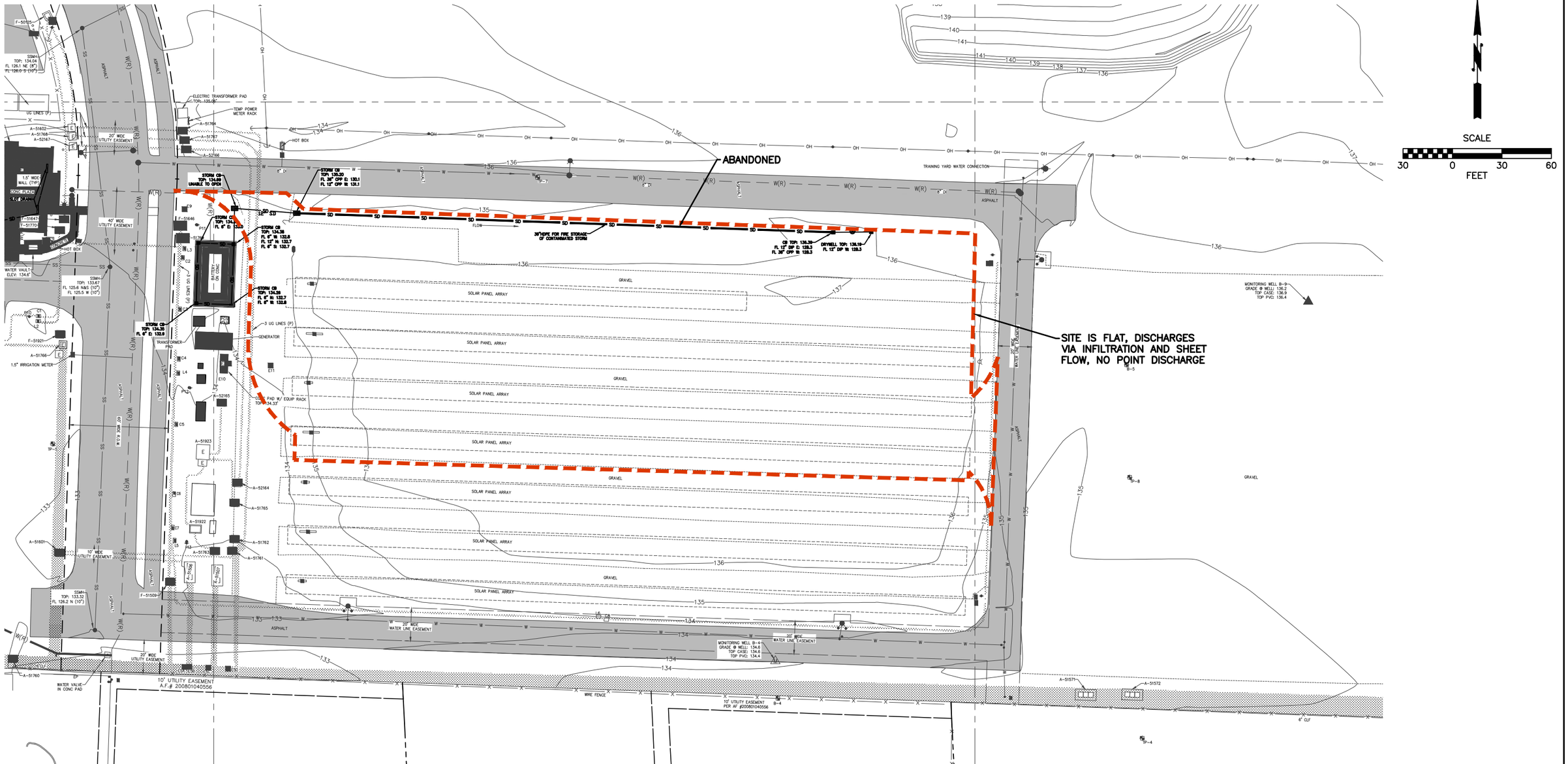
An operations and maintenance manual is included in Appendix E of this report.

The proposed drainage system consists of the following elements:

- Catch Basins
- Storm Drain Pipe
- Underdrain Pipe
- Infiltration Trench
- Modular Wetland

APPENDIX A

Existing Condition Figures



LEGEND

- SHEET FLOW
- TDA LIMITS
- DISCHARGE POINT
- OFFSITE FLOW ENTERS SITE
- SD — EXISTING STORM PIPE
- EXISTING TYPE 1 CB
- EXISTING TYPE 2 CB

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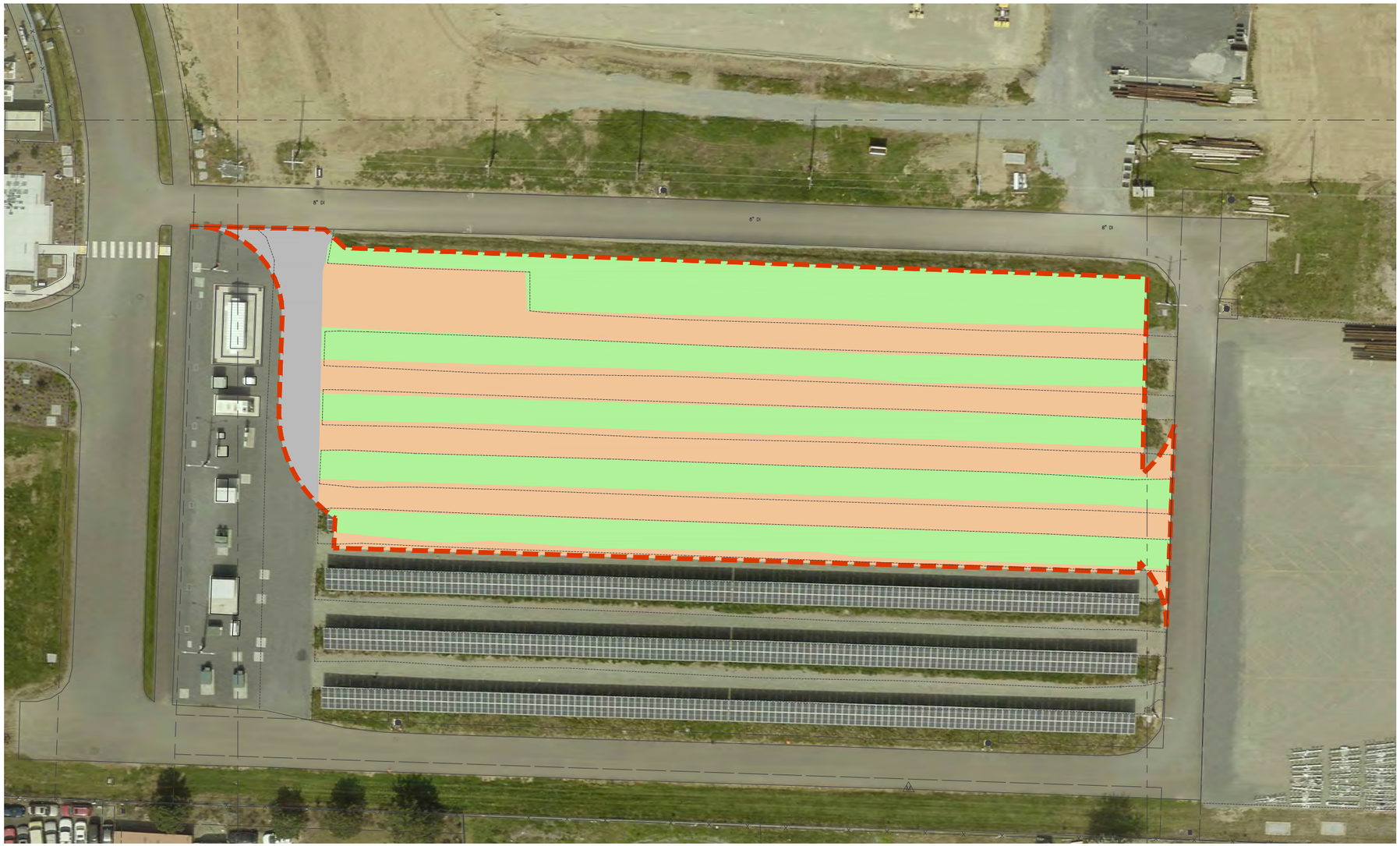
SNOHOMISH COUNTY PUD
25MW BESS
EXISTING DRAINAGE CONDITIONS

FIGURE A.1

Sep 30, 2024 - 2:48pm nathan.hahne X:\Snohomish County PUD\Projects\20230200 - 25MW BESS Arlington\CADD\05 - Exhibits\Drainage\20230200-Existing Drainage Conditions.dwg Layout Name: A.1



SCALE
30 0 30 60
FEET

LEGEND
- NPGIS
- PGIS
- PERVIOUS
- PROJECT LIMITS

	EXISTING PGIS	EXISTING NPGIS	**TOTAL IMPERVIOUS**	PERVIOUS	**TOTAL AREA**
PROJECT TOTAL	3,071 SF	29,772 SF	32,843 SF	34,276 SF	67,119 SF

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SNOHOMISH COUNTY PUD
25MW BESS
EXISTING IMPERVIOUS AREAS

FIGURE
A.2

Sep 30, 2024 - 2:19pm nathan.hahne X:\Snohomish County PUD\Projects\20230200 - 25MW BESS Arlington\CADD\05 - Exhibits\Drainage\20230200-Existing Impervious Areas.dwg Layout Name: A.1

APPENDIX B

Developed Condition Figures

Proposed Impervious Areas – B.1

SCALE

30 0 30 60

FEET

LEGEND

- NEW NPGIS
- REPLACED NPGIS
- NEW PGIS
- REPLACED PGIS
- CONVERTED NPGIS
- PERVIOUS
- PROJECT LIMITS

	NEW PGIS	REPLACED PGIS	NEW NPGIS	REPLACED NPGIS	**TOTAL NEW IMPERVIOUS**	NPGIS CONVERTED TO PGIS	PERVIOUS	**TOTAL AREA**
PROJECT TOTAL	55,147 SF		11,972 SF		67,119 SF			67,119 SF

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SNOHOMISH COUNTY PUD
25MW BESS
PROPOSED IMPERVIOUS AREAS

FIGURE B.1

Nov 06, 2024 - 10:40pm nathan.hahne X:\Snohomish County PUD\Projects\20230200 - 25MW BESS Arlington\CADD\05 - Exhibits\Drainage\20230200-Proposed Impervious Areas.dwg Layout Name: B.1

APPENDIX C

Calculations

Water Quality and Flow Control Calculations

20230200 – Snohomish County PUD 25MW BESS

CALCULATION REPORT	
Calculated by: Nathan Hahne, EIT	Date: 10/09/2024
Checked By:	Date:

Infiltration Trench Calculations

Objective: The purpose of this analysis is to:

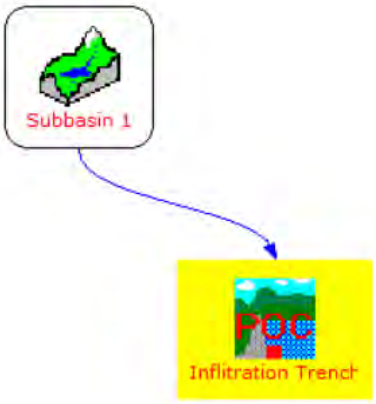
- Calculate the capacity of the proposed infiltration trench to meet flow control requirements

Key Design Factors and Assumptions:

- Hydrologic analysis was performed using MGSFlood.
- Puget East 48-inch MAP was used.
- A 15-minute time step was used for this calculation.
- The proposed trench is 156’ long, 10’ wide.
- The saturated hydraulic conductivity was assumed to be 17 in/hour.
- A void ratio of 0.4 was assumed.

Pre-development

Post-development



MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.57
Program License Number: 200310001
Project Simulation Performed on: 09/30/2024 3:05 PM
Report Generation Date: 09/30/2024 3:49 PM

Input File Name: InfilTrench.fld
Project Name: 25MW BESS Arlington
Analysis Title: Infiltration Trench
Comments: Sizing Infiltration trench to fully infiltrate site runoff

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 17

Full Period of Record Available used for Routing
Precipitation Station : 96004805 Puget East 48 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961048 Puget East 48 in MAP
Evaporation Scale Factor : 0.750

HSPF Parameter Region Number: 1
HSPF Parameter Region Name : Ecology Default

********** Default HSPF Parameters Used (Not Modified by User) **********

********** **WATERSHED DEFINITION** **********

Predevelopment/Post Development Tributary Area Summary

	Predeveloped	Post Developed
Total Subbasin Area (acres)	1.540	1.540
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	1.540	1.540

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

	-------Area (Acres) --------
C, Forest, Flat	1.540
Subbasin Total	1.540

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1

---------- Subbasin : Subbasin 1 ----------

	-------Area (Acres) --------
ROADS/FLAT	1.540
Subbasin Total	1.540

********** **LINK DATA** **********

----------SCENARIO: PREDEVELOPED
Number of Links: 0

********** **LINK DATA** **********

----------SCENARIO: POSTDEVELOPED
Number of Links: 1

Link Name: Inflitration Trench
Link Type: Structure
Downstream Link: None

User Specified Elevation Volume Table Used

Elevation (ft)	Pond Volume (cu-ft)
100.00	0.
100.20	125.
100.40	250.
100.60	374.
100.80	499.

101.00	624.
101.20	759.
101.40	901.
101.60	1045.
101.80	1186.
102.00	1322.
102.20	1495.
102.40	1620.
102.60	1745.
102.80	1870.
103.00	1995.
103.20	2119.
103.40	2244.
103.60	2369.
103.80	2494.
104.00	2619.

Constant Infiltration Option Used
Infiltration Rate (in/hr): 17.00

Riser Geometry
Riser Structure Type : Circular
Riser Diameter (in) : 24.00
Common Length (ft) : 0.000
Riser Crest Elevation : 103.99 ft

Hydraulic Structure Geometry

Number of Devices: 0

**********FLOOD FREQUENCY AND DURATION STATISTICS**********

----------SCENARIO: PREDEVELOPED
Number of Subbasins: 1
Number of Links: 0

----------SCENARIO: POSTDEVELOPED
Number of Subbasins: 1
Number of Links: 1

********** Link: Inflitration Trench ********** Link WSEL Stats
WSEL Frequency Data(ft)
(Recurrence Interval Computed Using Gringorten Plotting Position)

Tr (yrs)	WSEL Peak (ft)
1.05-Year	100.012
1.11-Year	100.013
1.25-Year	100.015
2.00-Year	100.027
3.33-Year	100.218
5-Year	100.433
10-Year	101.049
25-Year	101.562

50-Year 102.724
100-Year 103.784

*************Groundwater Recharge Summary ***************
Recharge is computed as input to Perlnd Groundwater Plus Infiltration in Structures

Total Predeveloped Recharge During Simulation

Model Element	Recharge Amount (ac-ft)
Subbasin: Subbasin 1	316.428
Total:	316.428

Total Post Developed Recharge During Simulation

Model Element		Recharge Amount (ac-ft)
Subbasin: Subbasin 1		0.000
Link:	Inflitration Trench	855.122
Total:		855.122

Total Predevelopment Recharge is Less than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 2.003 ac-ft/year, Post Developed: 5.412 ac-ft/year

*************Water Quality Facility Data ***************

----------SCENARIO: PREDEVELOPED

Number of Links: 0

----------SCENARIO: POSTDEVELOPED

Number of Links: 1

********** Link: Inflitration Trench **********

Basic Wet Pond Volume (91% Exceedance): 7990. cu-ft
Computed Large Wet Pond Volume, 1.5*Basic Volume: 11986. cu-ft

2-Year Discharge Rate : 0.000 cfs

15-Minute Timestep, Water Quality Treatment Design Discharge
On-line Design Discharge Rate (91% Exceedance): 0.27 cfs
Off-line Design Discharge Rate (91% Exceedance): 0.15 cfs

Time to Infiltrate 91% Treatment Volume, (Hours): 3.61

Infiltration/Filtration Statistics----------
Inflow Volume (ac-ft): 855.12
Inflow Volume Including PPT-Evap (ac-ft): 855.12

Total Runoff Infiltrated (ac-ft): 855.12, 100.00%
Total Runoff Filtered (ac-ft): 0.00, 0.00%
Primary Outflow To Downstream System (ac-ft): 0.00
Secondary Outflow To Downstream System (ac-ft): 0.00
Volume Lost to ET (ac-ft): 0.00
Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 100.00%

**********Compliance Point Results **********

Scenario Predeveloped Compliance Subbasin: Subbasin 1

Scenario Postdeveloped Compliance Link: Inflitration Trench

*** Point of Compliance Flow Frequency Data ***
Recurrence Interval Computed Using Gringorten Plotting Position

Infiltration trench modeled to fully infiltrate runoff.

Predevelopment Runoff		Postdevelopment Runoff	
Tr (Years)	Discharge (cfs)	Tr (Years)	Discharge (cfs)
2-Year	4.558E-02	2-Year	0.000
5-Year	6.787E-02	5-Year	0.000
10-Year	8.708E-02	10-Year	0.000
25-Year	0.125	25-Year	0.000
50-Year	0.137	50-Year	0.000
100-Year	0.149	100-Year	0.000
200-Year	0.234	200-Year	0.000
500-Year	0.348	500-Year	0.000

** Record too Short to Compute Peak Discharge for These Recurrence Intervals

**** Flow Duration Performance ****

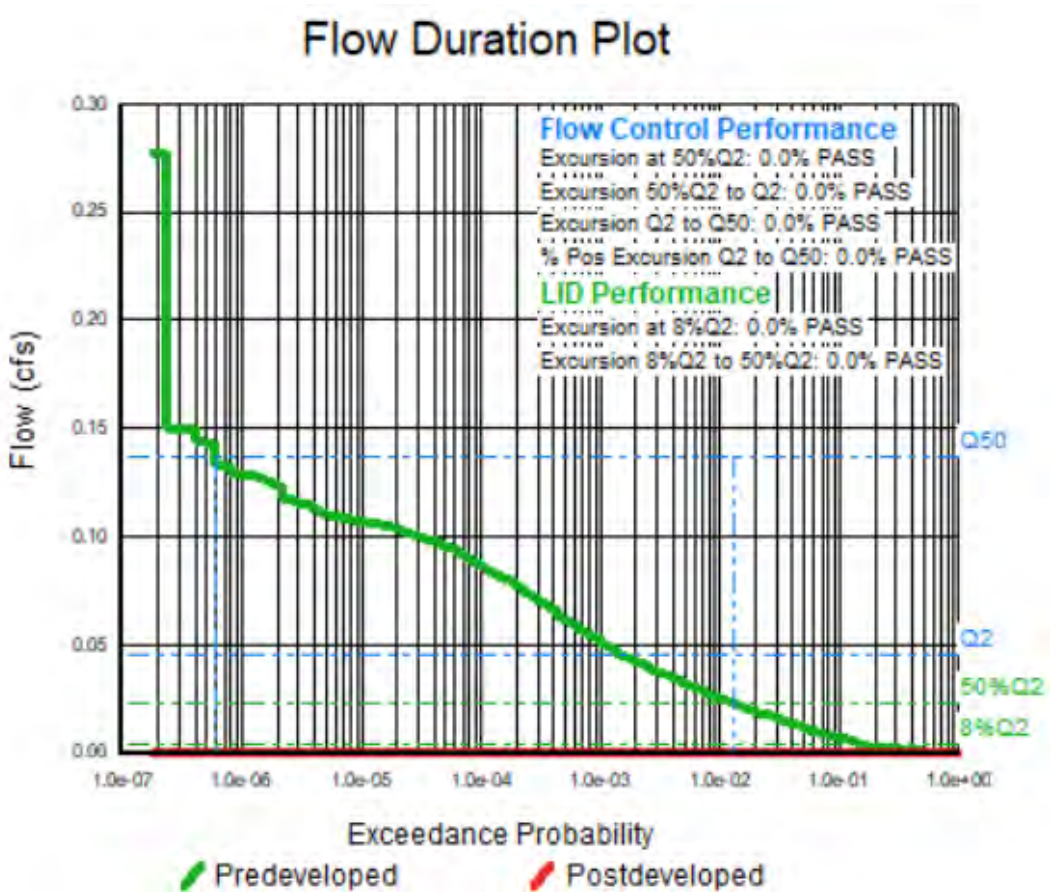
Excursion at Predeveloped 50%Q2 (Must be Less Than or Equal to 0%):	0.0%	PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	0.0%	PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	0.0%	PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

**** LID Duration Performance ****

Excursion at Predeveloped 8%Q2 (Must be Less Than 0%):	0.0%	PASS
Maximum Excursion from 8%Q2 to 50%Q2 (Must be Less Than 0%):	0.0%	PASS

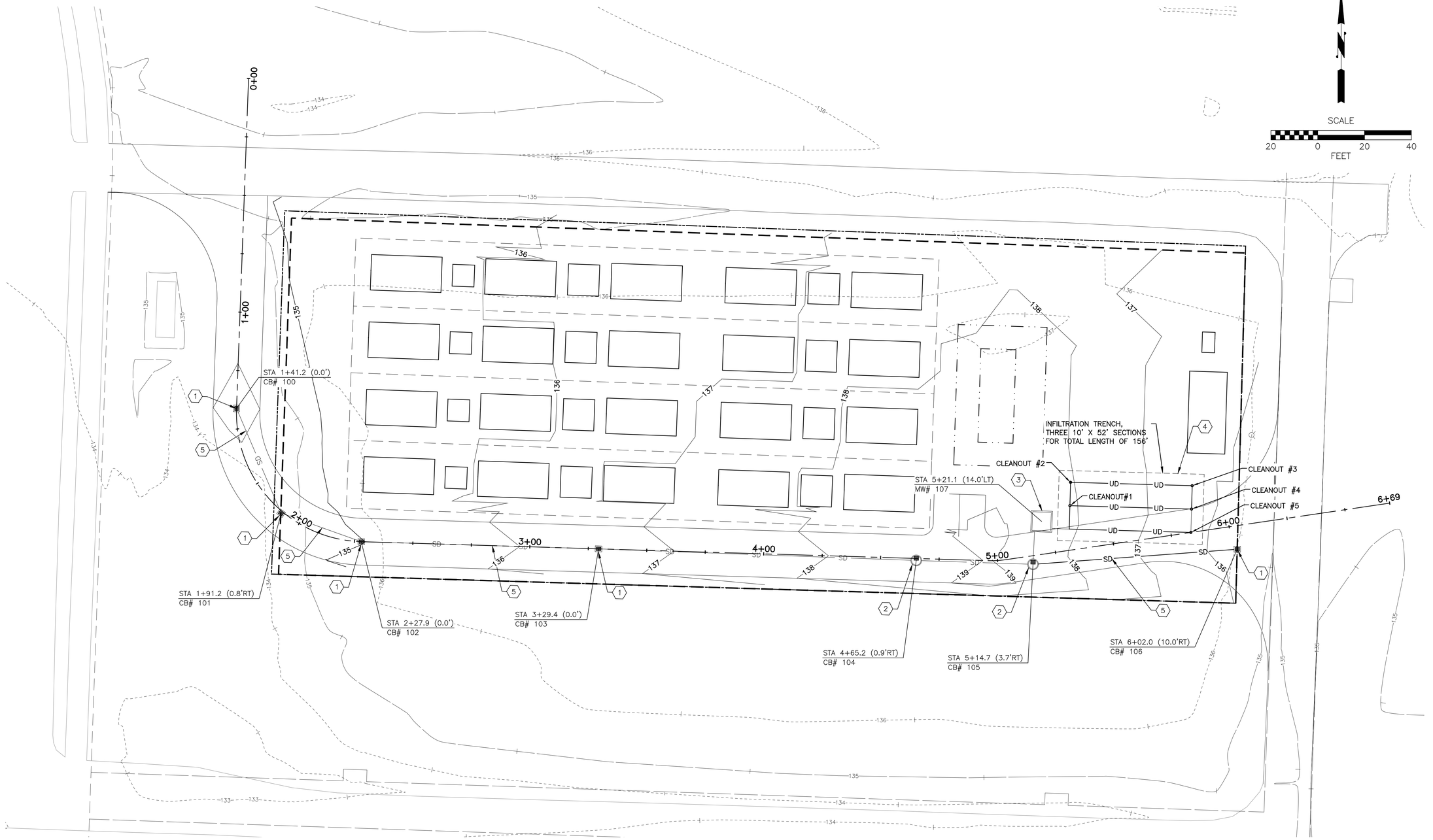
MEETS ALL LID DURATION DESIGN CRITERIA: PASS


Flow Duration Plot
Flow Control Performance
Excursion at 50%Q2: 0.0% PASS
Excursion 50%Q2 to Q2: 0.0% PASS
Excursion Q2 to Q50: 0.0% PASS
% Pos Excursion Q2 to Q50: 0.0% PASS
LID Performance
Excursion at 8%Q2: 0.0% PASS
Excursion 8%Q2 to 50%Q2: 0.0% PASS
Q50
Q2
50%Q2
8%Q2
Flow (cfs)
0.30
0.25
0.20
0.15
0.10
0.05
0.00
1.0e-07
1.0e-06
1.0e-05
1.0e-04
1.0e-03
1.0e-02
1.0e-01
1.0e+00
Exceedance Probability
Predeveloped
Postdeveloped

APPENDIX D

Proposed Drainage Plans

SEC. 15, T. 27 N, R. 4 E, W.M.



CITY OF ARLINGTON

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BY: _____
DEVELOPMENT SERVICES MANAGER

DATE: _____ THIS APPROVAL VALID FOR 18 MONTHS

CONSTRUCTION NOTES:

1. INSTALL CATCH BASIN TYPE 1 PER CITY OF ARLINGTON STD PLAN SD-020.
2. INSTALL CATCH BASIN TYPE 2 PER CITY OF ARLINGTON STD PLAN SD-030.
3. INTALL 8'x8' MODULAR WETLAND PER DETAIL ON SHEET DD1.
4. INSTALL INFILTRATION TRENCH PER DETAIL ON SHEET DD2.
5. INSTALL DUCTILE IRON STORM SEWER PIPE.

GENERAL NOTES:

1. REFER TO SHEET NT2 FOR THE OF CITY OF ARLINGTON'S STORM DRAINAGE NOTES.
2. ALL PROPOSED CATCH BASINS SHALL HAVE VANED GRATES PER CITY OF ARLINGTON STD PLAN SD-070 UNLESS OTHERWISE NOTED.
3. STORM SEWER PIPE MATERIAL SHALL BE PER CITY OF ARLINGTON DESIGN AND CONSTRUCTION STANDARDS AND SPECIFICATIONS. CONTRACTOR TO SELECT PREFERRED MATERIAL FROM THE CITY'S APPROVED LIST UNLESS A SPECIFIC MATERIAL IS SPECIFIED.
4. ALL UNDERDRAIN PIPE SHALL BE 12" DIAM. AND INSTALLED PER WSDOT STANDARD SPEC SECTION 7-01.3(2). CLEANOUTS SHALL BE INSTALLED PER DETAIL ON SHEET DD2.

LEGEND:

- CATCH BASIN TYPE 1
- CATCH BASIN TYPE 2
- MODULAR WETLAND
- SD — SD — STORM DRAINAGE PIPE
- UD — UD — UNDERDRAIN PIPE
- INFILTRATION TRENCH BOUNDARY
- CLEANOUT

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CLARK TARO KUNITA — STATE OF WASHINGTON — 21088 — REGISTERED PROFESSIONAL ENGINEER

PRELIMINARY NOT FOR CONSTRUCTION

SNOHOMISH COUNTY PUD 25MW BESS
AMERESCO
ARLINGTON, WA

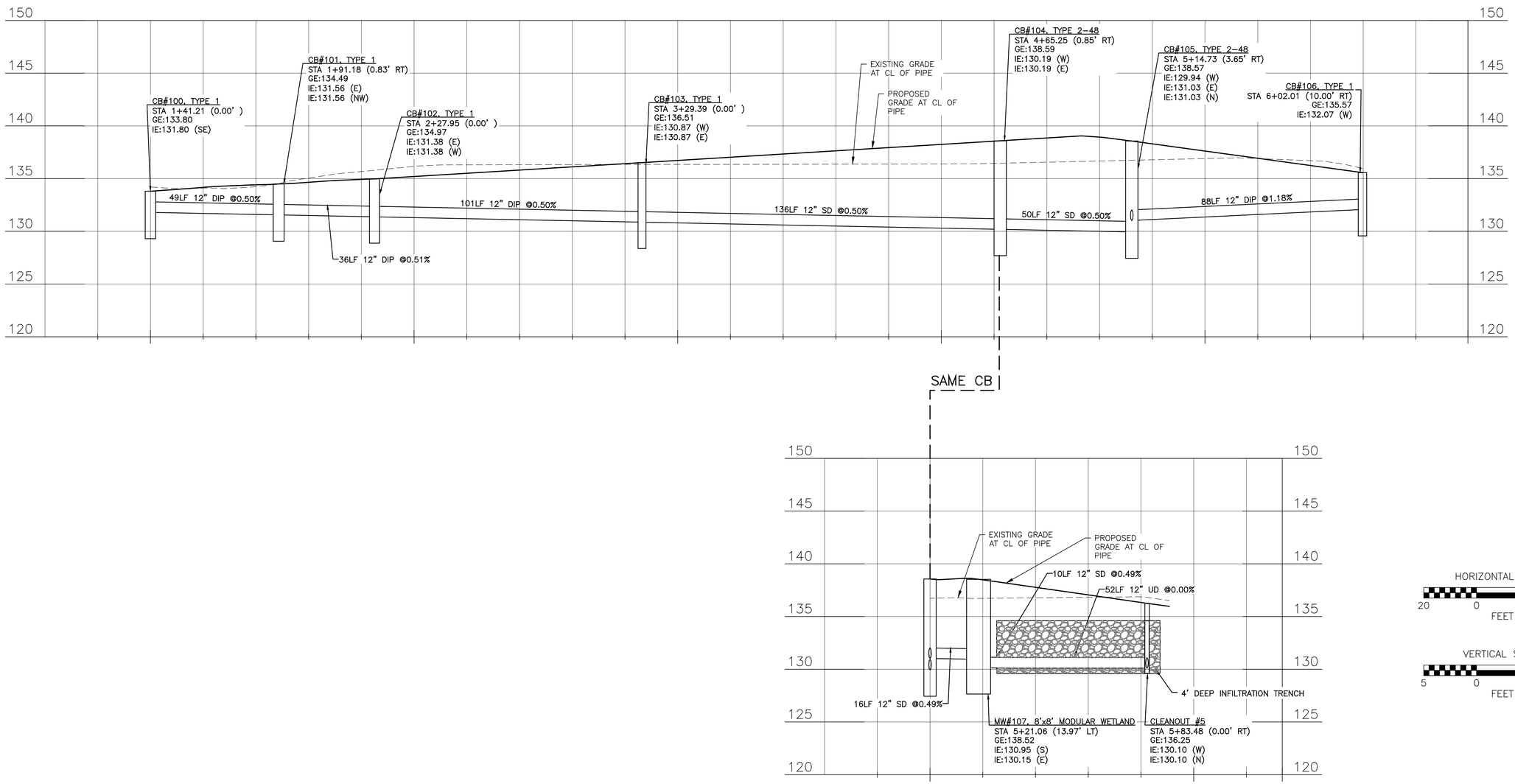
MARK	DATE	DESCRIPTION

PROJECT NO.:	1008707
CAD DWG. FILE:	20230200-DR.dwg
DRAWN BY:	BL
CHECKED BY:	NH

SHEET TITLE DR1

DRAINAGE PLAN

[AutoCAD 2020] Nov 06, 2024 - 2:27pm brendan.liddle X:\snohomish county pud\Projects\20230200 - 25mw bess arlington\CADD\02 - plan sheets\20230200-DR.dwg Layout Name: DR1



SAME CB

HORIZONTAL SCALE
20 0 20 40
FEET

VERTICAL SCALE
5 0 5 10
FEET

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AMERESCO
ARLINGTON, WA

MARK	DATE	DESCRIPTION

PROJECT NO.:	1008707
CAD DWG. FILE:	20230200-DP.dwg
DRAWN BY:	BL
CHECKED BY:	NH

SHEET TITLE DP1

DRAINAGE PROFILE

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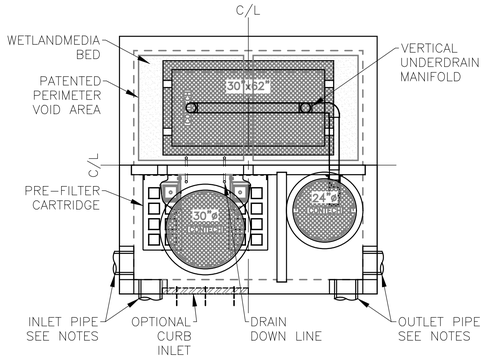
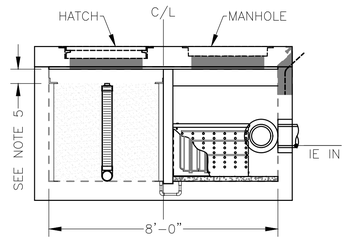
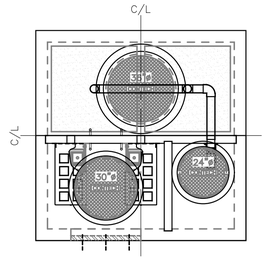
SITE SPECIFIC DATA			
PROJECT NUMBER		20230200.00	
PROJECT NAME		Snohomish County PUD 25MW BESS	
PROJECT LOCATION		Arlington, WA	
STRUCTURE ID		MW#106	
TREATMENT REQUIRED			
TREATMENT FLOW (CFS)			0.147
PRETREATMENT LOADING RATE (GPM/SF)			2.1 GPM/SF
WETLAND MEDIA LOADING RATE (GPM/SF)			1.00
PEAK BYPASS REQUIRED (CFS) – IF APPLICABLE			1.65 (CFS)
PIPE DATA	I.E.	MATERIAL	DIAMETER
INLET PIPE	130.95	PER GN#3 ON DR1	12"
OUTLET PIPE	130.15	PER GN#3 ON DR1	12"
	PRETREATMENT	BIOFILTRATION	DISCHARGE
RIM ELEVATION	138.52	138.52	138.52
SURFACE LOAD	HS-20		
NOTES:			



PLAN VIEW



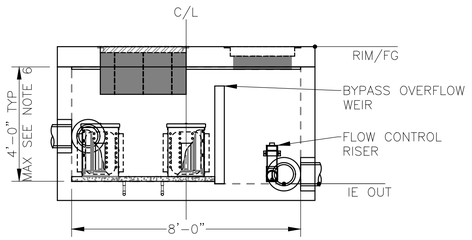
LEFT END VIEW



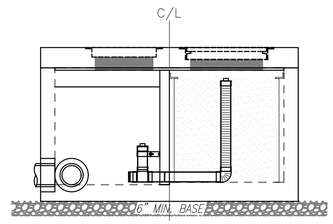
ALTERNATE DEEP ORIENTATION

INSTALLATION NOTES

1. CONTRACTOR TO PROVIDE ALL LABOR, EQUIPMENT, MATERIALS AND INCIDENTALS REQUIRED TO OFFLOAD AND INSTALL THE SYSTEM AND APPURTENANCES IN ACCORDANCE WITH THIS DRAWING AND THE MANUFACTURER'S SPECIFICATIONS, UNLESS OTHERWISE STATED IN MANUFACTURER'S CONTRACT.
2. UNIT MUST BE INSTALLED ON LEVEL BASE. MANUFACTURER RECOMMENDS A MINIMUM 6" LEVEL ROCK BASE UNLESS SPECIFIED BY THE PROJECT ENGINEER. CONTRACTOR IS RESPONSIBLE FOR VERIFYING PROJECT ENGINEER'S RECOMMENDED BASE SPECIFICATIONS.
3. CONTRACTOR TO SUPPLY AND INSTALL ALL EXTERNAL CONNECTING PIPES. ALL PIPES MUST BE FLUSH WITH INSIDE SURFACE OF CONCRETE (PIPES CANNOT INTRUDE BEYOND FLUSH). INVERT OF OUTFLOW PIPE MUST BE FLUSH WITH DISCHARGE CHAMBER FLOOR. ALL PIPES SHALL BE SEALED WATERTIGHT PER MANUFACTURER'S STANDARD CONNECTION DETAIL.
4. CONTRACTOR RESPONSIBLE FOR CONTACTING CONTECH FOR ACTIVATION OF UNIT. MANUFACTURER'S WARRANTY IS VOID WITHOUT PROPER ACTIVATION BY A CONTECH REPRESENTATIVE.
5. ALTERNATE DEEP FRAME & COVER ORIENTATION USED WHEN CEILING TO MEDIA DISTANCE IS 2.5' OR GREATER.
6. VERTICAL HEIGHT VARIES BASED ON SITE SPECIFIC REQUIREMENTS.



ELEVATION VIEW



RIGHT END VIEW

MODULAR WETLANDS — FOR PATENT INFORMATION, GO TO www.ContechES.com/IP

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MWS-L-8-8-V-UG
STORMWATER BIOFILTRATION SYSTEM
STANDARD DETAIL

CITY OF ARLINGTON

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SNOHOMISH COUNTY PUD 25MW BESS
AMERESCO
ARLINGTON, WA

MARK	DATE	DESCRIPTION

PROJECT NO.:	1008707
CAD DWG. FILE:	20230200-DD.dwg
DRAWN BY:	BL
CHECKED BY:	NH

SHEET TITLE DD1

DRAINAGE DETAILS

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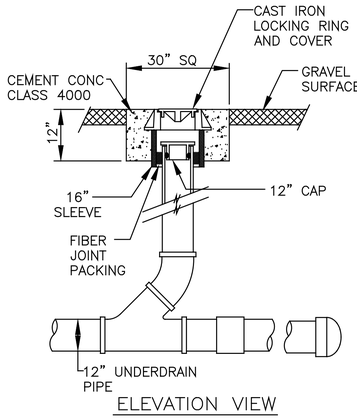
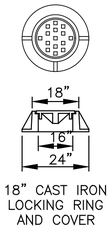


ELEVATION VIEW



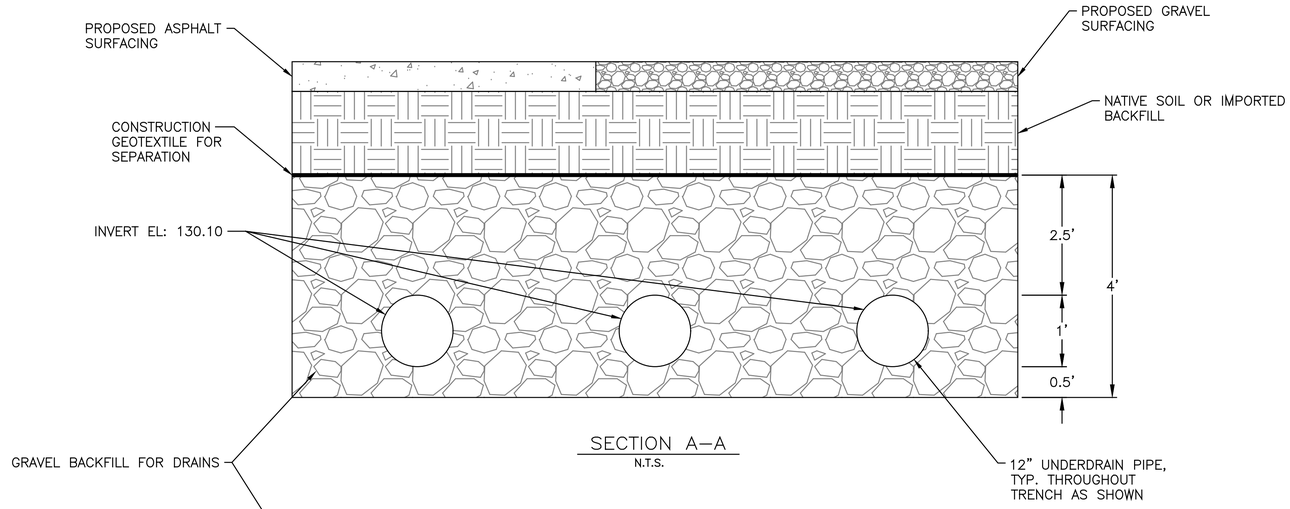
18" CAST IRON
LOCKING RING
AND COVER

NOTES:

1. STRAIGHT TEE IS NOT AN ACCEPTABLE REPLACEMENT FOR THE WYE.

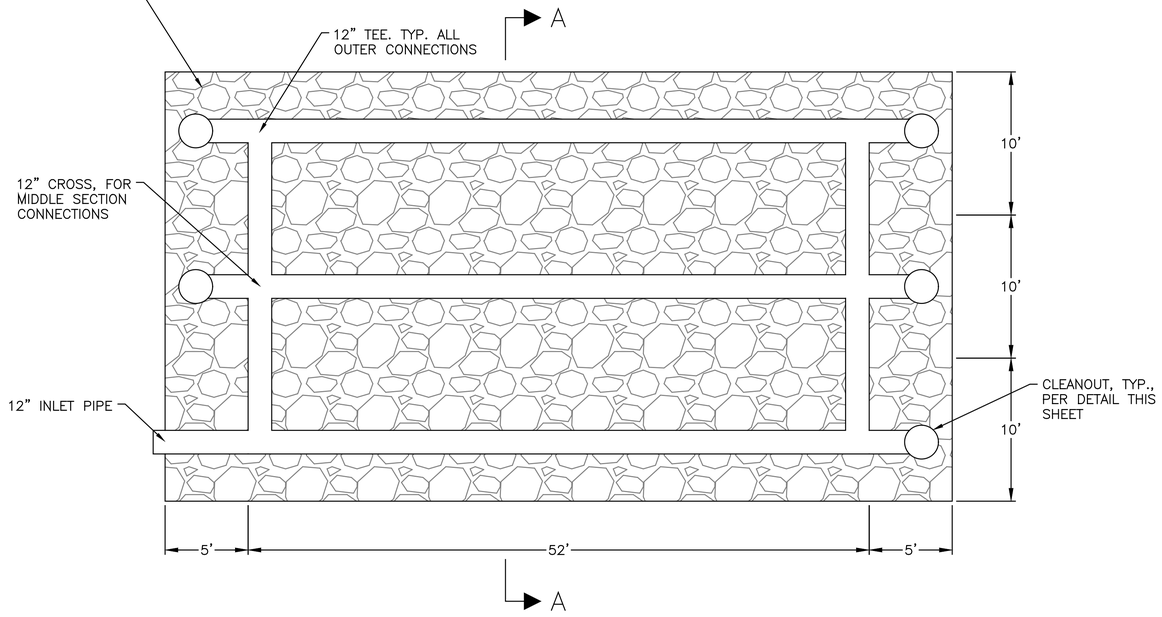
CLEANOUT DETAIL

N.T.S.



SECTION A–A

N.T.S.



INFILTRATION TRENCH DETAIL

N.T.S.

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SNOHOMISH COUNTY PUD 25MW BESS
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ARLINGTON, WA

MARK	DATE	DESCRIPTION

MARK	DATE	DESCRIPTION

PROJECT NO.:	1008707
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SHEET TITLE DD2

DRAINAGE DETAILS

SHEET 12 OF 15

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APPENDIX E

Operation and Maintenance Manual

Routine maintenance is an important part of any stormwater control plan. The major facilities listed below should be inspected and maintained as described. All other drainage features should also be regularly inspected (every 6 months or more frequently) and maintained as needed to maintain the effectiveness of the drainage system.

Inspection Point	Inspection Frequency	Maintenance Threshold
Catch basins / Pipes	Yearly	Conveyance elements should be cleaned when flow is impeded. It is advisable to remove sediment from catch basins on a regular schedule, every 2-3 years or when sump becomes half full, whichever is sooner.
Modular Wetland	Yearly	Maintain per Modular Wetland maintenance packet starting on the following page.
Underdrain Pipe	Yearly	It is advisable to remove any sediment from the underdrain when inspected.
Infiltration Trench	As Needed	Drain rock and geotextile to be replaced or cleaned when trench is no longer infiltrating all the runoff, for example if backwater is observed consistently upstream of the trench.

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Modular Wetlands® Linear Operatons & Maintenance Manual

MODULAR WETLANDS®

MODULAR WETLANDS LINEAR
OPERATION & MAINTENANCE MANUAL

TABLE OF CONTENTS

OVERVIEW

This operation and maintenance (O&M) manual is for the Modular Wetlands Linear Biofilter (MWL). Please read the instructions and equipment lists closely prior to starting. It is important to follow all necessary safety procedures associated with state and local regulations. Please contact Contech for more information on pre-authorized third-party service providers who can provide inspection and maintenance services in your area. For a list of service providers in your area, please visit www.conteches.com/maintenance.

WARNING

Confined space entry may be required. Contractor to obtain all equipment and training to meet applicable local and OSHA regulations regarding confined space entry. It is the Contractor's or entry personnel's responsibility to always proceed safely.

SAFETY NOTICE & PERSONAL SAFETY EQUIPMENT

Job site safety is a topic and a practice addressed comprehensively by others. The inclusions here are merely reminders to whole areas of Safety Practice that are the responsibility of the Owner(s), Manager(s), and Service Provider(s). OSHA and Canadian OSH, Federal, State/Provincial, and Local Jurisdiction Safety Standards apply on any given site or project. The knowledge and applicability of those responsibilities is the Service Provider's responsibility and outside the scope of Contech Engineered Solutions.

Safety Boots

Gloves

Hard Hat

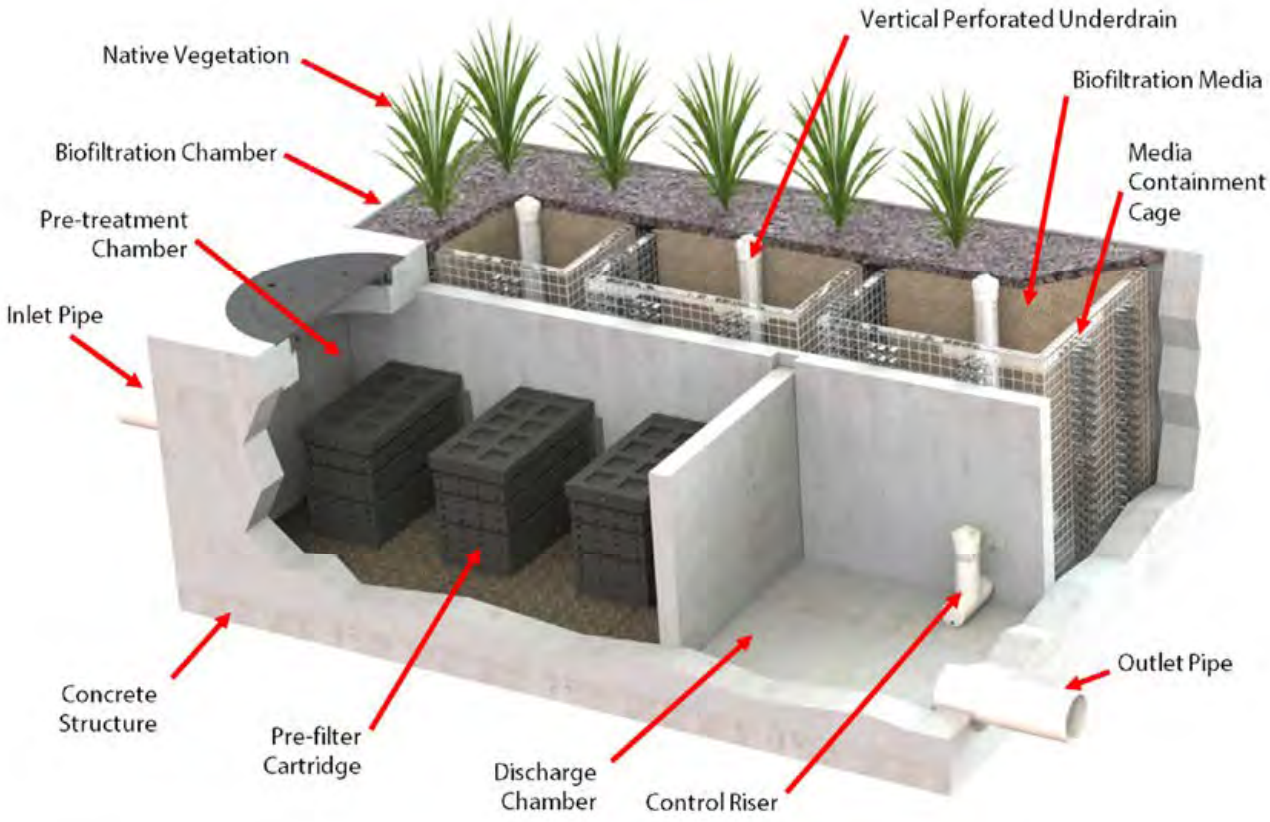
Eye Protection

Maintenance and Protection of Traffic Plan

MODULAR WETLANDS LINEAR COMPONENTS LIST

The MWL system comes in multiple sizes and configurations, including side by side or end to end layouts, both as open planters or underground systems. See shop drawings (plans) for project specific details.

The standard MWL system is comprised of the following components:



INSPECTION SUMMARY & EQUIPMENT LIST

Stormwater regulations require BMPs be inspected and maintained to ensure they are operating as designed to allow for effective pollutant removal and provide protection to receiving water bodies. It is recommended that inspections be performed multiple times during the first year to assess the site-specific loading conditions. The first year of inspections can be used to set inspection and maintenance intervals for subsequent years to ensure appropriate maintenance is provided.

- Inspect pre-treatment, biofiltration, and discharge chambers an average of once every six to twelve months. Varies based on site specific and local conditions.
- Average inspection time is approximately 15 minutes. Always ensure appropriate safety protocol and procedures are followed.

The following is a list of equipment required to allow for simple and effective inspection of the MWL:

Modular Wetlands Linear Inspection Form

Flashlight

Tape Measure

Access Cover Hook

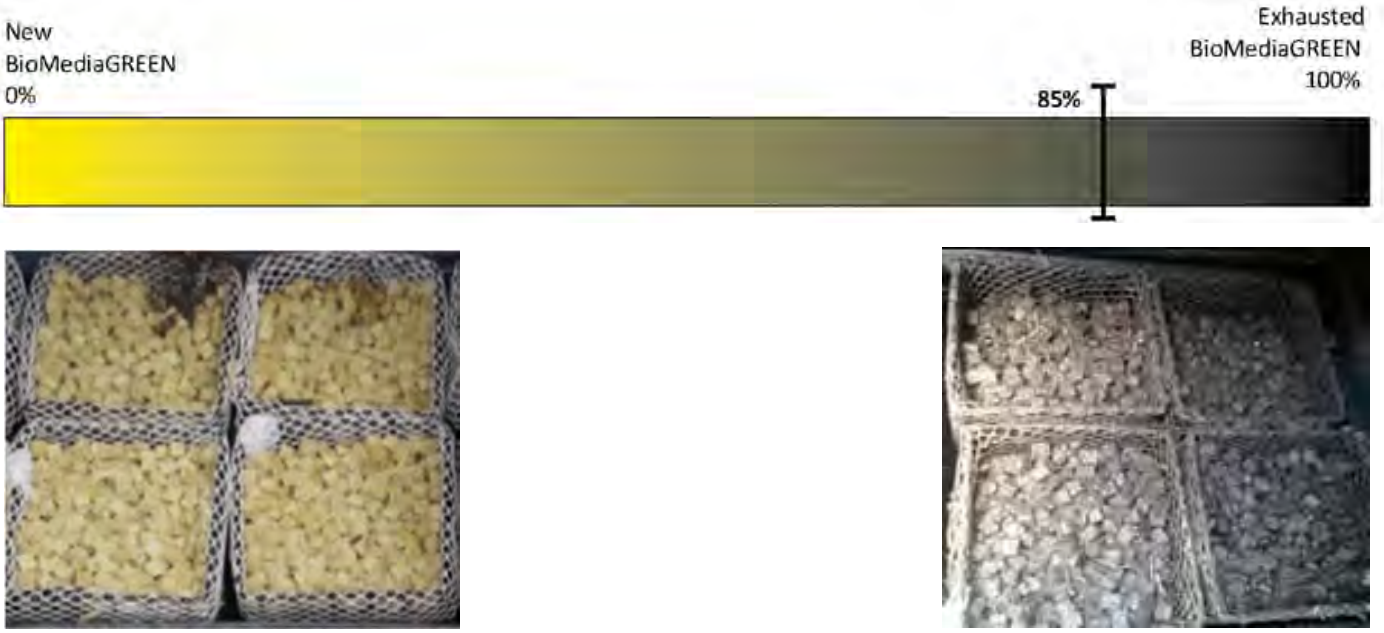
Ratchet
& 7/16" Socket
(if required for older pre-filter cartridges that have two bolts holding the lids on)

INSPECTION & MAINTENANCE NOTES

1. Following maintenance and/or inspection, it is recommended that the maintenance operator prepare a maintenance/inspection record. The record should include any maintenance activities performed, amount and description of debris collected, and condition of the system and its various filter mechanisms.
2. The owner should keep maintenance/inspection record(s) for a minimum of five years from the date of maintenance. These records should be made available to the governing municipality for inspection upon request at any time.
3. Transport all debris, trash, organics, and sediments to approved facility for disposal in accordance with local and state requirements.
4. Entry into chambers may require confined space training based on state and local regulations.
5. No fertilizer shall be used in the biofiltration chamber.
6. Irrigation should be provided as recommended by manufacturer and/or landscape architect. Amount of irrigation required is dependent on plant species. Some plants may not require irrigation after initial establishment.

INSPECTION PROCESS

1. Prepare the inspection form by writing in the necessary information including project name, location, date & time, unit number and other information (see inspection form).
2. Observe the inside of the system through the access covers. If minimal light is available and vision into the unit is impaired, utilize a flashlight to see inside the system and all chambers.
3. Look for any out of the ordinary obstructions in the inflow pipe, pre-treatment chamber, biofiltration chamber, discharge chamber or outflow pipe. Write down any observations on the inspection form.
4. Through observation and/or digital photographs, estimate the amount of trash, debris accumulated in the pre-treatment chamber. Utilizing a tape measure or measuring stick, estimate the amount of sediment in this chamber. Record this depth on the inspection form.
5. Through visual observation, inspect the condition of the pre-filter cartridges. Look for excessive build-up of sediment on the cartridges, any build-up on the tops of the cartridges, or clogging of the holes. Record this information on the inspection form. The pre-filter cartridges can be further inspected by removing the cartridge tops and assessing the color of the BioMediaGREEN filter cubes (requires entry into pre-treatment chamber - see notes previous notes regarding confined space entry). Record the color of the material. New material is a light green color. As the media becomes clogged, it will turn darker in color, eventually becoming dark brown or black. The closer to black the media is the higher percentage that the media is exhausted and in need of replacement.



6. The biofiltration chamber is generally maintenance-free due to the system's advanced pre-treatment chamber. For units which have open planters with vegetation, it is recommended that the vegetation be inspected. Look for any plants that are dead or showing signs of disease or other negative stressors. Record the general health of the plants on the inspection form and indicate through visual observation or digital photographs if trimming of the vegetation is required.

7. The discharge chamber houses the control riser (if applicable), drain down filter (only in California - older models), and is connected to the outflow pipe. It is important to check to ensure the orifice is in proper operating condition and free of any obstructions. It is also important to assess the condition of the drain down filter media which utilizes a block form of the BioMediaGREEN. Assess in the same manner as the cubes in the pre-filter cartridge as mentioned above.

8. Finalize the inspection report for analysis by the maintenance manager to determine if maintenance is required.

MAINTENANCE INDICATORS

Based upon the observations made during inspection, maintenance of the system may be required based on the following indicators:

- Missing or damaged internal components or cartridges.
- Obstructions in the system or its inlet and/or outlet pipes.
- Excessive accumulation of floatables in the pre-treatment chamber in which the length and width of the chamber is fully impacted more than 18".
- Excessive accumulation of sediment in the pre-treatment chamber of more than 6" in depth.
- Excessive accumulation of sediment on the BioMediaGREEN media housed within the pretreatment cartridges. When media is more than 85% clogged, replacement is required. The darker the BioMediaGREEN, the more clogged it is and in need of replacement.
- Excessive accumulation of sediment on the BioMediaGREEN media housed within the drain down filter (California only - older models).
- Overgrown vegetation.

MAINTENANCE SUMMARY & EQUIPMENT LIST

The time has come to maintain your MWL. All necessary pre-maintenance steps must be carried out before maintenance occurs. Once traffic control has been set up per local and state regulations and access covers have been safely opened, the maintenance process can begin. It should be noted that some maintenance activities require confined space entry. All confined space requirements must be strictly followed before entry into the system. In addition, the following is recommended:

- Prepare the maintenance form by writing in the necessary information including project name, location, date & time, unit number and other info (see maintenance form).
- Set up all appropriate safety and maintenance equipment.
- Ensure traffic control is set up and properly positioned.
- Prepared pre-checks (OSHA, safety, confined space entry) are performed.
    - A gas meter should be used to detect the presence of any hazardous gases prior to entering the system. If hazardous gases are present, do not enter the vault. Following appropriate confined space procedures, take steps such as utilizing a venting system to address the hazard. Once it is determined to be safe, enter the system utilizing appropriate entry equipment such as a ladder and tripod with harness.

The following is a list of equipment required for maintenance of the MWL:

Modular Wetlands Linear Maintenance Form

Flashlight

Access Cover Hook

Ratchet
& 7/16" Socket
(if required for older pre-filter cartridges that have two bolts holding the lids on)

Vacuum Assisted Truck with Pressure Washer

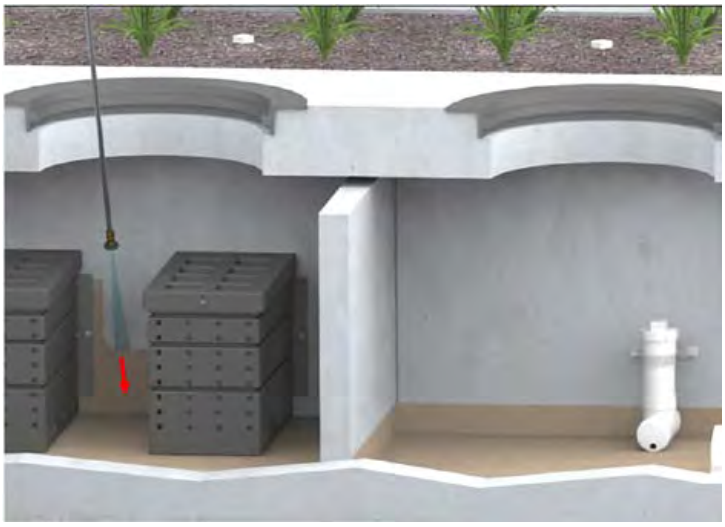
Replacement
BioMediaGREEN
(If Required)

(order BioMediaGREEN from Contech's Maintenance Team members at https://www.conteches.com/maintenance)

MAINTENANCE INSTRUCTIONS

1. ACCESS COVER REMOVAL

Upon determining that the vault is safe for entry, remove all access cover(s) and position the vacuum truck accordingly.



2. PRESSURE WASH SYSTEM CHAMBERS

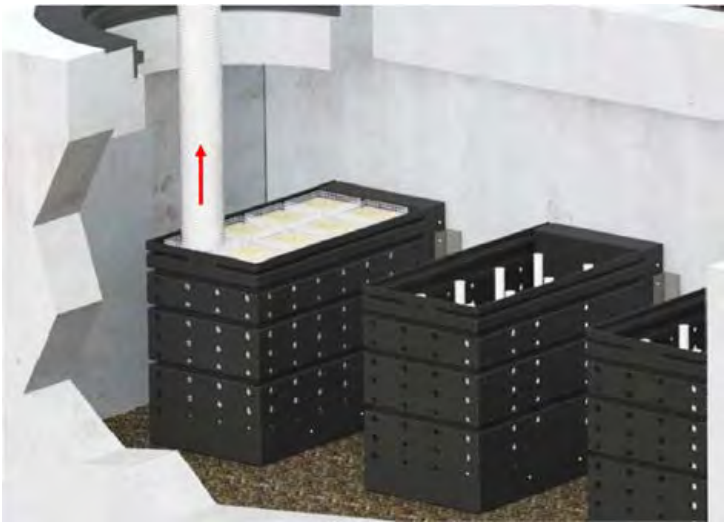
With the pressure washer, spray down pollutants accumulated on the walls and floors of the pre-treatment and discharge chambers. Then wash any accumulated sediment from the pre-filter cartridge(s).

3. VACUUM SYSTEM CHAMBERS

Vacuum out pre-treatment and discharge chambers and remove all accumulated pollutants including trash, debris, and sediments. Be sure to vacuum the pre-treatment floor until the pervious pavers are visible and clean. **(MWL systems outside of California may or may not have pervious pavers on the floor in the pre-treatment chamber)** If pre-filter cartridges require media replacement, proceed to **Step 4**. If not, replace the access cover(s) and proceed to **Step 7**.

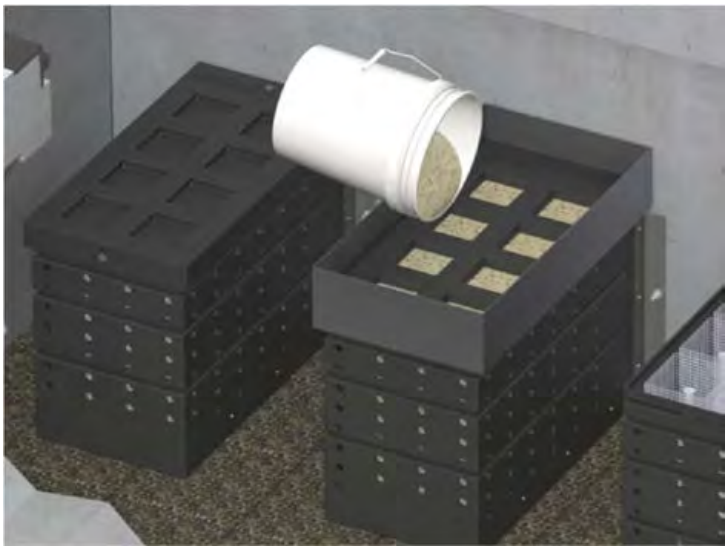
4. PRE-FILTER CARTRIDGE LID REMOVAL

After successfully cleaning out the pre-treatment chamber, enter the chamber and remove the lid(s) from the pre-filter cartridge(s) by removing the two thumb screws. (Older pre-filter cartridges have two bolts holding the lids on that require a 7/16" socket to remove)



5. VACUUM EXISTING PRE-FILTER MEDIA

Utilize the vacuum truck hose or hose extension to remove the filter media from each of the individual media cages. Once filter media has been sucked out, use a pressure washer to spray down the inside of the cartridge and its media cages. Remove cleaned media cages and place to the side. Once removed, the vacuum hose can be inserted into the cartridge to vacuum out any remaining material near the bottom of the cartridge.



6. PRE-FILTER MEDIA REPLACEMENT

Reinstall media cages and fill with new media from the manufacturer or outside supplier. Manufacturer will provide specification of media and sources to purchase. The easiest way to fill the media cages is to utilize a refilling tray that can also be sourced from the manufacturer. Place the refilling tray on top of the cartridge and fill with new bulk media shaking it down into the cages. Using your hands, lightly compact the media into each filter cage. Once the cages are full (each cartridge will hold five heaping 5gal buckets of bulk media), remove the refilling tray and replace the cartridge top, ensuring fasteners are properly tightened.

7. MAINTAINING VEGETATION

In general, the biofiltration chamber is maintenance-free with the exception of maintaining the vegetation. The MWL utilizes vegetation similar to surrounding landscape areas, therefore, trim vegetation to match surrounding vegetation. If any plants have died, replace them with new ones.

8. INSPECT UNDERDRAIN SYSTEM

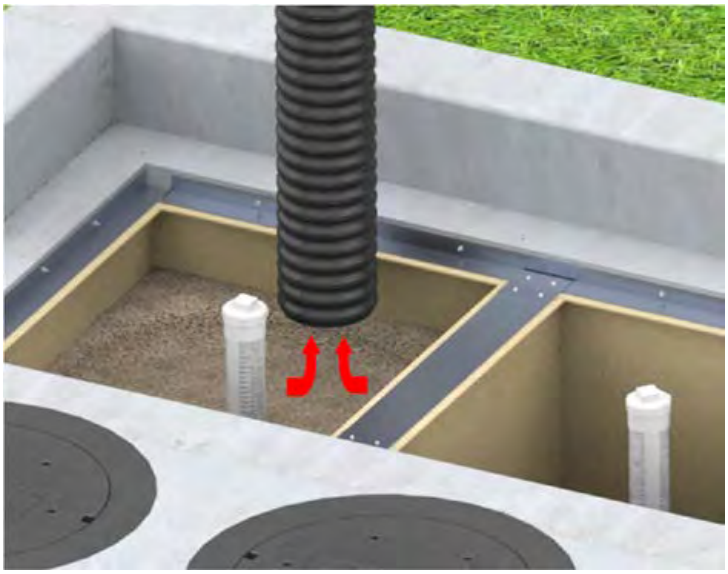
Each vertical under drain on the biofiltration chamber has a removable threaded cap that can be taken off to check for any blockages or root growth. Once removed, a jetting attachment to the pressure washer can be used to clean out the under drain and orifice riser if needed.

9. REPLACE ACCESS COVERS

Once maintenance is complete, replace all access cover(s)

REPLACING BIOFILTRATION MEDIA IF REQUIRED

As with all biofilter systems, at some point the biofiltration media will need to be replaced, either due to physical clogging or sorptive exhaustion (for dissolved pollutants) of the media ion exchange capacity (to remove dissolved metals and phosphorous). The general life of this media is 10 to 20 years based on site specific conditions and pollutant loading, so replacing the biofiltration media should not be a common occurrence. In the event that the biofiltration media requires replacement, contact one of Contech's Maintenance Team members at https://www.conteches.com/maintenance to order new biofiltration media. The quantity of media needed can be determined by providing the model number and unit depth. Media will be provided in super sacks for easy installation. Each sack will weigh between 1,000 and 2,000 lbs. Biofiltration media replacement can be done following the steps below:



1. VACUUM EXISTING BIOFILTRATION MEDIA

Remove the mulch and vegetation to access the biofiltration media, and then position the vacuum truck accordingly. Utilize the vacuum truck to vacuum out all the media. Once all media is removed, use the pressure washer to spray down all the netting and underdrain systems on the inside of the media containment cage. Vacuum out any remaining debris after spraying down netting. Inspect the netting for any damage or holes. If the netting is damaged, it can be repaired or replaced with guidance by the manufacturer.

2. INSTALLING NEW BIOFILTRATION MEDIA

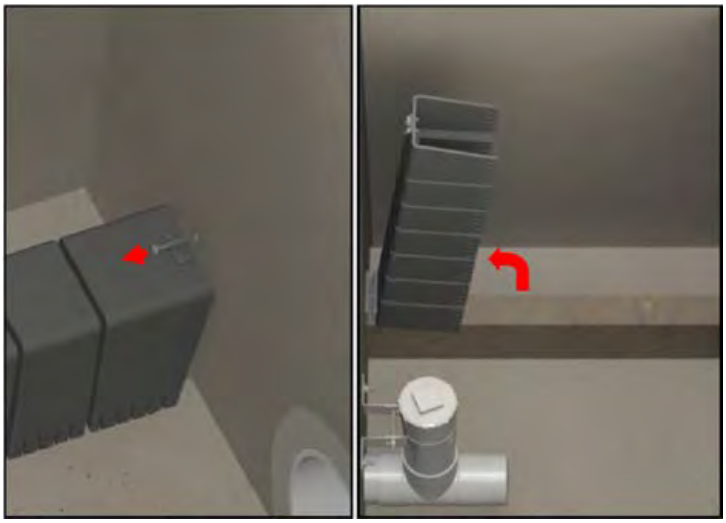
Ensure that the chamber is fully cleaned prior to installation of new media into the media containment cage(s). Media will be provided in super sacks for easy installation. A lifting apparatus (forklift, backhoe, boom truck, or other) is recommended to position the super sack over the biofiltration chamber. Add media in lifts to ensure that the riser pipes remain vertical. Be sure to only fill the media cage(s) up to the same level as the old media.

3. REPLANT VEGETATION

Once the media has been replaced, replant the vegetation and cover biofiltration chamber with approved mulch (if applicable). If the existing vegetation is not being reused, and new vegetation is being planted, you will need to acquire new plant establishment media that will be installed just below the mulch layer at each plant location. (see plan drawings for details). Contact one of Contech's Maintenance Team members at https://www.conteches.com/maintenance to order new plant establishment media.

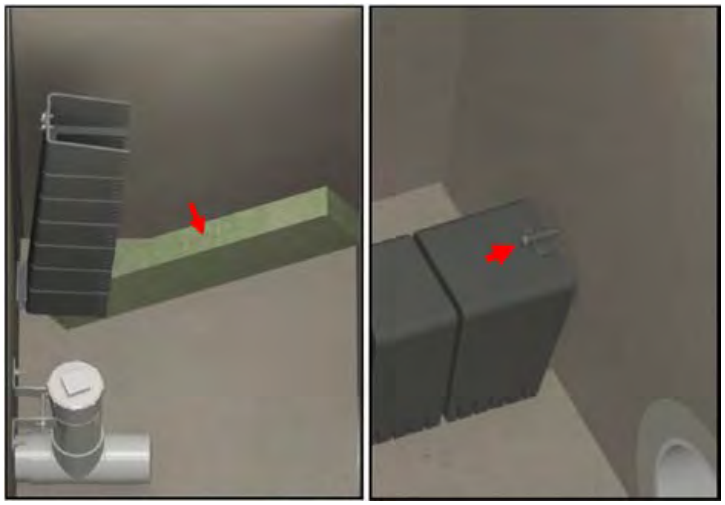
REPLACING DRAIN DOWN FILTER MEDIA (ONLY ON OLDER CALIFORNIA MODELS)

NOTE: The drain down filter is only found on units installed in California prior to 2023
If during inspection it was determined that the drain down filter media requires replacement, contact one of Contech's Maintenance Team members at https://www.conteches.com/maintenance to order new media.



1. REMOVE EXISTING DRAIN DOWN MEDIA

Pull knob back to unlock the locking mechanism and lift the drain down filter housing to remove the used BioMediaGREEN filter block.



2. INSTALL NEW DRAIN DOWN MEDIA

Ensure that the chamber and housing are fully cleaned prior to installation of new media, and then insert the new BioMediaGREEN filter block. The media filter block should fit snugly between the chamber walls and be centered under the filter housing. Lower the housing over the filter block and secure the locking mechanism.

NOTES

CONTECH® ENGINEERED SOLUTIONS

Inspection Report
Modular Wetlands Linear

Project Name _____

Project Address _____
(city) (Zip Code)

Owner / Management Company _____

Contact _____ Phone ( ) –

For Office Use Only
(Reviewed By)
(Date)
Office personnel to complete section to the left.

Inspector Name _____ Date ____/____/____ Time _____ AM / PM

Type of Inspection ☐ Routine ☐ Follow Up ☐ Complaint ☐ Storm Storm Event in Last 72-hours? ☐ No ☐ Yes

Weather Condition _____ Additional Notes _____

Inspection Checklist

Modular Wetland System Type (Curb, Grate or UG Vault): _____ Size (22', 14' or etc.): _____

Structural Integrity:	**Yes**	**No**	**Comments**
Damage to pre-treatment access cover (manhole cover/grate) or cannot be opened using normal lifting pressure?			
Damage to discharge chamber access cover (manhole cover/grate) or cannot be opened using normal lifting pressure?			
Does the MWS unit show signs of structural deterioration (cracks in the wall, damage to frame)?			
Is the inlet/outlet pipe or drain down pipe damaged or otherwise not functioning properly?			
Working Condition:			
Is there evidence of illicit discharge or excessive oil, grease, or other automobile fluids entering and clogging the unit?			
Is there standing water in inappropriate areas after a dry period?			
Is the filter insert (if applicable) at capacity and/or is there an accumulation of debris/trash on the shelf system?			
Does the depth of sediment/trash/debris suggest a blockage of the inflow pipe, bypass or cartridge filter? If yes, specify which one in the comments section. Note depth of accumulation in in pre-treatment chamber.			Depth:
Does the cartridge filter media need replacement in pre-treatment chamber and/or discharge chamber?			Chamber:
Any signs of improper functioning in the discharge chamber? Note issues in comments section.			
Other Inspection Items:			
Is there an accumulation of sediment/trash/debris in the wetland media (if applicable)?			
Is it evident that the plants are alive and healthy (if applicable)? Please note Plant Information below.			
Is there a septic or foul odor coming from inside the system?			

Waste:	**Yes**	**No**
Sediment / Silt / Clay		
Trash / Bags / Bottles		
Green Waste / Leaves / Foliage		

Recommended Maintenance	
No Cleaning Needed	
Schedule Maintenance as Planned	
Needs Immediate Maintenance	

Plant Information	
Damage to Plants	
Plant Replacement	
Plant Trimming	

Additional Notes: _____

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ENGINEERED SOLUTIONS

Cleaning and Maintenance Report
Modular Wetlands Linear

Project Name _____

Project Address _____
(city) (Zip Code)

Owner / Management Company _____

Contact _____ Phone ( ) –

Inspector Name _____ Date ____/____/_____ Time _____AM / PM

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(Reviewed By)
(Date)
Office personnel to complete section to the left.

Type of Inspection ☐ Routine ☐ Follow Up ☐ Complaint ☐ Storm Storm Event in Last 72-hours? ☐ No ☐ Yes

Weather Condition _____ Additional Notes _____

Site Map #	GPS Coordinates of Insert	Manufacturer / Description / Sizing	Trash Accumulation	Foliage Accumulation	Sediment Accumulation	Total Debris Accumulation	Condition of Media 25/50/75/100 (will be changed @ 75%)	Operational Per Manufactures' Specifications (If not, why?)
	Lat: Long:	MWS Catch Basins						
		MWS Sedimentation Basin						
		Media Filter Condition						
		Plant Condition						
		Drain Down Media Condition						
		Discharge Chamber Condition						
		Drain Down Pipe Condition						
		Inlet and Outlet Pipe Condition						

Comments:

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SUPPORT

DRAWINGS AND SPECIFICATIONS ARE AVAILABLE AT WWW.CONTECHES.COM

ModWetLinear OM Manual 03/24

Table V-A.5: Maintenance Standards - Control Structures (continued)

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
Clean-out Gate	Damaged or Missing	Clean-out gate is not watertight or is missing. Gate cannot be moved up and down by one maintenance person. Chain/rod leading to gate is missing or damaged. Gate is rusted over 50% of its surface area.	Gate is watertight and works as designed. Gate moves up and down easily and is watertight. Chain is in place and works as designed. Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Access Opening	See V-A.5 Maintenance Standards - Tanks and Vaults		
Catch Basin	See V-A.7 Maintenance Standards - Catch Basins		

V-A.7 Maintenance Standards - Catch Basins

Table V-A.6: Maintenance Standards - Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%. Trash or debris (in the basin) that exceeds 60% of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the debris surface to the invert of the lowest pipe. Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height. Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g. methane).	No Trash or debris located immediately in front of catch basin or on grate opening. No trash or debris in the catch basin. Inlet and outlet pipes free of trash or debris. No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60% of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	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 regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening. Vegetation growing in inlet/outlet pipe joints that is more than 6 inches tall and less than 6 inches apart.	No vegetation blocking opening to basin. No vegetation or root growth present.
	Contamination and Pol-	See V-A.2 Maintenance Standards - Detention Ponds	No pollution present.

Table V-A.6: Maintenance Standards - Catch Basins (continued)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	lution		
Catch Basin Cover	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.
	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.
Ladder	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.
Metal Grates (if applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	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.

V-A.8 Maintenance Standards - Debris Barriers (e.g. Trash Racks)

Table V-A.7: Maintenance Standards - Debris Barriers (e.g. Trash Racks)

Maintenance Components	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris	Trash or debris that is plugging more than 20% of the openings in the barrier.	Barrier cleared to design flow capacity.
Metal	Damaged/ Missing Bars	Bars are bent out of shape more than 3 inches. Bars are missing or entire barrier missing. Bars are loose and rust is causing 50% deterioration to any part of barrier.	Bars in place with no bends more than 3/4 inch. Bars in place according to design. Barrier replaced or repaired to design standards.
	Inlet/Outlet Pipe	Debris barrier missing or not attached to pipe	Barrier firmly attached to pipe

V-A.9 Maintenance Standards - Energy Dissipators

Table V-A.8: Maintenance Standards - Energy Dissipators

Maintenance Components	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
External			
Rock Pad	Missing or Moved Rock	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil.	Rock pad replaced to design standards.
	Erosion	Soil erosion in or adjacent to rock pad.	Rock pad replaced to design standards.
Dispersion Trench	Pipe Plugged with Sediment	Accumulated sediment that exceeds 20% of the design depth.	Pipe cleaned/flushed so that it matches design.

APPENDIX F

FEMA Map

National Flood Hazard Layer FIRMette

FEMA

122°8'59"W 48°9'34"N

122°8'21"W 48°9'10"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap Imagery Source: USGS National Map 2023

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 9/17/2024 at 4:23 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

APPENDIX G

GULDs

WASHINGTON STATE DEPARTMENT OF ECOLOGY

January 2024

GENERAL USE LEVEL DESIGNATION FOR BASIC (TSS) METALS AND PHOSPHORUS TREATMENT

For

Contech Engineered Solutions, LLC (Contech) Modular Wetlands Linear

Ecology's Decision

Based on Modular Wetland Systems, Inc, application submissions, including the Technical Evaluation Report, dated April 1, 2014, Ecology hereby issues the following use level designation:

1. General Use Level Designation (GULD) for the Modular Wetlands Linear Stormwater Treatment System for Basic, Phosphorus, and Metals treatment
    - Sized at a hydraulic loading rate of:
        - 1 gallon per minute (gpm) per square foot (sq ft) of Wetland Cell Surface Area
        - Prefilter box (approved at either 22 inches or 33 inches tall)
            - 3.0 gpm/sq ft of prefilter box surface area for moderate pollutant loading rates (low to medium density residential basins).
            - 2.1 gpm/sq ft of prefilter box surface area for high pollutant loading rates (commercial and industrial basins).
2. Ecology approves the Modular Wetlands Linear Stormwater Treatment System units for Basic, Phosphorus, and Metals treatment at the hydraulic loading rate listed above. Designers shall calculate the water quality design flow rates using the following procedures:
    - Western Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute water quality treatment design flow rate as calculated using the latest version of the Western Washington Hydrology Model or other Ecology- approved continuous runoff model.

- Eastern Washington: For treatment installed upstream of detention or retention, the water quality design flow rate is the peak 15-minute water quality treatment design flow rate as calculated using one of the three methods described in Chapter 2.7.6 of the Stormwater Management Manual for Eastern Washington (SWMMEW) or local manual.
- Entire State: For treatment installed downstream of detention, the water quality treatment design flow rate is the full 2-year release rate of the detention facility.

3. These use level designations have no expiration date but may be amended or revoked by Ecology, and are subject to the conditions specified below.

Ecology's Conditions of Use

Applicants shall comply with the following conditions:

1) Design, assemble, install, operate, and maintain the Modular Wetlands Linear Stormwater Treatment System units, in accordance with Contech's. applicable manuals and documents and the Ecology Decision.
2) Each site plan must undergo Contech review and approval before site installation. This ensures that site grading and slope are appropriate for use of a Modular Wetlands Linear Stormwater Treatment System unit.
3) Modular Wetlands Linear Stormwater Treatment System media shall conform to the specifications submitted to and approved by Ecology.
4) The applicant tested the Modular Wetlands Linear Stormwater Treatment System with an external bypass weir. This weir limited the depth of water flowing through the media, and therefore the active treatment area, to below the root zone of the plants. This GULD applies to Modular Wetlands Linear Stormwater Treatment Systems whether plants are included in the final product or not.
5) Maintenance: The required maintenance interval for stormwater treatment devices is often dependent upon the degree of pollutant loading from a particular drainage basin. Therefore, Ecology does not endorse or recommend a "one size fits all" maintenance cycle for a particular model/size of stormwater treatment technology.
    - Typically, Contech designs Modular Wetland systems for a target prefilter media life of 6 to 12 months.
    - Indications of the need for maintenance include effluent flow decreasing to below the design flow rate or decrease in treatment below required levels.
    - Owners/operators must inspect Modular Wetland systems for a minimum of twelve months from the start of post-construction operation to determine site-specific maintenance schedules and requirements. You must conduct inspections monthly during the wet season, and every other month during the dry season (According to the SWMMWW, the wet season in western Washington is October 1 to April 30. According to the SWMMEW, the wet

season in eastern Washington is October 1 to June 30). After the first year of operation, owners/operators must conduct inspections based on the findings during the first year of inspections.

- Conduct inspections by qualified personnel, follow manufacturer's guidelines, and use methods capable of determining either a decrease in treated effluent flowrate and/or a decrease in pollutant removal ability.
- When inspections are performed, the following findings typically serve as maintenance triggers:
    - Standing water remains in the vault between rain events, or
    - Bypass occurs during storms smaller than the design storm.
    - If excessive floatables (trash and debris) are present (but no standing water or excessive sedimentation), perform a minor maintenance consisting of gross solids removal, not prefilter media replacement.
    - Additional data collection will be used to create a correlation between pretreatment chamber sediment depth and pre-filter clogging (see *Issues to be Addressed by the Company* section below)

6) Discharges from the Modular Wetlands Linear Stormwater Treatment System units shall not cause or contribute to water quality standards violations in receiving waters.

Applicant:	Contech Engineered Solutions, LLC
Applicant's Address:	11815 NE Glenn Widing Dr. Portland, OR 97220

Application Documents:

Original Application for Conditional Use Level Designation, Modular Wetland System, Linear Stormwater Filtration System Modular Wetland Systems, Inc., January 2011

Quality Assurance Project Plan: Modular Wetland System – Linear Treatment System Performance Monitoring Project, draft, January 2011

Revised Application for Conditional Use Level Designation, Modular Wetland System, Linear Stormwater Filtration System Modular Wetland Systems, Inc., May 2011

Memorandum: Modular Wetland System-Linear GULD Application Supplementary Data, April 2014

Technical Evaluation Report: Modular Wetland System Stormwater Treatment System Performance Monitoring, April 2014

Applicant's Use Level Request:

- General Use Level Designation as a Basic, Metals, and Phosphorus treatment device in accordance with Ecology's Guidance for Evaluating Emerging Stormwater Treatment Technologies Technology Assessment Protocol – Ecology (TAPE) January 2011 Revision.

Applicant's Performance Claims:

- The Modular Wetlands Linear is capable of removing a minimum of 80-percent of TSS from stormwater with influent concentrations between 100 and 200 mg/L.
- The Modular Wetlands Linear is capable of removing a minimum of 50-percent of total phosphorus from stormwater with influent concentrations between 0.1 and 0.5 mg/L.
- The Modular Wetlands Linear is capable of removing a minimum 30-percent of dissolved copper from stormwater with influent concentrations between 0.005 and 0.020 mg/L.
- The Modular Wetlands Linear is capable of removing a minimum 60-percent of dissolved zinc from stormwater with influent concentrations between 0.02 and 0.30 mg/L.

Ecology's Recommendations:

- Contech has shown Ecology, through laboratory and field-testing, that the Modular Wetlands Linear Stormwater Treatment System filter system is capable of attaining Ecology's Basic, Phosphorus, and Metals treatment goals.

Findings of Fact:

<u>Laboratory Testing</u>

The Modular Wetlands Linear Stormwater Treatment System has the:

- Capability to remove 99 percent of total suspended solids (using Sil-Co-Sil 106) in a quarter-scale model with influent concentrations of 270 mg/L.
- Capability to remove 91 percent of total suspended solids (using Sil-Co-Sil 106) in laboratory conditions with influent concentrations of 84.6 mg/L at a flow rate of 3.0 gpm per square foot of media.
- Capability to remove 93 percent of dissolved Copper in a quarter-scale model with influent concentrations of 0.757 mg/L.
- Capability to remove 79 percent of dissolved Copper in laboratory conditions with influent concentrations of 0.567 mg/L at a flow rate of 3.0 gpm per square foot of media.

- Capability to remove 80.5-percent of dissolved Zinc in a quarter-scale model with influent concentrations of 0.95 mg/L at a flow rate of 3.0 gpm per square foot of media.
- Capability to remove 78-percent of dissolved Zinc in laboratory conditions with influent concentrations of 0.75 mg/L at a flow rate of 3.0 gpm per square foot of media.

Field Testing

- Modular Wetland Systems, Inc. conducted monitoring of an MWS-Linear (Model # MWS-L-4-13) from April 2012 through May 2013, at a transportation maintenance facility in Portland, Oregon. The manufacturer collected flow-weighted composite samples of the system's influent and effluent during 28 separate storm events. The system treated approximately 75 percent of the runoff from 53.5 inches of rainfall during the monitoring period. The applicant sized the system at 1 gpm/sq ft. (wetland media) and 3gpm/sq ft. (prefilter).
- Influent TSS concentrations for qualifying sampled storm events ranged from 20 to 339 mg/L. Average TSS removal for influent concentrations greater than 100 mg/L (n=7) averaged 85 percent. For influent concentrations in the range of 20-100 mg/L (n=18), the upper 95 percent confidence interval about the mean effluent concentration was 12.8 mg/L.
- Total phosphorus removal for 17 events with influent TP concentrations in the range of 0.1 to 0.5 mg/L averaged 65 percent. A bootstrap estimate of the lower 95 percent confidence limit (LCL95) of the mean total phosphorus reduction was 58 percent.
- The lower 95 percent confidence limit of the mean percent removal was 60.5 percent for dissolved zinc for influent concentrations in the range of 0.02 to 0.3 mg/L (n=11). The lower 95 percent confidence limit of the mean percent removal was 32.5 percent for dissolved copper for influent concentrations in the range of 0.005 to 0.02 mg/L (n=14) at flow rates up to 28 gpm (design flow rate 41 gpm). Laboratory test data augmented the data set, showing dissolved copper removal at the design flow rate of 41 gpm (93 percent reduction in influent dissolved copper of 0.757 mg/L).

Issues to be addressed by the Company:

1. Contech should collect maintenance and inspection data for the first year on all installations in the Northwest in order to assess standard maintenance requirements for various land uses in the region. Contech should use these data to establish required maintenance cycles.
2. Contech should collect pre-treatment chamber sediment depth data for the first year of operation for all installations in the Northwest. Contech will use these data to create a correlation between sediment depth and pre-filter clogging.

Technology Description:
Download at https://www.conteches.com/modular-wetlands

Contact Information:

Applicant: Jeremiah Lehman
Contech Engineered Solutions, LLC
11815 NE Glenn Widing Dr.
Portland, OR 97220
Jeremiah.Lehman@ContechES.com

Applicant website: http://www.conteches.com

Ecology web link: http://www.ecy.wa.gov/programs/wg/stormwater/newtech/index.html

Ecology: Douglas C. Howie, P.E.
Department of Ecology
Water Quality Program
(360) 870-0983
douglas.howie@ecy.wa.gov

Revision History

Date	Revision
June 2011	Original use-level-designation document
September 2012	Revised dates for TER and expiration
January 2013	Modified Design Storm Description, added Revision Table, added maintenance discussion, modified format in accordance with Ecology standard
December 2013	Updated name of Applicant
April 2014	Approved GULD designation for Basic, Phosphorus, and Enhanced treatment
December 2015	Updated GULD to document the acceptance of MWS – Linear Modular Wetland installations with or without the inclusion of plants
July 2017	Revised Manufacturer Contact Information (name, address, and email)
December 2019	Revised Manufacturer Contact Address
July 2021	Added additional prefilter sized at 33 inches
August 2021	Changed “Prefilter” to “Prefilter box”
November 2022	Changed Contacts to Contech ES
January 2024	Revised Dissolved Metals (Enhanced) to Metals

APPENDIX H

Special Reports

GEOTECHNICAL ENGINEERING REPORT
CROSSWIND SUBSTATION
17601 – 59th Avenue NE
Arlington, Washington

Project No. 2679.01
19 September 2023

Prepared for:
Snohomish County PUD No. 1

Prepared by:

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

ZipperGeo
Geoprofessional Consultants

Project No. 2679.01
19 September 2023

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

Attention: Mr. Jeff Colon, PE, Principal Engineer

Subject: Geotechnical Engineering Report
Crosswind Substation
17601 – 59th Avenue NE
Arlington, Washington

Dear Mr. Colon:

In accordance with your request, Zipper Geo Associates, LLC (ZGA) has completed the subsurface exploration and geotechnical engineering evaluation for the proposed Crosswind 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 Professional Services Contract No. CW2250618. Written authorization to proceed was provided by the District on 2 February 2023. We appreciate the opportunity to be of service to you on this project. If you have any questions or if we may be of further service, please do not hesitate to contact us.

Sincerely,
Zipper Geo Associates, LLC

David C. Williams, LG, LEG
Principal Engineering Geologist
Signed 9.19.23

State of Washington
Engineering Geologist
1172
Licensed Geologist
DAVID C. WILLIAMS

Justin L. Brooks, L.G.
Project Geologist
Signed 9.19.23

State of Washington
20120113
Licensed Geologist
Justin Lee Brooks

Robert A. Ross, P.E.
Managing Principal
Signed 9.19.23

ROBERT A. ROSS
STATE OF WASHINGTON
38384
REGISTERED
PROFESSIONAL ENGINEER

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

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CROSSWIND SUBSTATION
17601 – 59th AVENUE NE
ARLINGTON, WASHINGTON
Project No. 2679.01
19 September 2023

INTRODUCTION

This report summarizes the geotechnical engineering exploration and analysis completed for the proposed Crosswind Substation project in Arlington, Washington. Two borings (B-1 and B-2), six test pits (TP-1 through TP-6), and one cone penetrometer (CPT-1) were completed by ZGA to depths ranging from approximately 8 to 60 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 a relatively flat 1.4-acre gravel-surfaced lot in the southeast corner of the District's Arlington Microgrid facility. The site is located 0.2 miles south of 180th Street NE and 0.4 miles east of 59th Avenue NE and near the BNSF Railroad right-of-way. The railroad right-of-way adjoins the site at the east, industrial/commercial buildings and lots are to the south, and District facilities lie north and east. An asphalt-paved access drive is on the west. A stormwater infiltration drywell is located a short distance west of the site's northwest corner. The site and immediate vicinity are illustrated on the *Site and Exploration Plan*, Figure 1.

Site History

The proposed substation location is one of several function-specific areas within the Microgrid facility. The District retained GeoEngineers to completed multiple phases of geotechnical exploration and analysis, and we have relied upon information provided in the reports to supplement ZGA's substation-specific exploration and analysis. The GeoEngineers reports that we reviewed are listed below, and selected exploration logs are included in Appendix A:

- GeoEngineers, *Hydrogeologic Assessment, Proposed Pole Yard, Arlington, Washington*, File No. 0482-051-03, dated 26 April 2016;

- ____, *Geotechnical Engineering Services, North County Project, Arlington, Washington*, File No. 0482-051-03, dated 29 December 2017;

- ____, *Updated Groundwater Monitoring Data (Addendum No. 2), North County Project, Arlington, Washington*, File 0482-051-04, dated 20 June 2018;

- ____, *Geotechnical Engineering Services, Update 1 – Revision 1, North County Community Office Project, Early Site Development Phase, Arlington, Washington*, Field Nol 0482-051-04, dated 5 February 2021.

Project Description

A new double bank substation is proposed for construction on the site. Site improvements are expected to include:

- Dead end towers (termination structures) in the southern 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 and substation crushed rock placement to achieve a yard finished grade of approximately elevation 138 feet.

SITE CONDITIONS

Surface Conditions

The substation site is a relatively level area with ground surface elevations between about 135 and 136 feet. The site is mantled with about 4 to 6 inches of ¾-inch crushed gravel over a non-woven geotextile. A pre-cast concrete and steel vault in the north-central portion of the lot contains a groundwater monitoring well monument (B-9) installed by GeoEngineers in 2017. A fire hydrant is located near the northeast corner near the road. The District has material stored to the north and south of the site. We observed standing water throughout the lot during a site visit on 14 February 2023 following previous heavy rain. The access road on the east side is asphalt, about 20-feet wide and in a serviceable condition.

Subsurface Conditions

Local Geologic Conditions

We assessed the geologic setting of site and the surrounding vicinity by reviewing the *Geologic Map of the Arlington West 7.5 Minute Quadrangle, Snohomish County, Washington* (US Geological Survey, Map MF-1740, 1985). The published geologic mapping indicates the site is underlain by Vashon Recessional Outwash, Marysville Sand Member (Qvrm). 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 minimum thickness of about 65 feet. Subsurface conditions disclosed by the explorations advanced by ZGA and others are consistent with the published mapping. ZGA's explorations disclosed recent 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.

Our understanding of subsurface conditions is based upon observation of six test pits, two borings, and one cone penetrometer test (CPT). In addition, we reviewed the logs of three borings and one test pit completed by GeoEngineers at the substation site. Approximate exploration locations, as well as pertinent surface features, are shown on Figure 1. Observed soil conditions are summarized below.

Fill

The explorations disclosed about 4 to 6 inches of ¾-inch crushed gravel over a non-woven geotextile. We observed ponded water atop this layer throughout the site during our 14 February site visit. We attribute this to a thin layer of silt masking the surface of the geotextile at its interface with the crushed surfacing.

We observed apparent disturbed native soils or undocumented fill material consisting of brown to red-brown sand with trace to some silt extending to depths of approximately 1 to 1.5 feet at the test pit locations. We observed scattered woody debris with sizes ranging from roots to wood bark to an approximately 18-inch long and 4-inch diameter log.

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 medium dense to dense sand with gravel and a low fines content (the soil fraction passing the US No. 200 sieve). The soils above the water table were generally in a moist condition. The test pits were terminated at relatively shallow depths of approximately 7 to 8 feet due to caving associated with the relatively low density and low fines content of the material in combination with groundwater seepage

The deeper recessional deposits as disclosed by CPT-1 consist of medium dense to dense sand. The CPT disclosed horizons of medium dense to dense silty sand as well as horizons of dense to very dense gravelly sand. At about 28 feet bgs (below ground surface), a thin horizon of medium stiff silty clay to clayey silt was identified. Borings B-1 and B-2 disclosed somewhat similar conditions, with medium dense sand with trace silt and a variable gravel content to about 20 feet with medium dense sand to the borings' approximate 26-1/2 foot termination depth.

Groundwater

We observed groundwater seepage at depths of approximately 7 to 8-1/2 feet while excavating the test pits and at approximately 9 feet and 8 feet while advancing borings B-1 and B-2, respectively. We observed groundwater at approximately 10 feet at the infiltration drywell near the northwest corner of the site. At the previously installed well, GeoEngineers, B-9, henceforth referred to as GEB-9, we measured the depth to groundwater at 7.2 feet and 7.7 feet.

Our groundwater observations 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: Groundwater Observations				
Exploration/Feature	**Approximate Groundwater Depth/Elevation (feet)**	**Observation Date**	**Groundwater Depth/Elevation (feet)**	**Observation Date**
B-1	9 / 127	2.28.23	NA**	NA
B-2	8 / 127	2.28.23	NA	NA
TP-1	8-1/2 / 122-1/2	2.28.23	NA	NA
TP-2	7-1/2 / 123-1/2	2.28.23	NA	NA
TP-3	7 / 124	2.28.23	NA	NA
TP-4	7 / 124	2.28.23	NA	NA
TP-5	7-1/2 / 123-1/2	2.28.23	NA	NA
TP-6	7-1/2 / 123-1/2	2.28.23	NA	NA
GEB-9*	7.7 / 129.2	2.28.23	7.2 / 129.7	3.29.23
Deluge drywell	10 / 126	2.14.23	NA	NA
*Groundwater depth measured relative to the rim of the flush-mount well monument at elevation 136.9 feet per District survey **NA Not Applicable				

The GeoEngineers 20 June 2018 *Updated Groundwater Monitoring Data (Addendum No. 2)* includes groundwater data for GEB-9 (advanced in the north-central portion of the substation site) and GEB-4 (advanced about 150 feet west of the substation site's southwest corner). The shallowest groundwater levels observed by GeoEngineers were approximately elevations 128 feet and 130-1/2 feet at the GEB-4 and GEB-9 locations, respectively. These were measurements made manually with an electronic well sounder, rather than data downloaded from transducers installed in the wells. These elevations correspond to approximate depths below existing grade of 7-1/2 feet and 6-1/2 feet at the GEB-4 and GEB-9 locations, respectively.

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 shallow disturbed native soils / undocumented fill material 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 recessional outwash likely to be encountered during grading has a relatively low fines content and may be considered moderately moisture-sensitive relative to grading.

- We anticipate that deeper excavations for vaults and conduits may encounter groundwater during the wetter time of year, most likely necessitating dewatering. 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 native recessional outwash soils is favorable from the stormwater infiltration perspective.

- Based on our analyses, we estimate total settlement resultant from seismically-induced liquefaction of approximately 1 to 3 inches. We estimate differential seismic settlement of approximately ½ to 1½ inches over a horizontal distance of 40 feet. If these levels of seismically-induced liquefaction settlement are not acceptable for conventional spread footings, we recommend considering the installation of stone columns as 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).

Regulated Geologic Hazard Areas

Part V of Chapter 20.93.600 of the Arlington Municipal Code (AMC) defines regulated geologic hazard areas as follows:

"Geologic hazard areas" means lands or areas susceptible to erosion, sliding, earthquakes, liquefaction, or other geological events.

Erosion Hazard Areas

"Erosion hazard areas" are as defined by the USDA Soil Conservation Service, United States Geologic Survey, or by the Department of Ecology Coastal Zone Atlas. The following classes are high erosion hazard areas.

(A) Class 3, class U (unstable) includes severe erosion hazards and rapid surface runoff areas;
(B) Class 4, class UOS (unstable old slides) includes areas having severe limitations due to slope; and,
(C) *Class 5, class URS (unstable recent slides).*

The project site is essentially level and lacks significant slopes. It is our opinion that the site presents a low erosion hazard per the AMC definition.

Landslide Hazard Areas

"Landslide hazard areas" include areas subject to severe risk of landslide based on a combination of geologic, topographic, and hydrologic factors. Landslide hazard include any of the following:

(A) Areas characterized by slopes greater than fifteen percent and impermeable soils (typically silt and clay) frequently interbedded with permeable granular soils (predominantly sand and gravel) or impermeable soils overlain with permeable soils or springs or groundwater seepage; Low Hazard. Areas with slopes of less than 15 percent.
(B) Any area that has exhibited movement during the Holocene epoch (from ten thousand years ago to present) or which is underlain by mass wastage debris of that epoch;
(C) Any area potentially unstable due to rapid stream incision, stream bank erosion or undercutting by wave action;
(D) Any area located on an alluvial fan presently subject to or potentially subject to inundation by debris flows or deposition of stream-transported sediments;
(E) Any area with a slope of thirty-three percent or greater and a vertical relief of ten or more feet except areas composed of consolidated rock;
(F) Any area with slope defined by the United States Department of Agriculture Soil Conservation Service as having a severe limitation for building site development; and,
(G) Any shoreline designated or mapped as class U, UOS, or URS by the Department of Ecology Coastal Zone Atlas.

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 AMC definition.

Seismic Hazard Areas

Seismic Design Considerations: The seismic performance of the proposed site improvements was evaluated in accordance with the 2018 International Building Code (IBC). The seismic basis of design for the 2018 IBC, which refers to the American Society of Civil Engineers (ASCE) 7-16, is a risk-targeted maximum considered earthquake (MCE_R), which represents an earthquake with a 2 percent probability of

exceedance in 50 years (2,475-year return period).

Ground Fault Rupture: Based on review of the United States Geological Survey *Quaternary Fault and Fold Database of the United States* the nearest fault to the site is the South Whidbey Island Fault Zone mapped about 17 miles south-southwest of the site. Based on the mapped location of the fault relative to the site, it is our opinion that the risk associated with fault surface rupture at the site is low.

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 the 2018 IBC and ASCE 7-16. Specifically, our analysis used the following primary seismic ground motion parameters.

- A Modified Peak Ground Acceleration (PGA_M) of 0.52g based on Site Class D, per Section 11.8.3 of ASCE 7-16 (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 7.03 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 CLiq (Version 3.5.2.10) developed by GeoLogismiki. Our analysis was based on CPT-01 completed to a depth of about 60 feet below existing grade within the proposed development area and assumed a conservative groundwater depth of 2 feet during the design earthquake. The approximate exploration location is shown on the enclosed *Site and Exploration Plan, Figure 1*. Based on our analysis, a generally non-liquefiable crust of material exists in the upper 15 feet of the site. Below this crust, portions of the Marysville Sand Member have a moderate to high liquefaction potential during the design earthquake down to the full depth of the CPT exploration.

Liquefaction Settlement: The site is mantled by a generally dense and non-liquefiable crust on the order of 15 feet thick. As such, liquefaction-indicated settlements observed at the surface will initiate from potentially liquefiable layers present below the non-liquefiable crust. Research and case histories have shown that the expression of liquefaction-induced settlement at the ground surface is a function of the depth of the liquefiable layers, with deeper liquefiable layers contributing less to ground surface settlement than similar thickness shallow liquefiable layers (Cetin et al., 2009). Cetin proposed use of a "depth weighting factor" (DF_i) that reduces the impact of deep liquefiable layers on the estimated surface settlement. This factor is included in the CLiq program and was used in our settlement analysis.

Based on our analyses, we estimate a total seismic settlement of approximately 1 to 3 inches. We estimate a differential seismic settlement of approximately ½ to 1½ inches over a horizontal distance of 40 feet. If these levels of seismic induced liquefaction settlement are not acceptable for conventional spread

footings, we recommend that mitigative measures such as a mat foundation or stone columns be considered.

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. Given the relatively level nature of the site, lack of a free-face condition, and 15-foot-thick non-liquefiable crust, it is our opinion that the potential for distress at the site from lateral spreading is low.

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. Based on the results of the field evaluation, 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 of ASCE 7-16 do not apply, a ground motion hazard analysis may be required. Site Class D describes soils that are considered stiff with a shear wave velocity between 600 and 1,200 feet per second, average Standard Penetration Test values between 15 and 50, and an undrained shear strength between 1,000 and 2,000 psf.

Table 2: IBC Seismic Design Criteria	
Parameter	**Value**
2018 International Building Code Site Classification (IBC) [1]	Site Class F [2,3]
Site Latitude/Longitude	48.1560 /-122.1422
Spectral Short-Period Acceleration, S_S	1.050g
Spectral 1-Second Acceleration, S_1	0.375g
Site Coefficient for a Short Period, F_A	1.080
Site Coefficient for a 1-Second Period, F_V	See ASCE Section 11.4.8
Spectral Acceleration for a 0.2-Second Period, S_{MS}	1.134g
Spectral Acceleration for a 1-Second Period, S_{M1}	See ASCE Section 11.4.8
Design Short-Period Spectral Acceleration, S_{DS}	0.756g
Design 1-Second Spectral Acceleration, S_{D1}	See ASCE Section 11.4.8

1. IBC Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile.
2. CPT-01 completed by ZGA for this study extended to a maximum depth of about 60 feet below grade. ZGA therefore reviewed logs for CPT-1 and CPT-2 completed by GeoEngineers in 2017 (including shear wave velocity test results) about 2,000 and 1,200 feet west of the site, respectively, to determine IBC Site class with and without regard to liquefaction.
3. Per the *2018 International Building Code* and *ASCE 7-16*, Chapter 20, any profile containing soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils.

Engineering Soil Units

For purposes of describing soil conditions observed at the exploration locations and for reference in other sections of this report, soils with similar engineering characteristics were grouped together into Engineering Stratigraphic Units or ESUs. The following paragraphs provide our interpretation of ESUs encountered at the exploration locations. ESUs are described in a top down stratigraphic sequence described in the logs. The reader is referred to the logs attached in Appendix A for information regarding subsurface conditions.

ESU 1 – Disturbed native soils and undocumented fill: We observed soils interpreted to be disturbed native soil or undocumented fill at the test pit and boring locations to depths of about 1 to 1-1/2 feet below existing site grade. ESU 1 soils generally consisted of loose crushed rock above a non-woven geotextile and underlying loose to medium dense sand with a variable silt and gravel content as well as some woody debris. Engineering properties of ESU 1 soils are characterized as low strength and compressible materials.

ESU 2 – Medium dense recessional outwash and compacted structural fill: Soils interpreted to be shallow medium dense recessional outwash soils were observed at all of the exploration locations. Engineering

properties of ESU 2 soils are characterized as moderate strength low compressibility materials, and compacted structural fill is included in this category.

ESU 3 – Dense recessional outwash: Soils interpreted to be dense recessional outwash soils were observed at a depth of about 18 to 26-1/2 feet at the boring B-1 location, from about 18 to 23 feet at the boring B-2 location, and generally below about 5 feet at the CPT-1 location. Engineering properties of ESU 3 soils are characterized as high strength low compressibility materials.

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: At the time of our site visits, all but a small portion of the north end of the proposed substation had been stripped of vegetation, graded, and covered in a non-woven geotextile and about 4 to 6 inches

of crushed gravel. In preparation for grading, we recommend removal of any existing surficial vegetation, root mass, organic topsoil, and deleterious debris if present. These materials should be wasted from the substation footprint.

During our site visits that occurred during or shortly after heavy rain, we observed standing water across the site. We observed that silt and fine sand derived from the crushed gravel borrow that had been placed above the geotextile had washed down to the interface with the geotextile and was masking its surface, reducing its water transmissivity, and allowing standing water to develop. In order to increase the overall infiltration rate of the substation, we recommend stripping the crushed gravel (it may be stockpiled and used subsequently as structural fill) and removing the geotextile.

We also recommend selective removal of existing undocumented fill material or disturbed native soils containing substantial organics or deleterious debris and any relic organic topsoil from within the yard below structure and conduit run locations should it be encountered in excavations.

Variation in the undocumented fill and disturbed native soil depth and composition 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 currently below the geotextile and that will be 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 as this material has already been subject to heavy vehicle traffic and will not be subject to additional loading following construction of the new substation.

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 and gravel 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 concerns 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 moisture-sensitive soils that may be disclosed during grading 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

The District has indicated that the yard will have a finished elevation of 138 feet. This will necessitate placing about 1 to 2 feet of fill to allow placing a minimum of 8 inches of crushed surfacing base course

and 4 inches of substation rock. 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 below future improvements that will bear on these soils, they 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 project's stormwater management design relies on infiltration occurring through the existing soils following construction of the yard embankment. Consequently, additional compaction of the subgrade soils exposed following removal of the existing geotextile fabric, except as described above, is not recommended. The need for scarification of over-dense soils should be made at the time of construction following ZGA's subgrade observations.

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 and gravel with a relatively low fines content. The fines content of shallow soil samples that we tested (as deep as about 12 feet and likely to be encountered in excavations) ranged from approximately 1 to 9 percent. Overall, the native recessional outwash will be well-suited for use as structural fill. We observed the highest fines content in the very shallow soils, and using these materials as structural fill during wet weather could be difficult due to the high fines content and moisture sensitivity.

Imported Structural Fill: We recommend that structural fill consist of 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 3: 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
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 4: 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 rock ballast 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. Uncontrolled movement of water into trenches or foundation and slab excavations during construction should be prevented and it should be the responsibility of the contractor to implement measures to maintain positive drainage. Such measures may include, but may not be limited, to placing fill berms or shallow trenches around foundation, conduit, or storm sewer excavations.

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: Groundwater observations and measurements made as of the time that this report was prepared are described in Table 1. In summary, we have observed groundwater at depths of about 7 to 8-1/2 feet on site and at about 10 feet in the nearby UIC deluge drywell. ZGA is continuing to monitor groundwater at the GEB-9 well on site and others nearby, and quarterly summaries will be provided to the District.

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 to one of the open fields to the west of the site, into a nearby storm sewer, or Baker tank. Also, we suggest that the District consider using the existing UIC deluge drywell near the northwest corner of the site for a similar purpose until such time as it is decommissioned. 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 seasonal shallow groundwater condition, 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 medium dense native sand and gravel with a low fines content.

The vaults will exert a relatively low bearing pressure on the existing soils, and we estimate that up to approximately 1/2 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: Vaults installed below groundwater 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 previous GeoEngineers groundwater observations, we recommend considering a seasonal high groundwater elevation of about 130-1/2 feet.

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 medium dense native granular recessional outwash soils and properly compacted structural fill (ESU 2 soils) are adequate for support of shallow foundations. We have been provided with the following maximum compressive loads for the transfer, switchgear enclosure, and dead end structures as follows:

- Transformer: 100 kips
- Switchgear enclosure: 75 kips
- Dead end structures: 75 kips

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 ESU 2 soils. 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).

Recommended criteria for shallow foundations are summarized below.

Net allowable bearing pressure: 3,500 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 for standard column foundation: 4 feet

Minimum base dimension for continuous foundation: 14 inches

Minimum embedment for frost protection: 18 inches

Approximate total settlement: F-type footings: less than 1 inch; transformer slab, switchgear enclosure slab, and dead end structures: less than 1/2 inch

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

Ultimate passive resistance: 480 pcf. This value assumes that foundations are backfilled with native sand gravel 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 and does not include a factor of safety.

Modulus of subgrade reaction: 25 tons/ft^3.

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. 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 relatively shallow groundwater conditions will likely necessitate the use of casing during installation.

We understand that the District may 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 referenced boring B-2 location.** 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 design of the proposed drilled pier foundations and direct bury poles.

Table 5A: Recommended Soil Parameters Based on Boring B-2					
Depth interval in feet below existing grade	**Soil Condition**	**Average Standard Penetration Resistance (N)**	**Correlated Pressuremeter Elastic Modulus (kips/in²)[1]**	**Soil Wet Density (pcf)**	**Internal Friction Angle (Ø, in degrees)**
0 – 2	Med. dense Sand with some silt and gravel (Fill)	17	1.96	115	32
2 – 18	Med. dense gravelly Sand, trace silt	24	2.45	130[2]	34
18 – 23	Dense Sand with some silt, trace gravel	36	3.19	135[2]	38
23 – 26.5	Med. dense Sand, some silt, trace gravel	29	2.77	130[2]	36

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 depth of 8 feet. Subtract 62.4 pcf for buoyant unit density.

Table 5B: Recommended Soil Parameters Based on Boring B-2						
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 – 2	Med. dense Sand with some silt and gravel (Fill)	45	0.57	0.4	21	3.25/0.31
2 – 18	Med. dense gravelly Sand, trace silt	55	0.57	0.4	11[3]	3.54/0.28
18 – 23	Dense Sand with some silt, trace gravel	70	0.57	0.4	21[3]	4.2/0.24
23 – 26.5	Med. dense Sand, some silt, trace gravel	64	0.57	0.4	20[3]	3.85/0.26

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 at 8 feet.
4. Passive resistance in the upper 1.5 feet should be neglected entirely.

Recommended geotechnical input parameters for use in drilled foundation lateral analysis programs are provided in the table below.

Table 6: Soil Parameters for L-PILE Analysis Based On ZGA Boring B-2 and CPT-1*

Approx. Elevation (ft.) [Approx. Depth (ft.)]	Effective Unit Weight γ' (pcf)	Friction Angle, ϕ (degrees)		Cohesion, C (psf)	Modulus of Horizontal Subgrade Reaction, k (pci)		ε_{50} (%)	p-y Soil Model
		Static	Seismic #		Static	Seismic		
135 – 133 [0 – 2]	115	32	32	0	90	90	0	Sand above groundwater table
133 – 127 [2 – 8]	130	34	34	0	90	90	0	Sand above groundwater table
127 – 120 [8 – 15]	68	34	34	0	60	60	0	Sand below groundwater table
120 – 117 [15 – 18]	68	34	9	0	60	20	0	Sand below groundwater table
117 – 112 [18 – 23]	73	38	38	0	125	125	0	Sand below groundwater table
112 – 108.5 [23 – 26.5]	68	36	11	0	60	20	0	Sand below groundwater table

* B-2 and CPT-1 were advance at ground surface elevation of approximately 135 feet
\# Values for the Seismic condition include liquefaction effects

The planned yard finished grade elevation of 138 feet was provided to us when this report was prepared. The grade difference between the existing grade and the finished grade will be established by placing granular fill material compacted to at least 95 percent density per ASTM D 1557. Soil parameters for L-PILE analysis for granular fill compacted as described are presented in the table below.

Table 7: Soil Parameters for L-PILE Analysis For Compacted Structural Fill								
Approx. Elevation (ft.) [Approx. Depth (ft.)]*	**Effective Unit Weight γ' (pcf)**	**Friction Angle, ϕ (degrees)**		**Cohesion, C (psf)**	**Modulus of Horizontal Subgrade Reaction, k (pci)**		**ε_{50} (%)**	**p-y Soil Model**
		Static	**Seismic #**		**Static**	**Seismic**		
138 – 135 [0 – 3]*	130	34	34	0	90	90	0	Sand above groundwater table
*Relative to proposed finished grade = elevation 138 feet								

Drilled Shaft End Bearing Capacity

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. We recommend determining nominal unit base resistance via the following equation:

q_{BN} (expressed in tons/ft^2) = 0.60 X N_{60} (less than or equal to 30 tons/ft^2)

where q_{BN} = nominal unit base resistance and N_{60} is the average blowcount value between the pier base and two diameters beneath the base. For example, for a 4-foot diameter pier installed to 10 feet below the planned finished yard grade of 138 feet, a nominal unit base resistance of 16.8 tons/ft^2 may be considered.

Drilled Shaft Uplift Capacity

We recommend incorporating an ultimate uplift capacity due to skin friction between concrete piers and the surrounding soil of 0.38 tons/ft^2. The weight of the piers may be added to the skin friction value.

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 test pits, drilling, and probing processes did not suggest the presence of 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, particularly below groundwater. The contractor should be prepared to install full-depth casing or a sleeve through caving soil zones (temporary casing may be removed following concrete placement). 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 poles 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.

As described previously, the site is characterized by a shallow groundwater condition; previous monitoring by GeoEngineers identified a seasonal high groundwater elevation of about 130-1/2 feet. In the event that there is a need to place concrete in a dry drilled shaft, it is our understanding that some District contractors on other projects have elected to construct the foundation using a sacrificial steel casing, or a corrugated metal pipe (CMP) sleeve, in combination with a concrete plug at the bottom. In order to reduce the risk of destabilizing the granular soil at the bottom of the shaft, the use of slurry is recommended. Minimum levels of slurry in the excavation should be in general accordance with Section 6-19.3(4)B of the 2022 WSDOT Standard Specifications and as pertinent to the project site conditions and the District specifications.

In this case, the shaft would need to be drilled deeper than the design foundation depth such that concrete can be tremied into the base of the casing. The concrete plug installed at the base of the casing or sleeve would need to be thick enough to counteract the buoyant force at the base, and this will be dependent upon the groundwater depth at the time of construction. Once the concrete has cured, it will likely be feasible to pump the casing of water so that concrete can be installed via the free fall method, rather than via tremie through accumulated water, or that a direct-bury pole can be installed in the dry. It should be noted that the concrete plug may shrink during curing, and that some leakage around the plug may occur. Also, it should be noted that a permanent casing or sleeve will need to be cleaned prior to concrete placement.

Concrete Placement: Concrete for drilled piers should normally be placed via the free fall method in dry boreholes. 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 8. 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 8: IBC Non-constrained Pole Lateral Bearing Pressure

ZGA Boring	Recommended Lateral Bearing Pressure (lbs/ft^2/ft) of Embedment Depth[1,2,3]
B-2	1.5 to 2 feet: 150 2 to 18 feet: 185 18 to 23 feet: 225 23 to 26.5 feet: 200

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 estimated at about elevation 130-1/2 feet

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/ft^2/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.

Augercast Piles

We understand that augercast piles may be used in lieu of drilled pier foundations in some cases. Our recommendations regarding design and construction of augercast piles follow.

Pile Resistance: This section presents ultimate axial resistances for 24-inch diameter augercast piles. The resistances presented below were determined in general accordance with the methods presented in Geotechnical Engineering Circular No. 8, Design and Construction of Continuous Flight Auger (CFA) Piles (FHWA, 2007).

The ultimate axial compressive resistances provided in the tables below include side friction and end bearing. The capacities provided below assume that the finished grade will be elevation 138 feet, or about 3 feet above the grade at which boring B-2 was advanced. The ultimate axial compressive and uplift resistances ignore the contribution of side resistance in liquefiable soil zones. The foundation loads provided to us are relatively low and the estimated settlements are less than 1/2 inch. The capacities presented below assume a center-to-center spacing of no less than six pile diameters. For a closer spacing, ZGA can provide revised capacities due to group effects. The allowable capacities have a safety factor of 2.5 applied. Please note that the axial compressive capacities presented below do take into account the structural fill that will be added to the site and the resultant pile lengths.

Table 9: Axial Pile Capacities (based on ZGA boring B-2)

Pile Diameter, (in.)	Allowable Axial Static Compressive Resistance (kips)	Allowable Axial Seismic Compressive Resistance[1] (kips)	Allowable Static Uplift Resistance[2] (kips)	Allowable Seismic Uplift Resistance[2] (kips)
Tip Elevation = 115 feet (23 feet long)				
24	124	112	56	41

1. Recommended downdrag loads should be subtracted from these values.
2. Weight of pile should be added to the allowable uplift values.

We recommend that appropriate load and resistance factors be used in accordance with the applicable industry standard used for this project. The resistance factors used should assume that no field verification (such as load testing) of the recommended resistances will be performed during construction.

Pile Downdrag Loads: Liquefaction settlement during a design seismic event will result in downdrag loads on the piles. Design downdrag loads should be applied to piles in combination with other loads.

Table 10: Downdrag Load

Pile Diameter (inches)	Downdrag Load (kips/pile)
24	18

Lateral Resistance: Lateral loads can be resisted by a combination passive pressure soil resistance acting on embedded portions of the pile caps and lateral resistance of the piles. Recommendations for passive resistance are provided in the Shallow Foundations section of this report. Recommended geotechnical input parameters for use in lateral pile analysis programs are provided in Tables 7 and 8 .

Augercast Pile Construction Considerations: Augercast piles should be installed to the recommended pile tip elevations using a continuous-flight, hollow-stem auger. As is common practice, the pile grout would be pumped under pressure through the hollow stem as the auger is withdrawn.

We recommend that the augercast piles be installed by a contractor experienced in their placement and using suitable equipment. Grout pumps must be fitted with a volume-measuring device and a pressure gauge so that the volume of grout placed in each pile and the pressure head can be easily determined. While grouting, the rate of auger withdrawal must be controlled such that the volume of grout pumped is equivalent to at least 115 to 120 percent of the theoretical drilled hole volume. However, larger grout volumes may occur because the grout may tend to flow out into loose soil zones. A minimum grout line pressure of 100 psi must be maintained while grouting. Also, a minimum head of grout of 8 feet should be maintained above the auger tip at all times as the auger is being retracted from the hole. We recommend that there be a waiting period of at least 24 hours between installation of piles spaced closer than about 10 feet center-to-center in order to avoid disturbance of concrete undergoing curing in a previously cast pile.

Although no apparent obstructions were encountered within the recommended pile depths while advancing borings B-1 and B-2 and CPT-1, below-grade obstructions may be encountered during pile installation. The use of pre-excavation or other techniques may be required to remove obstructions and the contractor should be prepared to use these or other similar procedures where necessary. If pile refusal occurs above the recommended pile tip elevation, the pile should be relocated in accordance with the recommendations of the project structural engineer.

It should be noted that the recommended pile tip elevations and capacities presented above are based on assumed uniformity of soil conditions across the site. There may be unexpected variations in the depth to and characteristics of the supporting soils. In addition, no direct information regarding the capacity of augercast piles (e.g., driving resistance data) is obtained while this type of pile is being installed. Therefore, it is particularly important that the installation of augercast piles be completed under the direct observation of an experienced geotechnical engineer. Accordingly, we recommend that pile installation be monitored by a member of our staff who will observe installation procedures and evaluate the adequacy of individual pile installations. Additionally, we recommend construction specifications similar to those recommended in Geotechnical Engineering Circular No. 8, Design and Construction of Continuous Flight Auger Piles (FHWA 2007) be used for the project.

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 medium dense sand and gravel with a low 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 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:

$$\text{Log10}\,(K_{sat,\ initial}) = -1.57 + 1.9D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$ where:

$K_{sat,\ initial}$ = 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 11: Saturated Hydraulic Conductivity Summary		
Exploration / Sample	**Approximate sample depth (feet)**	**Unfactored Saturated Hydraulic Conductivity (inches per hour)**
B-1 / S-5	10	41.3
B-2 / S-3	5	50.6
TP-1 / S-1	2.5	48.5
TP-1 / S-2	4	59.2
TP-1 / S-3	6-1/2	80.3
TP-6 / S-1	1	34.7
TP-6 / S-2	4	58.5
TP-6 / S-3	7-1/2	105.8

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 determined via the grain size method (CF_T). Table 3.3.1 also requires applying correction factors for site variability and number of locations tested (CF_V) and the degree of influent control to prevent siltation and bio-buildup (CF_M). Based upon the site conditions, testing, and our experience with projects of a similar nature, we applied values of 0.5, 0.4, and 0.9 for CF_V, CF_T, and CF_M, respectively. We recommend using a factored rate (K_{sat}) of 17 inches/hour for the *in situ* native outwash sand and gravel 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

Previous groundwater monitoring by GeoEngineers included recording a seasonal high elevation of approximately 130-1/2 feet, or about 5-1/2 feet below existing grade and likely about 6-1/2 feet below substation finished grade. The depth of groundwater is not likely to adversely affect the substation's ability to adequately infiltrate stormwater falling on the site, in our opinion.

Storage Considerations

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 November 2012 geotechnical engineering report prepared by Terracon Consultants, Inc. which summarizes testing completed on a sample of CSBC sourced from the Iron Mountain Quarry.

Geotechnical Engineering Report
Cedar Valley Substation ▪ Snohomish County, Washington
30 November 2012 ▪ Terracon Project No.: 81125096

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.

We recently received from Iron Mountain Quarry the results of recent permeability testing of their CSBC completed by Krazan & Associates, Inc. The test results, which are included in Appendix B, were conducted on full samples of the CSBC, i.e., the plus 3/4-inch fraction was not removed prior to testing. Consistent with our conclusion pointed out above, the tests indicated permeability rates for two samples of 168.5 to 170.5 inches/hour when compacted to 98 percent of the modified Proctor maximum dry density.

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.

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 provided that fill with a high void ratio and permeability are required.

Table 12: 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 provided for our review indicate that the substation footprint encompasses slightly less than one acre. It appears that groundwater mounding analysis is not necessary per the *Manual* given the documented groundwater depth relative to the anticipated site improvements.

Driveway Flexible Pavement Section Recommendations

In the event that the substation is provided with an asphalt-paved driveway, we recommend considering the criteria described below. 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.

Deluge UIC Well Decommissioning

We understand that planned site improvements will render the existing deluge system UIC well unnecessary and that the District may decommission it. Toward that end, we offer the following:

- Per Washington Administrative Code (WAC) 173-218-040 *UIC well classification including allowed and prohibited wells*, the well meets the criteria a *Class V injection well*, a type that commonly

includes drywells installed for stormwater management purposes [WAC 173-218-040(5) and WAC 173-218-040(5)(a)(i)].

- Per WAC 173-218-120 *Decommissioning a UIC well* Section (3)(b), *Class V wells must be decommissioned by filling or plugging the well so that it will not result in an environmental, public health, or safety hazard, and will not serve as a channel for movement of water or pollution to an aquifer*.

- In addition, per Section 3(b0(i), *UIC wells that are in contact with an aquifer, even if they are in contact with only the seasonal high aquifer, must be decommissioned in accordance with the most applicable method found in Chapter 173-160 WAC Minimum standards for construction and maintenance of wells.*

- The drywell meets the criteria for a "dug well" per *WAC 173-160-381 What are the standards for decommissioning a well?* Section (2)(3), in our opinion.

- Per *WAC 173-160-381 What are the standards for decommissioning a well? any well which is unusable, abandoned, or whose use has been permanently discontinued* (emphasis added by ZGA), *or which is in such disrepair that its continued use is impractical or is an environmental, safety or public health hazard shall be decommissioned. The decommissioning procedure (as prescribed by these regulations) must be recorded and reported as required by the department.*

- *(3) Dug wells -*

  (a) The following criteria are required for the decommissioning of all dug wells:

  (i) Remove all debris, accumulated sediments, and obstructions that impede decommissioning or that may contaminate the aquifer from within the dug well.

  (ii) Dug wells may have a maximum of three feet of soil cover from top of sealing material to land surface.

  (iii) Dug wells shall be sealed with either unhydrated bentonite, neat cement, neat cement grout, or concrete. The use of controlled density fill (CDF), bentonite slurry, or fly ash is prohibited (emphasis added by ZGA).

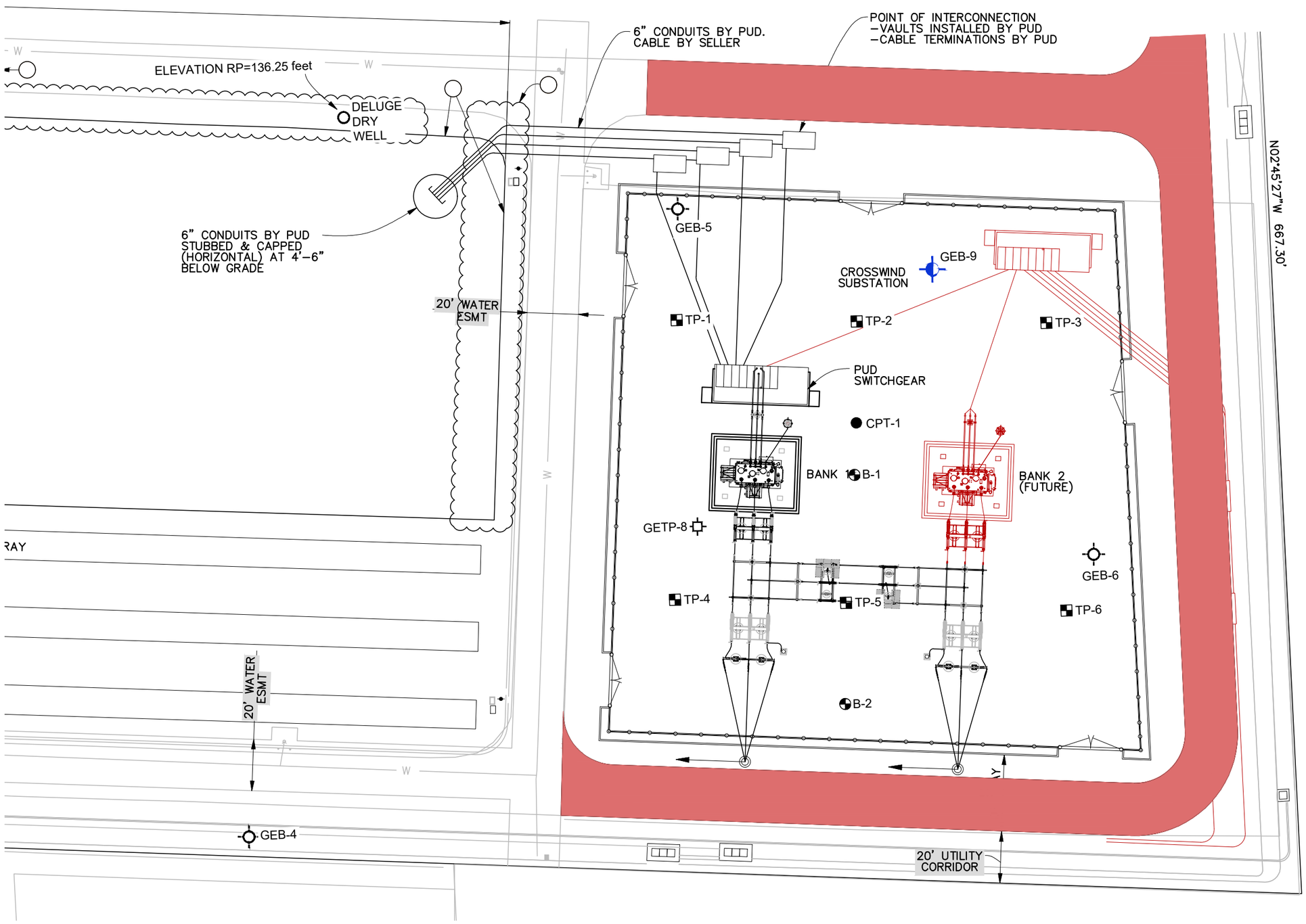
Please note that until such time as the drywell is permanently abandoned, the District is not required to decommission it.

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	BORING NUMBER AND APPROXIMATE LOCATION
TP-1	TEST PIT NUMBER AND APPROXIMATE LOCATION
GEB-6	GEO ENGINEERS BORING NUMBER AND APPROXIMATE LOCATION
GETP-8	GEO ENGINEERS TEST PIT NUMBER AND APPROXIMATE LOCATION
	DELUGE DRY WELL APPROXIMATE LOCATION
CTP-1	CPT NUMBER AND APPROXIMATE LOCATION

N

40 0 20 40

SCALE IN FEET

REFERENCE: SNOHOMISH COUNTY PUBLIC UTILITIES DISTRICT SITE PLAN DATED JANUARY 26, 2023

CROSSWIND SUBSTATION
17601 59th Avenue NE
Arlington, WA

SITE AND EXPLORATION PLAN

4/15/2023 Job No. 2679.01

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

FIGURE 1
SHT.1 of 1

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 two borings (B-1 and B-2), advancing one cone penetrometer test (CPT-1), and excavating six test pits (TP-1 through TP-6). The approximate exploration locations are presented on Figure 1, the *Site and Exploration Plan*. Exploration locations were determined in the field using steel and fiberglass tapes by measuring distances from existing site features shown on the *Central Arlington Rebuild Concept A* plan, dated 26 August 2021, provided by the District. The approximate ground surface elevation at the exploration locations was interpolated from contours shown on Sheet SV1.08, *North County Community Office*, dated 22 March 2022. 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 trailer-mounted drill rig operated by an independent drilling company (Geologic Drilling Partners) 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.

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.

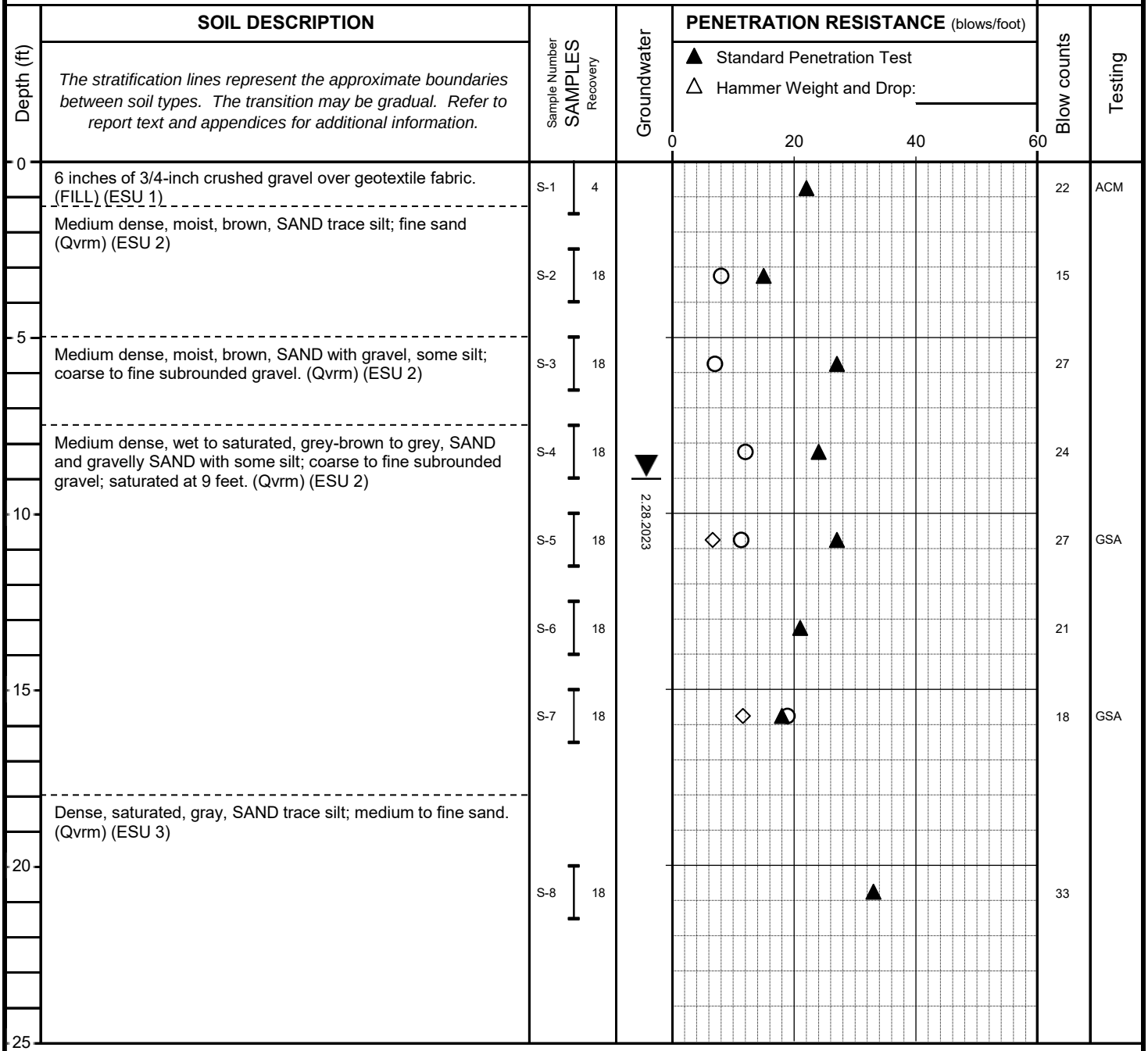
Sample Screening

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.

Exploration Logs by Others

The 29 December 2017 GeoEngineers report *Geotechnical Engineering Services, North County Project, Arlington, Washington* (File No. 0482-051-03) includes the logs of numerous explorations completed at the Microgrid site. This appendix includes the logs of one test pit and four borings that GeoEngineers completed in or very near the proposed substation location, the approximate locations of which are illustrated on Figure 1.

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Geologic Drill	Bore Hole Dia.: 6 inch	**B-1**
Top Elevation: 136 Feet	Drilling Method: HSA	Hammer Type: Cathead	
Date Drilled: 2.28.2023	Drill Rig: Trailer rig	Logged by: JLB	



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. 11/2/12

TESTING KEY

GSA = Grain Size Analysis

200W = 200 Wash Analysis

Consol. = Consolidation Test

Att. = Atterberg Limits

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ⊣—○—⊢ Liquid Limit

Natural Water Content

Crosswind Substation
17601 59th Avenue NE
Arlington, WA

Date: 3.15.2023 Project No.: 2679.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-1

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Geologic Drill	Bore Hole Dia.: 6 inch	**B-1**
Top Elevation: 136 Feet	Drilling Method: HSA	Hammer Type: Cathead	
Date Drilled: 2.28.2023	Drill Rig: Trailer rig	Logged by: JLB	

Depth (ft)	SOIL DESCRIPTION	Sample Number / SAMPLES / Recovery	Groundwater	PENETRATION RESISTANCE (blows/foot) ▲ Standard Penetration Test △ Hammer Weight and Drop: 0 20 40 60	Blow counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.					
25	Medium dense, saturated, grey, SAND trace gravel, some silt. (Qvrm) (ESU 2)	S-9 18		◇ ○ ▲	30	GSA
	Borehole completed at 26.5 feet below ground surface (bgs). Groundwater observed at 9 feet bgs at time of drilling. Drilling mud added at 10 feet due to heaving conditions.					
30						
35						
40						
45						
50						

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
- ▼ 11/2/12 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

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Crosswind Substation
17601 59th Avenue NE
Arlington, WA

Date: 3.15.2023 Project No.: 2679.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-1

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Geologic Drill	Bore Hole Dia.: 6 inch	**B-2**
Top Elevation: 135 Feet	Drilling Method: HSA	Hammer Type: Cathead	
Date Drilled: 2.28.2023	Drill Rig: Trailer rig	Logged by: JLB	

Depth (ft)	SOIL DESCRIPTION	Sample Number	SAMPLES Recovery	Groundwater	PENETRATION RESISTANCE (blows/foot) ▲ Standard Penetration Test △ Hammer Weight and Drop: 0 20 40 60	Blow counts	Testing
0	*The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.*						
	6 inches of 3/4 inch crushed gravel over geotextile fabric. (FILL) (ESU 1)	S-1	15			17	ACM
	Medium dense, moist to saturated, brown, gravelly SAND, trace silt; fine subrounded gravel, saturated at 8 feet. (Qvrm) (ESU 2)	S-2	18			15	
5		S-3	18			26	GSA
		S-4	18	▼ 2.28.2023		25	
10		S-5	18			28	
		S-6	18			28	GSA
15	Medium dense to dense, saturated, grey-brown, SAND trace gravel, some silt; medium to fine sand. (Qvrm) (ESU 2)	S-7	18			23	
	Dense, saturated, grey-brown SAND with trace gravel and some silt (Qvrm) (ESU 3)						
20		S-8	18			36	GSA
	Medium dense to dense, saturated, grey-brown, SAND trace gravel, some silt; medium to fine sand. (Qvrm) (ESU 2)						
25							

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
- ▼ 11/2/12 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

Crosswind Substation
17601 59th Avenue NE
Arlington, WA

Date: 3.15.2023 Project No.: 2679.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-2

Boring Location: See Figure 1, Site and Exploration Plan	Drilling Company: Geologic Drill	Bore Hole Dia.: 6 inch	**B-2**
Top Elevation: 135 Feet	Drilling Method: HSA	Hammer Type: Cathead	
Date Drilled: 2.28.2023	Drill Rig: Trailer rig	Logged by: JLB	

Depth (ft)	SOIL DESCRIPTION	Sample Number / SAMPLES / Recovery	Groundwater	PENETRATION RESISTANCE (blows/foot) ▲ Standard Penetration Test △ Hammer Weight and Drop: 0 20 40 60	Blow counts	Testing
	The stratification lines represent the approximate boundaries between soil types. The transition may be gradual. Refer to report text and appendices for additional information.					
25	Medium dense to dense, saturated, grey-brown, SAND trace gravel, some silt; medium to fine sand. (Qvrm) (ESU 2)	S-9 18		○ ▲	29	
	Borehole completed at 26.5 feet below ground surface (bgs). Groundwater observed at 8 feet bgs at time of drilling. Drilling mud added at 15 feet bgs due to heaving conditions.					
30						
35						
40						
45						
50						

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
- ▼ 11/2/12 Groundwater level at time of drilling (ATD) or on date of measurement.

TESTING KEY

GSA = Grain Size Analysis

200W = 200 Wash Analysis

Consol. = Consolidation Test

Att. = Atterberg Limits

◇ % Fines (<0.075 mm)

○ % Water (Moisture) Content

Plastic Limit ⊢—○—⊣ Liquid Limit

Natural Water Content

Crosswind Substation
17601 59th Avenue NE
Arlington, WA

Date: 3.15.2023 Project No.: 2679.01

Zipper Geo Associates
19019 36th Ave. W, Suite E
Lynnwood, WA

BORING LOG: B-2

ZipperGeo
Geoprofessional Consultants

Test Pit TP-1

Location: See Attached Site and Exploration Plan in Figure 1

Approximate Ground Surface Elevation: 136 feet

Project: Crosswind Substation

Project Number: 2679.01

Date Excavated: 2.22.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	About 4 inches of 3/4 inch crushed GRAVEL over non-woven geotextile over loose, moist, brown, SAND with woody debris/logs max 16 inches long and 4 inches diameter. (FILL)	S-ACM			ACM
2					
3	Loose to medium dense, moist, yellow-brown, SAND trace gravel, trace silt; medium to fine sand. (Qvrm)	S-1 @ 2-1/2 feet	0.1	9	GSA
4					
5	Loose to medium dense, moist, yellow-brown, gravelly SAND trace silt; subrounded gravel. (Qvrm)	S-2 @ 4 feet	0.1	6	GSA
6					
7	Loose to medium dense, moist, grey, sandy GRAVEL trace silt; subrounded gravel. (Qvrm)	S-3 @ 6-1/2 feet	0.2	4	GSA
8					
9	Loose to medium dense, grey, wet, GRAVEL with cobbles, with sand; subrounded cobbles, subrounded gravel. (Qvrm)	S-4 @ 8 feet	0.1		
10					
11	Exploration completed at 8-1/2 feet on 2.22.2023 Moderate groundwater seepage observed at approximately 8 feet at time of excavation				
12	Slight to moderate caving observed from 7-8 feet				
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

	Test Pit TP-2	**Project:** Crosswind Substation			
	Location: See Attached Site and Exploration Plan in Figure 1	**Project Number:** 2679.01			
	Approximate Ground Surface Elevation: 136 feet	**Date Excavated:** 2.22.2023			
Depth (ft)	**Material Description**	**Sample**	**PID**	**% M**	**Testing**
1	About 4 inches of 3/4 -inch crushed GRAVEL over non-woven geotextile over loose, moist, brown, SAND some organics/woody debris. (FILL)	S-ACM			ACM
2	Loose to medium dense, moist, yellow-brown, SAND some silt; medium to fine sand. (Qvrm)	S-1 @ 1-1/2 feet	0.1	5	
3					
4					
5					
6	Loose to medium dense, moist, yellow-brown, SAND with gravel; subrounded gravel. (Qvrm)	S-2 @ 5 feet	0.1	5	
7					
8	Loose to medium dense, wet, grey-brown, SAND with cobbles, with gravel; subrounded cobbles, subrounded gravel. (Qvrm)	S-3 @ 7 feet	0.1	8	
9					
10	Exploration completed at 7-1/2 feet on 2.22.2023 Moderate groundwater seepage observed at approximately 7-1/2 feet at time of excavation				
11	Slight caving observed from approximately 7 feet				
12					
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

	Test Pit TP-3	**Project:** Crosswind Substation			
	Location: See Attached Site and Exploration Plan in Figure 1	**Project Number:** 2679.01			
	Approximate Ground Surface Elevation: 136 feet	**Date Excavated:** 2.22.2023			
Depth (ft)	**Material Description**	**Sample**	**PID**	**% M**	**Testing**
1	About 3 inches of 3/4 inch crushed GRAVEL over non-woven geotextile over loose, moist, brown, SAND with silt, some organics/woody debris. (FILL)	S-ACM			ACM
2	Loose to medium dense, moist, red-brown, SAND trace silt; medium to fine sand. (Qvrm)	S-1 @ 1-1/2 feet	0.2	5	
3					
4	Loose to medium dense, moist, yellow-brown, SAND with cobbles, with gravel; subrounded cobbles, subrounded gravel. (Qvrm)	S-2 @ 3 feet	0.1	4	
5					
6					
7	Loose to medium dense, wet, grey, GRAVEL with sand; subrounded gravel. (Qvrm)	S-3 @ 6-1/2 feet	0.1	6	
8					
9	Exploration completed at 7-1/2 feet on 2.22.2023 Moderate groundwater seepage observed at approximately 7 feet at time of excavation No caving observed.				
10					
11					
12					
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

	Test Pit TP-4	**Project:** Crosswind Substation			
	Location: See Attached Site and Exploration Plan in Figure 1	**Project Number:** 2679.01			
	Approximate Ground Surface Elevation: 135 feet	**Date Excavated:** 2.22.2023			
Depth (ft)	**Material Description**	**Sample**	**PID**	**% M**	**Testing**
1	About 3 inches of 3/4-inch crushed GRAVEL over non-woven geotextile over loose, moist, red-brown, SAND with silt, some organics/woody debris, with FE. (FILL)	S-1 @ 1 feet	0.2		ACM
2					
3	Loose to medium dense, moist, brown, SAND trace to with gravel, trace silt; with subrounded cobbles at 6 feet; subrounded gravel. (Qvrm)	S-2 @ 2-1/2 feet	0.1		
4					
5		S-3 @ 4-1/2 feet	0.1		
6					
7	Loose to medium dense, wet, grey, SAND with gravel; subrounded gravel, coarse to fine sand. (Qvrm)	S-4 @ 6 feet	0.1		
8		S-5 @ 7 feet	0.1		
9	Exploration completed at 8 feet on 2.22.2023 Moderate groundwater seepage observed at approximately 7 feet at time of excavation Moderate caving observed at approximately 7 feet.				
10					
11					
12					
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

	Test Pit TP-5 **Location:** See Attached Site and Exploration Plan in Figure 1 **Approximate Ground Surface Elevation:** 136 feet	**Project:** Crosswind Substation **Project Number:** 2679.01 **Date Excavated:** 2.22.2023			
Depth (ft)	**Material Description**	**Sample**	**PID**	**% M**	**Testing**
1	4 inches of 3/4-inch crushed GRAVEL over non-woven geotextile over loose to medium dense, moist, red-brown, SAND trace to some wood debris, with Fe. (FILL)	S-ACM			ACM
2		S-1 @ 1-1/2 feet	0.2	7	
3					
4	Loose to medium dense, moist, yellow-brown, SAND some gravel, trace silt; subrounded gravel. (Qvrm)	S-2 @ 3 feet	0.1	4	
5					
6	Loose to medium dense, moist, grey-brown, GRAVEL with sand, with cobbles at 7 feet; subrounded cobbles; subrounded gravel. (Qvrm)	S-3 @ 5 feet	0.1	2	
7					
8		S-4 @ 7 feet	0.1	9	
9	Exploration completed at 8 feet on 2.22.2023 Moderate seepage observed at approximately 7-1/2 feet at time of excavation Slight to moderate caving observed from approximately 7-8 feet.				
10					
11					
12					
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

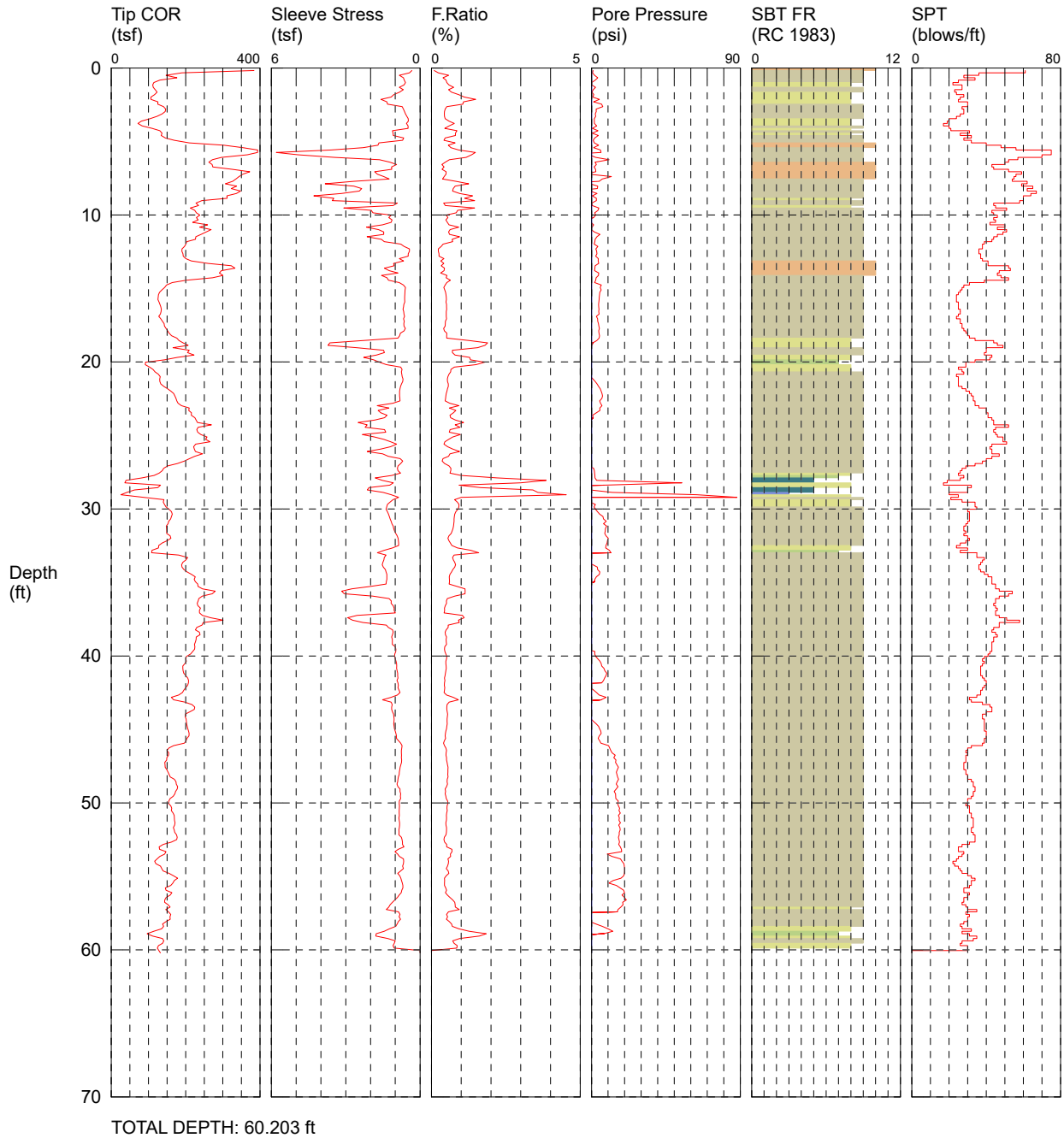
	Test Pit TP-6	**Project:** Crosswind Substation			
	Location: See Attached Site and Exploration Plan in Figure 1	**Project Number:** 2679.01			
	Approximate Ground Surface Elevation: 136 feet	**Date Excavated:** 2.22.2023			
Depth (ft)	**Material Description**	**Sample**	**PID**	**% M**	**Testing**
1	3-4 inches of 3/4-inch crushed GRAVEL over non-woven geotextile over loose to medium dense, moist, red-brown, SAND trace gravel, some silt, trace to some wood debris, with Fe. (FILL)	S-1 @ 1 feet	0.1	12	GSA ACM
2					
3					
4					
5	Loose to medium dense, moist, yellow-brown, gravelly SAND, trace silt; subrounded gravel. (Qvrm)	S-2 @ 4 feet	0.1	6	GSA
6					
7					
8	Loose to medium dense, grey-brown, moist, gravelly SAND with cobbles, trace silt; subrounded cobbles, subrounded gravel. (Qvrm)	S-3 @ 7-1/2 feet	0.1	10	GSA
9					
10	Exploration completed at approximately 8 feet.				
11	Moderate groundwater seepage observed at approximately 7-1/2 feet at time of excavation				
12	Slight caving observed from approximately 7-8 feet.				
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

CPT-01

CPT Contractor: In Situ Engineering
CUSTOMER: ZipperGeo
LOCATION: Arlington
JOB NUMBER: 2679.01

OPERATOR: Forinash
CONE ID: DDG1351
TEST DATE: 2/24/2023 9:46:02 AM
Coring: 0ft
Backfill: 20% Bentonite Slurry + Bentonite Chip
Surface Patch: None



TOTAL DEPTH: 60.203 ft

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

*SBT/SPT CORRELATION: UBC-1983

GeoEngineers Exploration Logs

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	6/14/2012	6/14/2012	26.5	SMJ	BPD	Geologic Drill Explorations, Inc.	Hollow-stem Auger

Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D-50 Track Rig
Surface Elevation (ft)	134.5	Top of Casing Elevation (ft)	
Vertical Datum	NAVD88		
Easting (X)		Horizontal Datum	
Northing (Y)			

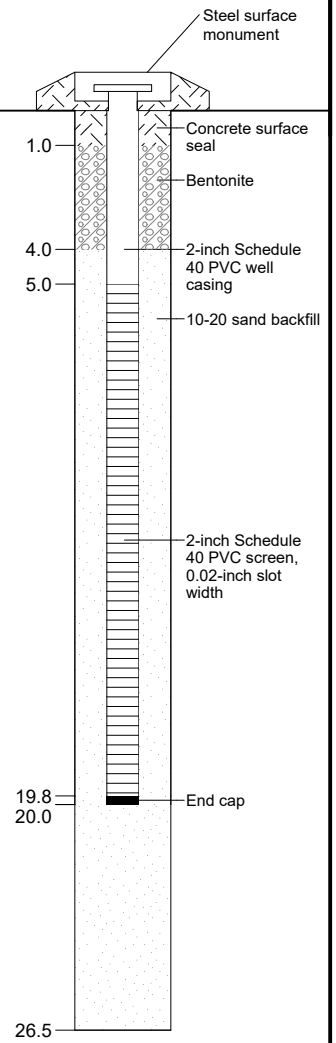
DOE Well I.D.: BHJ196
A 2 (in) well was installed on to a depth of 20 (ft).

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
6/25/2012	5.7	128.8

Notes: Elevation estimated from base survey map

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample: Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0						TS	9 inches topsoil and roots		
							SM	Light brown silty fine to medium sand with gravel, trace organic matter (loose, moist)		
130		18	8	1 MC					11	
	5	18	22	2 MC	▼		SP-SM	Light brown fine to medium sand with silt and gravel (medium dense, moist) (recessional outwash)	6	
		12	22	3				Becomes wet		
125							SP	Grayish brown fine to medium sand with gravel (medium dense, wet)		
	10	18	23	4						
							SP-SM	Grayish brown fine to medium sand with silt and occasional gravel (medium dense, wet) Driller added drilling mud at 13 feet		
120										
	15	18	21	5						
							SM	Grayish brown silty fine to medium sand (medium dense to dense, wet)		
115										
	20	18	30	6 MC				1 foot heave at 20 feet	12	
110										
	25	18	12	7						

WELL LOG



Notes: See Figure A-1 for explanation of symbols.
Elevation estimated from base survey map

Log of Boring B-4

GeoEngineers

Project:	Arlington Site Development
Project Location:	Arlington, Washington
Project Number:	0482-051-03

Figure A-5
Sheet 1 of 1

Seattle: Date:5/4/16 Path:P:\0\0482051\GINT\048205103.GPJ DBTemplate\LibTemplate\GEOENGINEERS8.GDT/GEI8_GEOTECH_WELL

Drilled	Start 6/13/2012	End 6/13/2012	Total Depth (ft) 26.5	Logged By SMJ / Checked By BPD	Driller Geologic Drill Explorations, Inc.	Drilling Method Hollow-stem Auger
Surface Elevation (ft) 136.5 / Vertical Datum NAVD88			Hammer Data Autohammer 140 (lbs) / 30 (in) Drop		Drilling Equipment Diedrich D-50 Track Rig	
Easting (X) / Northing (Y)			System Datum		Groundwater: Date Measured / Depth to Water (ft) / Elevation (ft) — See Remarks	

Notes: Elevation estimated from base survey map

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample: Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
135	0						TS	6 inches topsoil and roots			Recently mowed weeds and blackberries
							SP-SM	Grayish brown fine to medium sand with silt, trace roots (loose, moist) (recessional outwash)			
		14	9	1 MC					6		
130	5	18	15	2 SA				Becomes medium dense with gravel	7	8	
		12	16	3				Becomes wet			Groundwater seepage observed at 8 feet
125	10	18	23	4							Driller added drilling mud at 10 feet
							SW-SM	Grayish brown fine to coarse sand with silt and gravel (medium dense, wet)			
120	15	10	27	5							
							SM	Grayish brown silty fine to medium sand (medium dense, wet)			
115	20	12	12	6							
110	25	12	22	7							

Notes: See Figure A-1 for explanation of symbols.
Elevation estimated from base survey map

Log of Boring B-5

GeoEngineers

Project: Arlington Site Development
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-6
Sheet 1 of 1

Seattle: Date:5/4/16 Path:P:\0\0482051\GINT\0482051 03.GPJ DBTemplate\LibTemplate\GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled	Start 6/13/2012	End 6/13/2012	Total Depth (ft)	26.5	Logged By / Checked By	SMJ / BPD	Driller	Geologic Drill Explorations, Inc.	Drilling Method	Hollow-stem Auger
Surface Elevation (ft) / Vertical Datum	136.5 NAVD88		Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop			Drilling Equipment	Diedrich D-50 Track Rig		
Easting (X) / Northing (Y)			System Datum				Groundwater: Date Measured	Depth to Water (ft)	Elevation (ft)	
Notes: Elevation estimated from base survey map							See Remarks			

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample: Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)	REMARKS
135	0						TS	6 inches topsoil and roots			Recently mowed weeds and blackberries
		12	14	1			SM	Light brown silty fine to medium sand with occasional gravel, organic matter (medium dense, moist) (recessional outwash)	20		
130	5	12	24	2			SP-SM	Light brown fine to medium sand with silt and occasional gravel (medium dense, moist) (recessional outwash)	7		
		18	30	3				Becomes medium dense to dense and wet			Groundwater seepage observed at 7½ feet
125	10	17	30	4			SW-SM	2 inch silt lense Grayish brown fine to coarse sand with gravel (medium dense to dense, wet)			
							SM	Grayish brown silty fine to medium sand with occasional gravel (medium dense, wet)			
120	15	18	28	5							
115	20	18	25	6							
110	25	18	24	7			SM	Brown silty fine to medium sand (medium dense, wet)			3 feet heave at 25 feet

Notes: See Figure A-1 for explanation of symbols.
Elevation estimated from base survey map

Log of Boring B-6

GeoEngineers

Project: Arlington Site Development
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-7
Sheet 1 of 1

Seattle: Date:5/4/16 Path:P:\0\0482051\GINT\048205103.GPJ DBTemplate\LibTemplate\GEOENGINEERS8.GDT/GEI8_GEOTECH_STANDARD

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	3/8/2017	3/8/2017	26.5	NS	KMS	Holocene Drilling, Inc.	Hollow-stem Auger

Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D50 Track-mounted
Surface Elevation (ft) Vertical Datum	137 NAVD88	Top of Casing Elevation (ft)	137
Easting (X) Northing (Y)	1320413 424926	Horizontal Datum	WA State Plane North NAD83 (feet)

DOE Well I.D.: BJY257
A 2 (in) well was installed on 3/8/2017 to a depth of 20 (ft).

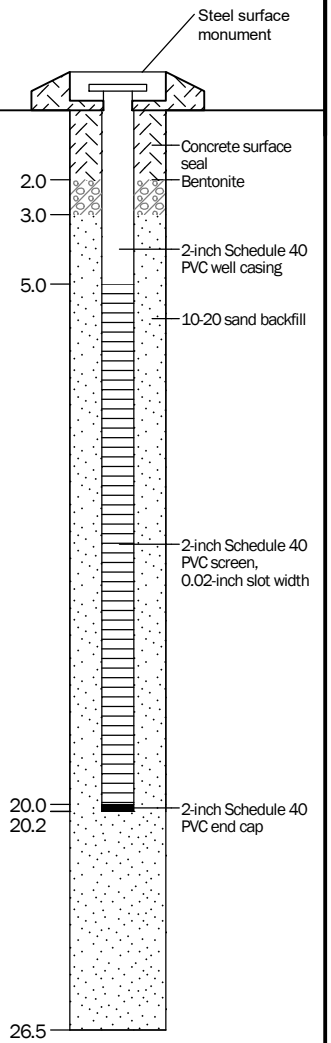
Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
4/13/2017	7.4	129.6

Notes: Environmental field screening was completed on each soil sample. Sheen and head space vapor were not observed unless otherwise noted.

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0							TS	Topsoil with roots (upper 6 inches)		
135		16	13		1 MC			SM	Reddish brown silty fine to medium sand with occasional organic matter (medium dense, moist)	7	
	5	4	62*		2			SP-SM	Light brown fine to medium sand with silt and occasional gravel and cobbles (medium dense to dense, moist) (recessional outwash)		
130		8	36*		3 SA	▼		SP-SM	Light brown fine to coarse sand with silt, gravel and occaional cobbles (medium dense, wet)	7	9
	10	10	23		4			SP	Light gray fine to coarse sand with gravel (medium dense, wet)		
125		9	23		5 %F					15	4
	15	18	21		6				Becomes gray		
120								SP-SM	Gray fine to medium sand with silt and occasional gravel (medium dense, wet)		
	20	18	19		7 %F			SP	Gray fine to medium sand (medium dense, wet)	20	4
115											
	25	18	18		8						

* Sampler bouncing on rock, blow count not representative.

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Hand-held GPS (±18 ft), Vertical approximated based on Survey Basemap (±1 ft)

Log of Boring B-8

GeoEngineers

Project: Arlington Local Office Replacement
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-3
Sheet 1 of 1

Bellingham: Date:4/24/17 Path:P:\0\0482051\GINT\048205103.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_APRIL_2017.GDT/GEIB_GEOTECH_WELL_%F

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	3/8/2017	3/8/2017	26.5	NS	KMS	Holocene Drilling, Inc.	Hollow-stem Auger

Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D50 Track-mounted
Surface Elevation (ft) Vertical Datum	136 NAVD88	Top of Casing Elevation (ft)	137
Easting (X) Northing (Y)	1321085 424465	Horizontal Datum	WA State Plane North NAD83 (feet)

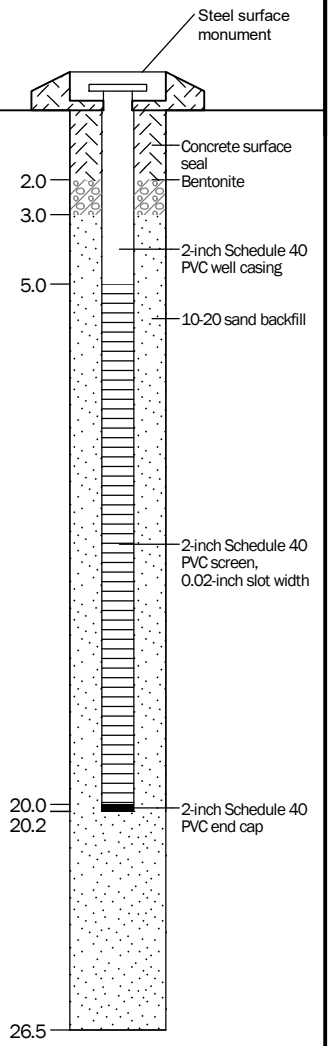
DOE Well I.D.: BJY258
A 2 (in) well was installed on 3/8/2017 to a depth of 20 (ft).

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
4/13/2017	2.7	133.3

Notes: Environmental field screening was completed on each soil sample. Sheen and head space vapor were not observed unless otherwise noted.

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
135	0							TS	Topsoil with roots (upper 6 inches)		
		10	8		1 %F	▼		SP-SM	Brown fine to coarse sand with silt and occasional gravel (loose, wet) (recessional outwash)	14	5
130	5	12	12		2 SA			SP	Brown fine to coarse sand with gravel (medium dense, wet)	20	2
		14	20		3						
125	10	12	26		4 %F			SP-SM	Brown fine to medium sand with silt and occasional gravel (medium dense, wet)	15	6
		8	29		5						
120	15	18	28		6						
115	20	18	40		7 %F				Becomes dense	14	7
110	25	18	24		8			SP-SM	Brown fine sand with silt (medium dense, wet)		

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Hand-held GPS (±18 ft), Vertical approximated based on Survey Basemap (±1 ft)

Log of Boring B-9

GeoEngineers

Project: Arlington Local Office Replacement
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-4
Sheet 1 of 1

Bellingham: Date:4/24/17 Path:P:\0\0482051\GINT\048205103.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_APRIL_2017.GDT/GEIB_GEOTECH_WELL_%F

Date Excavated: 6/15/2012 Logged By: SMJ

Equipment: Rubber Tire Backhoe Total Depth (ft) 12.0

Elevation (feet)	Depth (feet)	SAMPLE: Testing Sample	SAMPLE: Sample Name / Testing	Graphic Log	Group Classification	Encountered Water	MATERIAL DESCRIPTION	Moisture Content, %	REMARKS
			1		TS		8-inches topsoil and roots		Recently mowed weeds and blackberries Probe(P) = 12 inches
135	1				SM		Reddish brown silty fine to medium sand with organic matter (loose to medium dense, moist)		P = 8 inches
134	2								P = 8 inches
133	3	X	2 SA					17	P = 4 inches SA (%F = 27)
132	4								
131	5								
130	6	X	3 SA		SP		Light brown fine to medium sand with gravel (medium dense, moist) (recessional outwash)	5	P = 2 inches SA (%F = 3)
129	7								
128	8								
127	9	X	4						
126	10						Grades to grayish brown and becomes wet		
125	11				SP-SM		Grayish brown fine to medium sand with gravel and occasional cobbles (medium dense, wet)		
124	12	X	5						

Moderate groundwater seepage observed at 10 feet.
Moderate caving observed at 10 feet.

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.
Elevation estimated from base survey map

Seattle: Date:5/4/16 Path:P:\0\0482051\GINT\048205103.GPJ DBTemplate\LibTemplate\GEOENGINEERS8.GDT/GEI8_TESTPIT_1P_GEOTEC

Log of Test Pit TP-8

GeoEngineers

Project: Arlington Site Development
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-15
Sheet 1 of 1

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)

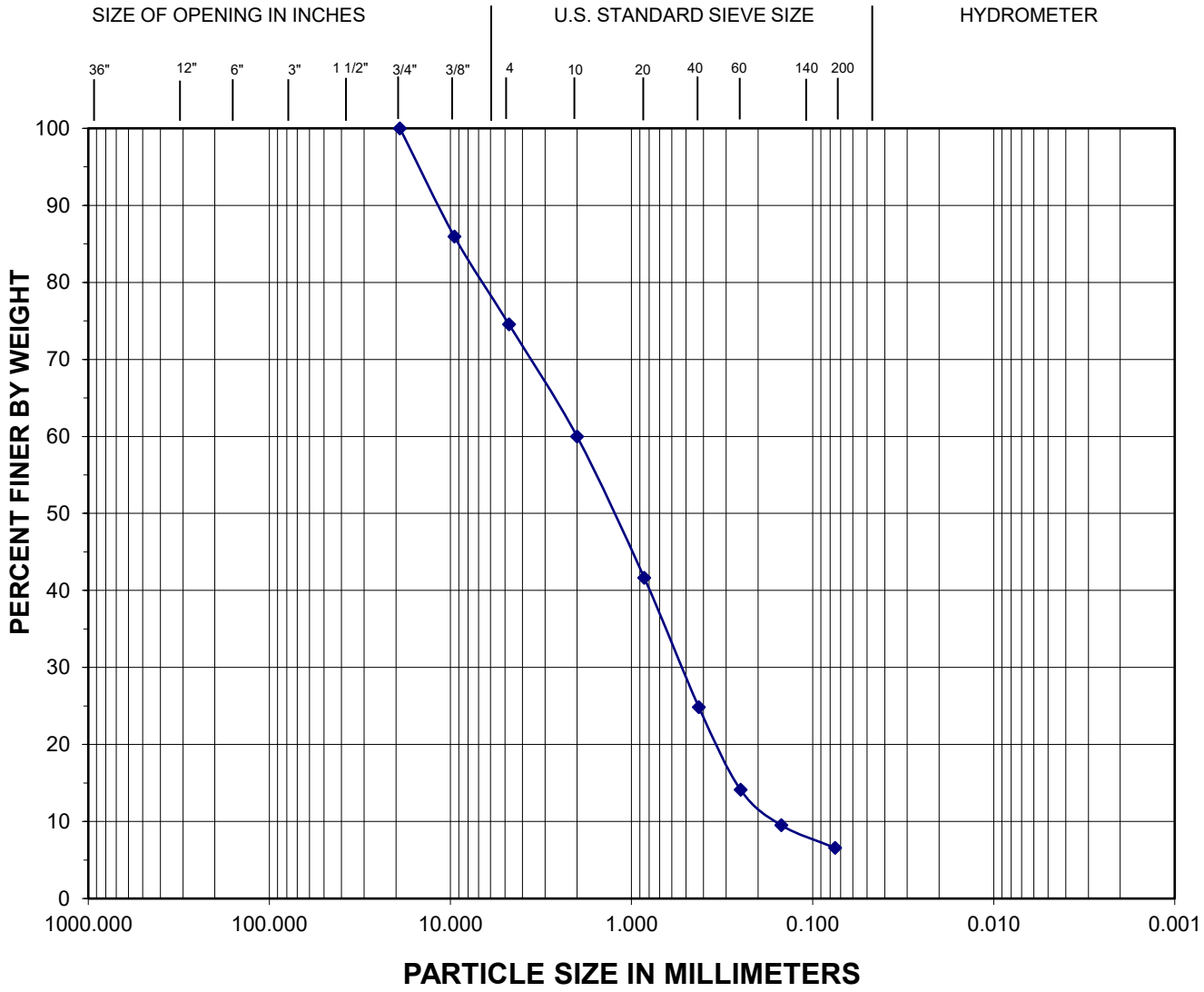
Five samples of existing fill material were collected from the test pits and borings in order to test for the presence of ACM. Examination of these samples was conducted for the presence of identifiable asbestos fibers using polarized light microscopy (PLM) with dispersion staining in accordance with 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



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

Comments:

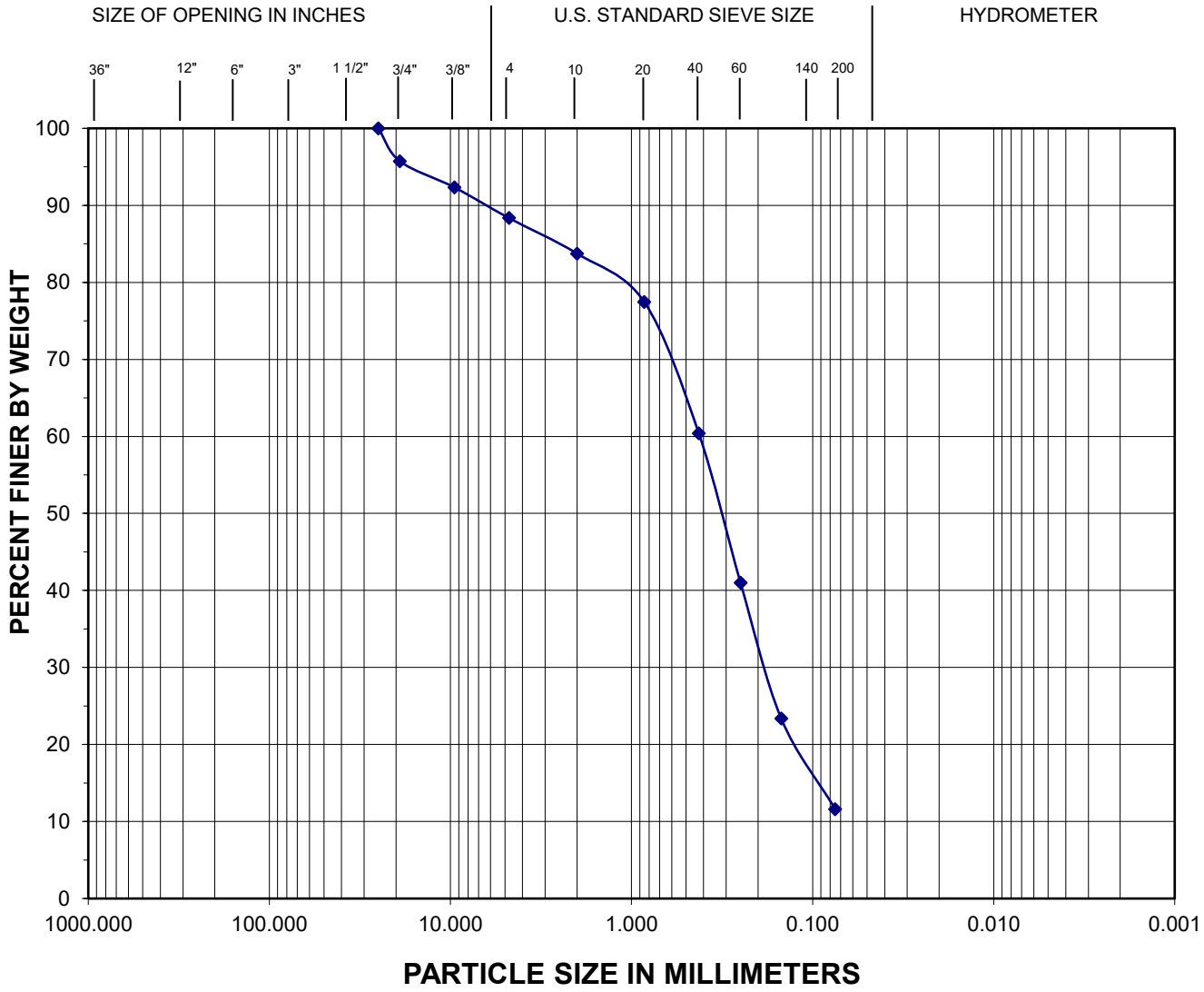
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-5	10	11.3	6.6	Gravelly SAND, some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

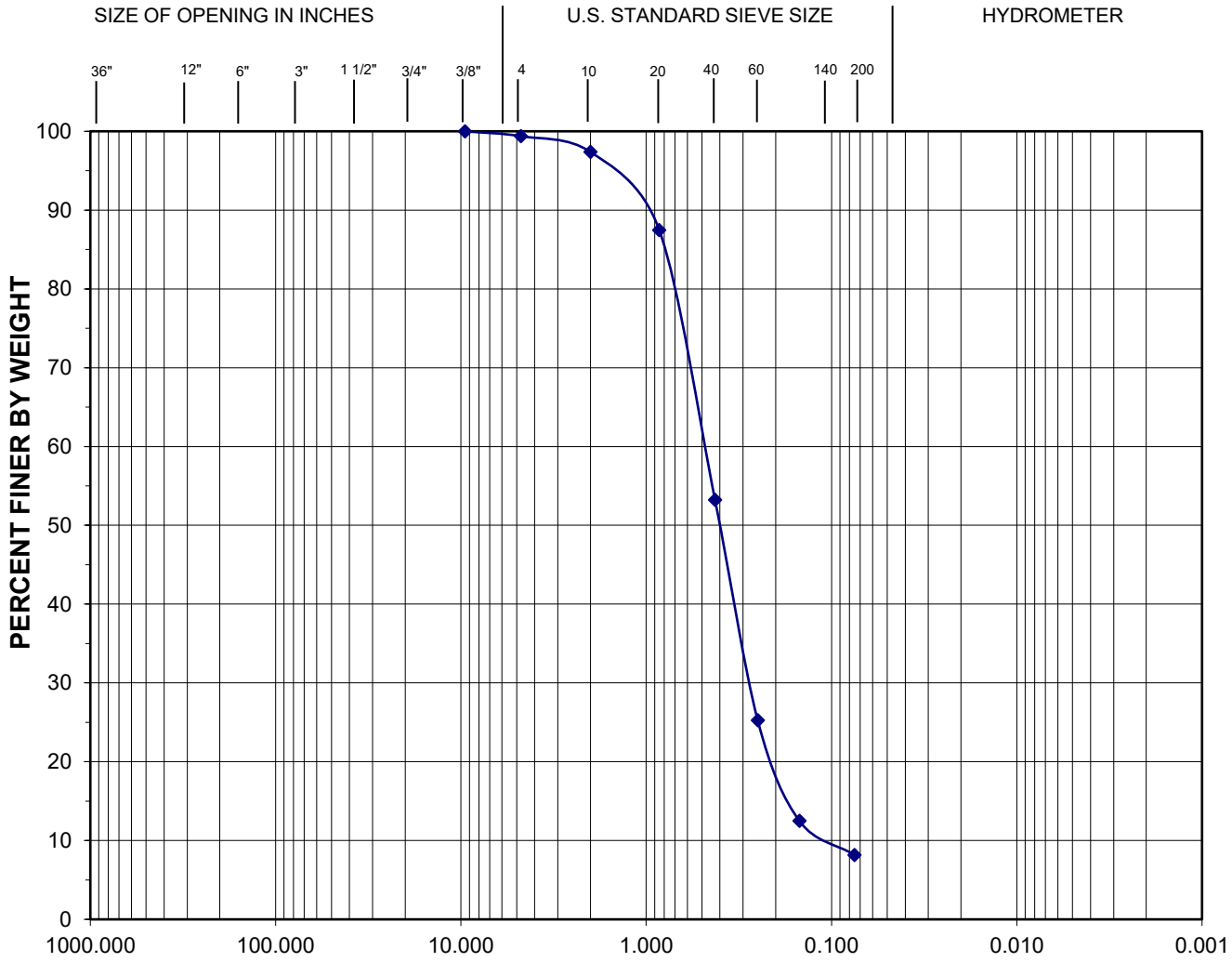
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-7	15	18.9	11.6	SAND, some gravel and silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

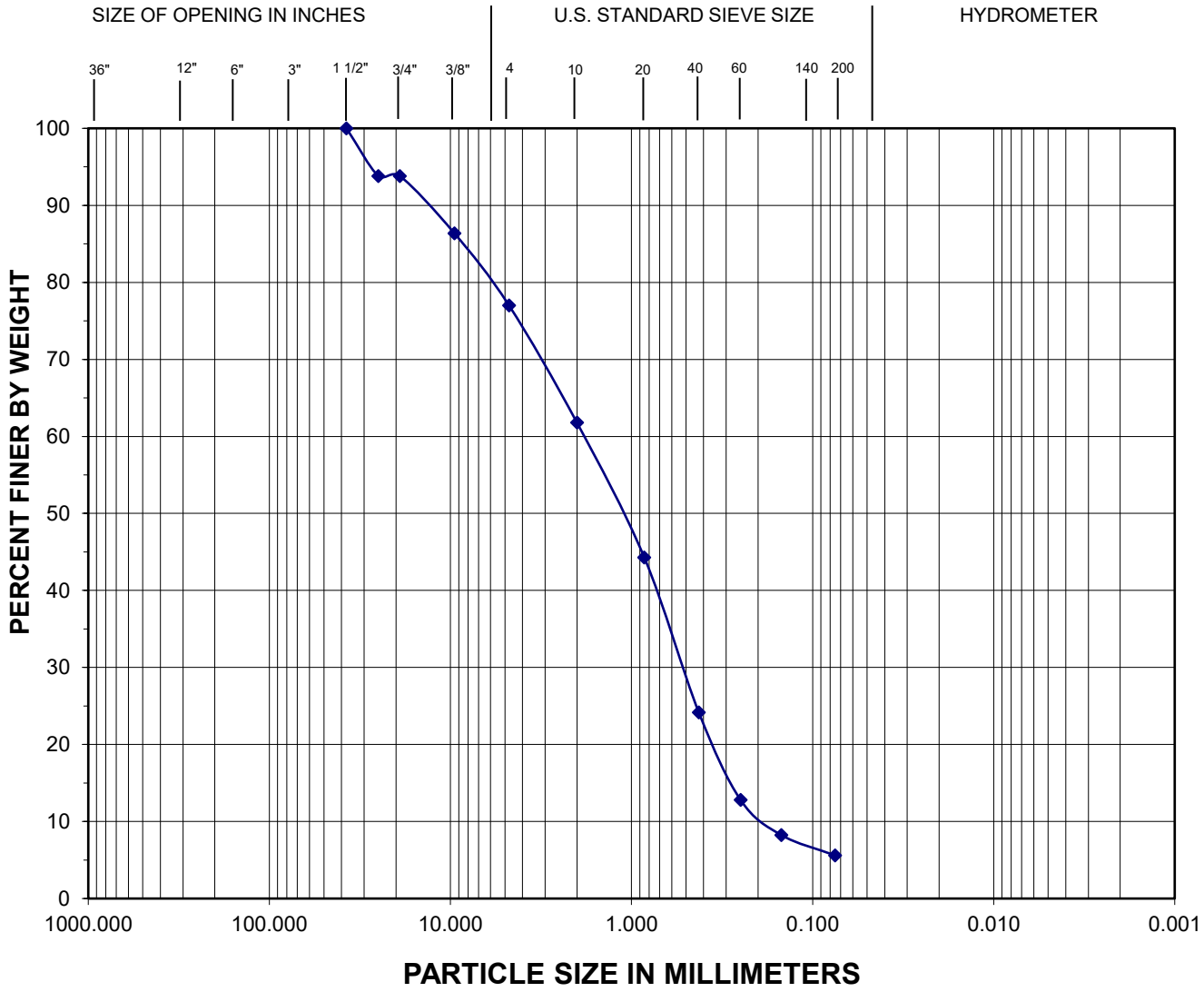
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-1	S-9	25	19.3	8.2	SAND, some silt, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

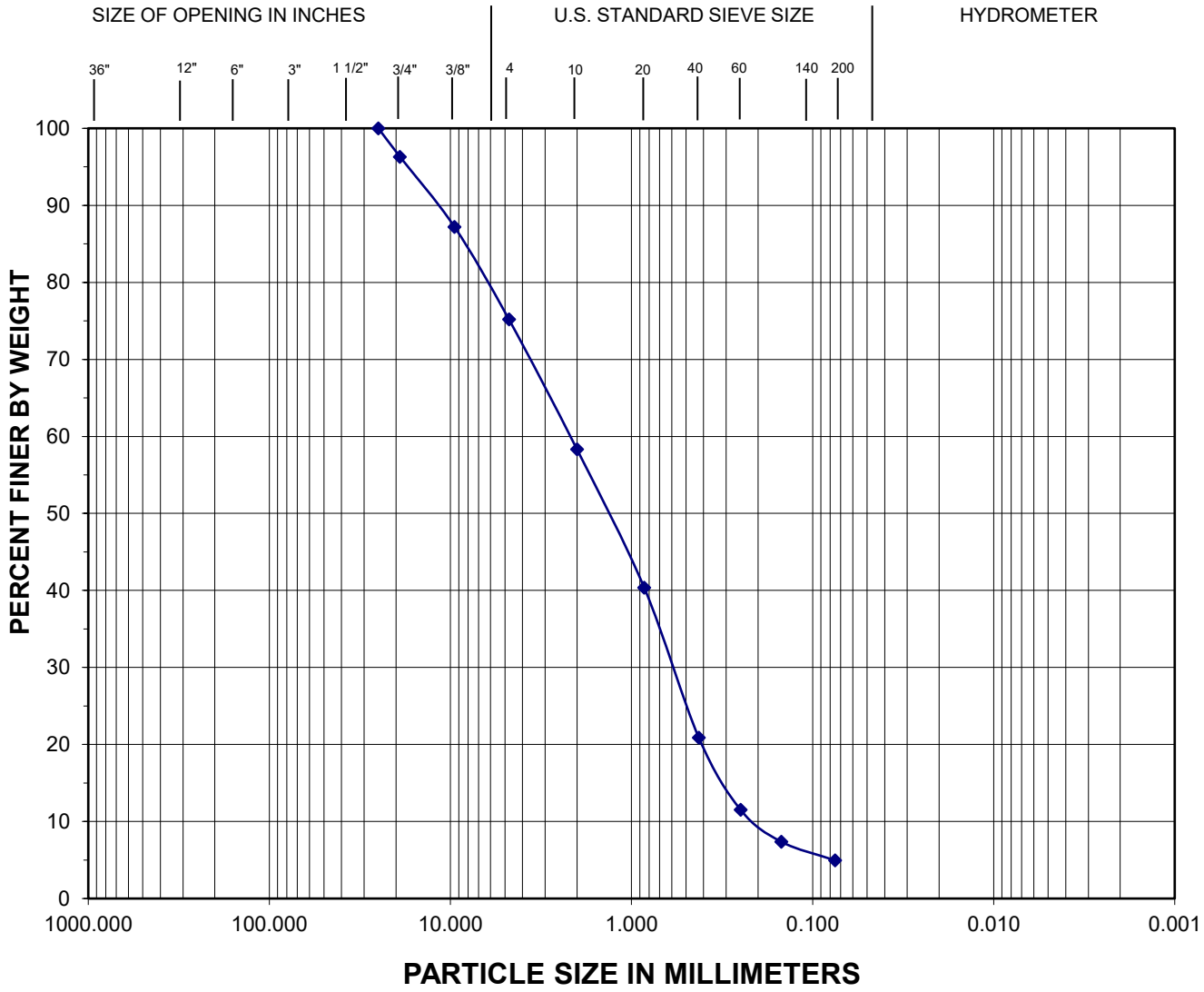
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-2	S-3	5	4.8	5.6	Gravelly SAND, some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

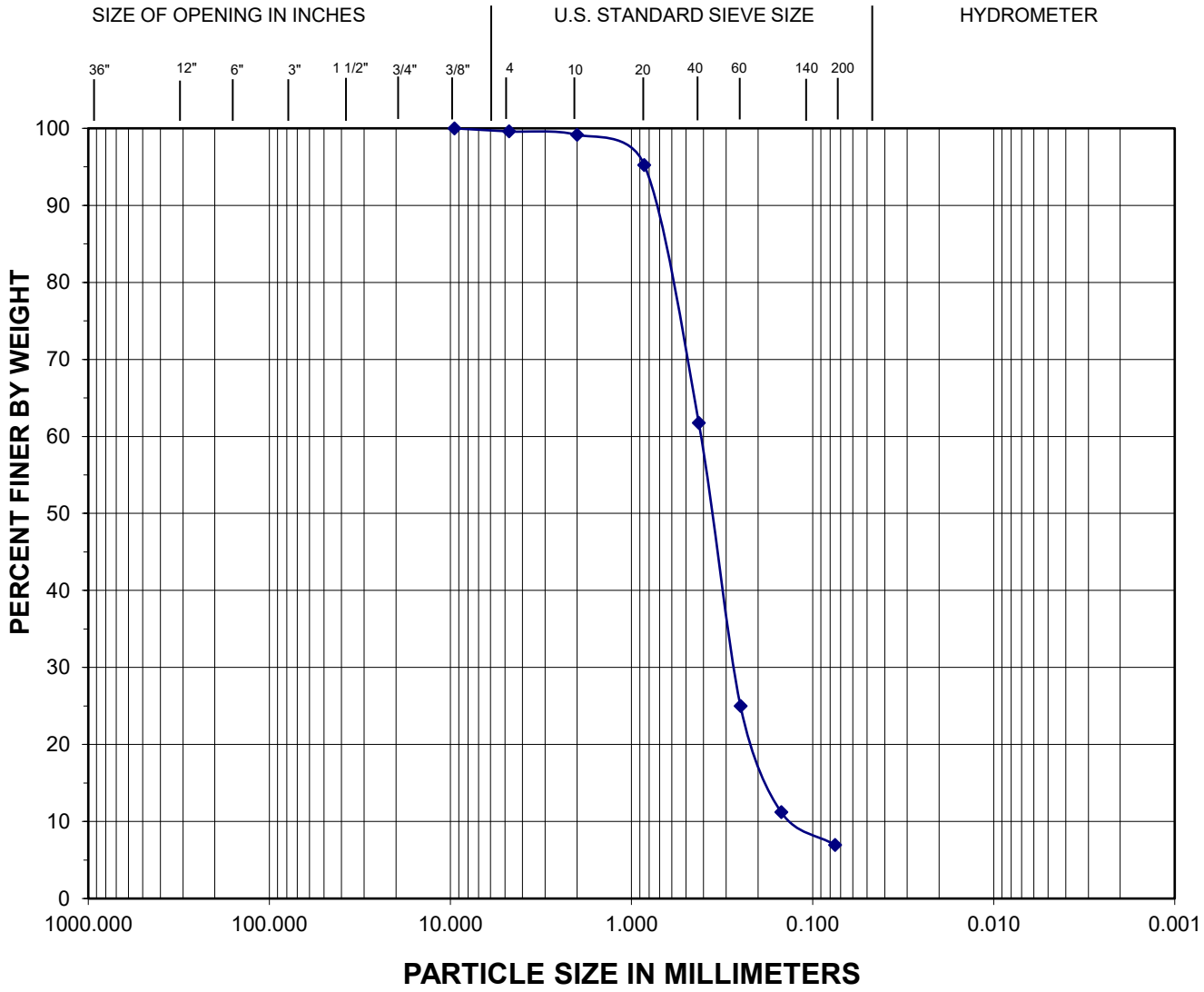
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-2	S-6	12.5	11.6	4.9	SAND, with gravel, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

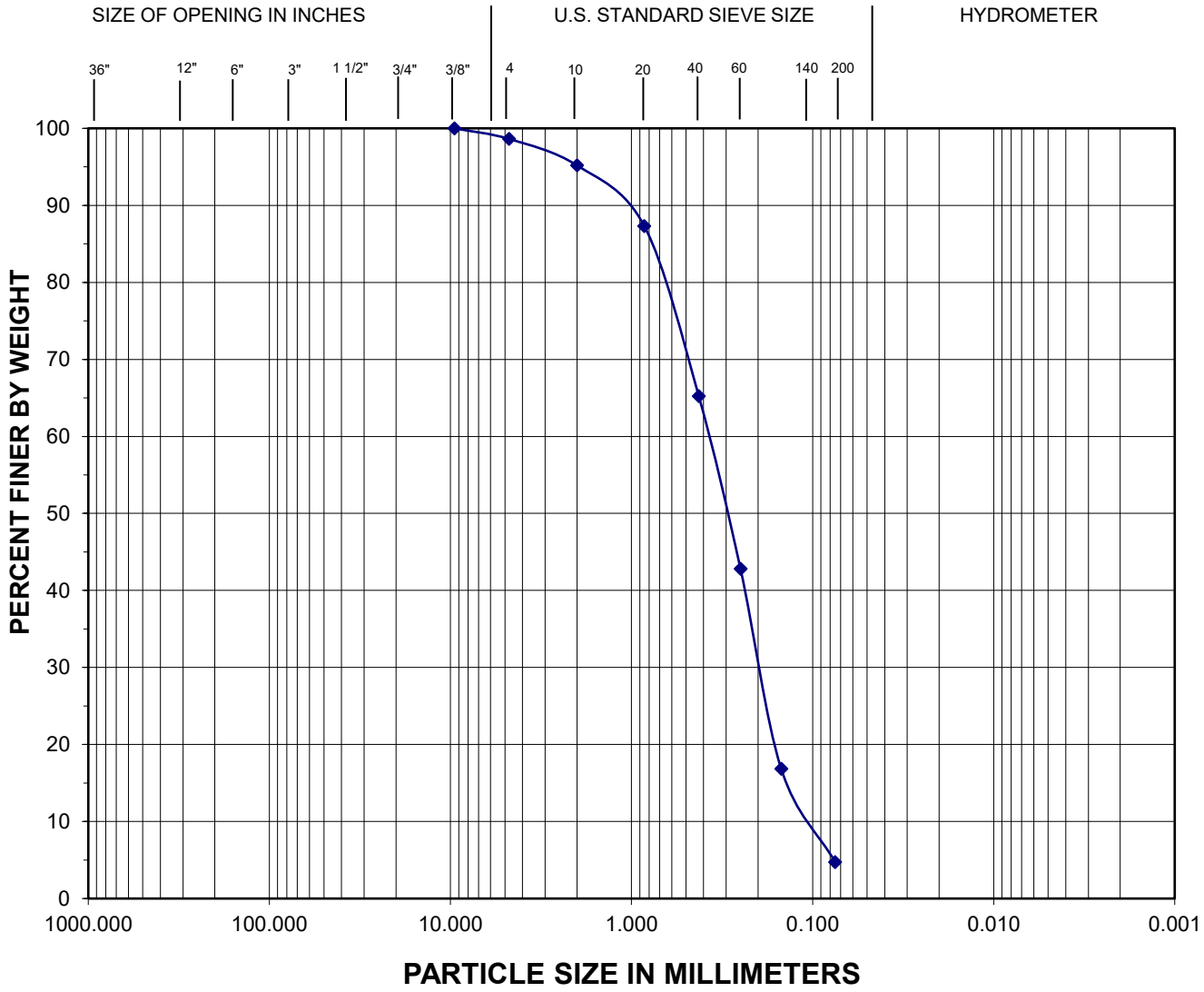
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
B-2	S-8	20	21.1	6.9	SAND, some silt, Trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

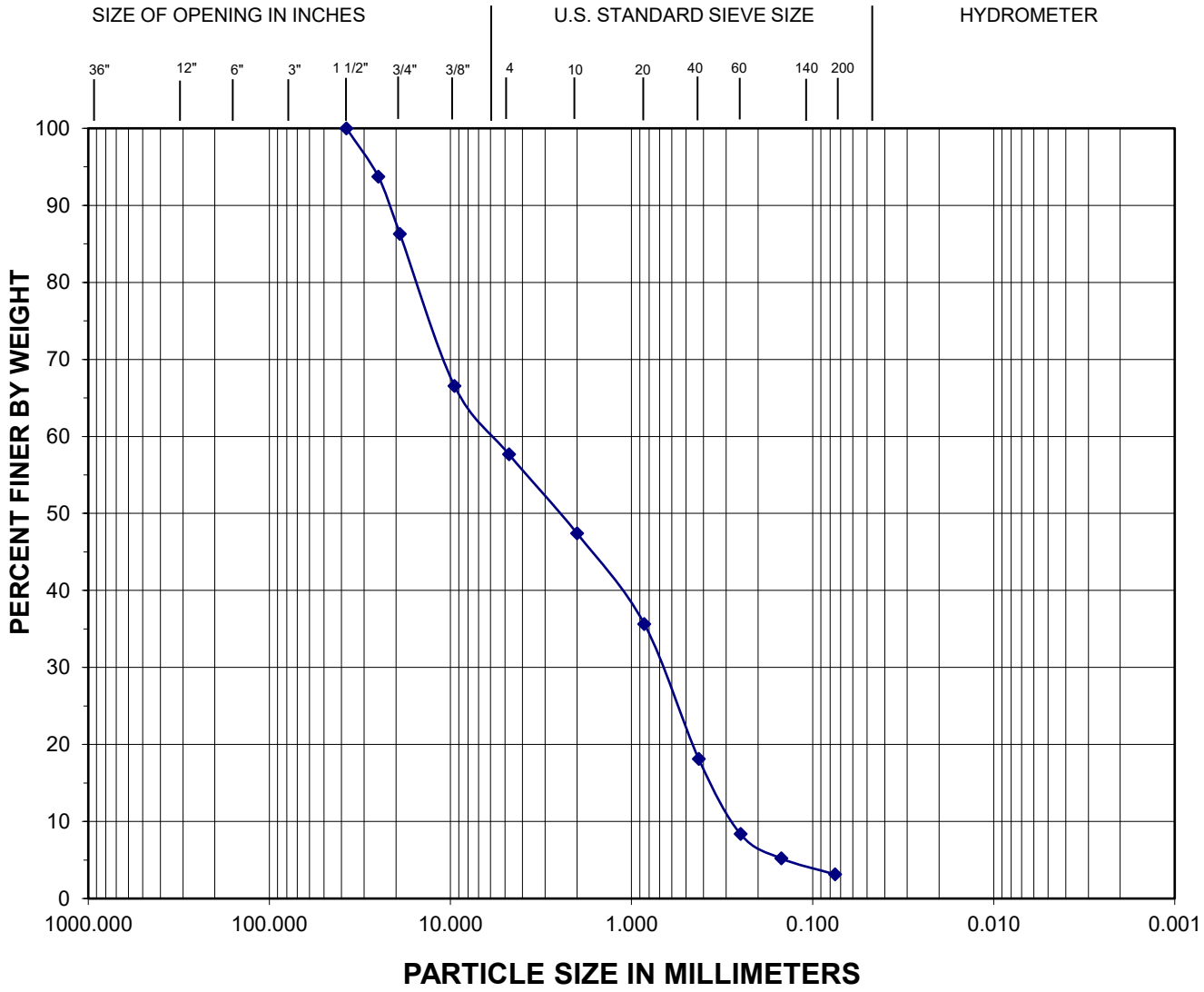
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-1	2.5	9.4	4.7	SAND, trace silt and gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

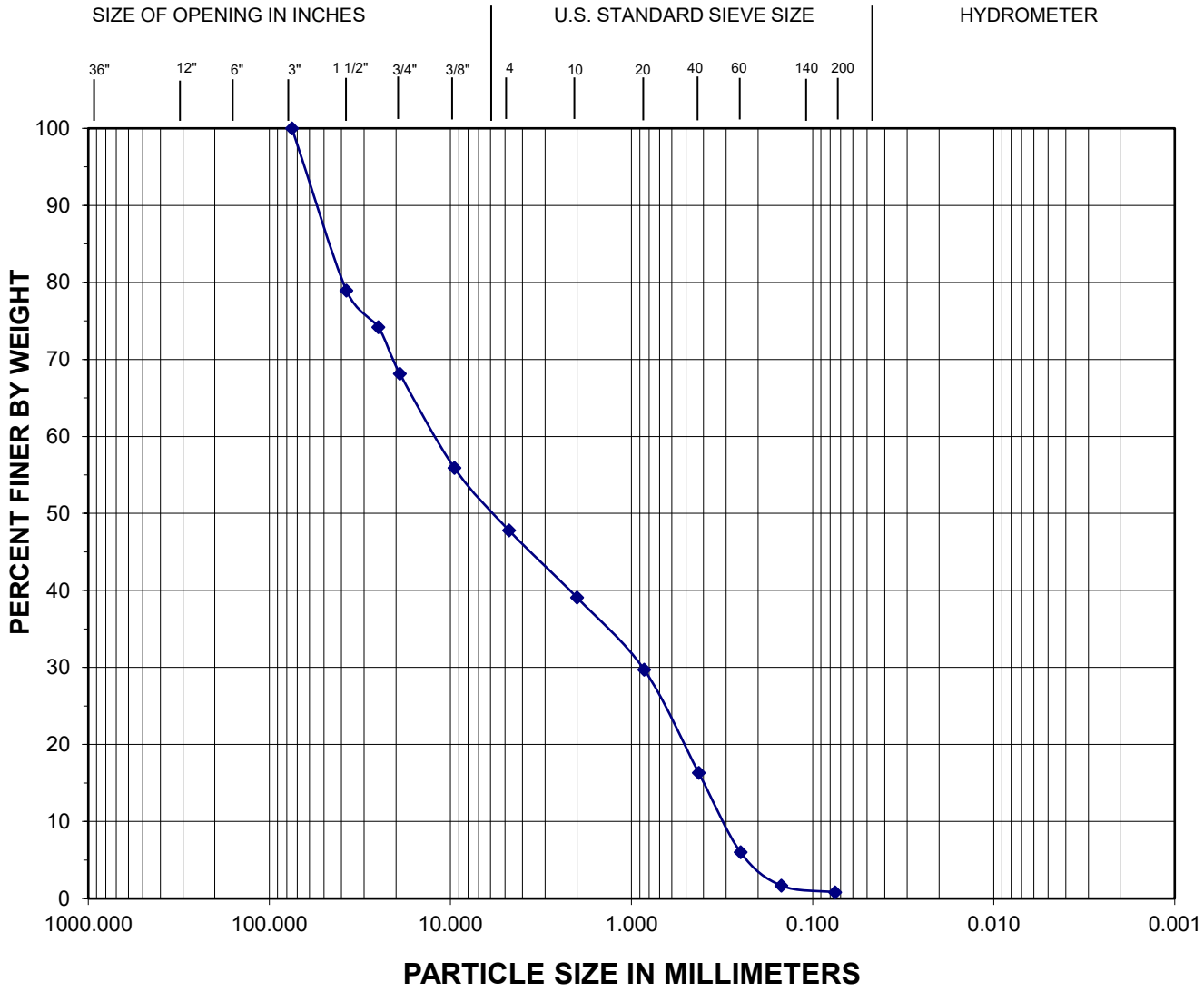
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-2	4	5.8	3.1	Gravelly SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

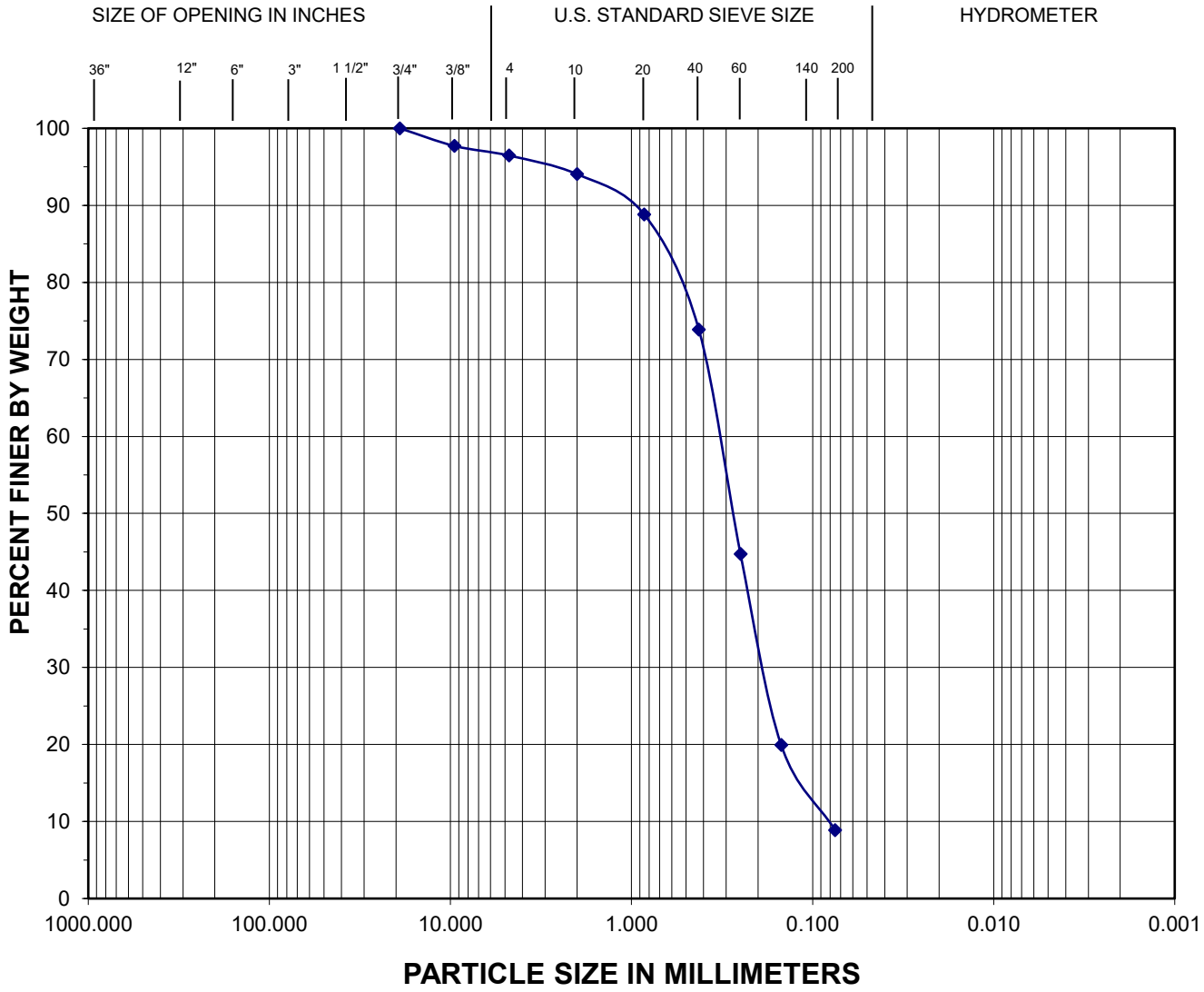
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-3	6.5	4.1	0.8	Sandy Gravel, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

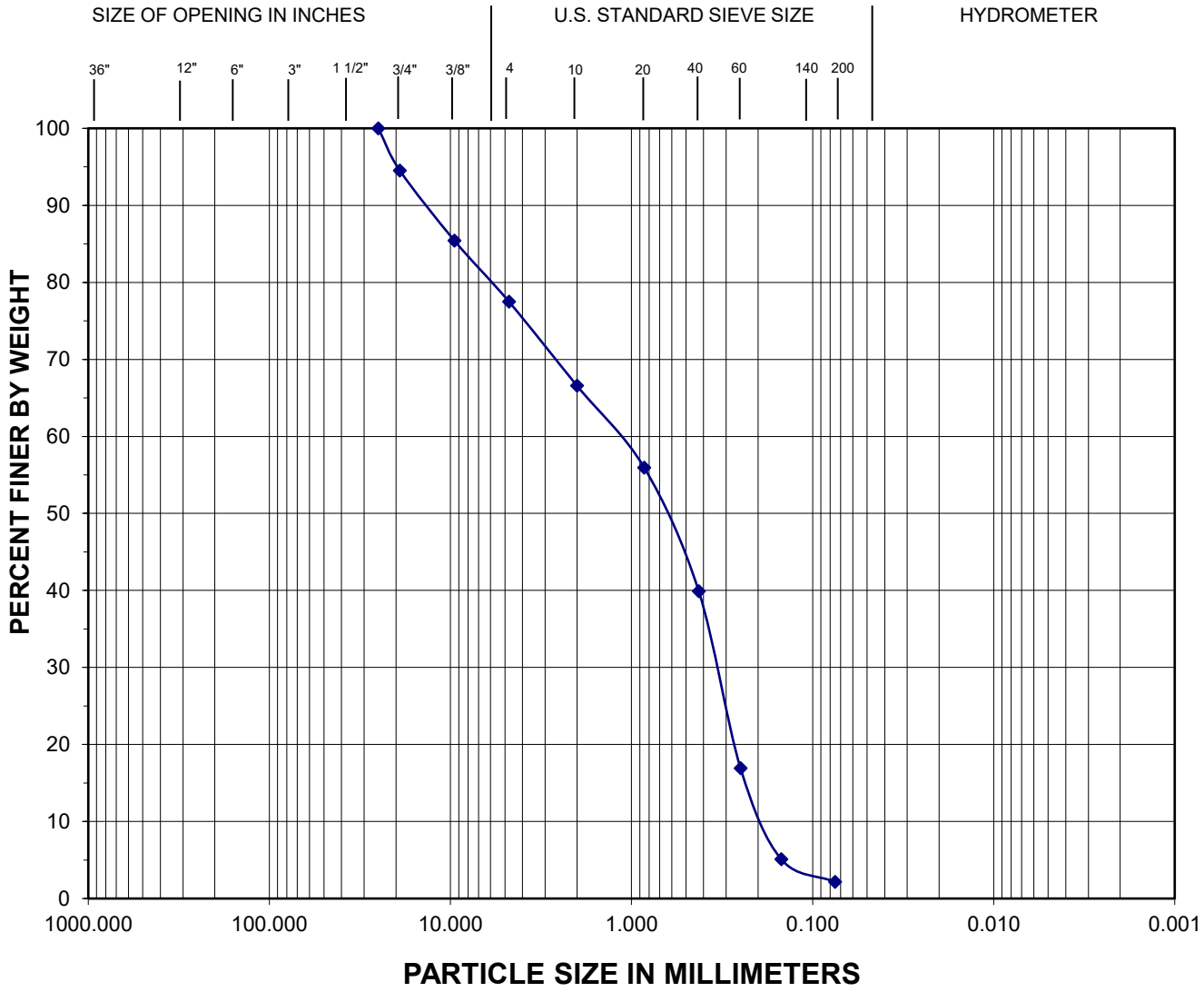
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-6	S-1	1	12.2	8.9	SAND, some silt, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

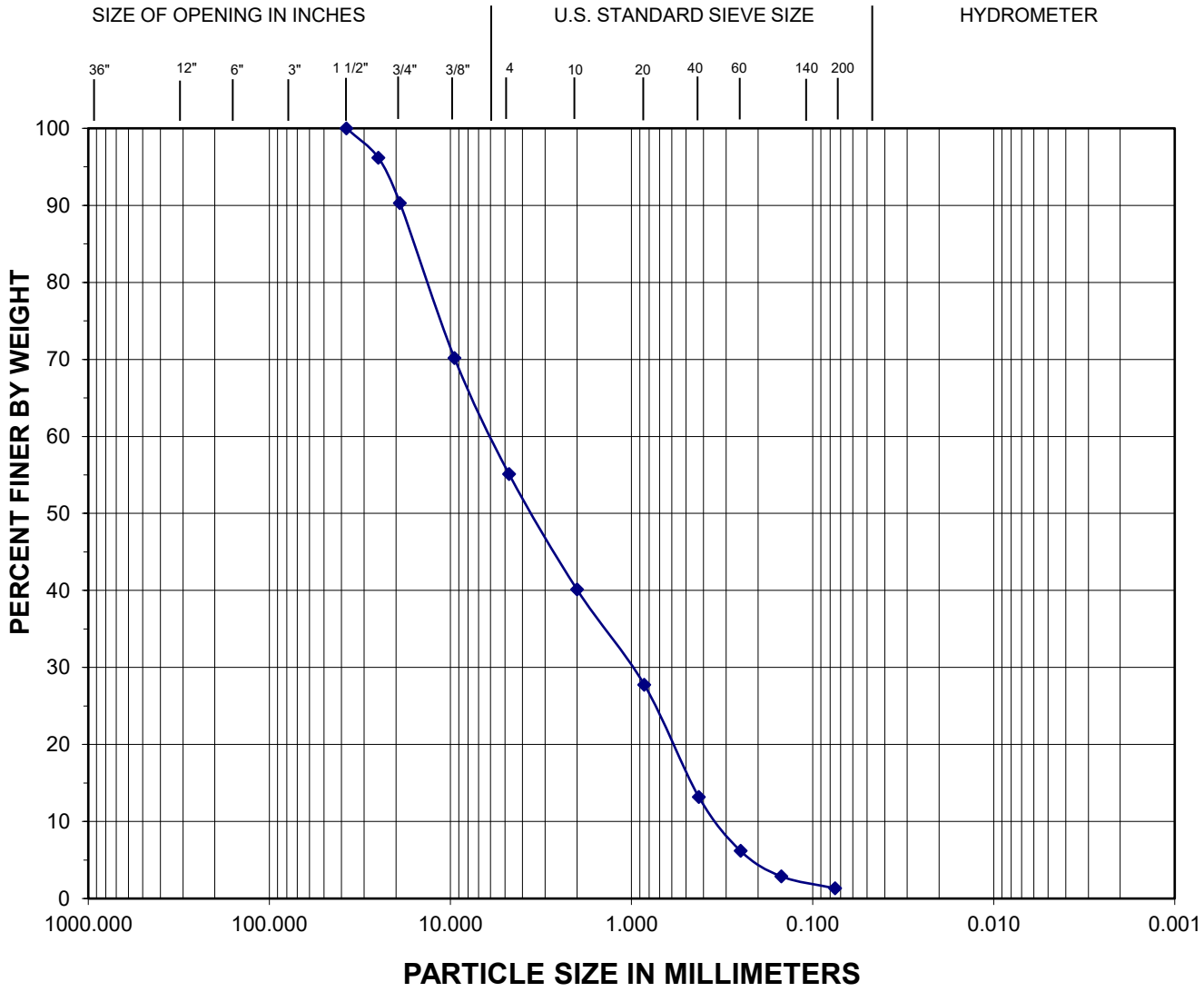
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-6	S-2	4	6.1	2.1	SAND, with gravel, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

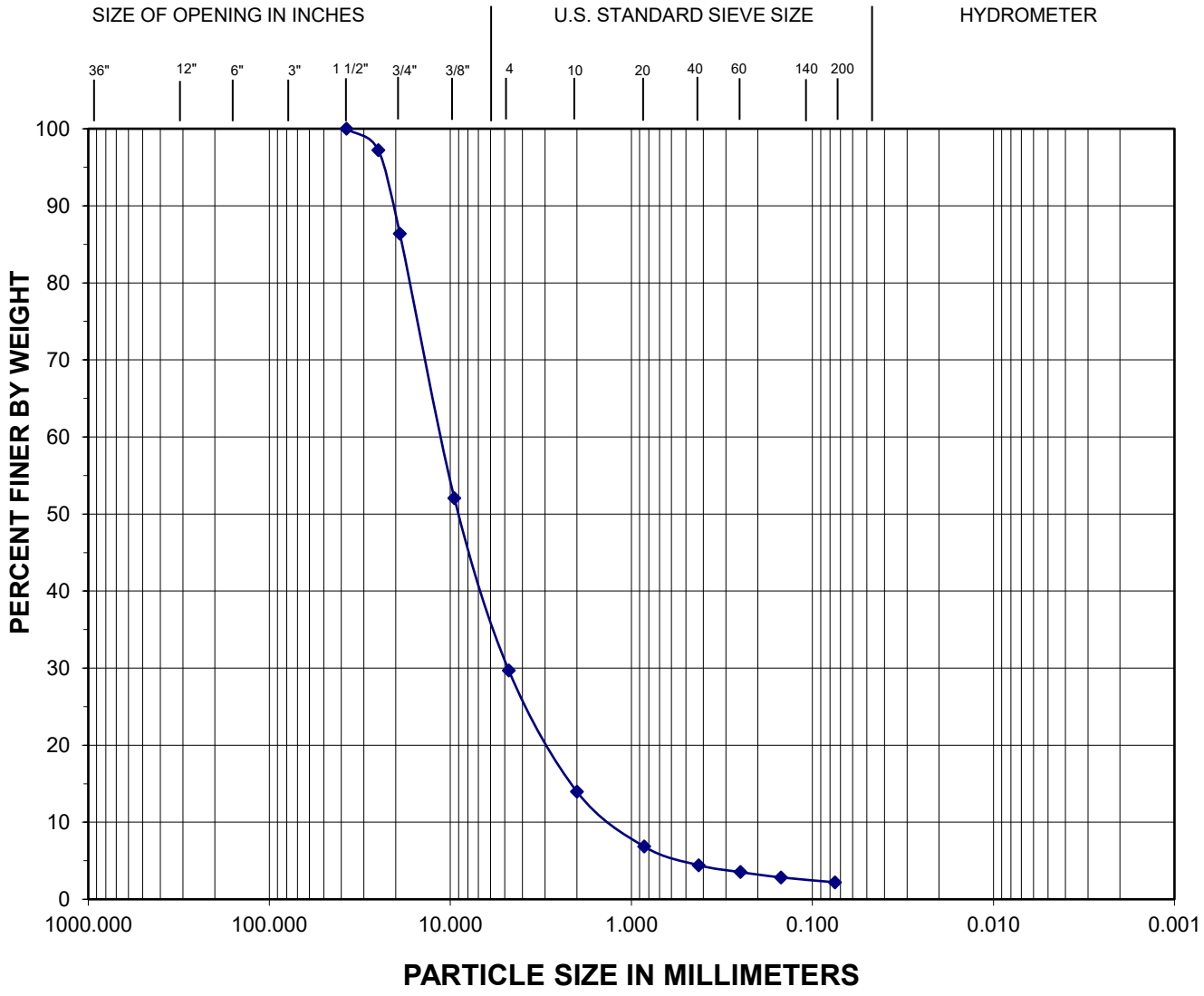
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-6	S-3	7.5	9.5	1.3	Gravelly SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
Grab	032923	Stockpile	0.3	2.2	Iron Mtn. CSBC

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 3/2/2023	PROJECT NAME: Crosswind Substation

March 3, 2023

Justin Brooks
Zipper Geo Associates, LLC
19019 36th Avenue West, Suite E
Lynnwood, WA 98036

RE: Bulk Asbestos Fiber Analysis; NVL Batch # 2303348.00

Client Project: 2679.01
Location: Arlington WA

Dear Mr. Brooks,

Enclosed please find test results for the 8 sample(s) submitted to our laboratory for analysis on 3/1/2023.

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,

Nick Ly, Technical Director

NVLAP Testing
Lab Code: 102063-0

Enc.: Sample Results

Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

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

Attention: Mr. Justin Brooks
Project Location: Arlington WA

Batch #: 2303348.00
Client Project #: 2679.01
Date Received: 3/1/2023
Samples Received: 8
Samples Analyzed: 8
Method: EPA/600/R-93/116

Lab ID: 23021416 **Client Sample #: TP 1**
Location: Arlington WA

Layer 1 of 1 **Description:** Gray sandy material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Sand, Fine grains, Fine particles	None Detected ND	**None Detected ND**

Lab ID: 23021417 **Client Sample #: TP 2**
Location: Arlington WA

Layer 1 of 1 **Description:** Brown sandy material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Sand, Fine grains, Fine particles	None Detected ND	**None Detected ND**

Lab ID: 23021418 **Client Sample #: TP 3**
Location: Arlington WA

Layer 1 of 1 **Description:** Brown sandy material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Sand, Fine grains, Fine particles	None Detected ND	**None Detected ND**

Lab ID: 23021419 **Client Sample #: TP 4**
Location: Arlington WA

Layer 1 of 1 **Description:** Brown sandy material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Sand, Fine grains, Fine particles	None Detected ND	**None Detected ND**

Lab ID: 23021420 **Client Sample #: TP 5**
Location: Arlington WA

Layer 1 of 1 **Description:** Brown sandy material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Sand, Fine grains, Fine particles	None Detected ND	**None Detected ND**

Sampled by: Client
Analyzed by: Akane Yoshikawa **Date:** 03/03/2023
Reviewed by: Nick Ly **Date:** 03/03/2023

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 EPA 40 CFR Appendix E to Subpart E of Part 763 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

Attention: Mr. Justin Brooks
Project Location: Arlington WA

Batch #: 2303348.00
Client Project #: 2679.01
Date Received: 3/1/2023
Samples Received: 8
Samples Analyzed: 8
Method: EPA/600/R-93/116

Lab ID: 23021421 **Client Sample #: TP 6**
Location: Arlington WA

Layer 1 of 1 **Description:** Beige sandy material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Sand, Fine grains, Fine particles	None Detected ND	**None Detected ND**

Lab ID: 23021422 **Client Sample #: B 1**
Location: Arlington WA

Layer 1 of 1 **Description:** Gray sandy material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Sand, Fine grains, Cementitious particles	None Detected ND	**None Detected ND**

Lab ID: 23021423 **Client Sample #: B 2**
Location: Arlington WA

Layer 1 of 2 **Description:** Brown sandy material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Sand, Fine grains, Fine particles	None Detected ND	**None Detected ND**

Layer 2 of 2 **Description:** Black fibrous material

Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
Binder/Filler	Synthetic fibers 97%	**None Detected ND**

Sampled by: Client
Analyzed by: Akane Yoshikawa **Date:** 03/03/2023
Reviewed by: Nick Ly **Date:** 03/03/2023

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 EPA 40 CFR Appendix E to Subpart E of Part 763 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**	**2303348.00**
Address	19019 36th Avenue West, Suite E Lynnwood, WA 98036	**TAT** 2 Days	**AH** No
		Rush TAT	
Project Manager	Mr. Justin Brooks	**Due Date** 3/3/2023	**Time** 1:35 PM
Phone	(425) 582-9928	**Email**	jbrooks@zippergeo.com
Cell	(813) 205-3481	**Fax**	(425) 582-9930

Project Name/Number: 2679.01 **Project Location:** Arlington WA

Subcategory PLM Bulk

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

Total Number of Samples 8 Rush Samples

	Lab ID	Sample ID	Description	A/R
1	23021416	TP 1		A
2	23021417	TP 2		A
3	23021418	TP 3		A
4	23021419	TP 4		A
5	23021420	TP 5		A
6	23021421	TP 6		A
7	23021422	B 1		A
8	23021423	B 2		A

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

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Hieu Ta		NVL	3/1/23	1335
Analyzed by	Akane Yoshikawa		NVL	3/3/23	
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Date: 3/1/2023
Time: 2:32 PM
Entered By: Hilary Crumley

CHAIN of CUSTODY SAMPLE LOG

2303348

LABORATORY · MANAGEMENT · [illegible]

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

Project Manager Mr. Justin Brooks
Project Location ARLINGTON, WA

Phone: (425) 582-9928 Fax: (425) 582-9930

NVL Batch Number
Client Job Number 2679.01
Total Samples 8
Turn Around Time ☐ 1 Hr ☐ 6 Hrs ☐ 3 Days ☐ 10 Days ☐ 2 Hrs ☐ 1 Day ☐ 4 Days ☐ 4 Hrs ☑ 2 Days ☐ 5 Days
Please call for TAT less than 24 Hrs

Email address jbrooks@zippergeo.com
Cell (813) 205-3481

☐ Asbestos Air ☐ PCM (NIOSH 7400) ☐ TEM (NIOSH 7402) ☐ TEM (AHERA) ☐ TEM (EPA Level II) ☐ Other
☑ Asbestos Bulk ☑ PLM (EPA/600/R-93/116) ☐ PLM (EPA Point Count) ☐ PLM (EPA Gravimetry) ☐ TEM BULK
☐ Mold/Fungus ☐ Mold Air ☐ Mold Bulk ☐ Rotometer Calibration

METALS	Det. Limit	Matrix		RCRA Metals		Other Metals
☐ Total Metals	☐ FAA (ppm)	☐ Air Filter	☐ Paint Chips in %	☐ Arsenic (As)	☐ Lead (Pb)	☐ All 3
☐ TCLP	☐ ICP (ppm)	☐ Drinking water	☐ Paint Chips in cm2	☐ Barium (Ba)	☐ Mercury (Hg)	☐ Copper (Cu)
☐ Cr 6	☐ GFAA (ppb)	☐ Dust/wipe (Area)	☐ Waste Water	☐ Cadmium (Cd)	☐ Selenium (Se)	☐ Nickel (Ni)
	☐ CVAA (ppb)	☐ Soil	☐ Other	☐ Chromium (Cr)	☐ Silver (Ag)	☐ Zinc (Zn)
					☐ All 8	

☐ Other Types of Analysis ☐ Fiberglass ☐ Silica ☐ Nuisance Dust ☐ Respirable Dust ☐ Other (Specify) _____

Condition of Package: ☐ Good ☐ Damaged (no spillage) ☐ Severe damage (spillage)

Seq. #	Lab ID	Client Sample Number	Comments (e.g Sample are, Sample Volume, etc)	A/R
1		TP 1	SAND to SILTY SAND	
2		TP 2	↓	
3		TP 3	↓	
4		TP 4	↓	
5		TP 5	✓	
6		TP 6		
7		B-1		
8		B-2		
9				
10				
11				
12				
13				
14				
15				

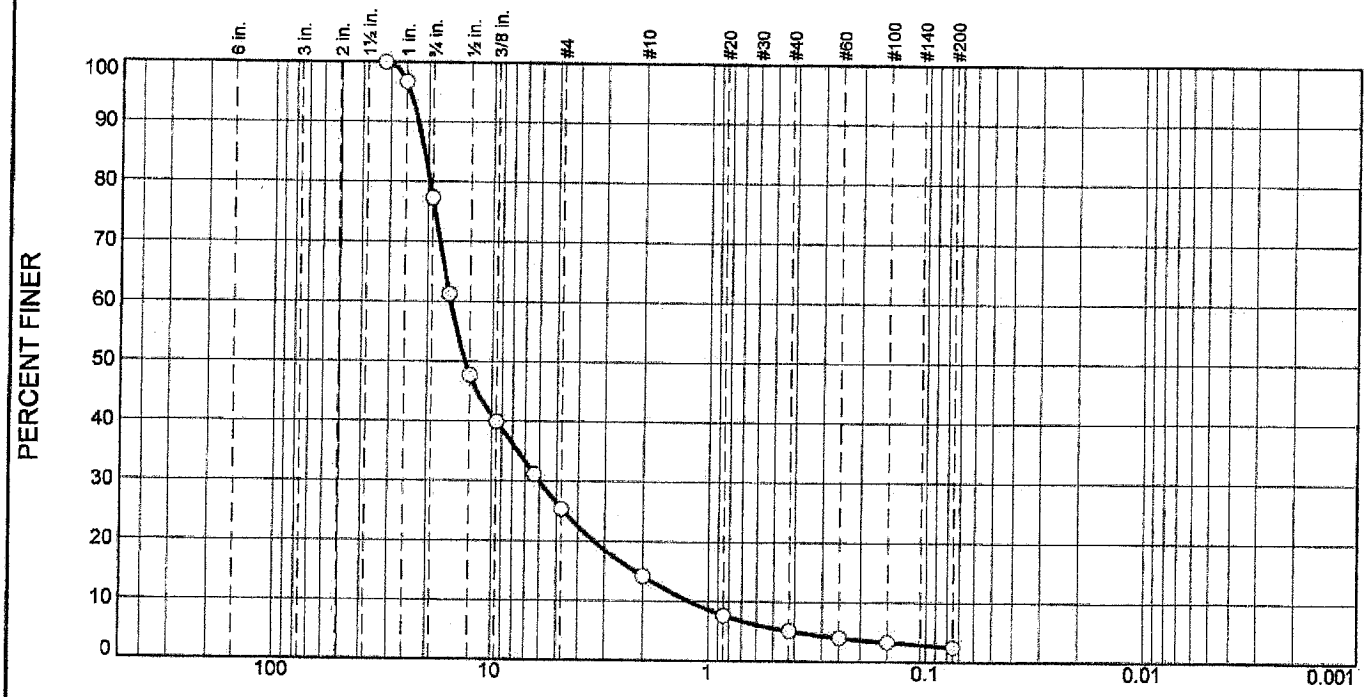
	Print Below	Sign Below	Company	Date	Time
Sampled by	JUSTIN L BROOKS	[signature]	Zipper GeoAssoc	~~3-1-23~~ 2-28	1329
Relinquished by	JUSTIN BROOKS	[signature]	Zipper GEO	3-1-23	1329
Received by	Hieu Ta	[signature]	NVL Labs	3/1/23	1335
Analyzed by					
Results Called by					
Results Faxed by					

Special Instructions: Unless requested in writing, all samples will be disposed of two (2) weeks after analysis.

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

Grain size distribution plots and permeability testing results for Iron Mountain Quarry crushed surfacing base course follow

Krazan & Associates Sieve Analysis



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	22.7	51.9	11.1	9.2	2.6	2.5	

Test Results (ASTM C-136 & ASTM C-117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
1.25	100.0		
1	96.8		
.75	77.3		
.625	61.2		
.5	47.7		
.375	39.9		
.25	31.1		
#4	25.4		
#10	14.3		
#20	7.7		
#40	5.1		
#60	4.0		
#100	3.3		
#200	2.5		

* (no specification provided)

Material Description

Permeable Base Course Aggregate

Atterberg Limits (ASTM D 4318)

PL= NP LL= NP PI= NP

Classification

USCS (D 2487)= GW AASHTO (M 145)= A-1-a

Coefficients

D_{90}= 22.3387 D_{85}= 20.8670 D_{60}= 15.6250
D_{50}= 13.3510 D_{30}= 6.0182 D_{15}= 2.1603
D_{10}= 1.2184 C_u= 12.82 C_c= 1.90

Remarks

Fracture Face (WSDOT T-335): 100% (Spec = 75% MIN)
Permeability Rate (ASTM D-2434): 170.5 in/hr. (Spec = 40 inches per hour at 98% compaction).

Date Received: 4/11/2022 **Date Tested:** 4/11/2022

Tested By: Thomas Khilfeh

Checked By: Cole Demas

Title: Lab Manager

Location: Client Supplied
Sample Number: 77953

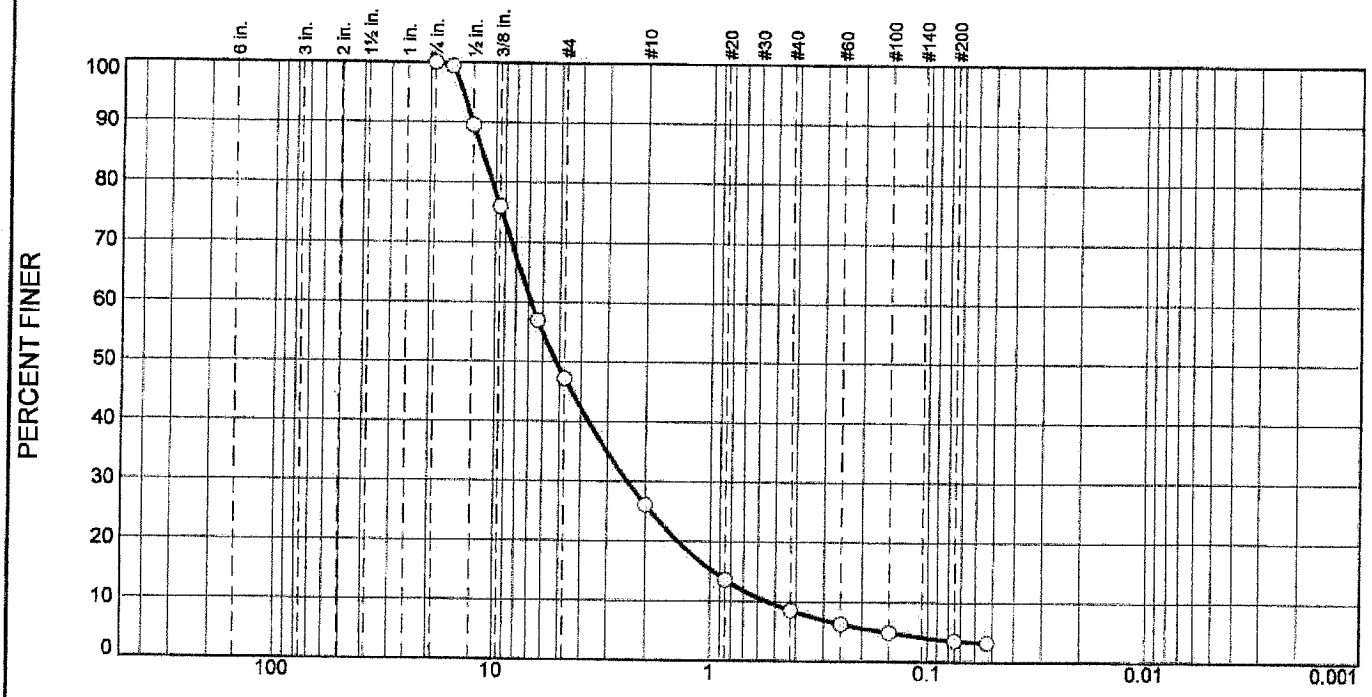
Date Sampled: 4/11/2022

Krazan

Client: Iron Mountain Quarry
Project: 2022 Control Sample

Project No: 09622094 **Figure**

Krazan & Associates Sieve Analysis



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	0.0	52.8	21.1	17.5	5.1	3.5	

Test Results (ASTM C-136 & ASTM C-117)

Opening Size	Percent Finer	Spec.* (Percent)	Pass? (X=Fail)
.75	100.0		
.625	99.4		
.5	89.5		
.375	75.9		
.25	57.0		
#4	47.2		
#10	26.1		
#20	13.6		
#40	8.6		
#60	6.3		
#100	4.9		
#200	3.5		
#270	3.2		

* (no specification provided)

Material Description

Permeable Top Course Aggregate

Atterberg Limits (ASTM D 4318)

PL= NP LL= NP PI= NP

Classification

USCS (D 2487)= GW AASHTO (M 145)= A-1-a

Coefficients

D_{90}= 12.8232 D_{85}= 11.5908 D_{60}= 6.8198
D_{50}= 5.2088 D_{30}= 2.4245 D_{15}= 0.9681
D_{10}= 0.5445 C_u= 12.53 C_c= 1.58

Remarks

Fracture Face (WSDOT T-335): 100% (Spec = 75%Min)
Permebility Rate (ASTM D-2434): 168.5 in/hr (Spec = 20 inches per hour at 98% compaction).

Date Received: 4/11/2022 **Date Tested:** 4/12/2022

Tested By: Thomas Khilfeh

Checked By: Cole Demas

Title: Lab Manager

Location: Client Supplied
Sample Number: 77954

Date Sampled: 4/11/2022

Krazan

Client: Iron Mountain Quarry
Project: 2022 Control Sample

Project No: 09622094 **Figure**

APPENDIX C
LIQUEFACTION ANALYSIS OUTPUT PLOT

Zipper Geo Associates, LLC
19019 36th Avenue West, Suite E
Lynnwood, Washington
(425) 582-9928

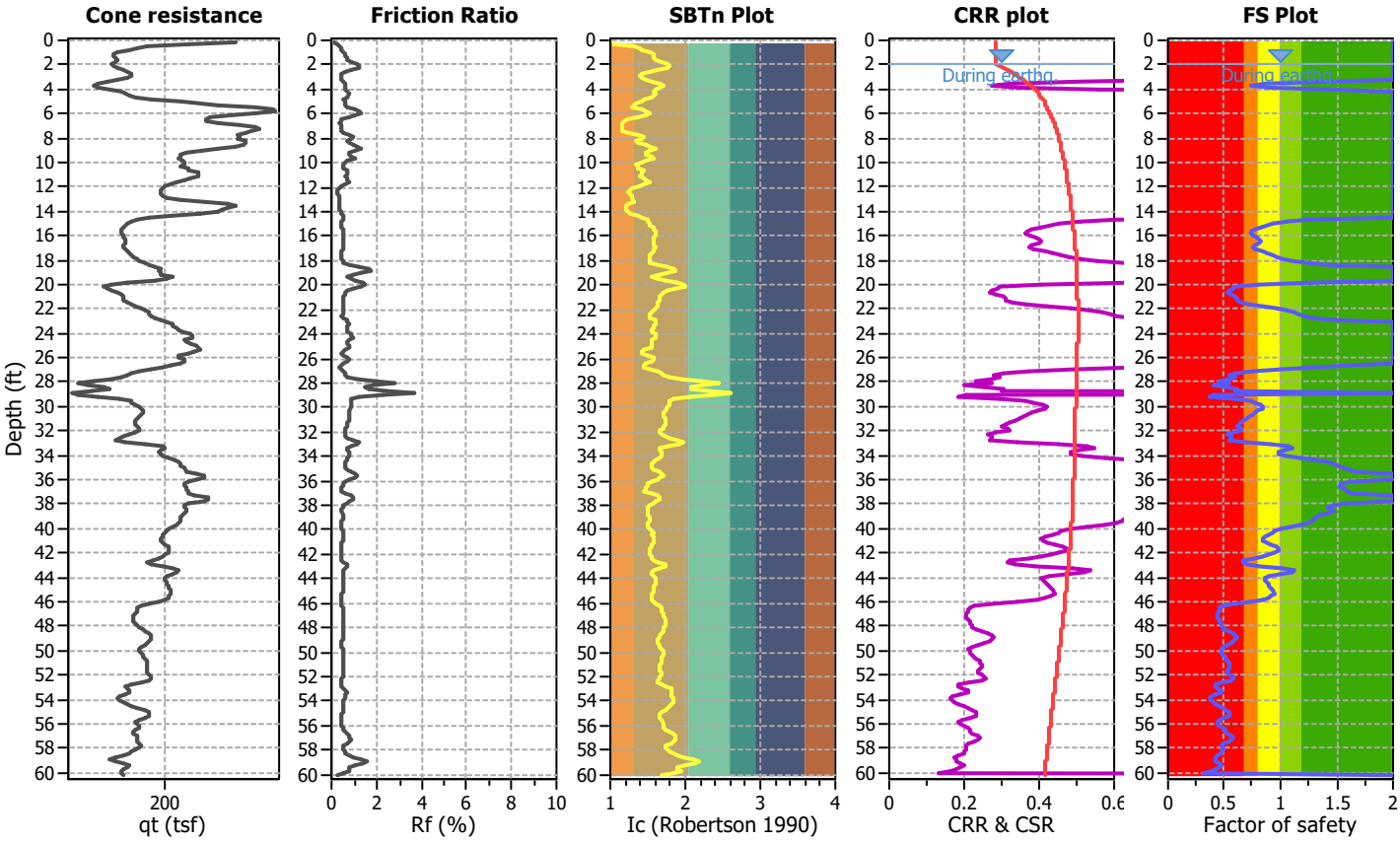
LIQUEFACTION ANALYSIS REPORT

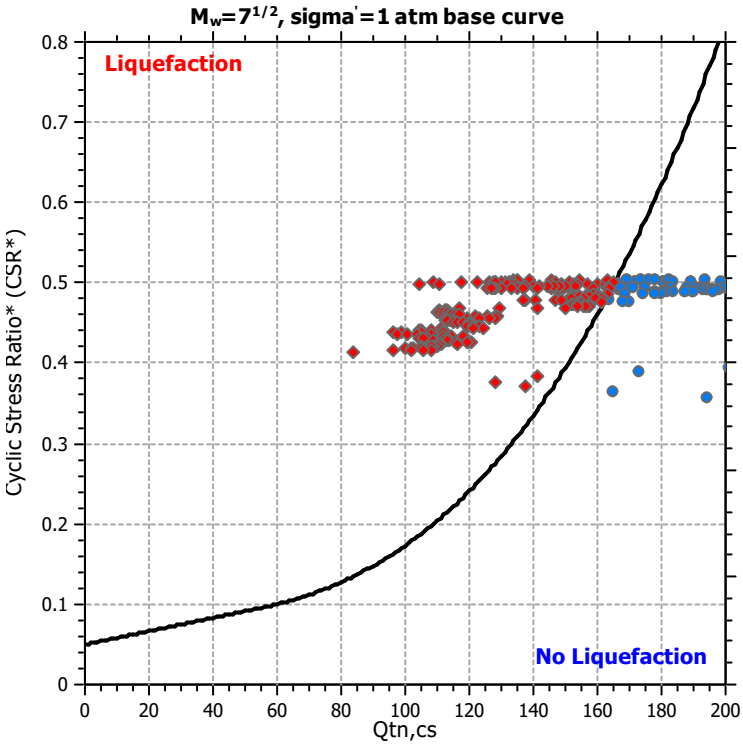
Project title : Crosswind Substation **Location : Arlington, Washington**

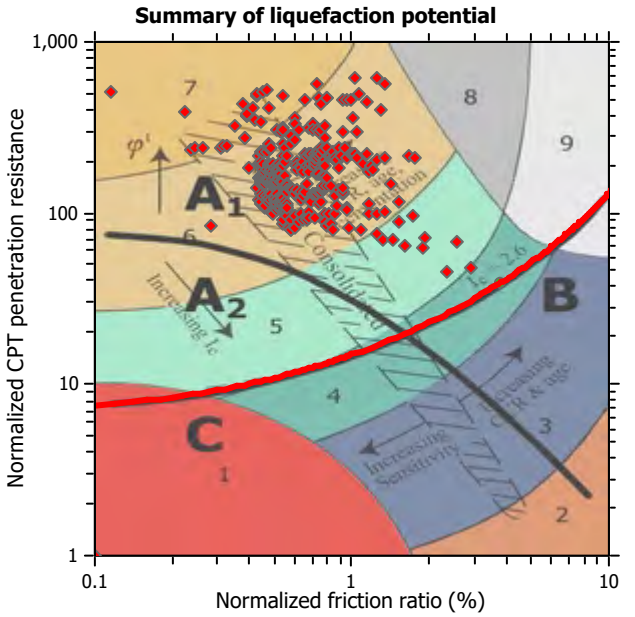
CPT file : CPT-01

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	7.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	2.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	7.03	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.52	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

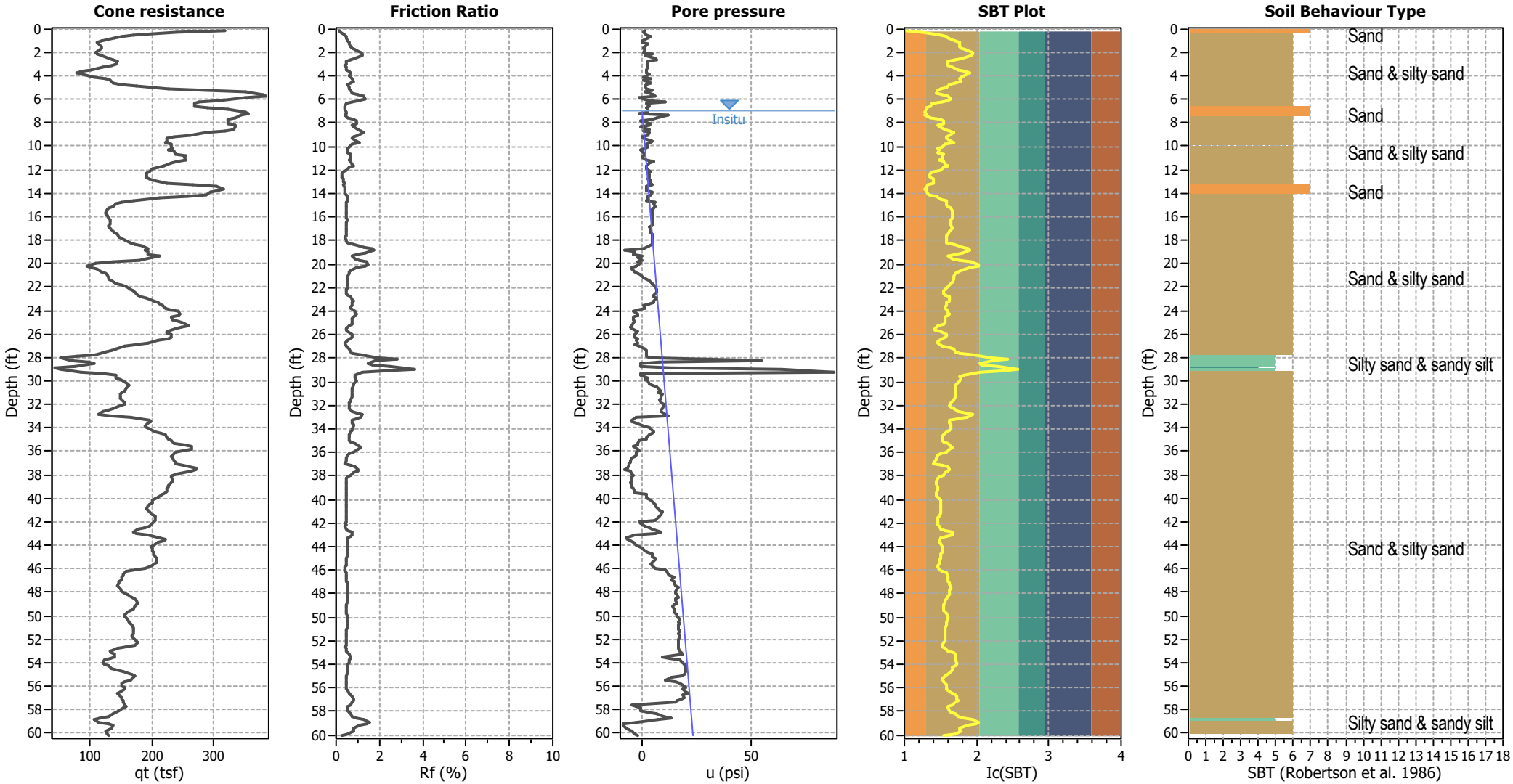






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



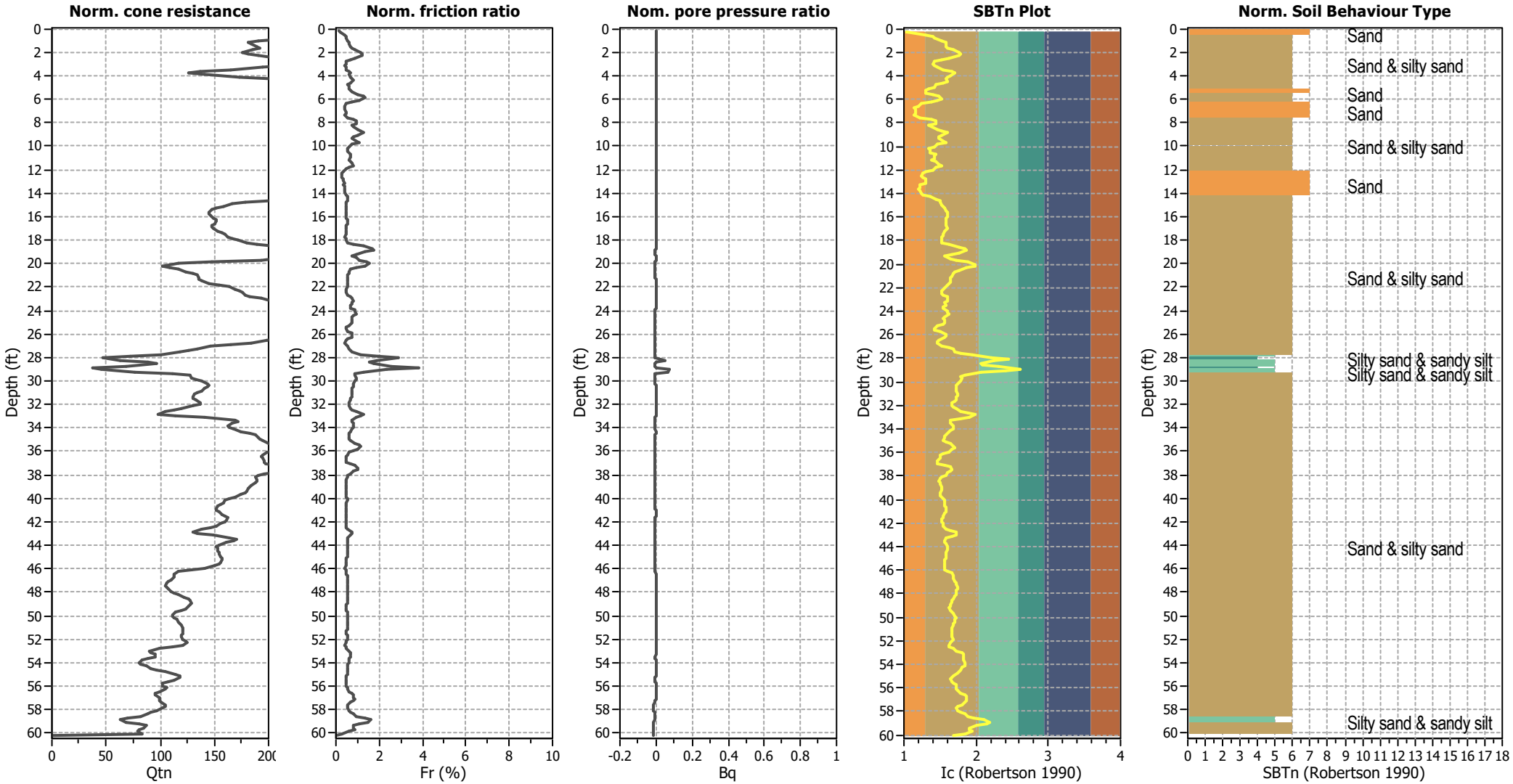
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.03	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.52	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	7.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



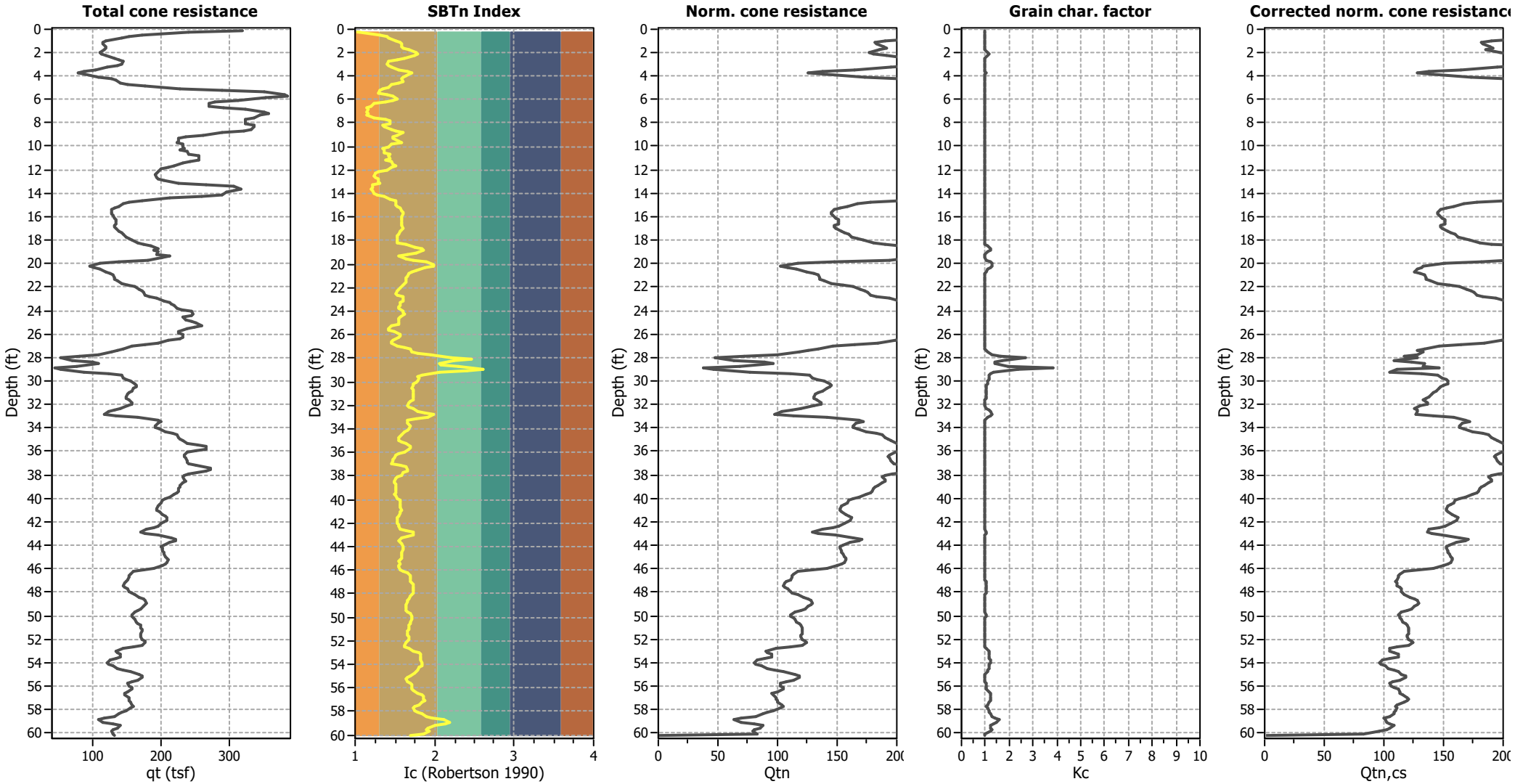
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.03	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.52	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	7.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

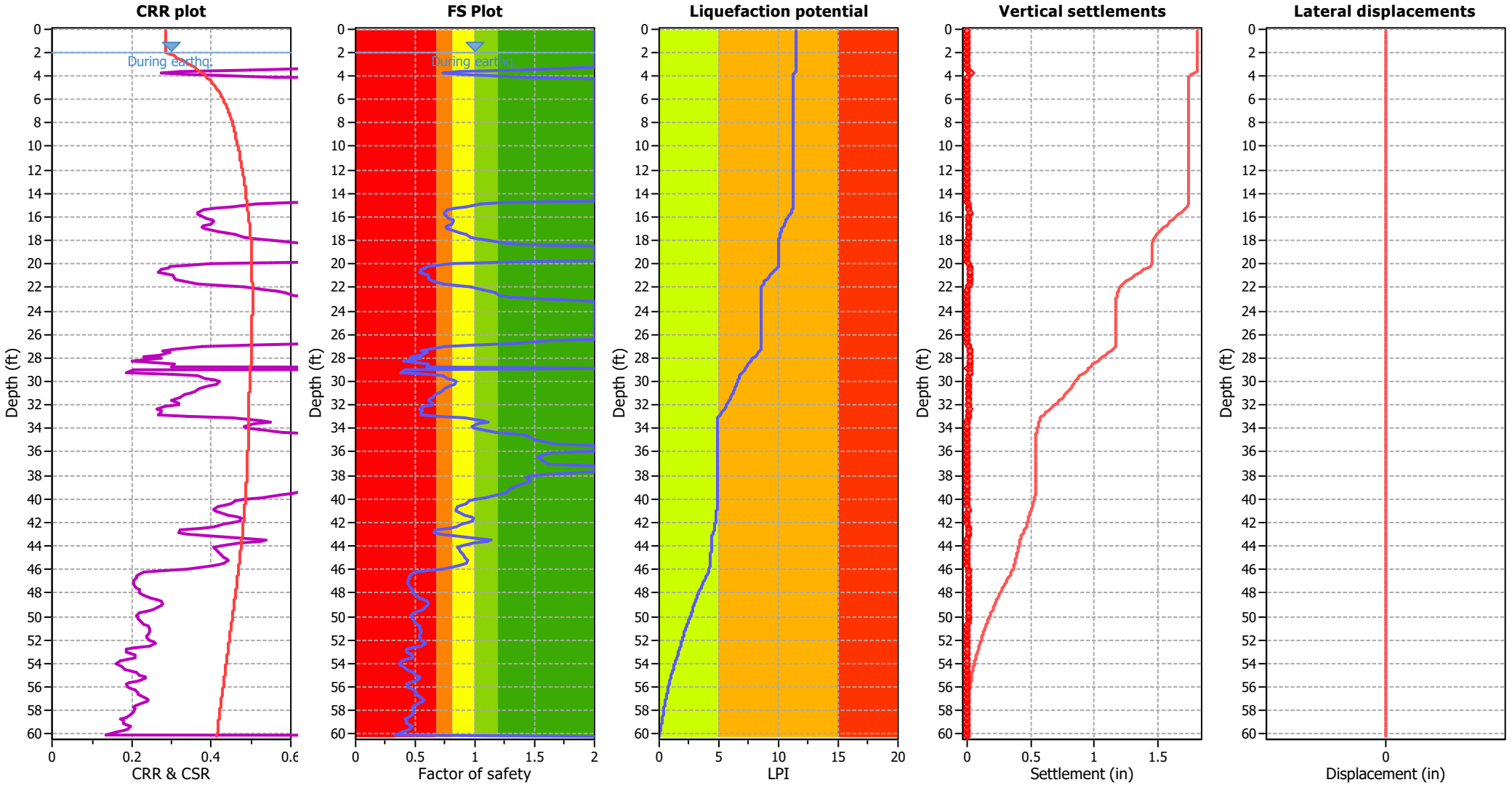
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.03	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.52	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	7.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.03	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.52	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	7.00 ft	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk

GEOTECHNICAL ENGINEERING REPORT
NORTH COUNTY SPECIAL USE PERMIT
17601 – 59th Avenue NE
Arlington, Washington

Project No. 2679.01
2 August 2023

Prepared for:
Snohomish County PUD No. 1

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

ZipperGeo
Geoprofessional Consultants

Project No. 2679.01
2 August 2023

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

Attention: Mr. Jerome Drescher, Engineer

Subject: Geotechnical Engineering Report
North County Special Use Permit
17601 – 59th Avenue NE
Arlington, Washington

Dear Mr. Drescher:

In accordance with your request, Zipper Geo Associates, LLC (ZGA) has completed the subsurface exploration and geotechnical engineering evaluation for the proposed North County Special Use Permit project. 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 Professional Services Contract No. CW2250618 Amendment No. 1. Written authorization to proceed was provided by the District on 15 April 2023. 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

David C. Williams, LG, LEG
Principal Engineering Geologist
Signed 8.2.23

State of Washington
Engineering Geologist
1172
Licensed Geologist
DAVID C. WILLIAMS

Justin L. Brooks, LG
Project Geologist
Signed 8.2.23

State of Washington
20120113
Licensed Geologist
Justin Lee Brooks

Robert A. Ross, P.E.
Managing Principal
Signed 8.2.23

ROBERT A. ROSS
STATE OF WASHINGTON
38384
REGISTERED
PROFESSIONAL ENGINEER

ZipperGeo
Geoprofessional Consultants

TABLE OF CONTENTS

GEOTECHNICAL ENGINEERING REPORT
NORTH COUNTY SPECIAL USE PERMIT
17601 – 59th AVENUE NE
ARLINGTON, WASHINGTON
Project No. 2679.01
2 August 2023

INTRODUCTION

This report summarizes the geotechnical engineering exploration and analysis completed for the proposed North County Special Use Permit project in Arlington, Washington. Eleven test pits (TP-1 through TP-11), and one hand auger boring (HA-1) were completed by ZGA to depths ranging from approximately 6.5 to 10.5 feet below the existing ground surface to evaluate subsurface conditions. We also relied upon subsurface information developed as part of completing the geotechnical exploration and analysis for the planned Crosswind substation in the southeastern portion of the site earlier this year, as well as explorations completed by GeoEngineers as described subsequently. 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 Description

The project site is located in the southern portion of the District's Arlington Microgrid facility. The site is located 0.2 miles south of 180th Street NE and 0.4 miles east of 59th Avenue NE and near the BNSF Railroad right-of-way. The railroad right-of-way adjoins the site at the east, industrial/commercial buildings and lots are to the south, and District facilities lie north and east. An asphalt-paved public road (63rd Avenue NE) roughly bisects the site. The site currently includes a previously graded grassy field at the west, a solar array to the east, a gravel-surfaced lot at the southeast (future home of the Crosswind substation), and a District crew training facility at the northeast. A large battery structure is located at the northwest corner of the existing solar array and is part of the power backup storage system. The site and immediate vicinity are illustrated on the *Site and Exploration Plan*, Figure 1.

Project Description

Site improvements planned as part of the Special Use Permit application that are addressed in this report include the following:

- Relocation of a portion of the existing solar array to the open field in the western portion of the site.

- Construction of a paved access road that will extend along the southeastern, eastern, and northeastern portions of the site east of 63rd Street.

- Stormwater system improvements to accommodate runoff from the new paved access road and storage areas.

- We understand that a new battery energy storage system will be installed in a portion of the existing solar array facility. However, addressing geotechnical considerations associated with this project element was not included in our scope of services.

Site History

The District retained GeoEngineers to completed multiple phases of geotechnical exploration and analysis since the District began development of the Microgrid property, and we have relied upon information provided in some of the GeoEngineers reports to supplement ZGA's Special Use Permit-specific exploration and analysis. The GeoEngineers reports that we reviewed are listed below, and selected exploration logs are included in Appendix A:

- GeoEngineers, *Hydrogeologic Assessment, Proposed Pole Yard, Arlington, Washington*, File No. 0482-051-03, dated 26 April 2016;

- GeoEngineers*, Geotechnical Engineering Services, North County Project, Arlington, Washington*, File No. 0482-051-03, dated 29 December 2017;

- GeoEngineers, *Updated Groundwater Monitoring Data (Addendum No. 2), North County Project, Arlington, Washington*, File 0482-051-04, dated 20 June 2018;

- GeoEngineers*, Geotechnical Engineering Services, Update 1 – Revision 1, North County Community Office Project, Early Site Development Phase, Arlington, Washington*, Field Nol 0482-051-04, dated 5 February 2021.

SITE CONDITIONS

Surface Conditions

The new solar array site in the western portion of the site is a relatively level area with ground surface elevations between about 128 and 131 feet. The site is irregularly vegetated with grasses. Water mains have been installed on site and two fire hydrants are located at some distance from each other along the southern border of the site. A pre-cast concrete and steel vault in the north-central portion of the lot contains a groundwater monitoring well monument (GEB-3) installed by GeoEngineers. The District has a large pile of soil material stored at the eastern side of the site. The adjoining 63rd Avenue NE to the east

side is asphalt-paved, two lanes, and in a serviceable condition. During our site visits we observed some isolated puddles following heavy rain, but these drained relatively quickly.

The existing solar array to the east occupies a relatively level area with ground surface elevations ranging from about 133 to 137 feet. The area is vegetated with grasses and supports single-lane gravel-surfaced access drives between the rows of solar panels. Numerous power and fiber optic vaults are located along the west side and adjacent to 63rd Avenue NE.

The future Crosswind substation site at the southeast is a relatively level area with ground surface elevations ranging from about 135 to 136 feet. The site is mantled with about 4 to 6 inches of ¾-inch crushed gravel over a non-woven geotextile. A pre-cast concrete and steel vault in the north-central portion of the lot contains a groundwater monitoring well monument (B-9) installed by GeoEngineers in 2017. A fire hydrant is located near the northeast corner. The District has material stored to the north, east, and south of the gravel pad. We observed standing water throughout the lot during a site visit on 14 February 2023 following previous heavy rain, but it drained relatively quickly.

The line crew training area to the northeast is relatively level and mostly bare ground, although some areas have been mantled with hog fuel. The area is used for excavator training, pole and line setting, and equipment operator training. We observed isolated puddles in high vehicle traffic areas following heavy rain.

It should be noted that almost the entire Special Use Permit area has been disturbed by previous grading activity. Underground utilities have been installed throughout the site, including in the open field where the solar array will be moved and also along the south, east, and north perimeter of the area east of 63rd Avenue NE where the new access road is planned. These include water, power, and fiber optic cabling. Consequently, disturbance of the upper soil horizon has occurred and fill material is present as well.

Subsurface Conditions

Local Geologic Conditions

We assessed the geologic setting of site and the surrounding vicinity by reviewing the *Geologic Map of the Arlington West 7.5 Minute Quadrangle, Snohomish County, Washington* (US Geological Survey, Map MF-1740, 1985). The published geologic mapping indicates the site is underlain by Vashon Recessional Outwash, Marysville Sand Member (Qvrm). 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 meltwater flowing south from the stagnating and receding Vashon glacier. The outwash is reported to have a minimum thickness of about 65 feet. Subsurface conditions disclosed by the explorations advanced by ZGA and others are consistent with the published mapping. ZGA's explorations disclosed recent 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.

Our understanding of subsurface conditions is based upon observation of eleven test pits and one hand boring. In addition, we reviewed the logs of borings and test pits completed by GeoEngineers through most of the site and explorations recently completed by ZGA at the Crosswind substation site. Approximate exploration locations, as well as pertinent surface features, are shown on Figure 1. Soil conditions are summarized below.

Fill

With the exception of test pit TP-7, we did not observe fill material in the explorations completed in the field at the western side of the site. However, we did observe fill in all the explorations completed along the planned access road east of 63rd Avenue NE. The fill observed at the TP-7 location extended about 1.5 feet below ground surface (bgs) and consisted of woody debris with a maximum dimension of about 12 inches as well as glass and other deleterious debris. The fill material in the eastern portion of the site contained much more woody debris in addition to metal pipe, glass, and solid waste and extended to depths ranging from about 1 to 3.5 feet bgs. Please note that the nature of undocumented fill is such that its composition and thickness can vary over relatively short distances.

We submitted twelve samples of the fill material to an analytical laboratory to test for the presence of asbestos. The test results were negative.

Topsoil

We observed about 1 to 1.5 feet of loose, moist, red-brown, silty sand and sandy silt with fine organic material and fine to medium roots and roots hairs at the locations of the test pits completed west of 63rd Avenue NE. We have interpreted this material as topsoil. The area east of 63rd Avenue NE has been graded in order to prepare the existing pad where the Crosswind substation will be located and along the southern, eastern, and northern perimeter of the site where underground fiber optic utilities have been installed. We observed some relic topsoil between about 1 and 2 feet in depth below some fill material at the hand auger HA-1 location. We did not observe topsoil at the locations of the other explorations in this portion of the site.

Recessional Outwash

The test pits and explorations disclosed that the native recessional outwash soils consisted of loose to dense sand with gravel and a low fines content (the soil fraction passing the US No. 200 sieve). The soils above the water table were generally in a moist condition. The test pits were terminated at depths of approximately 6 to 10.5 feet. Mild to moderate caving with no groundwater seepage was observed in the test pits completed west of 63rd Avenue NE, while we observed moderate caving with rapid groundwater seepage as shallow as about 5 feet at the locations of test pits to the east.

Groundwater

We did not observe groundwater seepage while excavating the test pits located west of 63rd Avenue NE. The soil was moist to depths of about 10.5 fee. East of 63rd Avenue NE, we observed groundwater seepage at depths of approximately 5 to 8.5 feet while excavating the test pits and the hand auger boring.

Our recent groundwater observations, including a recent measurement made in boring GEB-9 at the Crosswind substation site, 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. ZGA is currently monitoring groundwater and will forward results in memorandum format on a quarterly basis.

Table 1: Recent Groundwater Observations

Exploration	Approximate Groundwater Depth/Elevation (feet)	Observation Date
HA-1	5.5 / 129.5	4.25.23
TP-1 through TP-8	Not observed	4.24.23
TP-9	5.5 / 129.5	4.25.23
TP-10	5 / 131	4.25.23
TP-11	8 / 128	4.25.23
GEB-9	7.2 / 129	3.29.23
Geb-9	10.8 / 125.4	6.5.23

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 shallow organic topsoil, disturbed native soils, or undocumented fill material from below foundations is recommended.

- Re-use of the existing non-organic native soil during grading may be feasible provided that the soil moisture content can be adequately controlled prior to compaction. Any material proposed for re-use will need to be approved by the District. The native recessional outwash likely to be encountered during grading has a relatively low fines content and may be considered moderately moisture-sensitive relative to grading. The contractor should be aware that weather conditions may result in soil moisture conditions that make re-use of some soils infeasible.

- We anticipate that deeper excavations for vaults and conduits may encounter groundwater during the wetter time of year, possibly necessitating dewatering.

- The granular nature of the shallow native recessional outwash soils is favorable from the stormwater infiltration, although it appears that the likely relatively high infiltration rate will preclude relying on the shallow native soils for treatment purposes unless they are amended.

- The non-organic native soils are favorable for pavement support. Pavement longevity will be improved by removing shallow organic soils prior to grading paved areas.

- Based on our analyses, we estimate total settlement resultant from seismically-induced liquefaction of approximately 1 to 3 inches. We estimate differential seismic settlement of approximately ½ to 1½ inches over a horizontal distance of 40 feet. We anticipate that this degree of potential settlement can be adequately accommodated by the new solar array foundations.

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 reports by others, and our current understanding of the proposed project design. ASTM testing methods and WSDOT specifications co 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).

Regulated Geologic Hazard Areas

Part V of Chapter 20.93.600 of the Arlington Municipal Code (AMC) defines regulated geologic hazard areas as follows:

"Geologic hazard areas" means lands or areas susceptible to erosion, sliding, earthquakes, liquefaction, or other geological events.

Landslide Hazard Areas

"Landslide hazard areas" include areas subject to severe risk of landslide based on a combination of geologic, topographic, and hydrologic factors. Landslide hazard include any of the following:

(A) Areas characterized by slopes greater than fifteen percent and impermeable soils (typically silt and clay) frequently interbedded with permeable granular soils (predominantly sand and gravel) or impermeable soils overlain with permeable soils or springs or groundwater seepage; Low Hazard. Areas with slopes of less than 15 percent.

(B) Any area that has exhibited movement during the Holocene epoch (from ten thousand years ago to present) or which is underlain by mass wastage debris of that epoch;

(C) Any area potentially unstable due to rapid stream incision, stream bank erosion or undercutting by wave action;

(D) Any area located on an alluvial fan presently subject to or potentially subject to inundation by debris flows or deposition of stream-transported sediments;

(E) Any area with a slope of thirty-three percent or greater and a vertical relief of ten or more feet except areas composed of consolidated rock;

(F) Any area with slope defined by the United States Department of Agriculture Soil Conservation Service as having a severe limitation for building site development; and,

(G) Any shoreline designated or mapped as class U, UOS, or URS by the Department of Ecology Coastal Zone Atlas.

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 AMC definition.

Seismic Hazard Areas

Seismic Design Considerations: The seismic performance of the proposed site improvements was evaluated in accordance with the 2018 International Building Code (IBC). The seismic basis of design for the 2018 IBC, which refers to the American Society of Civil Engineers (ASCE) 7-16, is a risk-targeted maximum considered earthquake (MCE_R), which represents an earthquake with a 2 percent probability of exceedance in 50 years (2,475-year return period).

Ground Fault Rupture: Based on review of the United States Geological Survey *Quaternary Fault and Fold Database of the United States* the nearest fault to the site is the South Whidbey Island Fault Zone mapped about 17 miles south-southwest of the site. Based on the mapped location of the fault relative to the site, it is our opinion that the risk associated with fault surface rupture at the site is low.

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 the 2018 IBC and ASCE 7-16. Specifically, our analysis used the following primary seismic ground motion parameters.

- A Modified Peak Ground Acceleration (PGA_M) of 0.52g based on Site Class D, per Section 11.8.3 of ASCE 7-16 (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 7.03 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 CLiq (Version 3.5.2.10) developed by GeoLogismiki. Our analysis was based on CPT-01 completed to a depth of about 60 feet below existing grade within the proposed development area and assumed a conservative groundwater depth of 2 feet during the design earthquake. The approximate exploration location is shown on the enclosed *Site and Exploration Plan, Figure 1*. Based on our analysis, a generally non-liquefiable crust of material exists in the upper 15 feet of the site. Below this crust, portions of the Marysville Sand Member have a moderate to high liquefaction potential during the design earthquake down to the full depth of the CPT exploration.

Liquefaction Settlement: The site is mantled by a generally dense and non-liquefiable crust on the order of 15 feet thick. As such, liquefaction-indicated settlements observed at the surface will initiate from potentially liquefiable layers present below the non-liquefiable crust. Research and case histories have shown that the expression of liquefaction-induced settlement at the ground surface is a function of the depth of the liquefiable layers, with deeper liquefiable layers contributing less to ground surface settlement than similar thickness shallow liquefiable layers (Cetin et al., 2009). Cetin proposed use of a "depth weighting factor" (DF_i) that reduces the impact of deep liquefiable layers on the estimated surface settlement. This factor is included in the CLiq program and was used in our settlement analysis.

Based on our analyses, we estimate a total seismic settlement of approximately 1 to 3 inches. We estimate a differential seismic settlement of approximately ½ to 1½ inches over a horizontal distance of 40 feet. Appendix C contains selected seismic analysis data sheets.

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. Given the relatively level nature of the site, lack of a free-face condition, and 15-foot-thick non-liquefiable crust, it is our opinion that the potential for distress at the site from lateral spreading is low.

Additional Liquefaction Analysis: The District retained Hart Crowser to complete a liquefaction analysis at the Microgrid site, and their conclusions and recommendations are summarized in the report titled *Geotechnical Engineering Design Study, North County Development, Arlington, Washington* (Project No. 19583-00, dated 20 January 2022). The Hart Crowser report is relevant to the Special Use Permit site as they are adjacent. Hart Crowser's analysis was based on subsurface information provided in the GeoEngineers reports described earlier. Similar to the results of ZGA analysis, Hart Crowser concluded that liquefaction-induced settlement on the order of 2 to 4 inches resultant from the modeled maximum credible seismic event was likely, and recommended designing project structures for 2 inches of differential settlement over a distance of 30 feet.

Table 2: IBC Seismic Design Criteria

Parameter	Value
2018 International Building Code Site Classification (IBC) [1]	Site Class F [2,3]
Site Latitude/Longitude	48.1560 /-122.1422
Spectral Short-Period Acceleration, S_S	1.050g
Spectral 1-Second Acceleration, S_1	0.375g
Site Coefficient for a Short Period, F_A	1.080
Site Coefficient for a 1-Second Period, F_V	See ASCE Section 11.4.8
Spectral Acceleration for a 0.2-Second Period, S_{MS}	1.134g
Spectral Acceleration for a 1-Second Period, S_{M1}	See ASCE Section 11.4.8
Design Short-Period Spectral Acceleration, S_{DS}	0.756g
Design 1-Second Spectral Acceleration, S_{D1}	See ASCE Section 11.4.8

1. IBC Site Class is based on the average characteristics of the upper 100 feet of the subsurface profile.
2. CPT-01 completed by ZGA for this study extended to a maximum depth of about 60 feet below grade. Therefore ZGA reviewed logs for CPT-1 and CPT-2 completed by GeoEngineers in 2017 (including shear wave velocity test results) about 2,000 and 1,200 feet west of the site, respectively, to determine IBC site class with and without regard to liquefaction.
3. Per the *2018 International Building Code* and *ASCE 7-16*, Chapter 20, any profile containing soils vulnerable to potential failure or collapse under seismic loading such as liquefiable soils.

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. Based on the results of the field evaluation, 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 of ASCE 7-16 do not apply, a ground motion hazard analysis may be required. Site Class D describes soils that are considered stiff with a shear wave velocity between 600 and 1,200 feet per second, average Standard Penetration Test values between 15 and 50, and an undrained shear strength between 1,000 and 2,000 psf.

Engineering Soil Units

For purposes of describing soil conditions observed at the exploration locations and for reference in other sections of this report, soils with similar engineering characteristics were grouped together into Engineering Stratigraphic Units or ESUs. The following paragraphs provide our interpretation of ESUs encountered at the exploration locations. ESUs are described in a top down stratigraphic sequence described in the logs. The reader is referred to the logs attached in Appendix A for information regarding subsurface conditions.

ESU 1 – Topsoil: Soils located in the western relocated solar area between about 1 and 1.5 feet deep are interpreted to be topsoil characterized as loose, silty sand and sandy silt with trace gravel and a high organic content. Engineering properties of ESU 1 soils are characterized as low strength and compressible materials.

ESU 2 –Undocumented fill/disturbed native soil: We observed soils interpreted to be undocumented fill at one test pit location (TP-7) west of 63rd Avenue NE to a depth of about 1.5 feet below existing site grade. Along the rail line at the eastern area of the site, ESU-2 soils were observed from about 1 to 1.5 feet bgs. ESU 2 fill soils generally consisted of loose silt, sand, gravel, cobbles, and deleterious material such as glass, metal pipes, branches, and plastic debris. The disturbed native soils were of similar density and composition but lacked the deleterious debris and are related to previous site grading. Engineering properties of ESU 2 soils are characterized as low strength and compressible materials. Please note that while we only observed fill material at the test pit TP-7 location in the western portion of the site, additional fill material is present in the form of backfilled underground utility trenches across the entire site.

ESU 3 – Loose to medium dense recessional outwash (Qvrm – Marysville Sand Member): Soils interpreted to be shallow loose to medium dense recessional outwash soils were observed at most of the exploration locations. These loose to medium dense materials tend to be moderately weathered and extend from about 1.5 feet to 4 feet bgs. Engineering properties of ESU 3 soils are characterized as low to moderate strength low compressibility materials.

ESU 4 – Medium dense to dense recessional outwash (Qvrm – Marysville Sand Member): Soils interpreted to be medium dense recessional outwash soils were generally observed at depths below about 4 feet. Engineering properties of ESU 4 soils are characterized as moderate to high strength low compressibility materials. ESU 4 soils include structural fill compacted to at least 95 percent density per ASTM D 1557.

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 embankments, foundations, pavements, 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 any existing surficial vegetation, root mass, organic topsoil, and deleterious debris if present. These materials should be removed from the project area. We also recommend selective removal of existing undocumented fill material or disturbed native soils containing substantial organics or deleterious debris and any relic organic topsoil from below solar array foundations, pavements, or other settlement-sensitive project improvements.

Variation in the undocumented fill and disturbed native soil depth and composition 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. Soil with no more than about 3 percent organic material and lacking deleterious material may generally be left in place. The resultant excavations should be backfilled in accordance with the subsequent recommendations for structural fill placement and compaction. The amount of soil removed during the stripping process may be reduced if root rakes are employed. Root rakes allow segregation of roots from the surrounding mineral soil, and can be beneficial in terms of reducing the amount of soil likely removed during stripping.

Site Preparation and Grading Scheduling: Most of the native soils likely to be exposed during grading consist of sand and gravel with a variable 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 concerns 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 moisture-sensitive soils that may be disclosed during grading 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 potential need for construction dewatering.

Structural Fill Placement and Compaction

A grading plan was not available at the time this report was prepared. However, we anticipate that substantial grading will not be required in association with construction of the relocated solar array, new parking/materials storage, perimeter road, and stormwater management elements. 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, they 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 conditioned 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.

Limitations Regarding Re-use of On-site Soils: Soil expected to be encountered in excavations include predominantly native soil typically consisting of sand and gravel with a variable fines content. The fines content of soil samples that we tested (as deep as about 12 feet and likely to be encountered in excavations) ranged at the western portion of the site from about 2 to 11 percent with an outlier at TP-8 of 23 percent and, in the eastern portion of the site, from about 1 to 18 percent. Please note that the samples with the higher fines contents were the shallow weathered soils. We observed the highest fines content in the very shallow soils; the fines content generally decreased with depth. Using the shallow soils with the higher fines content as structural fill during wet weather could be difficult due to the soils' increased moisture sensitivity.

Imported Structural Fill: We recommend that structural fill consist of well-graded sand and gravel with a low fines content. An example gradation is shown in the table below.

Table 3: Recommended Gradation of Imported Structural Fill	
US Standard Sieve Size	**Percent Passing by Dry Weight Basis**
2 inch	100
½ inch	56 - 100
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.

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 4: Recommended Soil Compaction Levels	
Location	**Minimum Percent Compaction***
Below foundations and slabs	95
Below pavements and concrete hardscapes	95
General fill embankments	90 – 95 (refer to report text)
Utility trenches, foundation, and slab backfill	95
* 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 rock ballast 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.

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

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: Groundwater observations and measurements made as of the time that this report was prepared are described in Table 1 on Page 5. In summary, we did not observe groundwater while excavating test pits in the future relocated solar array area in the western portion of the site, although we did observe groundwater seepage at depths of about 5 to 8 feet in explorations in the eastern portion of the site. ZGA is continuing to monitoring groundwater at the Microgrid property and quarterly summaries will be provided to the District.

Depending upon the time of year that the work takes place and the depth of the utilities, groundwater seepage could 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 a nearby storm sewer or Baker tank. 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.

Solar Array Foundation Recommendations

Based upon our review of RBI Solar design documents associated with the existing solar array (dated 18 February 2019) and provided by the District, it appears that the relocated solar array components may be supported by either cast-in-place drilled pier foundations, conventional shallow column foundations, or by small driven C-piles or H-piles. Our conclusions and recommendations regarding foundations for the relocated array are summarized below.

Drilled Pier Foundations

Drilled Pier End Bearing and Settlement: The existing array design called for 18-inch diameter drilled piers installed to a depth of 6 feet. Based on conditions disclosed by the GeoEngineers and ZGA explorations completed in the relocated solar array location, we recommend using an allowable end bearing value of 9 kips per square foot (ksf) for drilled piers installed into the dense recessional outwash soils. This value incorporates a factor of safety of three and may be increased by one third for short-term transient loading. Foundation settlement is expected to be less than one-half inch.

Drilled Pier Uplift Capacity: Uplift forces acting on the drilled piers may be counteracted by the weight of the piers and skin friction between the piers and the surrounding soil. An allowable uplift capacity of 2.8 tons due to skin friction may be considered. This value incorporates a factor of safety of 2.5.

Open Shaft Construction Considerations: Given the soil conditions encountered at the explorations locations, we anticipate that construction of the shafts can be accomplished with standard drilling equipment. We observed undisturbed native soils, as well as some likely disturbed native soils and some

undocumented fill material to depths of about 1.5 feet below existing grade. The contractor should be prepared to deal with the presence of cobbles, concrete clasts, and wood over the drilled depth interval. In the event that obstructions cannot be removed, it will be necessary to excavate them and then backfill the excavation with either compacted structural fill or Controlled Density Fill (CDF) prior to attempting to re-drill the shafts.

We anticipate that sidewall caving may occur while drilling the granular soils, some of which have a relatively low fines content. We recommend that the contractor be prepared to case the drilled shaft boreholes to reduce sidewall sloughing. We recommend that the contractor be required to have on site sufficient material to case the entire drilled depth of the drilled pier foundations. The drilling contractor should be prepared to clean out the bottom of the shafts if loose soil is observed or suspected. We recommend that the drilling contractor have a cleanout bucket on site to remove loose soils from the bottom of the borings.

Concrete Placement: We recommend that the foundation concrete be tremied from the bottom of the hole to displace water and to reduce the risk of contaminating or segregating the concrete mix should any accumulate in the shafts. A minimum 5-foot head of concrete should be maintained above the tremie. The *Drilled Shaft Manual* published by the Federal Highway Administration recommends that concrete be placed by tremie methods if more than 3 inches of water has accumulated in the excavation. Otherwise, if the shafts are dry or nearly dry, concrete may be placed via conventional chute delivery.

We recommend that a ZGA representative observe construction of the drilled pier foundations in order to verify that the bearing conditions are consistent with those described in this report.

Conventional Shallow Foundations

The existing array design called for 5.3-foot square isolated cast-in-place spread foundations to be constructed a depth of 1.5 feet. Our shallow foundation recommendations are summarized below.

Net allowable bearing pressure: 3,500 psf for ESU 4 soils. 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 for standard column foundation per previous design: 5.3 feet

Minimum embedment for frost protection: 18 inches

Approximate total settlement: 1 inch

Estimate differential settlement: One half of total settlement

Ultimate passive resistance: 480 pcf. This value assumes that foundations are backfilled with native sand and gravel 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 and does not include a factor of safety.

Shallow Foundation Construction Considerations: The base of all foundation excavations should be free of water, loose soil, or debris prior to placing concrete, and loose soil disturbed during excavation should be compacted as recommended in this report. Concrete should be placed soon after excavating and form and reinforcing installation 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.

Driven Pile Foundation Considerations

We understand that RBI Solar installed six test piles (five C8X3 piles and one W6X9 piles) during the existing solar array design process. The test pile program included the use of a proprietary hammer system, and the tests indicated that adequate capacities could be achieved by installing the piles at a maximum depth of 8 feet below grade. Soil conditions at the test piles locations are similar to those observed in the area where the relocated solar array will be installed, and we anticipate that the use of driven piles installed as described in the RBI Solar design documentation will be adequate at the new array location as well.

Stormwater Infiltration Feasibility

Construction of the new parking/materials storage area north of the relocated solar array and the new perimeter access road east of 63rd Avenue NE will introduce impervious surfaces, and the stormwater runoff will need to be accommodated by new stormwater management features. The site is underlain by permeable native granular soil and is characterized by a variable depth 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:

$$\text{Log10}\,(K_{sat,\ initial}) = -1.57 + 1.9D_{10} + 0.015D_{60} - 0.013D_{90} - 2.08f_{fines}$$ where:

$K_{sat,\ initial}$ = 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 5: Saturated Hydraulic Conductivity Summary

Exploration / Sample	Approximate Sample Depth (feet)	Unfactored Saturated Hydraulic Conductivity (inches per hour)	Factored Saturated Hydraulic Conductivity (inches per hour)
Location: West of 63rd Avenue NE			
TP-1 / S-3	3.5	63.4	9.4
TP-2 / S-3	3	80.7	12
TP-4 / S-2	1.5	170.9	25.4
TP-5 / S-2	2.5	23	3.4
TP-6 / S-2	2.5	30.2	4.5
TP-7 / S-2	3	14.7	2.2
TP-8 / S-2	2	14.6	2.2
TP-8 / S-3	3	69.4	10.3
Location: East of 63rd Avenue NE			
HA-1 / S-2	1.5	18	2.7
HA-1 / S-4	3.5	34.5	5.1
TP-9 / S-2	3	42.7	6.3
TP-10 / S-2	2.5	43.8	6.5
TP-10 / S-3	5	151.9	22.6
TP-11 / S-1	0.5	20.2	3

Table 5: Saturated Hydraulic Conductivity Summary			
Exploration / Sample	**Approximate Sample Depth (feet)**	**Unfactored Saturated Hydraulic Conductivity (inches per hour)**	**Factored Saturated Hydraulic Conductivity (inches per hour)**
TP-11 / S-3	8	104.3	15.5

Design Saturated Hydraulic Conductivity Rate

The *Manual* requires applying correction factors to the baseline (initial) 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 determined via the grain size method (CF_T). Table 3.3.1 also requires applying correction factors for site variability and number of locations tested (CF_V) and the degree of influent control to prevent siltation and bio-buildup (CF_M). Based upon the observed site conditions, testing results, and our experience with projects of a similar nature, we applied values of 0.33, 0.5, and 0.9 for CF_V, CF_T, and CF_M, respectively. Factored rates are included in Table 5 above.

We anticipate that runoff from the new access road east of 63rd Avenue NE may be accommodated by relatively shallow infiltration features, such as bioswales or trenches. Based upon this condition, we recommend applying an allowable long-term infiltration rate of 5.3 inches/hour for facilities constructed east of 63rd Avenue NE. We recommend applying an allowable long-term infiltration rate of 4.7 inches/hour for facilities west of 63rd Avenue NE.

In Situ Stormwater Treatment

To assess the feasibility of using shallow native soils to provide stormwater runoff treatment, five shallow soil samples were tested for Cation Exchange Capacity (CEC) as well as organic content. The *Manual* requires that the infiltration receptor soil possess a minimum CEC value of 5 meq/100g of dry soil determined in accordance with the USEPA Method 9081 and an organic content of 1 percent or greater as determined via the ASTM D2974-07 test method in order to provide adequate *in situ* treatment of stormwater. Four of the five samples had CEC values greater than 5 meq/100g; only the sample from test pit TP-10 along the far east side of the site had a lesser value of 3.3 meq/100g. Each of the samples had an organic content exceeding 1 percent. Based on the test results and our observation of shallow soils, it appears that overall shallow soil conditions are favorable for *in situ* treatment provided that some soil amendment is completed in the vicinity of test pit TP-10.

SSC-4 Soil Infiltration Rate/Drawdown Time from the *Manual* indicates that the measured (initial/unfactored) soil infiltration should be 9 inches/hour or less for *in situ* treatment to be effective. However, the unfactored infiltration rates we determined exceeded 9 inches/hour. Consequently, it appears that some form of soil amendment of the native soils will be necessary to reduce the soil

infiltration rate, or that treatment may be provided by using an imported soil mix that has been demonstrated to meet the *Manual* requirements.

It would be necessary to complete additional laboratory testing of amended site soils in order to determine the type and quantity of amendments necessary for the treated on-site soil to meet the relatively low infiltration rate described in the *Manual* for effective treatment. We can assist the District in this regard if requested. Alternatively, it would be feasible to import ready-made manufactured amended soil rather than attempting to amend the site soils. In the event that imported material is used for treatment purposes, we recommend considering the grain size distribution shown in the table below.

Table 6: Recommended Imported Treatment Fill Gradation

US Standard Sieve Size	Percent Passing by Dry Weight Basis
3/8 inch	100
No. 4	95 - 100
No. 10	75 - 90
No. 40	25 - 40
No. 100	4 - 10
No. 200	< 5

In addition to the gradation criteria list in the table above, we recommend that the material have a Coefficient of Uniformity (Cu) = D_{60}/D_{10} greater than or equal to 4 and a Coefficient of Curve (Cc) = $(D_{30})^2/(D_{60} \text{ X } D_{10})$ greater than or equal to 1 and less than or equal to 3. This material may be amended with compost. Please note that the imported fill gradation criteria are taken from the bioretention mix material described in the WDOE *Stormwater Management Manual for Western Washington.*

Groundwater Considerations

Groundwater conditions observed while completing the test pits and hand auger boring advanced for this evaluation are presented in Table 1 on Page 5. The reported seasonal high groundwater observations at the site described in GeoEngineers' two-year groundwater monitoring effort undertaken in 2017 and 2018 are summarized in Table 7 below. These observations illustrate that the depth to groundwater increased from east to west during the monitoring period. Our recent observations confirmed this condition.

Table 7: GeoEngineers Reported Historical Seasonal High Groundwater			
Exploration/Well	**Reported Seasonal High Groundwater Depth/Elevation* (feet)**	**Observation Date**	**Ground Surface Elevation* (feet)**
GEB-3	7.2 / 126.7	4.20.18	133.9
GEB-4	2.6 / 132.0	4.18.18	134.6
GEB-8	6.1 / 129.9	2.18.18	136.0
GEB-9	1.0 / 135.2	4.17.18	136.2
GEB-10	7.5 / 125.5	4.20.18	133
GEB-11	6.1 / 127.9	4.20.18	134
*Ground surface elevations reported on North County Community Office survey (9 sheets), by David Evans & Associates, Inc., dated 3.22.22.			

The previously observed shallow depth to seasonal high groundwater reported by GeoEngineers for borings GEB-4 and GEB-9 east of 63rd Avenue NE suggest that a shallow stormwater infiltration feature, such as a bioretention swale, may be required in order to meet the minimum separation distance between the bottom of infiltration BMPs and seasonal high groundwater. Separation as low as 1 foot may be permissible when using bioretention features. Alternatively, some other form of shallow infiltration, such as permeable pavement, may be necessary.

Flexible Pavement Section Recommendations

Improvement plans include constructing an asphalt-paved access road along the perimeter of the eastern portion of the site. When developing our recommendations, we considered that the pavements will be subject to passenger vehicles, typical District service vehicles, and occasional heavy trucks. Our recommended minimum pavement section may be inadequate in the event that the District plans to operate heavily loaded solid-tire forklifts in the new material storage area. If this is the case, please confirm the anticipated equipment to be used in this area and its frequency so that we can evaluate alternative pavement sections. Our recommendations for flexible pavement section are summarized below.

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: Shallow pavement subgrade soils are anticipated to consist of well-compacted sand with a variable fines content and generally low gravel content. This condition may be considered "fair" relative to pavement support. 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 3 inches of asphalt-treated base (ATB) over 6 inches (compacted thickness) of crushed surfacing base course (CSBC).

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

Subgrade Preparation and Compaction: We anticipate that the pavement subgrade will consist of non-organic native soil and structural fill that has been prepared in accordance with the recommendations presented in the *Subgrade Preparation* section of this report. All subgrade soils 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. 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.

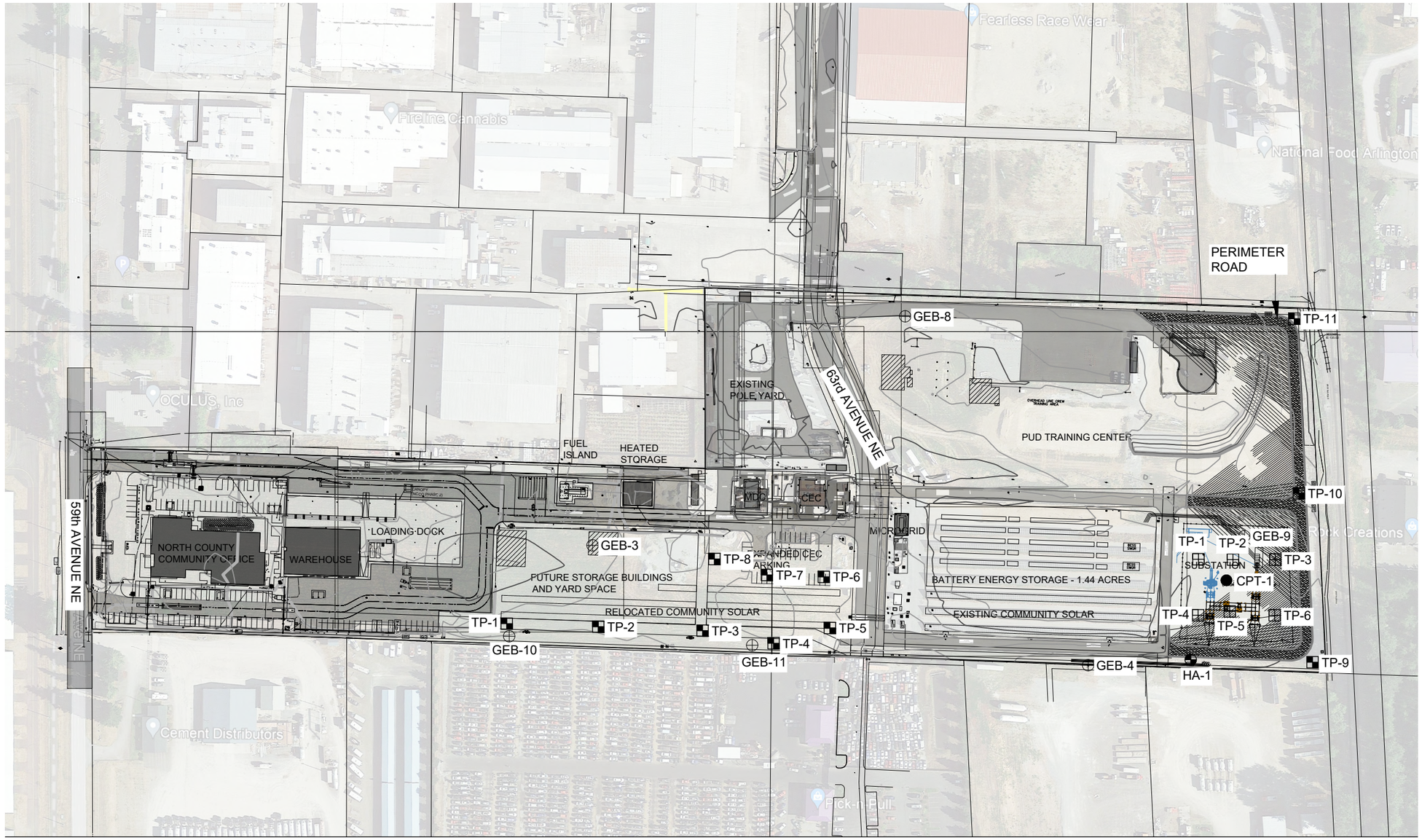
CLOSURE

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 pavements 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

- HA-1 HAND AUGER NUMBER AND APPROXIMATE LOCATION
- TP-1 TEST PIT NUMBER AND APPROXIMATE LOCATION
- TP-1 FEB 2023 ZIPPER GEO TEST PIT NUMBER AND APPROXIMATE LOCATION
- GEB-1 2012 GEO ENGINEERS BORING NUMBER AND APPROXIMATE LOCATION
- CPT-1 FEB 2023 ZIPPER GEO CPT NUMBER AND APPROXIMATE LOCATION

N

50 0 25 50

SCALE IN FEET

REFERENCE: SNOHOMISH COUNTY PUD SITE PLAN PRELIMINARY, SHEET A1.1. DATED 12/20/22

NORTH COUNTY SPECIAL USE PERMIT
17601 59th Avenue NE
Arlington, WA

SITE AND EXPLORATION PLAN

June 2, 2023 Job No. 2679.01

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

FIGURE 1
SHT.1 of 1

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, excavating eleven test pits (TP-1 through TP-11) and advancing one hand auger boring (HA-1). The approximate exploration locations are presented on Figure 1, the *Site and Exploration Plan*. Exploration locations were determined in the field using steel and fiberglass tapes by measuring distances from existing site features shown on the *Site Plan Preliminary* plan, Sheet A1.1, dated 20 December 2022, provided by the District. The approximate ground surface elevation at the exploration locations was interpolated from contours shown on Sheet SV1.08, *North County Community Office*, dated 22 March 2022. 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.

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.

Hand Auger

Hand auger boring HA-1 was advanced using a post hole digger and 3.25-inch diameter hand auger. An engineering geologist from ZGA performed the exploration. Samples were obtained as cuttings when the soil composition changed, stored in moisture-tight containers, and transported to our laboratory for further visual classification and testing.

The enclosed hand auger log indicates the vertical sequence of soils and materials encountered in the hand auger, 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. Our log also indicates the approximate depths of groundwater observed in the exploration, as well as all sample numbers and sampling locations.

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.

Cone Penetrometer Testing

Cone penetrometer test CPT-1 was completed by a ZGA subcontractor (In Situ Engineering) using a truck-mounted rig during a geotechnical exploration of the proposed Crosswind substation site, located in the southeastern portion of the Special Use Permit site. 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 indicates the recorded tip resistance, friction, friction ratio, pore pressure, correlation to the Standard Penetration Test, and a graphic representation of the soil type.

Exploration Logs by Others

The 29 December 2017 GeoEngineers report *Geotechnical Engineering Services, North County Project, Arlington, Washington* (File No. 0482-051-03) includes the logs of numerous explorations completed at the Microgrid site. This appendix includes the logs of six borings/monitoring wells that GeoEngineers completed within the limits of the Special Use Permit site, the approximate locations of which are illustrated on Figure 1.

ZipperGeo
Geoprofessional Consultants

Hand Auger HA-1

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 135 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.25.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist,red-brown, silty SAND with gravel, trace organics, root hairs; subrounded gravel. ESU-2 (FILL)	S-1 @ 0.5 feet	0.0		ACM
2	Loose, moist, brown, SILT with sand, some gravel, some organics, root hairs; fine subrounded gravel. ESU-2 (Relic Topsoil) CEC = 6.7	S-2 @ 1.5 feet	0.0	30	GSA CEC
3		S-3 @ 2.5 feet	0.0		
4	Loose to medium dense, moist, yellow-brown, SAND with gravel, some silt; fine subrounded gravel. ESU-3 (Qvrm)	S-4 @ 3.5 feet	0.0	11	GSA
5					
6	Medium dense, wet to saturated, grey, poorly graded SAND with gravel; fine subangular to subrounded gravel. ESU-4	S-5 @ 5 feet	0.0		
7		S-6 @ 6 feet	0.0		
8	Exploration completed at approximately 6.5 feet. Rapid groundwater seepage observed at 5.5 feet at time of excavation				
9					
10					
11					
12					
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

Test Pit TP-1

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 133 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.24.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist, red-brown, silty SAND to sandy SILT, fine roots, root hairs. ESU-1 (Topsoil)	S-1 @ 0.5 feet	0.0		ACM
2					
3	Loose, moist, orange, silty SAND trace organics, roots, root hairs; some Fe; moderately weathered. ESU-3 (Qvrm) Organic Content = 5.6%	S-2 @ 2 feet	0.0		OC
4	Loose to medium dense, moist, tan, poorly graded SAND, trace silt, trace gravel; subrounded gravel. ESU-3	S-3 @ 3.5 feet	0.0	7.7	GSA
5					
6					
7	Medium dense, moist, grey brown, poorly graded GRAVEL with sand; subrounded gravel; medium dense to dense at 8.5 feet. ESU-4	S-6 @ 6 feet	0.0		
8					
9					
10	Exploration completed at approximately 9 feet.				
11	No groundwater seepage observed at time of excavation				
12	Slight caving observed from approximately 3 feet.				
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

Test Pit TP-2

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 133 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.24.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist, red-brown, silty SAND to sandy SILT, roots, root hairs. ESU-1 (Topsoil)	S-1 @ 0.5 feet	0.0		ACM
2	Loose, moist, orange, silty SAND trace coarse gravel; some Fe; moderately weathered. ESU-3 (Qvrm)				
3		S-2 @ 2 feet	0.0		
4	Medium dense, moist, tan, poorly graded SAND trace to some gravel; becomes medium dense to dense poorly graded SAND with gravel, trace silt at 3 feet; subrounded gravel. ESU-4				
5		S-3 @ 3.5 feet	0.0	5.4	GSA
6					
7					
8					
9					
10	Exploration completed at approximately 9.5 feet.	S-4 @ 9 feet	0.0		
11	No groundwater seepage observed at time of excavation				
12	Moderate caving observed from approximately 3 feet.				
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

	Test Pit TP-3	**Project:**	North County SUP		
	Location: See Site and Exploration Plan, Figure 1	**Project Number:**	2679.01A		
	Approximate GSE: 134 feet	**Date Excavated:**	4.24.2023		
Depth (ft)	**Material Description**	**Sample**	**PID**	**% M**	**Testing**
1	Loose, moist, brown, sandy SILT to silty SAND, roots, root hairs. ESU-1 (Topsoil)	S-1 @ 0.5 feet	0.0		ACM
2					
3	Loose, moist, orange, silty SAND trace coarse gravel; some Fe; moderately weathered. ESU-3 (Qvrm)	S-2 @ 2 feet	0.0		
4					
5	Medium dense, moist, grey, poorly graded SAND with gravel; subrounded gravel. ESU-4	S-3 @ 4.5 feet	0.0		
6					
7					
8					
9		S-4 @ 9 feet	0.0		
10	Exploration completed at approximately 9.5 feet.				
11	No groundwater seepage observed at time of excavation				
12	Moderate caving observed from approximately 3 feet.				
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

	Test Pit TP-4	**Project:**	North County SUP		
	Location: See Site and Exploration Plan, Figure 1	**Project Number:**	2679.01A		
	Approximate GSE: 134 feet	**Date Excavated:**	4.24.2023		
Depth (ft)	**Material Description**	**Sample**	**PID**	**% M**	**Testing**
1	Loose, moist, brown, sandy SILT, fine to medium roots, root hairs. ESU 1 (Topsoil)	S-1 @ 0.5 feet	0.0		ACM
2	Loose, moist, orange, SAND with silt, fine roots, root hairs, some Fe; moderately weathered. ESU 3 (Qvrm)	S-2 @ 1.5 feet	0.0		GSA
3					
4	Medium dense, moist, yellow-grey, poorly graded SAND trace gravel; with gravel at 6 feet, trace silt at 9.5 feet, with cobbles at 9.5 feet; subrounded cobbles; subrounded gravel. ESU 4	S-3 @ 3.5 feet	0.0		
5					
6					
7		S-4 @ 6 feet	0.0		
8					
9					
10		S-5 @ 9.5 feet	0.0		
11	Exploration completed at approximately 10 feet.				
12	No groundwater seepage observed at time of excavation				
13	Moderate caving observed from approximately 3 feet.				
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

Test Pit TP-5

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 134 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.24.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist, brown, sandy SILT trace gravel, fine roots, root hairs; coarse subrounded gravel. ESU -1 (Topsoil)	S-1 @ 0.5 feet	0.0		ACM
2					
3	Loose, moist, orange, poorly graded SAND with silt, trace gravel, with organics, roots, root hairs, some Fe; moderately weathered. ESU -3 (Qvrm)	S-2 @ 2.5 feet	0.0		GSA
4					
5		S-3 @ 4.5 feet	0.0		
6	Medium dense, moist, grey-brown, poorly graded SAND with gravel, becomes medium dense to dense at 10 feet, becomes moist to wet at 10 feet; subrounded gravel. ESU-4				
7					
8					
9		S-4 @ 8 feet	0.0		
10					
11		S-5 @ 10 feet	0.0		
12	Exploration completed at approximately 10.5 feet. No groundwater seepage observed at time of excavation				
13	Moderate caving observed from approximately 3 feet.				
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

Test Pit TP-6

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 134 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.24.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist, brown, silty SAND with gravel, fine roots, root hairs; coarse subrounded gravel. ESU-1 (Topsoil)	S-1 @ 0.5 feet	0.0		ACM
2					
3	Loose, moist, orange, SAND some silt, trace gravel, trace organics, roots, root hairs, some Fe; moderately weathered. ESU-3 (Qvrm)	S-2 @ 2.5 feet	0.0	14.9	GSA
4					
5	Medium dense, moist, grey-brown, poorly graded SAND trace to some gravel, trace silt at 4 feet; subrounded gravel. ESU-4	S-3 @ 4 feet	0.0		
6					
7		S-4 @ 6 feet	0.0		
8					
9		S-5 @ 8.5 feet	0.0		
10	Exploration completed at approximately 9 feet.				
11	No groundwater seepage observed at time of excavation				
12	Mild caving observed from approximately 3 feet.				
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

Test Pit TP-7

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 134 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.24.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist, dark brown, sandy SILT, fine roots, root hairs, some glass and plastic debris. ESU-2 (FILL)	S-1 @ 0.5 feet	0.0		ACM
2					
3	Loose, moist, orange, sandy SILT to silty SAND trace to some organics, fine roots, root hairs, some Fe; moderately weathered. ESU-3 (Qvrm) Organic Content = 6.7% CEC = 12				
4		S-2 @ 3 feet	0.0	23.6	GSA/CEC/ OC
5					
6	Medium dense, moist, grey, SAND with silt, trace gravel; subrounded gravel. ESU-4				
7					
8		S-3 @ 7 feet	0.0		
9					
10		S-5 @ 9.5 feet	0.0		
11					
12	Exploration completed at approximately 10 feet. No groundwater seepage observed at time of excavation				
13	Moderate caving observed from approximately 4 feet.				
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

	Test Pit TP-8	**Project:** North County SUP			
	Location: See Site and Exploration Plan, Figure 1	**Project Number:** 2679.01A			
	Approximate GSE: 134 feet	**Date Excavated:** 4.24.2023			
Depth (ft)	**Material Description**	**Sample**	**PID**	**% M**	**Testing**
1	Loose, moist, dark brown, sandy SILT, medium to fine roots, root hairs. ESU-1 (Topsoil)	S-1 @ 0.5 feet	0.0		ACM
2	Loose, moist, orange, SAND with silt, trace gravel, trace to some organics, fine roots, root hairs, some Fe; moderately weathered. ESU-3 (Qvrm) Organic Content = 3.4% CEC = 5.2				
3		S-2 @ 2 feet	0.0	20.1	GSA/CEC/OC
4	Loose to medium dense, moist, grey-brown, poorly graded SAND some gravel, trace silt; subrounded gravel. ESU-3	S-3 @ 3 feet	0.0	6.8	GSA
5					
6					
7	Medium dense, moist, grey-brown, poorly graded SAND with gravel with cobbles at 10 feet; subrounded cobbles; subrounded gravel. ESU-4	S-4 @ 6.5 feet	0.0		
8					
9					
10					
11		S-5 @ 10 feet	0.0		
12	Exploration completed at approximately 10.5 feet. No groundwater seepage observed at time of excavation				
13	Severe caving observed from approximately 3-3.5 feet.				
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

Test Pit TP-9

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 135 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.24.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist, red-brown, silty SAND with gravel; subrounded gravel. ESU-2 (FILL)	S-1 @ 0.5 feet	0.0		ACM
2					
3					
4	Loose, moist, yellow-brown, poorly graded SAND with gravel, some silt; subrounded gravel; slightly weathered. ESU-3 (Qvrm)	S-2 @ 3 feet	0.0		GSA
5					
6	Loose to medium dense, wet, grey, poorly graded SAND with gravel; subrounded gravel. ESU -3	S-3 @ 5.5 feet	0.0		
7	Loose to medium dense, saturated, grey, poorly graded GRAVEL with sand; subrounded gravel. ESU-3				
8		S-4 @ 7 feet	0.0		
9					
10	Exploration completed at approximately 8 feet. Rapid groundwater seepage observed at 5.5 feet at time of excavation				
11					
12	Moderate caving observed from approximately 5.5 feet.				
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

Test Pit TP-10

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 136 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.24.2023

Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist to wet, black, sandy SILT with cobbles, wood, branches, plastic, glass, metal; subrounded cobbles. ESU-2 (FILL)	S-1 @ 0.5 feet	0.0		ACM
2					
3	Loose, moist to wet, yellow-brown, poorly graded SAND with gravel, some silt, some wood, branches; subrounded gravel. ESU-2 (FILL) Organic Content = 1.6% CEC = 3.3	S-2 @ 2.5 feet	0.0	9.3	GSA OC
4					
5	Medium dense, wet to saturated, yellow-brown, gravelly SAND trace silt; subrounded gravel. ESU-4 (Qvrm)				
6		S-3 @ 5.5 feet	0.0	8.2	GSA
7	Exploration completed at approximately 6 feet.				
8	Rapid groundwater seepage observed at 5 feet at time of excavation				
9	Slight caving observed from approximately 3 feet.				
10					
11					
12					
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

ZipperGeo
Geoprofessional Consultants

Test Pit TP-11

Location: See Site and Exploration Plan, Figure 1

Approximate GSE: 136 feet

Project: North County SUP

Project Number: 2679.01A

Date Excavated: 4.24.2023

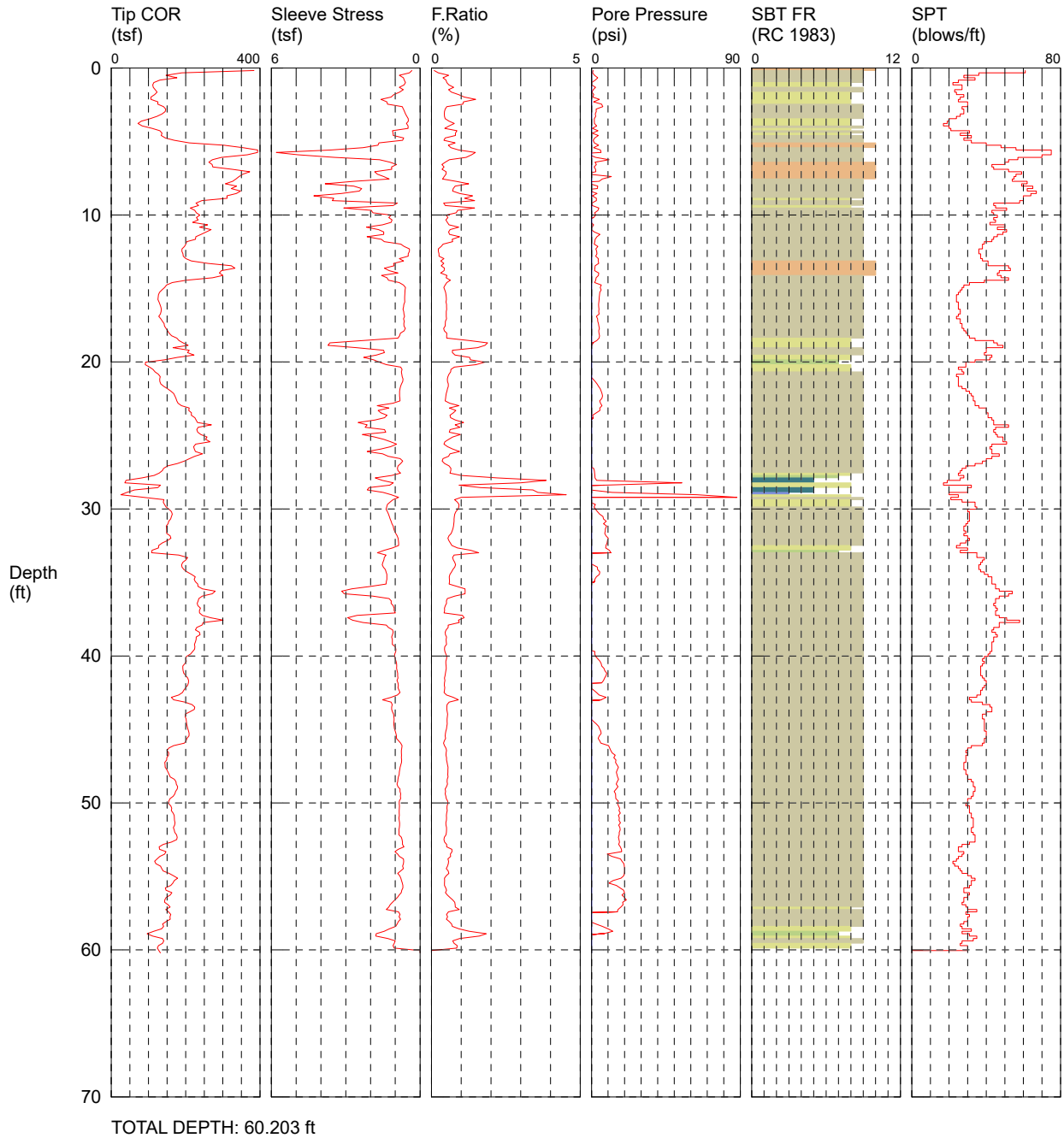
Depth (ft)	Material Description	Sample	PID	% M	Testing
1	Loose, moist, brown to tan, SAND with silt, with gravel, fine to medium roots, root hairs, plastic, metal pipes. ESU-2 (FILL) Organic Content = 4.7% CEC = 6.2	S-1 @ 0.5 feet	0.0	17.6	ACM/GSA/ CEC/OC
2					
3	Loose, moist to wet, grey-brown, poorly graded SAND with gravel, some Fe; subrounded gravel; moderately weathered. ESU-3 (Qvrm)	S-2 @ 2.5 feet	0.0		
4					
5	Medium dense, wet to saturated, grey-brown, poorly graded SAND with gravel to gravelly SAND trace silt; subrounded gravel. ESU-4				
6					
7					
8					
9		S-3 @ 8 feet	0.0	10.3	GSA
10	Exploration completed at approximately 8.5 feet.				
11	Rapid groundwater seepage observed at 8 feet at time of excavation				
12	Mild to moderate caving observed from approximately 4.5 feet.				
13					
14					

Note: PID is the displayed hydrocarbon concentration in parts per million (ppm).

CPT-01

CPT Contractor: In Situ Engineering
CUSTOMER: ZipperGeo
LOCATION: Arlington
JOB NUMBER: 2679.01

OPERATOR: Forinash
CONE ID: DDG1351
TEST DATE: 2/24/2023 9:46:02 AM
Coring: 0ft
Backfill: 20% Bentonite Slurry + Bentonite Chip
Surface Patch: None



TOTAL DEPTH: 60.203 ft

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

*SBT/SPT CORRELATION: UBC-1983

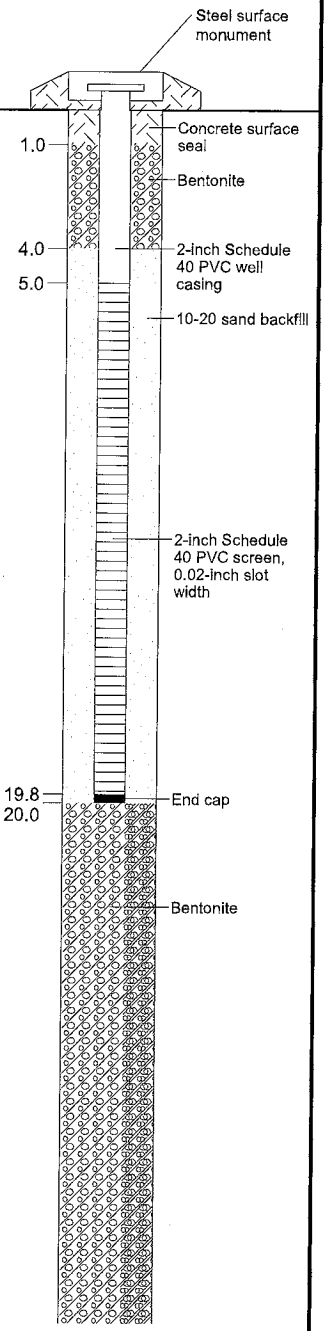
GeoEngineers Exploration Logs

Drilled Start 6/14/2012	End 6/14/2012	Total Depth (ft) 51.5	Logged By SMJ / Checked By BPD	Driller Geologic Drill Explorations, Inc.	Drilling Method Hollow-stem Auger
Hammer Data Autohammer 140 (lbs) / 30 (in) Drop			Drilling Equipment Diedrich D-50 Track Rig	DOE Well I.D.: BHJ197 A 2 (in) well was installed on to a depth of 20 (ft).	
Surface Elevation (ft) 134 Vertical Datum NAVD88			Top of Casing Elevation (ft)	Groundwater Date Measured 6/25/2012	Depth to Water (ft) 9.7 / Elevation (ft) 124.3
Easting (X) Northing (Y)			Horizontal Datum		

Notes: Elevation estimated from base survey map

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample / Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0						TS	6 inches topsoil and roots		
130		16	14	1 SA			SM	Light brown silty fine to medium sand with gravel, trace organic matter (medium dense, moist)	11	13
	5	12	14	2			SP	Light brown and gray fine to medium sand with trace gravel (loose, moist) (recessional outwash)	5	
125		12	30	3			SP-SM	Grayish brown fine to medium sand with silt and gravel (medium dense, moist)	7	
	10	5	25	4	▼		SW-SM	Brown fine to coarse sand with silt and gravel (medium dense, wet)		
120							SP-SM	Grayish brown fine to medium sand with silt and occasional gravel (medium dense, wet)		
	15	18	29	5				Driller added drilling mud at 15 feet		
115										
	20	9	23	6 %F					12	6
110										
	25	16	25	7						
105							SM	Grayish brown silty fine to medim sand with occasional gravel (medium dense, wet)		
	30	14	25	8						
100							ML	Grayish brown silt with occasional interbedded fine to medium sand with gravel (medium dense, wet)		
	35									

WELL LOG



Notes: See Figure A-1 for explanation of symbols.
Elevation estimated from base survey map

Log of Boring B-3

GeoEngineers

Project: Arlington Site Development
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-4
Sheet 1 of 2

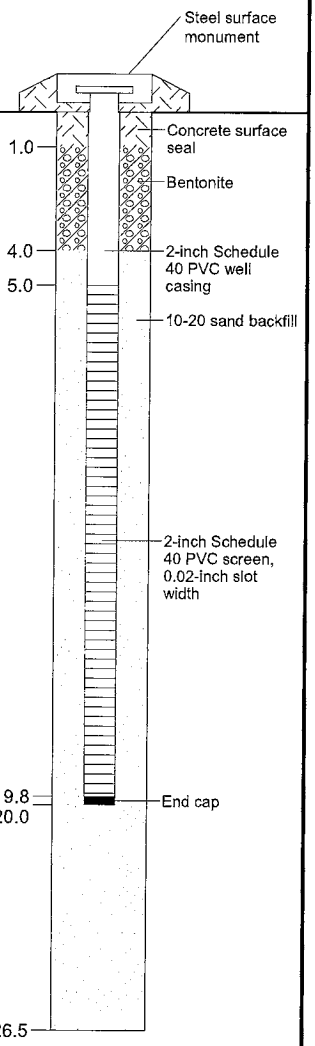
Seattle: Date:5/4/16 Path:P:\0\0482051\GINT\0482051.GPJ DBTemplate/LibTemplate:GEOENGINEERS8.GDT/GEI8_GEOTECH_WELL

Drilled Start 6/14/2012	End 6/14/2012	Total Depth (ft) 26.5	Logged By SMJ / Checked By BPD	Driller Geologic Drill Explorations, Inc.	Drilling Method Hollow-stem Auger
Hammer Data: Autohammer 140 (lbs) / 30 (in) Drop			Drilling Equipment: Diedrich D-50 Track Rig	DOE Well I.D.: BHJ196 A 2 (in) well was installed on to a depth of 20 (ft).	
Surface Elevation (ft): 134.5 Vertical Datum: NAVD88			Top of Casing Elevation (ft)	Groundwater Date Measured: 6/25/2012 Depth to Water (ft): 5.7 Elevation (ft): 128.8	
Easting (X) Northing (Y)			Horizontal Datum		

Notes: Elevation estimated from base survey map

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample / Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0						TS	9 inches topsoil and roots		
		18	8	1 MC			SM	Light brown silty fine to medium sand with gravel, trace organic matter (loose, moist)	11	
130	5	18	22	2 MC	▼		SP-SM	Light brown fine to medium sand with silt and gravel (medium dense, moist) (recessional outwash)	6	
		12	22	3				Becomes wet		
125	10	18	23	4			SP	Grayish brown fine to medium sand with gravel (medium dense, wet)		
							SP-SM	Grayish brown fine to medium sand with silt and occasional gravel (medium dense, wet) Driller added drilling mud at 13 feet		
120	15	18	21	5						
							SM	Grayish brown silty fine to medium sand (medium dense to dense, wet)		
115	20	18	30	6 MC				1 foot heave at 20 feet	12	
110	25	18	12	7						

WELL LOG



Notes: See Figure A-1 for explanation of symbols.
Elevation estimated from base survey map

Log of Boring B-4

GeoEngineers

Project: Arlington Site Development
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-5
Sheet 1 of 1

Seattle: Date:5/4/16 Path:P:\0\0482051\GINT\0482051103.GPJ DBTemplate\LibTemplate\GEOENGINEERS8.GDT/GEI8_GEOTECH_WELL

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	3/8/2017	3/8/2017	26.5	NS	KMS	Holocene Drilling, Inc.	Hollow-stem Auger

Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D50 Track-mounted
Surface Elevation (ft) Vertical Datum	137 NAVD88	Top of Casing Elevation (ft)	137
Easting (X) Northing (Y)	1320413 424926	Horizontal Datum	WA State Plane North NAD83 (feet)

DOE Well I.D.: BJY257
A 2 (in) well was installed on 3/8/2017 to a depth of 20 (ft).

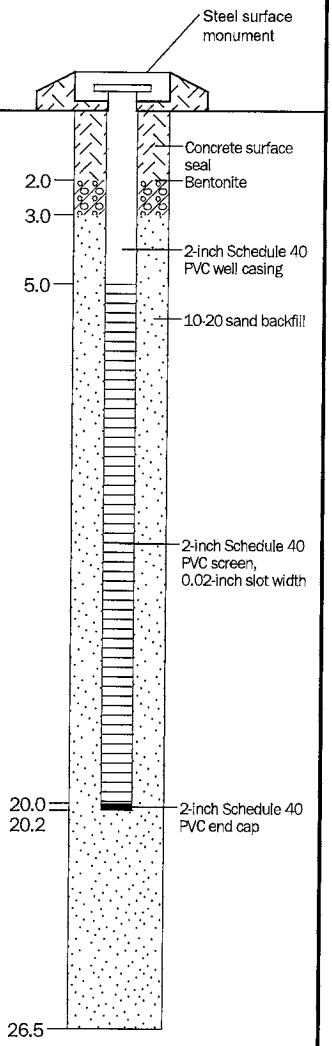
Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
4/13/2017	7.4	129.6

Notes: Environmental field screening was completed on each soil sample. Sheen and head space vapor were not observed unless otherwise noted.

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample / Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0						TS	Topsoil with roots (upper 6 inches)		
135		16	13	1 MC			SM	Reddish brown silty fine to medium sand with occasional organic matter (medium dense, moist)	7	
	5	4	62*	2			SP-SM	Light brown fine to medium sand with silt and occasional gravel and cobbles (medium dense to dense, moist) (recessional outwash)		
130		8	36*	3 SA	▼		SP-SM	Light brown fine to coarse sand with silt, gravel and occaional cobbles (medium dense, wet)	7	9
	10	10	23	4			SP	Light gray fine to coarse sand with gravel (medium dense, wet)		
125		9	23	5 %F					15	4
	15	18	21	6				Becomes gray		
120							SP-SM	Gray fine to medium sand with silt and occasional gravel (medium dense, wet)		
	20	18	19	7 %F			SP	Gray fine to medium sand (medium dense, wet)	20	4
115										
	25	18	18	8						

* Sampler bouncing on rock, blow count not representative.

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Hand-held GPS (±18 ft), Vertical approximated based on Survey Basemap (±1 ft)

Log of Boring B-8

GeoEngineers

Project: Arlington Local Office Replacement
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-3
Sheet 1 of 1

Bellingham: Date:4/24/17 Path:P:\0\0482051\GINT\0482051103.GPJ DBTemplate/LibTemplate/GEOENGINEERS_DF_STD_US_APRIL_2017.GDT/GEI8_GEOTECH_WELL_%F

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	3/8/2017	3/8/2017	26.5	NS	KMS	Holocene Drilling, Inc.	Hollow-stem Auger

Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D50 Track-mounted
Surface Elevation (ft) Vertical Datum	136 NAVD88	Top of Casing Elevation (ft)	137
Easting (X) Northing (Y)	1321085 424465	Horizontal Datum	WA State Plane North NAD83 (feet)

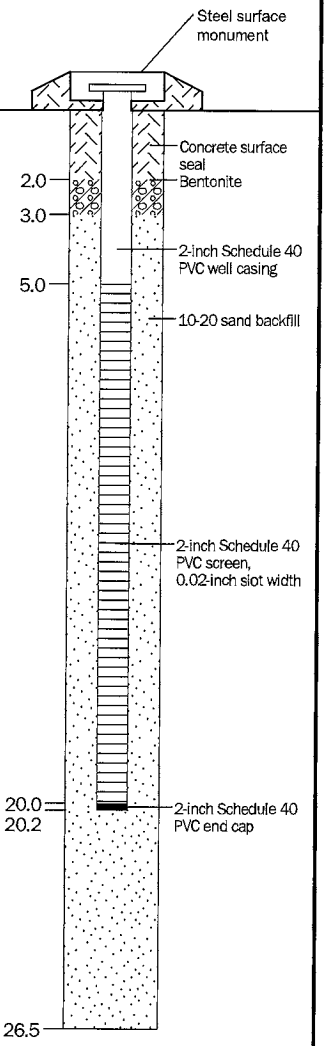
DOE Well I.D.: BJY258
A 2 (in) well was installed on 3/8/2017 to a depth of 20 (ft).

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
4/13/2017	2.7	133.3

Notes: Environmental field screening was completed on each soil sample. Sheen and head space vapor were not observed unless otherwise noted.

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
135	0							TS	Topsoil with roots (upper 6 inches)		
		10	8		1 %F	▼		SP-SM	Brown fine to coarse sand with silt and occasional gravel (loose, wet) (recessional outwash)	14	5
130	5	12	12		2 SA			SP	Brown fine to coarse sand with gravel (medium dense, wet)	20	2
		14	20		3						
125	10	12	26		4 %F			SP-SM	Brown fine to medium sand with silt and occasional gravel (medium dense, wet)	15	6
		8	29		5						
120	15	18	28		6						
115	20	18	40		7 %F				Becomes dense	14	7
110	25	18	24		8			SP-SM	Brown fine sand with silt (medium dense, wet)		

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Hand-held GPS (±18 ft), Vertical approximated based on Survey Basemap (±1 ft)

Log of Boring B-9

GeoEngineers

Project: Arlington Local Office Replacement
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-4
Sheet 1 of 1

Bellingham: Date:4/24/17 Path:P:\0\0482051\GINT\0482051031.GPJ DBTemplate/LibTemplate\GEOENGINEERS_DF_STD_US_APRIL_2017.GDT/GEI8_GEOTECH_WELL_%F

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	3/8/2017	3/8/2017	26.5	NS	KMS	Holocene Drilling, Inc.	Hollow-stem Auger

Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D50 Track-mounted
Surface Elevation (ft)	133	Top of Casing Elevation (ft)	133
Vertical Datum	NAVD88		
Easting (X)	1319707	Horizontal Datum	WA State Plane North
Northing (Y)	424320		NAD83 (feet)

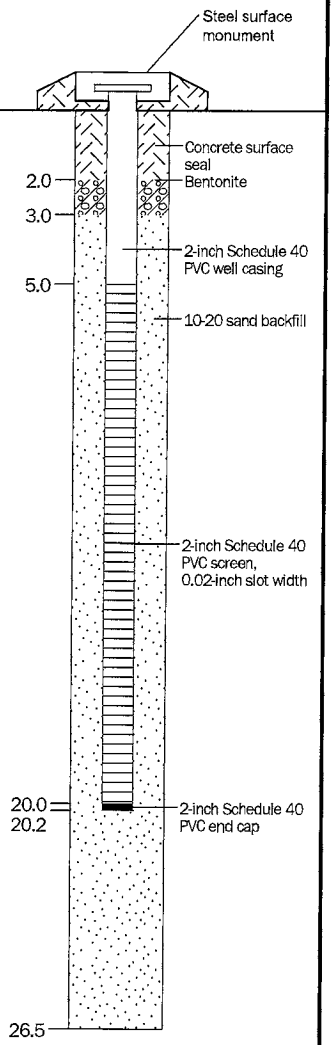
DOE Well I.D.: BJY260
A 2 (in) well was installed on 3/8/2017 to a depth of 20 (ft).

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
4/13/2017	8.3	124.7

Notes: Environmental field screening was completed on each soil sample. Sheen and head space vapor were not observed unless otherwise noted

Elevation (feet)	Depth (feet)	Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0							TS	Topsoil with roots		
								SM	Dark brown silty fine sand with organic matter, roots (topsoil)		
130		18	16	1	(B-10-2.5) %F; CA			SP-SM	Light brown fine to medium sand with silt (medium dense, moist) (recessional outwash) (Slight sheen)	8	5
	5	12	36	2	(B-10-5.0) SA; CA			SP-SM	(Moderate sheen; PID 2.8 ppm) Brown fine to medium sand with silt and occasional gravel (dense, moist)	6	7
125		14	45	3	(B-10-7.5) MC; CA	▼		SP	Gravel in shoe (Slight sheen, PID <1 ppm) Gray fine to coarse sand with gravel (dense, moist)	4	
	10	17	41	4	%F				Becomes wet	11	3
120		18	34	5							
	15	17	55	6					Becomes very dense		
115											
	20	6	25	7				SP-SM	Brown fine to medium sand with silt (medium dense, wet)		
110											
	25		36	8	%F				Becomes dense	19	11

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Hand-held GPS (±18 ft), Vertical approximated based on Survey Basemap (±1 ft)

Log of Boring B-10

GeoEngineers

Project: Arlington Local Office Replacement
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-5
Sheet 1 of 1

Bellingham: Date:4/24/17 Path:P:\0\0482051\GINT\0482051103.GPJ DBTemplate/LibTemplate:GEOENGINEERS_DF_STD_US_APRIL_2017.GDT/GEI8_GEOTECH_WELL_%F

Drilled	Start	End	Total Depth (ft)	Logged By	Checked By	Driller	Drilling Method
	3/8/2017	3/8/2017	26.5	NS	KMS	Holocene Drilling, Inc.	Hollow-stem Auger

Hammer Data	Autohammer 140 (lbs) / 30 (in) Drop	Drilling Equipment	Diedrich D50 Track-mounted
Surface Elevation (ft) Vertical Datum	134 NAVD88	Top of Casing Elevation (ft)	134
Easting (X) Northing (Y)	1320129 424309	Horizontal Datum	WA State Plane North NAD83 (feet)

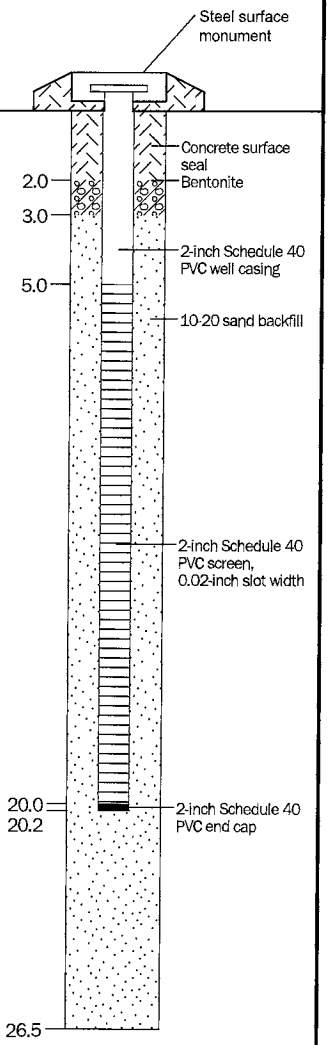
DOE Well I.D.: BJY259
A 2 (in) well was installed on 3/8/2017 to a depth of 20 (ft).

Groundwater Date Measured	Depth to Water (ft)	Elevation (ft)
4/13/2017	7.4	126.6

Notes: Environmental field screening was completed on each soil sample. Sheen and head space vapor were not observed unless otherwise noted.

Elevation (feet)	Depth (feet)	FIELD DATA: Interval Recovered (in)	Blows/foot	Collected Sample	Sample Name Testing	Water Level	Graphic Log	Group Classification	MATERIAL DESCRIPTION	Moisture Content (%)	Fines Content (%)
	0							TS	Topsoil with roots (upper 6 inches)		
130		18	13		1 %F			SM	Dark brown silty fine to medium sand with occasional organic matter, roots (loose, moist)	25	13
	5							SP	Light brown fine to medium sand (medium dense, moist) (recessional outwash)		
		16	12		2 (B-11-5.0) SA; CA			SP-SM	With occasional gravel (Slight sheen; PID 2.8 ppm)	7	4
125		17	33		3 (B-11-7.5) MC; CA	▼			Brown fine to medium sand with silt (loose, moist)	5	
	10							SP-SM	With occasoinal gravel (Moderate sheen; PID 7.6 ppm)		
		18	30		4 (B-11-10.0) %F; CA			SP	Gray fine to coarse sand with silt and occasional gravel (dense, moist)	7	4
120		12	46		5				Gray fine to coarse sand with gravel (dense, wet)		
	15	18	34		6						
115											
	20	11	24		7 %F					27	47
110								SM	Brown silty fine sand with thin silt lenses, horizontal bedding (medium dense, wet)		
	25	18	24		8			SP-SM	Gray fine to medium sand with silt (medium dense, wet)		
	26.5										

WELL LOG



Note: See Figure A-1 for explanation of symbols.
Coordinates Data Source: Horizontal approximated based on Hand-held GPS (±18 ft), Vertical approximated based on Survey Basemap (±1 ft)

Log of Boring B-11

GeoEngineers

Project: Arlington Local Office Replacement
Project Location: Arlington, Washington
Project Number: 0482-051-03

Figure A-6
Sheet 1 of 1

Bellingham: Date:4/24/17 Path:P:\0\0482051\GINT\0482051103.GPJ DBTemplate/LibTemplate\GEOENGINEERS_DF_STD_US_APRIL_2017.GDT/GEI8_GEOTECH_WELL_%F

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.

Cation Exchange Capacity

Selected samples were tested for Cation Exchange Capacity (CEC) by a subcontract analytical testing laboratory (AmTest Laboratories of Kirkland, Washington). The tests were completed in general accordance with the EPA Laboratory Method 9081 testing procedure. The test results are presented in this appendix and discussed in the report text.

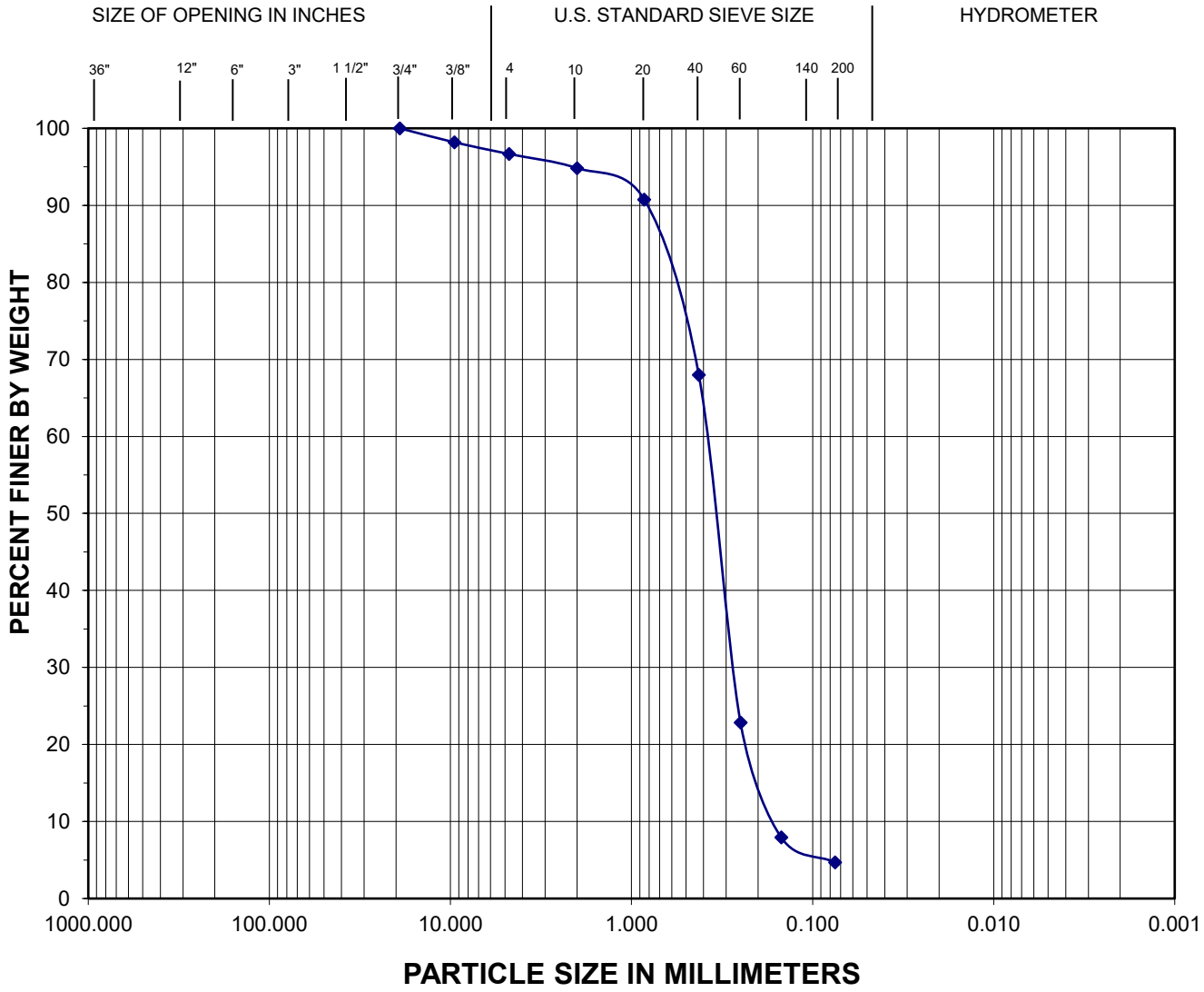
Organic Content

The organic content of selected samples was determined in general accordance with ASTM D 2974. The results of the tests are discussed in the report text.

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

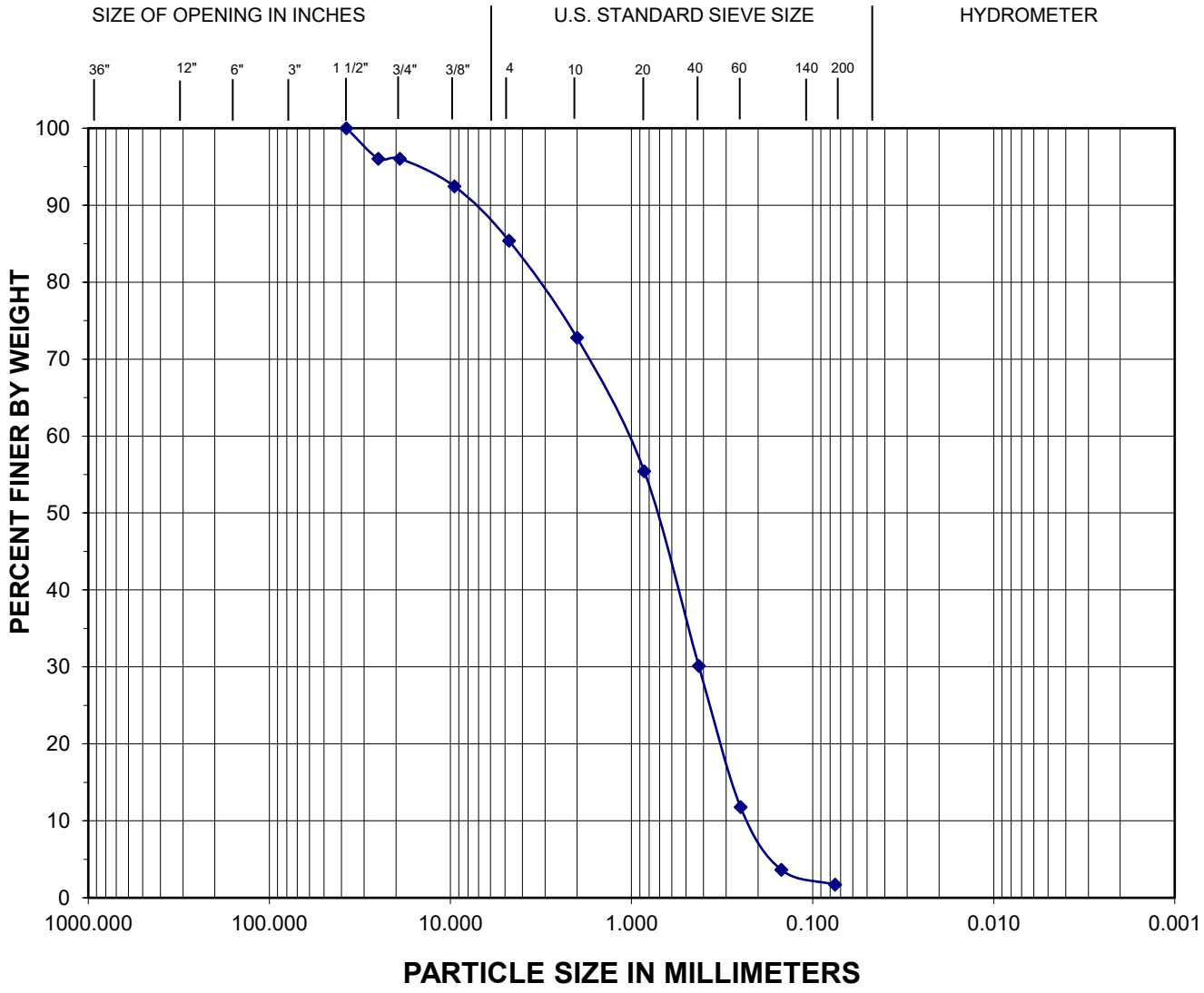
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-1	S-3	3.5	7.7	4.7	SAND, trace silt and gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

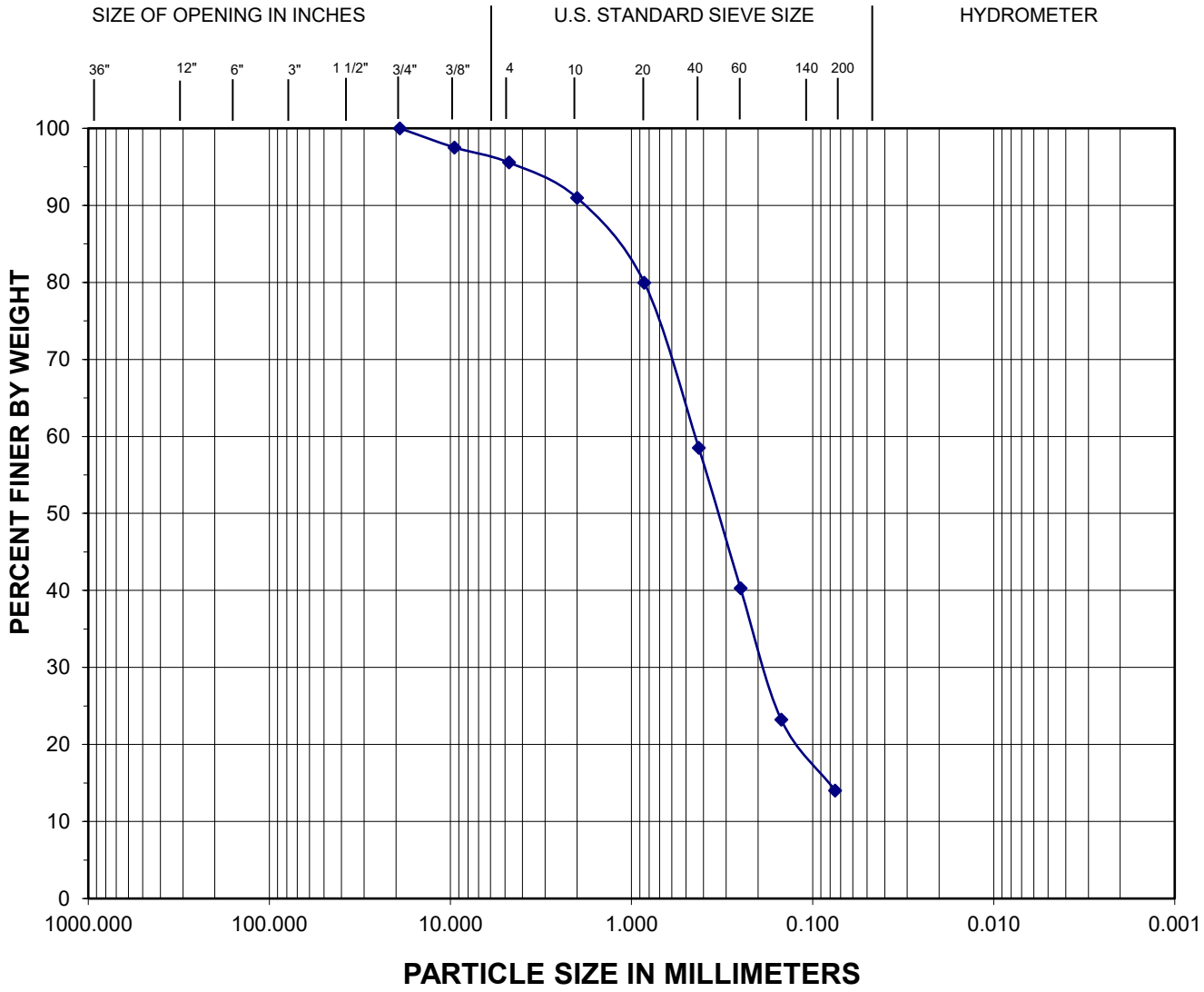
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-2	S-3	3	5.4	1.7	SAND, with gravel, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

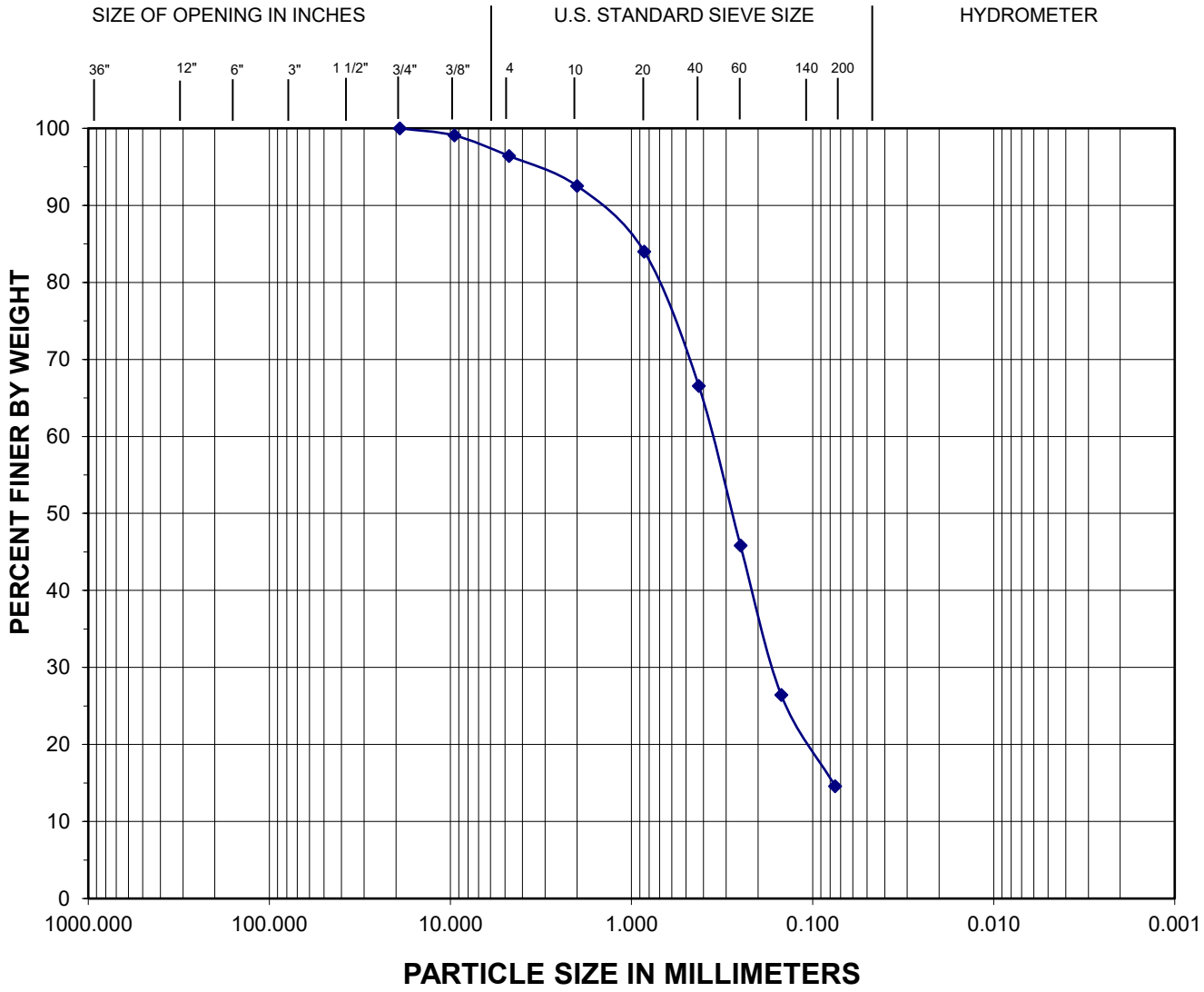
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-4	S-2	1.5	16.2	14.0	SAND with silt, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 5/22/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

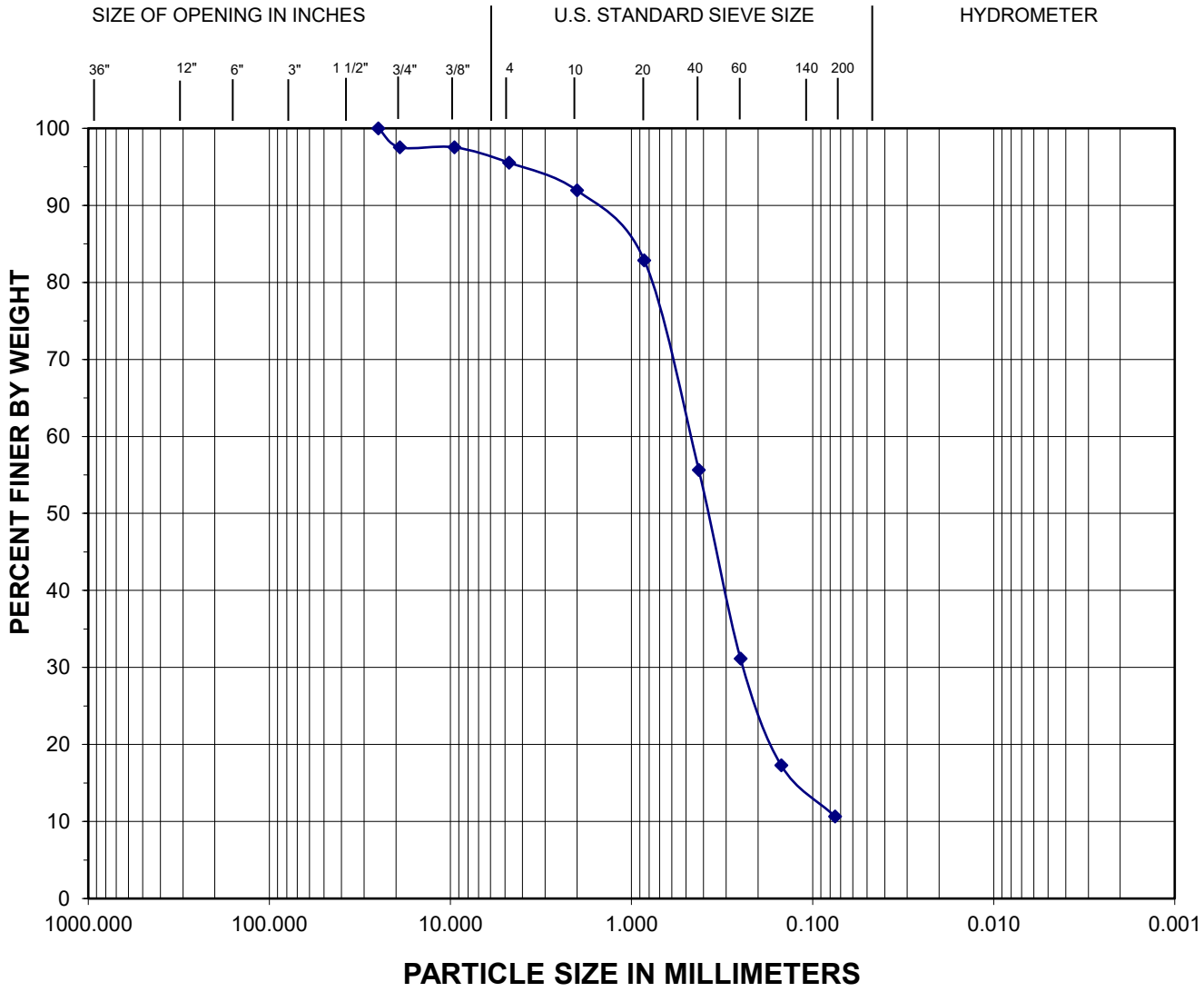
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-5	S-2	2.5	16.7	14.6	SAND with silt, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 5/22/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

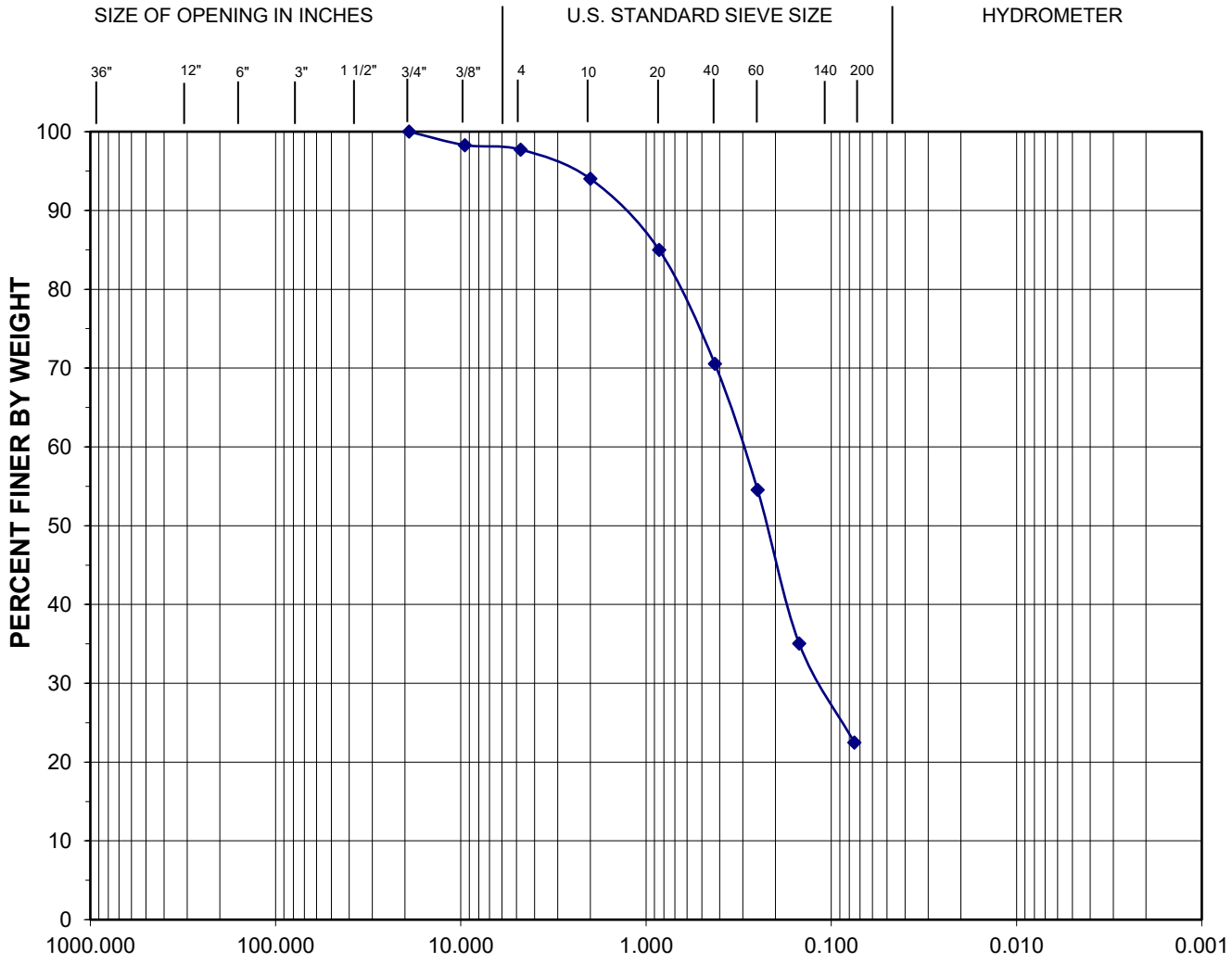
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-6	S-2	2.5	14.9	10.6	SAND, some silt, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

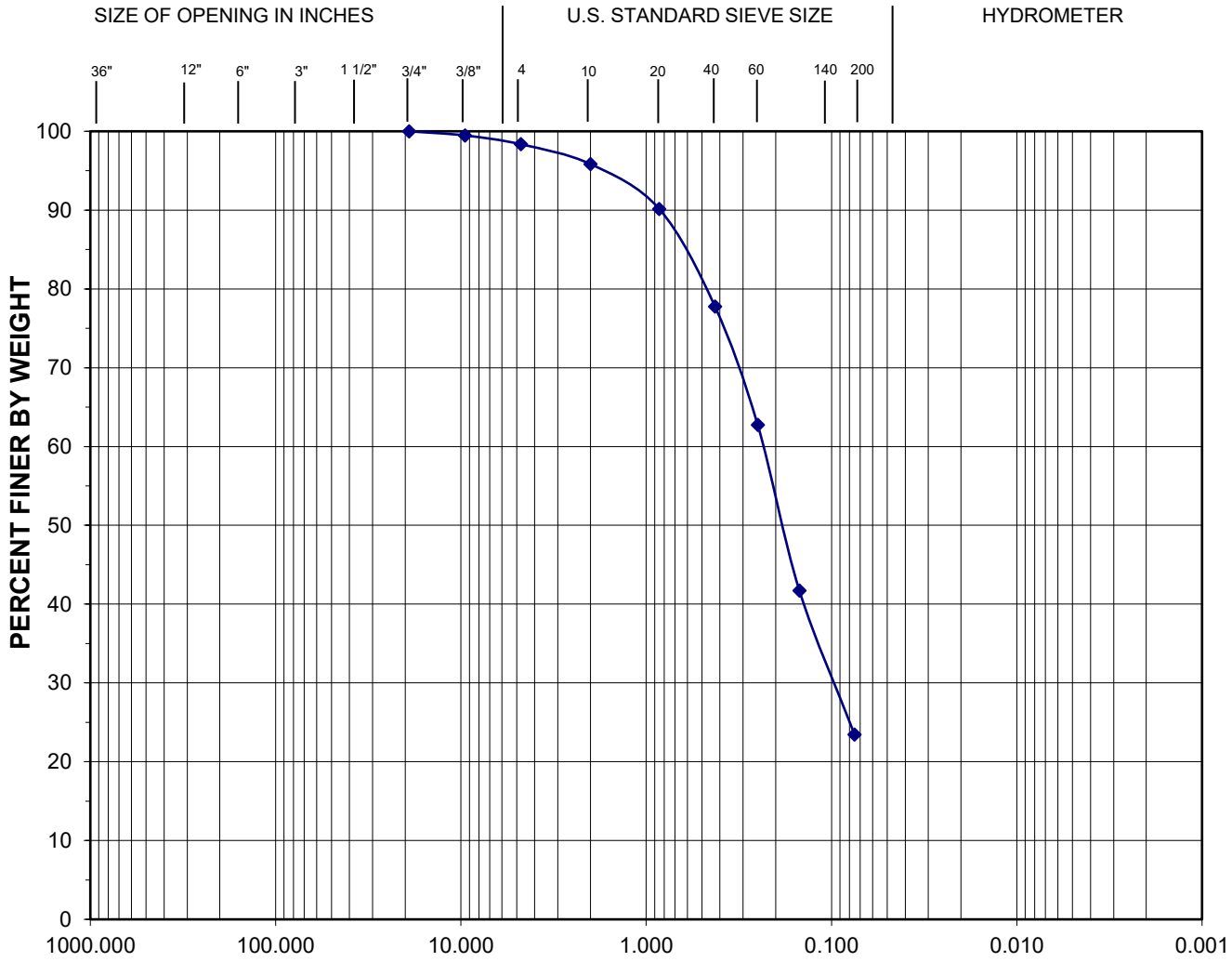
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-7	S-2	3	23.6	22.5	SAND, with silt, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

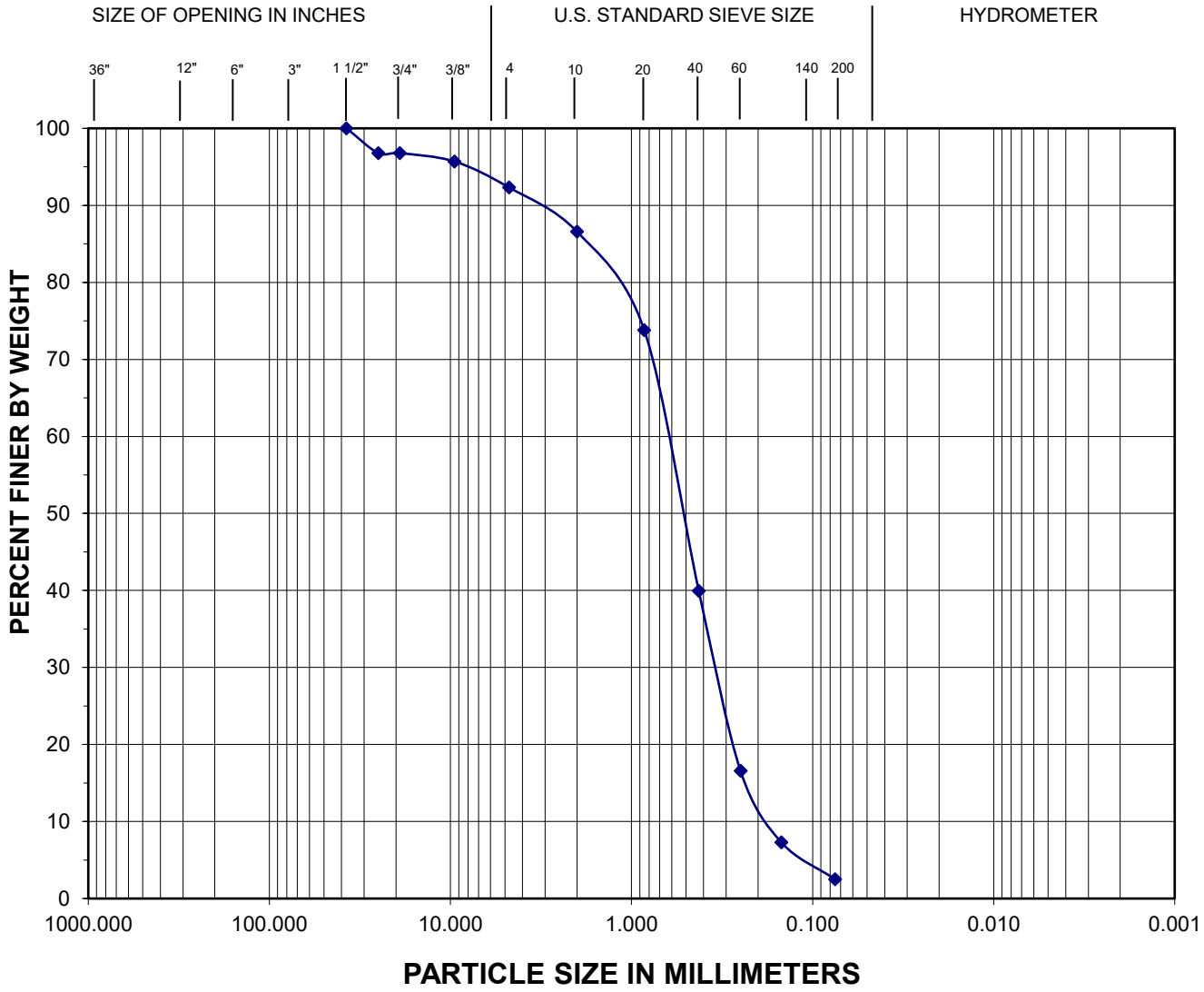
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-8	S-2	2	20.1	23.4	SAND, with silt, trace gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

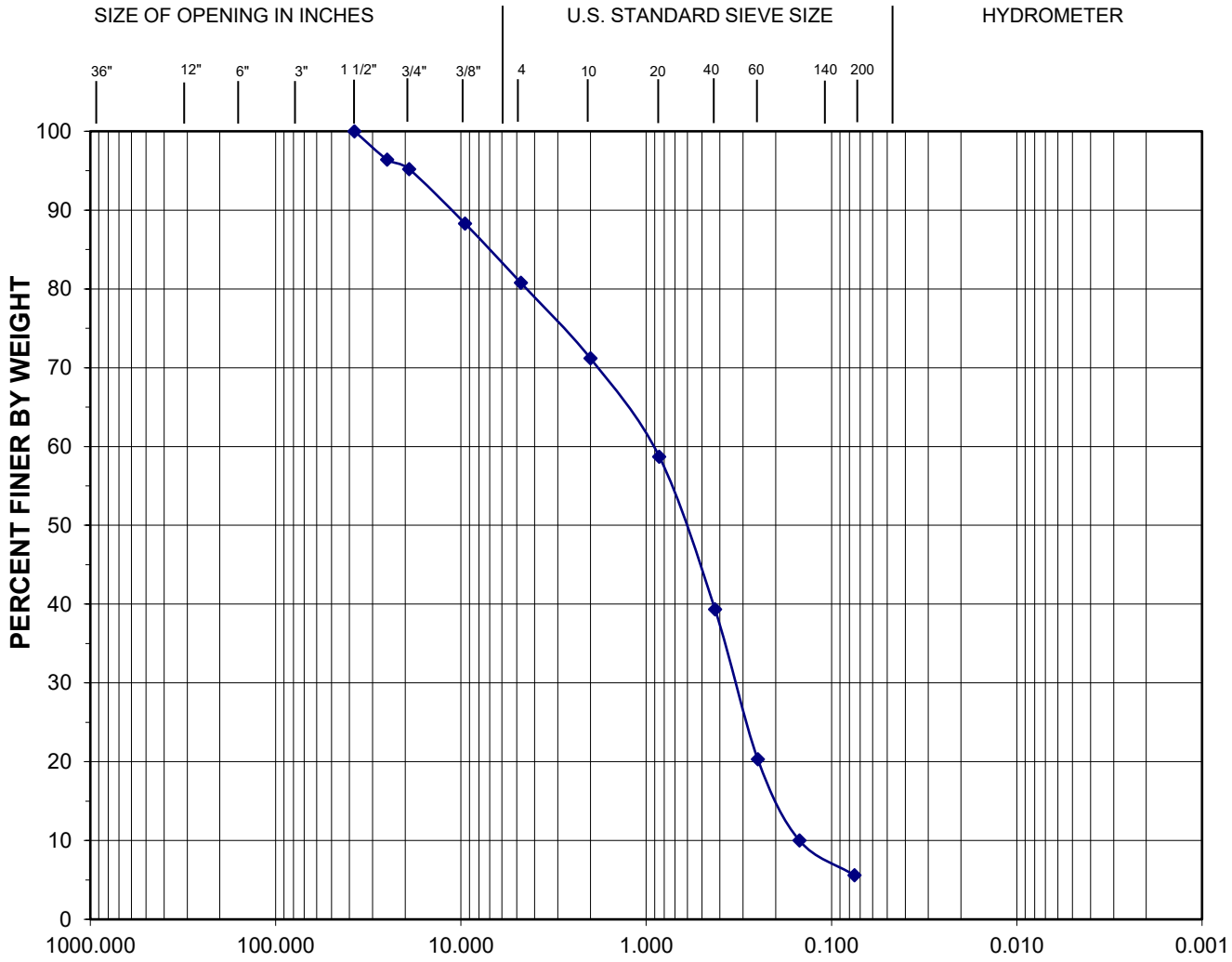
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-8	S-3	3	6.8	2.5	SAND, some gravel, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

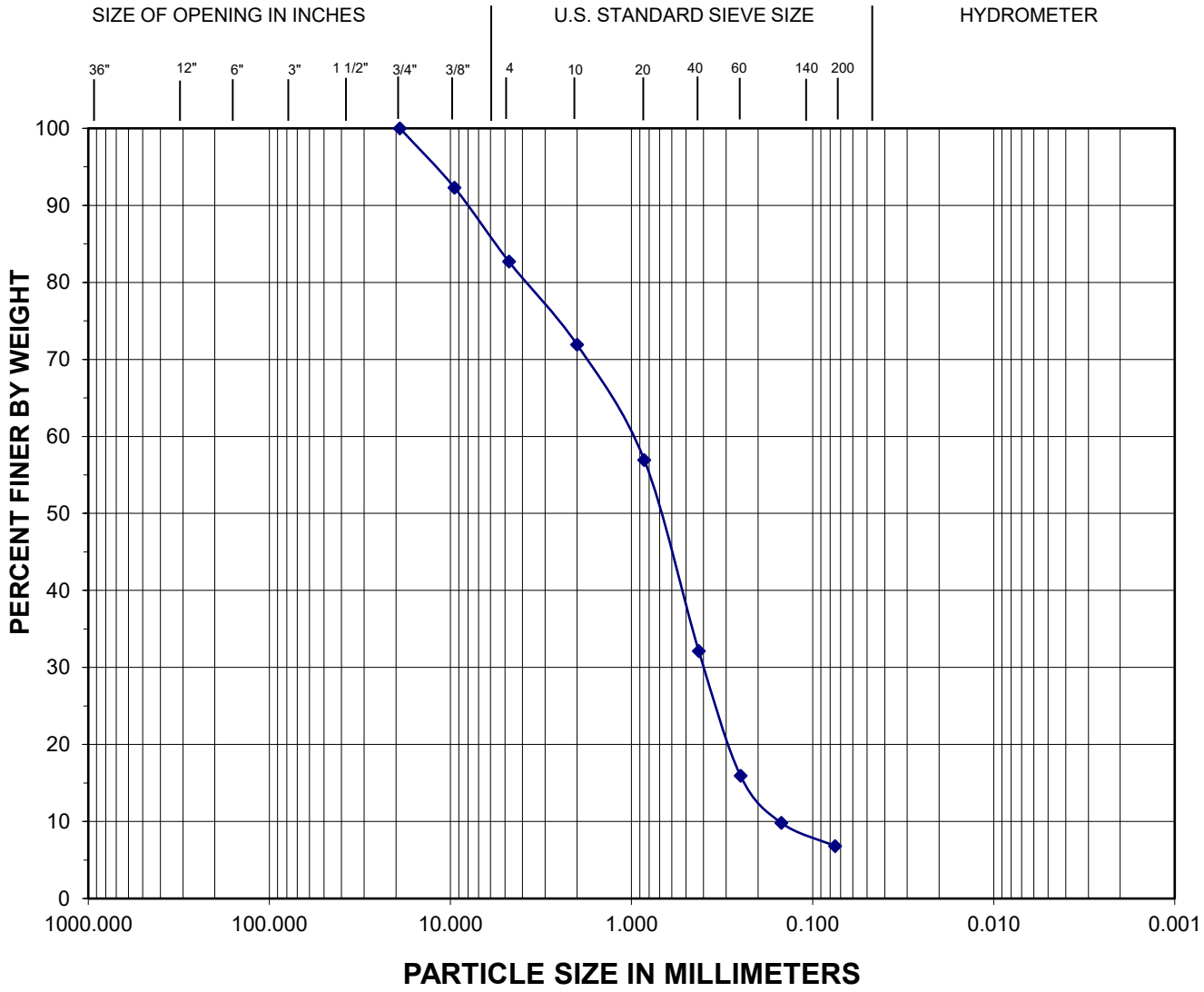
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-9	S-2	3	8.2	5.6	SAND with gravel,some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01 DATE OF TESTING: 5/22/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

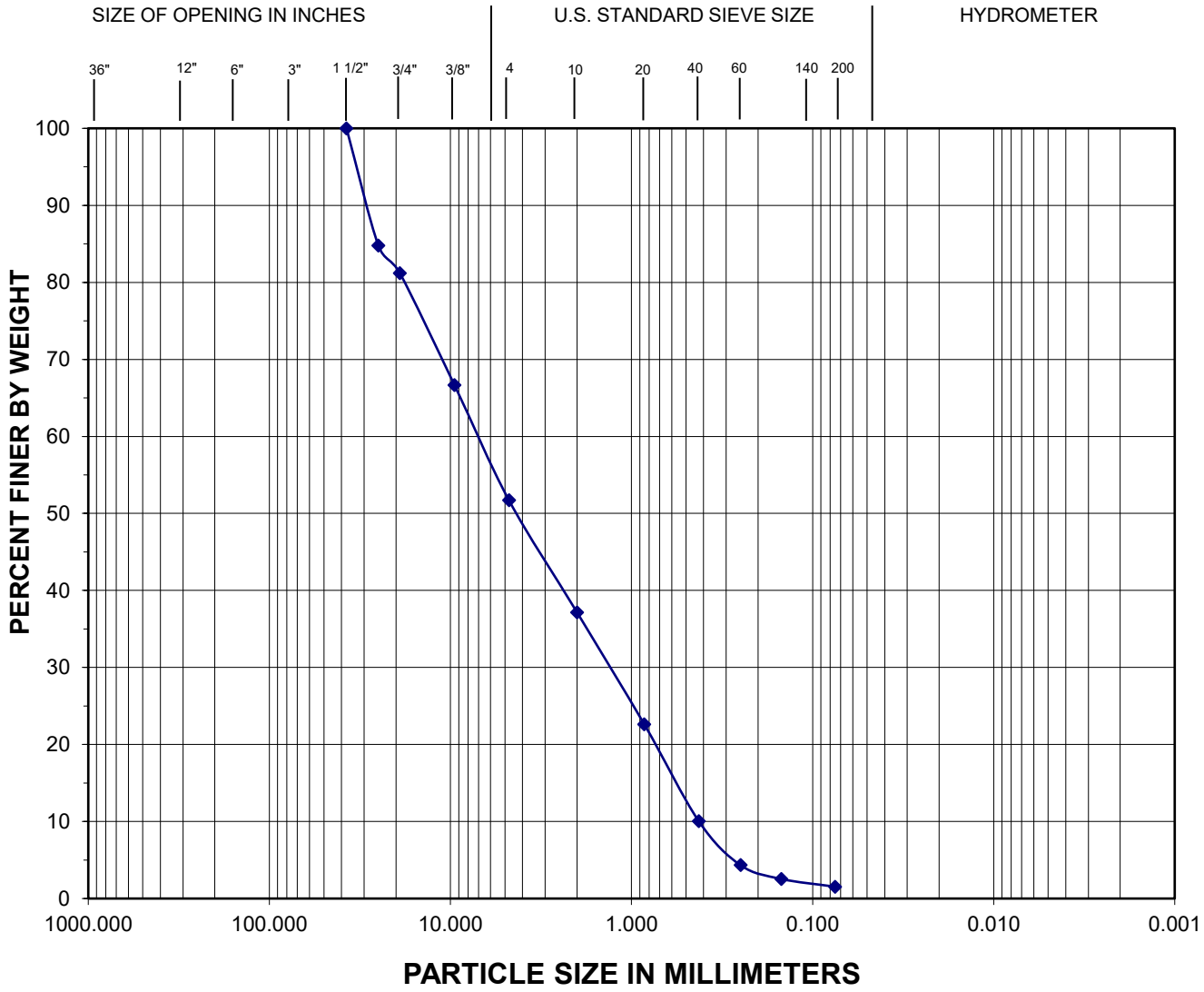
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-10	S-2	2.5	9.3	6.8	SAND, with gravel, some silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

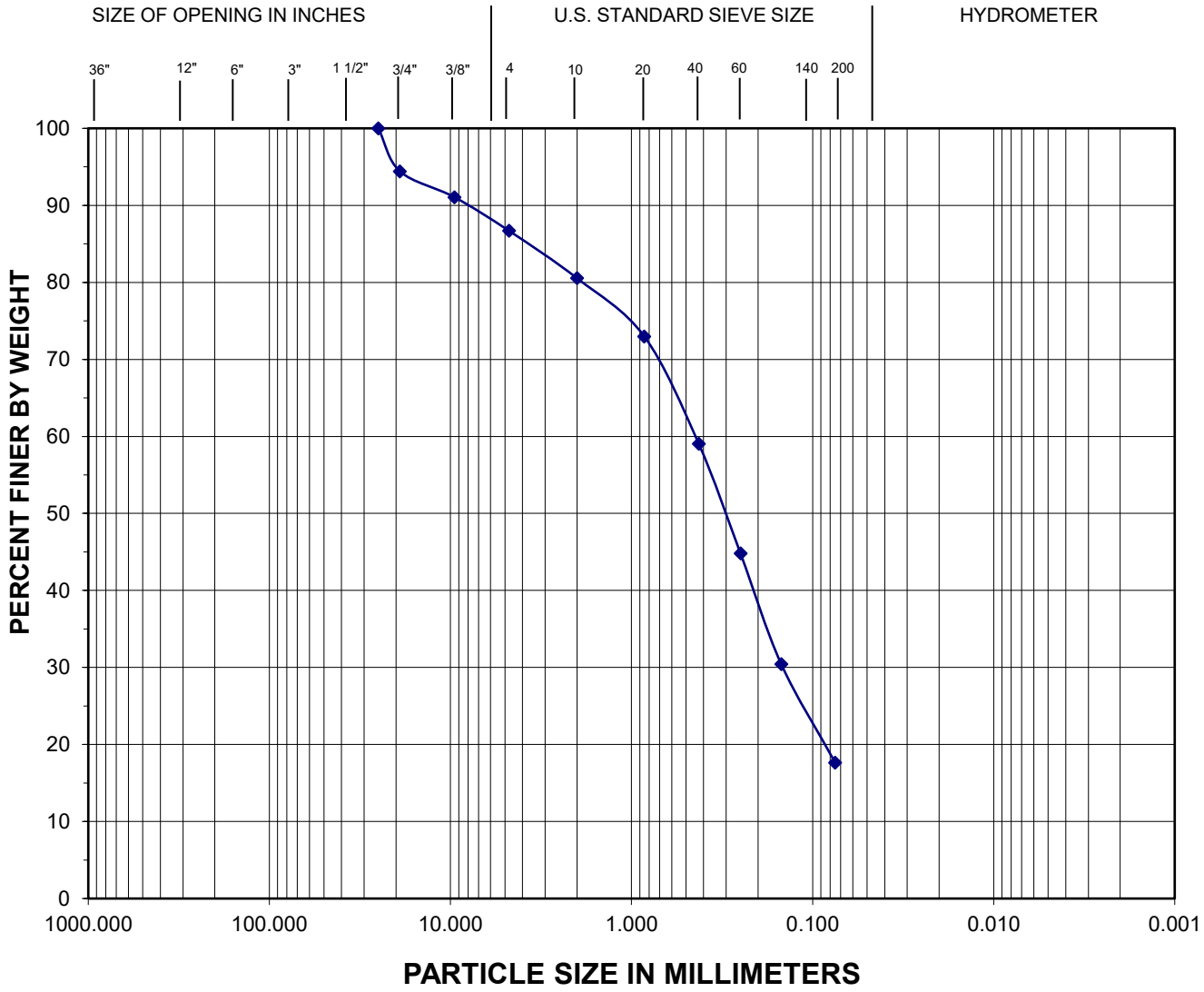
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-10	S-3	5	8.2	1.5	Gravelly SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

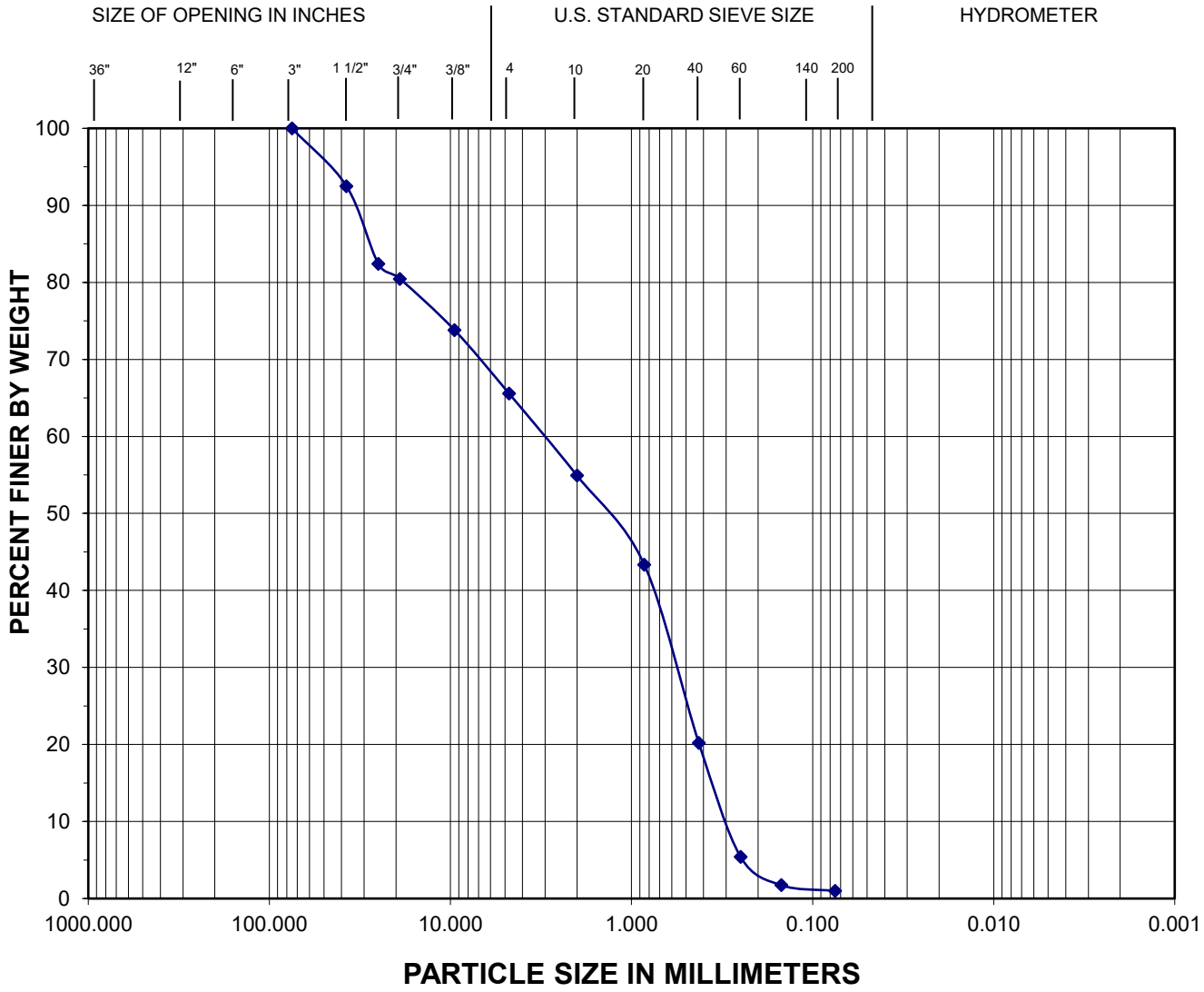
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-11	S-1	0.5	17.6	17.6	SAND, with silt and gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

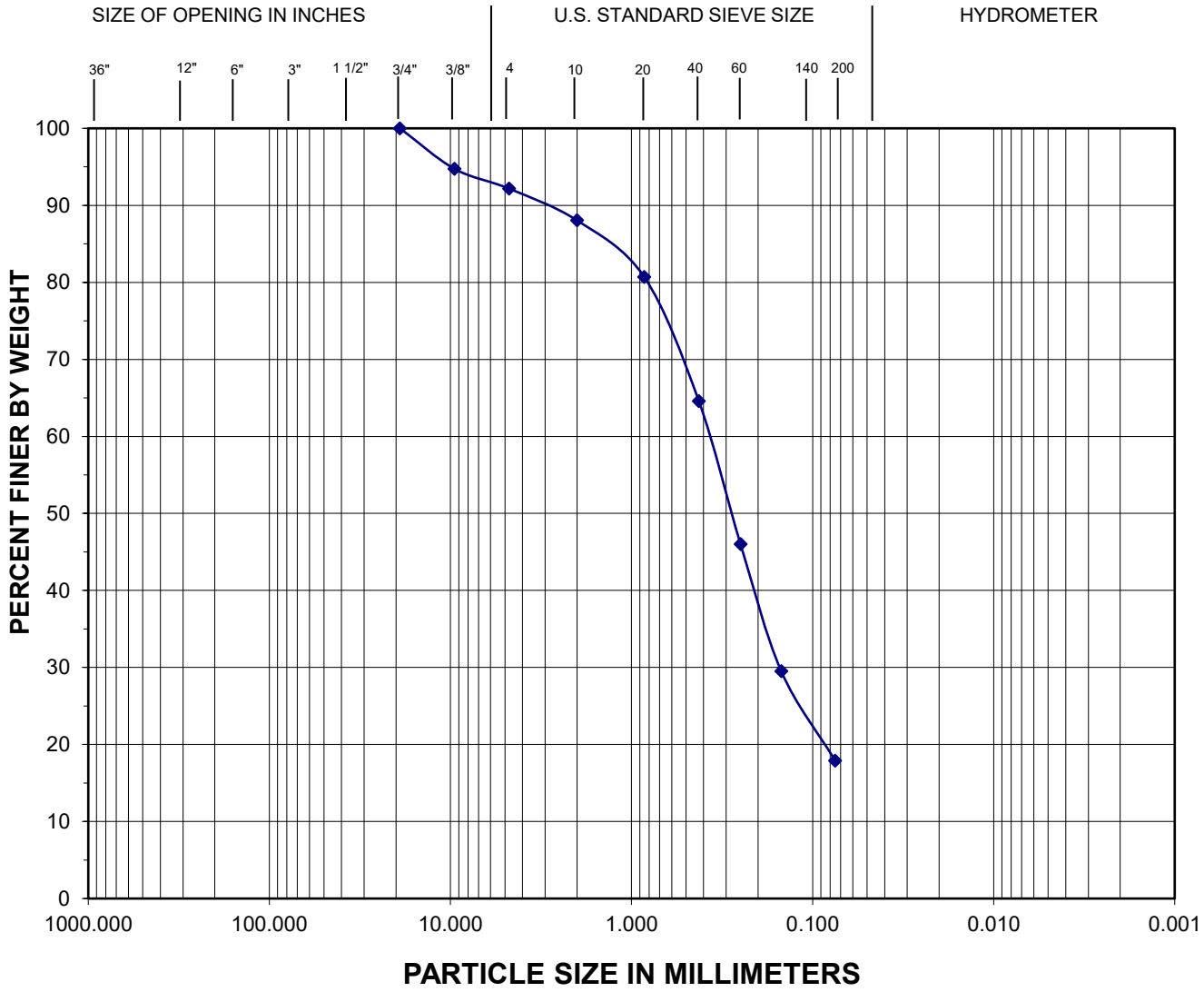
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
TP-11	S-3	8	10.3	1.0	Gravelly SAND, trace silt

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

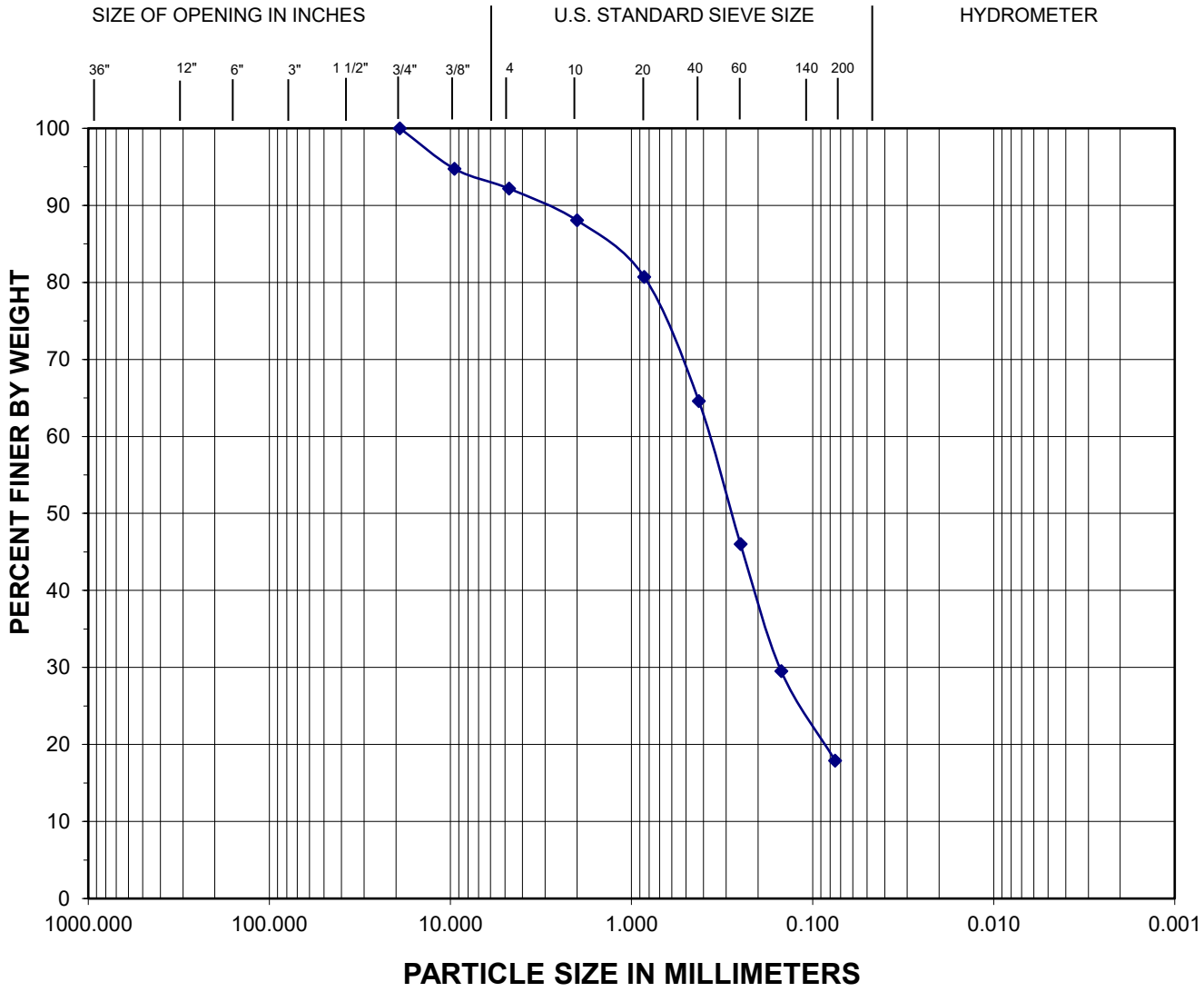
Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
HA-1	S-2	1.5	30.0	17.9	SAND with silt, some gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

GRAIN SIZE ANALYSIS

Test Results Summary

ASTM D6913



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

Comments:

Exploration	Sample	Depth (feet)	Moisture (%)	Fines (%)	Description
HA-1	S-2	1.5	30.0	17.9	SAND with silt, some gravel

Zipper Geo Associates, LLC Geotechnical and Environmental Consultants	PROJECT NO: 2679.01A DATE OF TESTING: 5/5/2023	PROJECT NAME: Special Use Permit

Krazan & ASSOCIATES, INC.

GEOTECHNICAL ENGINEERING • ENVIRONMENTAL ENGINEERING
CONSTRUCTION TESTING & INSPECTION

May 10, 2023

KA No. 096-23255
Lab Report No. 01

Mr. David Williams(E-Mail)
ZIPPER GEO ASSOCIATES LLC
19019 36th Avenue W, Suite E
Lynnwood, WA 98036

RE: SOILS LABORATORY TESTING
Crosswind
4303 198th Street SW
Lynnwood, Washington

Dear Mr. Williams,

In accordance with your request and authorization, we have performed laboratory tests for the above referenced project.

Laboratory testing was performed in accordance with ASTM standards. The results of the laboratory tests are presented on the following pages. If you have any questions; or if we can be of further assistance, please do not hesitate to contact our office.

Sample ID No:	82504-A	82504-B	82504-C	82504-D	82504-E
Test Date:	**5/8/2023**				
Sample Location:	**Substation: 2679.01**				
	TP-A-1 / S-2	**TP-8 / S-2**	**TP-10 / S-2**	**TP-7 / S-2**	**TP-11 / S-1**
Organic Content:	**5.6%**	**3.4%**	**1.6%**	**6.7%**	**4.7%**
Moisture, Ash, and Organic Matter of Peat and Other Organic Soils (ASTM D2974)					

Respectfully submitted,
KRAZAN & ASSOCIATES, INC.

Jeffrey S. Mercer
Operations Manager
Pacific Northwest Division

JSM/lkj

AMTEST LABORATORIES

AmTest Chain of Custody Record

13600 NE 126th PL, Suite C, Kirkland, WA 98034
Ph (425) 885-1664 Fx (425) 820-0245
www.amtestlab.com

Chain of Custody No. 5000

Client Name & Address:	Invoice To:
Zipper Geo Associates 19019 36th Avenue W, Suite E Lynnwood, WA 98036	Zipper Geo Associates 19019 36th Avenue W, Suite E Lynnwood WA 98036
Contact Person: David Williams	Invoice Contact: David Williams
Phone No: 425-218-4619	PO Number: 425-218-4619
Fax No:	Invoice Ph/Fax:
E-mail: dwilliams@zippergeo.com	Invoice E-mail: dwilliams@zippergeo.com
Report Delivery: (Choose all that apply) Mail / Fax / (Email) / Posted Online	Data posted to online account: YES / NO Web Login ID:

Special Instructions:

Requested TAT: **(Rush must be pre-approved by lab)**
Standard RUSH (5 Day / 3 Day / 48 HR / 24 HR)

Temperature upon Receipt: 31.2°C

Project Name: Crosswind Substation
Project Number: 2679.01

AmTest ID	Client ID (35 characters max)	Date Sampled	Time Sampled	Matrix	No. of containers	Analysis Requested: CEC									QA/QC
7661	TP-7, S-2	4/24/23			1	X									
7662	TP-8, S-2	4/24/23			1	X									
7663	TP-10, S-2	4/24/23			1	X									
7664	TP-11, S-1	4/24/23			1	X									
7665	HA-1, S-2	4/25/23			1	X									

Collected/Relinquished By:	Date	Time	Received By:	Date	Time
[signature]	4.28.23	4:30 PM	KH	4/26/23	1630
Relinquished By:	Date	Time	Received By:	Date	Time
Relinquished By:	Date	Time	Received By:	Date	Time

COMMENTS:

Am Test Inc.
13600 NE 126TH PL
Suite C
Kirkland, WA 98034
(425) 885-1664
www.amtestlab.com

Professional Analytical Services

ANALYSIS REPORT

ZIPPER GEO ASSOCIATES, LLC
19019 36TH AVENUE W
LYNNWOOD, WA 98036
Attention: DAVID WILLIAMS
Project Name: CROSSWIND SUBSTATION
Project #: 2679.01
All results reported on an as received basis.

Date Received: 04/28/23
Date Reported: 5/ 9/23

AMTEST Identification Number **23-A007661**
Client Identification **TP-7,S-2**
Sampling Date **04/24/23**

Conventionals

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Cation Exchange Capacity	12.	meq/100g		0.5	SW-846 9081	CM	05/03/23

AMTEST Identification Number **23-A007662**
Client Identification **TP-8,S-2**
Sampling Date **04/24/23**

Conventionals

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Cation Exchange Capacity	5.2	meq/100g		0.5	SW-846 9081	CM	05/03/23

ZIPPER GEO ASSOCIATES, LLC
Project Name: CROSSWIND SUBSTATION
AmTest ID: 23-A007663

AMTEST Identification Number **23-A007663**
Client Identification **TP-10,S-2**
Sampling Date **04/24/23**

Conventionals

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Cation Exchange Capacity	3.3	meq/100g		0.5	SW-846 9081	CM	05/03/23

AMTEST Identification Number **23-A007664**
Client Identification **TP-11,S-1**
Sampling Date **04/24/23**

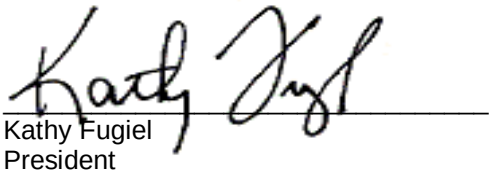
Conventionals

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Cation Exchange Capacity	6.2	meq/100g		0.5	SW-846 9081	CM	05/03/23

AMTEST Identification Number **23-A007665**
Client Identification **HA-1,S-2**
Sampling Date **04/24/23**

Conventionals

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Cation Exchange Capacity	6.7	meq/100g		0.5	SW-846 9081	CM	05/03/23



Kathy Fugiel
President

Am Test Inc.
13600 NE 126th PL
Suite C
Kirkland, WA, 98034
(425) 885-1664
www.amtestlab.com

Professional Analytical Services

QC Summary for sample numbers: 23-A007661 to 23-A007665

DUPLICATES

SAMPLE #	ANALYTE	UNITS	SAMPLE VALUE	DUP VALUE	RPD
23-A007665	Cation Exchange Capacity	meq/100g	6.7	7.0	4.4

STANDARD REFERENCE MATERIALS

ANALYTE	UNITS	TRUE VALUE	MEASURED VALUE	RECOVERY
Cation Exchange Capacity	meq/100g	2.0	2.0	100. %

BLANKS

ANALYTE	UNITS	RESULT
Cation Exchange Capacity	meq/100g	< 0.2

April 28, 2023

Justin Brooks
Zipper Geo Associates, LLC
19019 36th Avenue West, Suite E
Lynnwood, WA 98036

RE: Bulk Asbestos Fiber Analysis; NVL Batch # 2306722.00

Client Project: 2679 Crosswind SubStation
Location: Arlington

Dear Mr. Brooks,

Enclosed please find test results for the 12 sample(s) submitted to our laboratory for analysis on 4/26/2023.

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,

Nick Ly, Technical Director

NVLAP Testing
Lab Code: 102063-0

Enc.: Sample Results

Bulk Asbestos Fibers Analysis

By Polarized Light Microscopy

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

Attention: Mr. Justin Brooks
Project Location: Arlington

Batch #: 2306722.00
Client Project #: 2679 Crosswind SubStation
Date Received: 4/26/2023
Samples Received: 12
Samples Analyzed: 12
Method: EPA/600/R-93/116

Lab ID: 23041630 **Client Sample #: TP.1**
Location: Arlington
Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1	Description: Loose brown crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Fine particles, Fine grains	Cellulose	**None Detected ND**
	Mineral grains, Organic debris		

Lab ID: 23041631 **Client Sample #: TP.2**
Location: Arlington
Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1	Description: Loose tan crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Fine grains, Fine particles	Cellulose	**None Detected ND**
	Mineral grains, Organic debris		

Lab ID: 23041632 **Client Sample #: TP.3**
Location: Arlington
Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1	Description: Loose brown crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Mineral grains, Fine particles	Cellulose	**None Detected ND**
	Fine grains, Organic debris	Wood fibers	

Lab ID: 23041633 **Client Sample #: TP.4**
Location: Arlington
Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Sampled by: Client
Analyzed by: Hilary Crumley **Date:** 04/28/2023
Reviewed by: Nick Ly **Date:** 04/28/2023

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 EPA 40 CFR Appendix E to Subpart E of Part 763 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

Attention: Mr. Justin Brooks
Project Location: Arlington

Batch #: 2306722.00
Client Project #: 2679 Crosswind SubStation
Date Received: 4/26/2023
Samples Received: 12
Samples Analyzed: 12
Method: EPA/600/R-93/116

Layer 1 of 1	**Description:** Loose brown crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Fine particles, Mineral grains	Wood fibers	**None Detected ND**
	Fine grains, Organic debris	Cellulose	

Lab ID: 23041634 **Client Sample #: TP.5**

Location: Arlington

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

Layer 1 of 1	**Description:** Loose dark brown crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Fine grains, Mineral grains	Cellulose	**None Detected ND**
	Fine particles, Organic debris		

Lab ID: 23041635 **Client Sample #: TP.6**

Location: Arlington

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

Layer 1 of 1	**Description:** Loose brown crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Mineral grains, Fine grains	Cellulose	**None Detected ND**
	Fine particles, Organic debris		

Lab ID: 23041636 **Client Sample #: TP.7**

Location: Arlington

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

Layer 1 of 1	**Description:** Loose dark brown crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Fine particles, Fine grains	Cellulose	**None Detected ND**
	Mineral grains, Organic debris	Wood fibers	

Sampled by: Client
Analyzed by: Hilary Crumley **Date:** 04/28/2023
Reviewed by: Nick Ly **Date:** 04/28/2023

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 EPA 40 CFR Appendix E to Subpart E of Part 763 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

Attention: Mr. Justin Brooks
Project Location: Arlington

Batch #: 2306722.00
Client Project #: 2679 Crosswind SubStation
Date Received: 4/26/2023
Samples Received: 12
Samples Analyzed: 12
Method: EPA/600/R-93/116

Lab ID: 23041637 **Client Sample #: TP.8**
Location: Arlington
Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1	Description: Loose brown crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Fine grains, Fine particles	Cellulose	**None Detected ND**
	Mineral grains, Organic debris		

Lab ID: 23041638 **Client Sample #: TP.9**
Location: Arlington
Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1	Description: Loose tan crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Fine grains, Mineral grains	Cellulose	**None Detected ND**
	Fine particles, Debris		

Lab ID: 23041639 **Client Sample #: TP.10**
Location: Arlington
Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Layer 1 of 1	Description: Loose brown crumbly material with debris		
	Non-Fibrous Materials:	Other Fibrous Materials:%	**Asbestos Type: %**
	Binder/Filler, Mineral grains, Fine grains	Cellulose	**None Detected ND**
	Fine particles, Organic debris		

Lab ID: 23041640 **Client Sample #: TP.11**
Location: Arlington
Comments: Qualitative analysis was conducted for the presence of asbestos fibers in this sample.

Sampled by: Client
Analyzed by: Hilary Crumley **Date:** 04/28/2023
Reviewed by: Nick Ly **Date:** 04/28/2023

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 EPA 40 CFR Appendix E to Subpart E of Part 763 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

Attention: Mr. Justin Brooks
Project Location: Arlington

Batch #: 2306722.00
Client Project #: 2679 Crosswind SubStation
Date Received: 4/26/2023
Samples Received: 12
Samples Analyzed: 12
Method: EPA/600/R-93/116

Layer 1 of 1 **Description:** Loose brown crumbly material with debris

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

Lab ID: 23041641 **Client Sample #: HA.1**

Location: Arlington

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

Layer 1 of 1 **Description:** Loose tan crumbly material with debris

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

Sampled by: Client
Analyzed by: Hilary Crumley **Date:** 04/28/2023
Reviewed by: Nick Ly **Date:** 04/28/2023

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 EPA 40 CFR Appendix E to Subpart E of Part 763 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**	**2306722.00**
Address	19019 36th Avenue West, Suite E Lynnwood, WA 98036	**TAT** 3 Days **Rush TAT**	**AH** No
Project Manager	Mr. Justin Brooks	**Due Date** 5/1/2023	**Time** 9:00 AM
Phone	(425) 582-9928	**Email**	jbrooks@zippergeo.com
Cell	(813) 205-3481	**Fax**	(425) 582-9930

Project Name/Number: 2679 Crosswind SubStation **Project Location:** Arlington

Subcategory PLM Bulk

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

Total Number of Samples 12 Rush Samples

	Lab ID	Sample ID	Description	A/R
1	23041630	TP.1		A
2	23041631	TP.2		A
3	23041632	TP.3		A
4	23041633	TP.4		A
5	23041634	TP.5		A
6	23041635	TP.6		A
7	23041636	TP.7		A
8	23041637	TP.8		A
9	23041638	TP.9		A
10	23041639	TP.10		A
11	23041640	TP.11		A
12	23041641	HA.1		A

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

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Rachelle Miller		NVL	4/26/23	900
Analyzed by	Hilary Crumley		NVL	4/28/23	
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions: Samples were dried prior to analysis.

Date: 4/26/2023
Time: 8:49 AM
Entered By: Rachelle Miller

ASBESTOS LABORATORY SERVICES

NVL

Company	Zipper Geo Associates, LLC	**NVL Batch Number**	**2306722.00**
Address	19019 36th Avenue West, Suite E Lynnwood, WA 98036	**TAT**	3 Days **AH** No
		Rush TAT	
Project Manager	Mr. Justin Brooks	**Due Date**	5/1/2023 **Time** 9:00 AM
Phone	(425) 582-9928	**Email**	jbrooks@zippergeo.com
Cell	(813) 205-3481	**Fax**	(425) 582-9930

Project Name/Number: 2679 Crosswind SubStation **Project Location:** Arlington

Subcategory PLM Bulk

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

Total Number of Samples 12 Rush Samples

	Lab ID	Sample ID	Description	A/R
1	23041630	TP.1		A
2	23041631	TP.2		A
3	23041632	TP.3		A
4	23041633	TP.4		A
5	23041634	TP.5		A
6	23041635	TP.6		A
7	23041636	TP.7		A
8	23041637	TP.8		A
9	23041638	TP.9		A
10	23041639	TP.10		A
11	23041640	TP.11		A
12	23041641	HA.1		A

	Print Name	Signature	Company	Date	Time
Sampled by	Client			4.26.23	0850
Relinquished by	Client				

Office Use Only	Print Name	Signature	Company	Date	Time
Received by	Rachelle Miller		NVL	4/26/23	900
Analyzed by			NVL		
Results Called by					
☐ **Faxed** ☐ **Emailed**					

Special Instructions:

Entered By: Rachelle Miller Date: 4/26/2023 Time: 8:49 AM 1 of 1

APPENDIX C
LIQUEFACTION ANALYSIS OUTPUT PLOT

Zipper Geo Associates, LLC
19019 36th Avenue West, Suite E
Lynnwood, Washington
(425) 582-9928

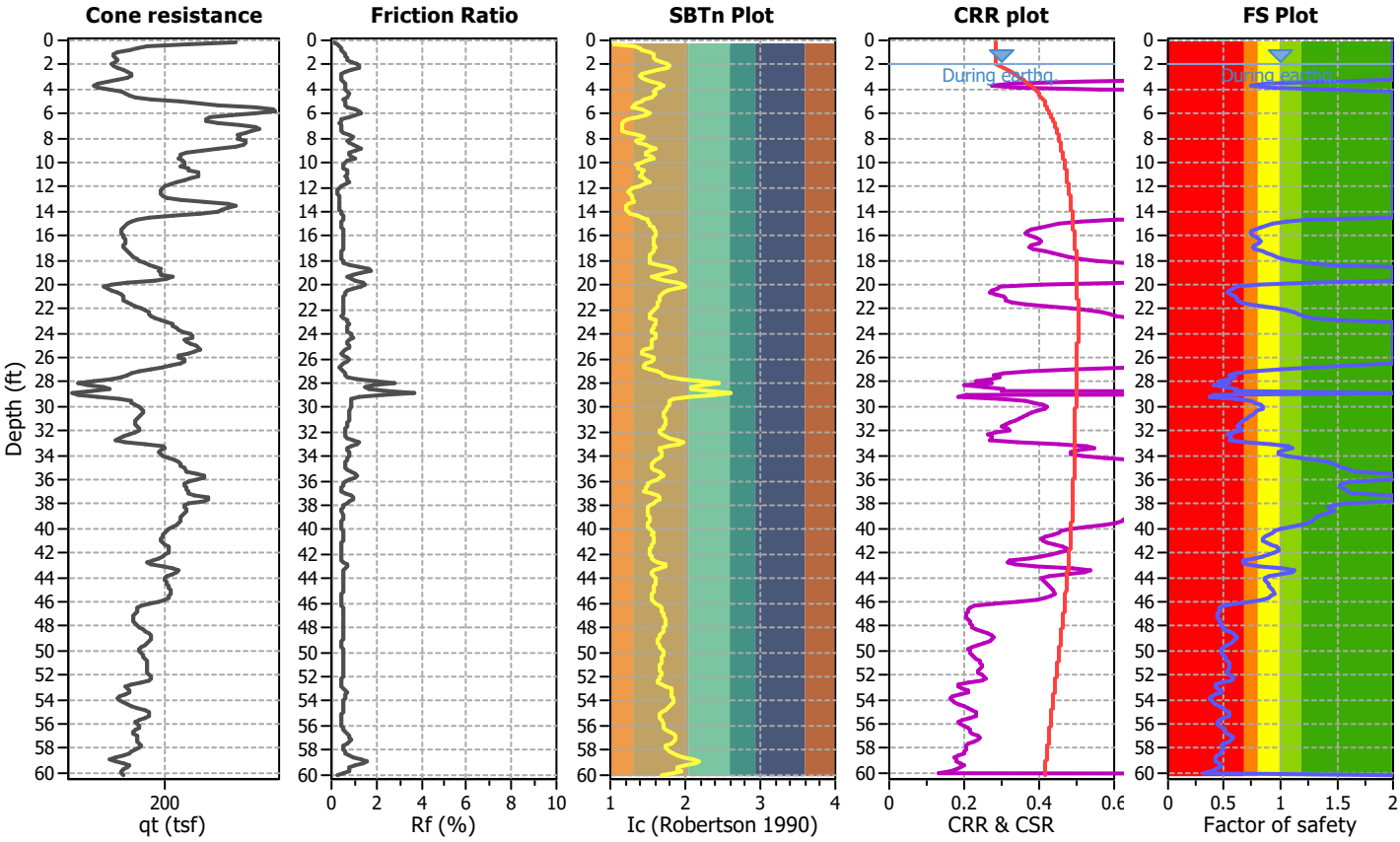
LIQUEFACTION ANALYSIS REPORT

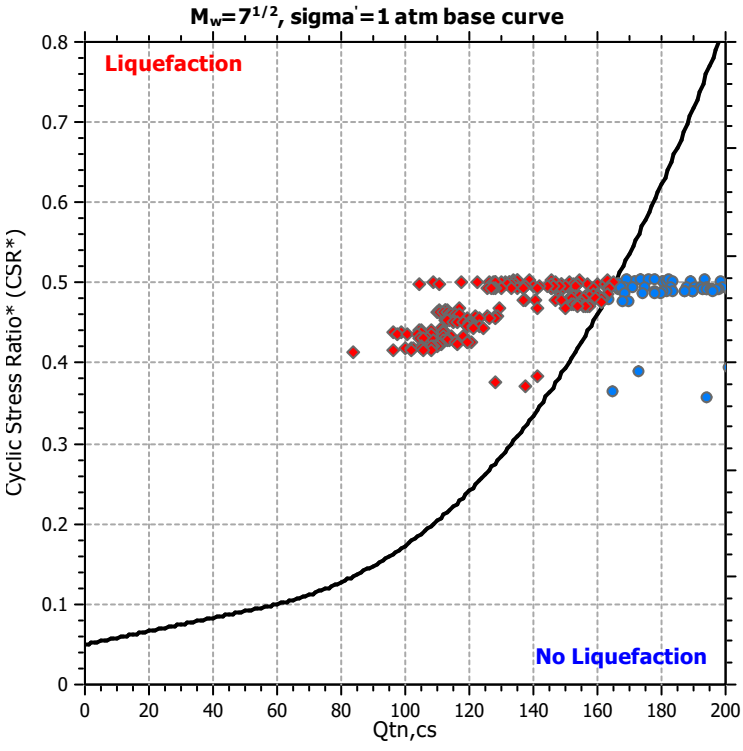
Project title : Crosswind Substation **Location : Arlington, Washington**

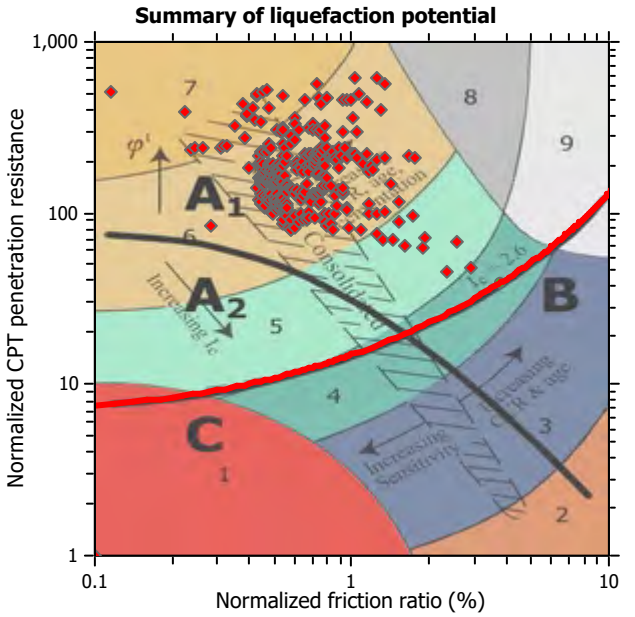
CPT file : CPT-01

Input parameters and analysis data

Analysis method:	NCEER (1998)	G.W.T. (in-situ):	7.00 ft	Use fill:	No	Clay like behavior applied:	Sands only
Fines correction method:	NCEER (1998)	G.W.T. (earthq.):	2.00 ft	Fill height:	N/A	Limit depth applied:	No
Points to test:	Based on Ic value	Average results interval:	3	Fill weight:	N/A	Limit depth:	N/A
Earthquake magnitude M_w:	7.03	Ic cut-off value:	2.60	Trans. detect. applied:	No	MSF method:	Method based
Peak ground acceleration:	0.52	Unit weight calculation:	Based on SBT	K_σ applied:	Yes		

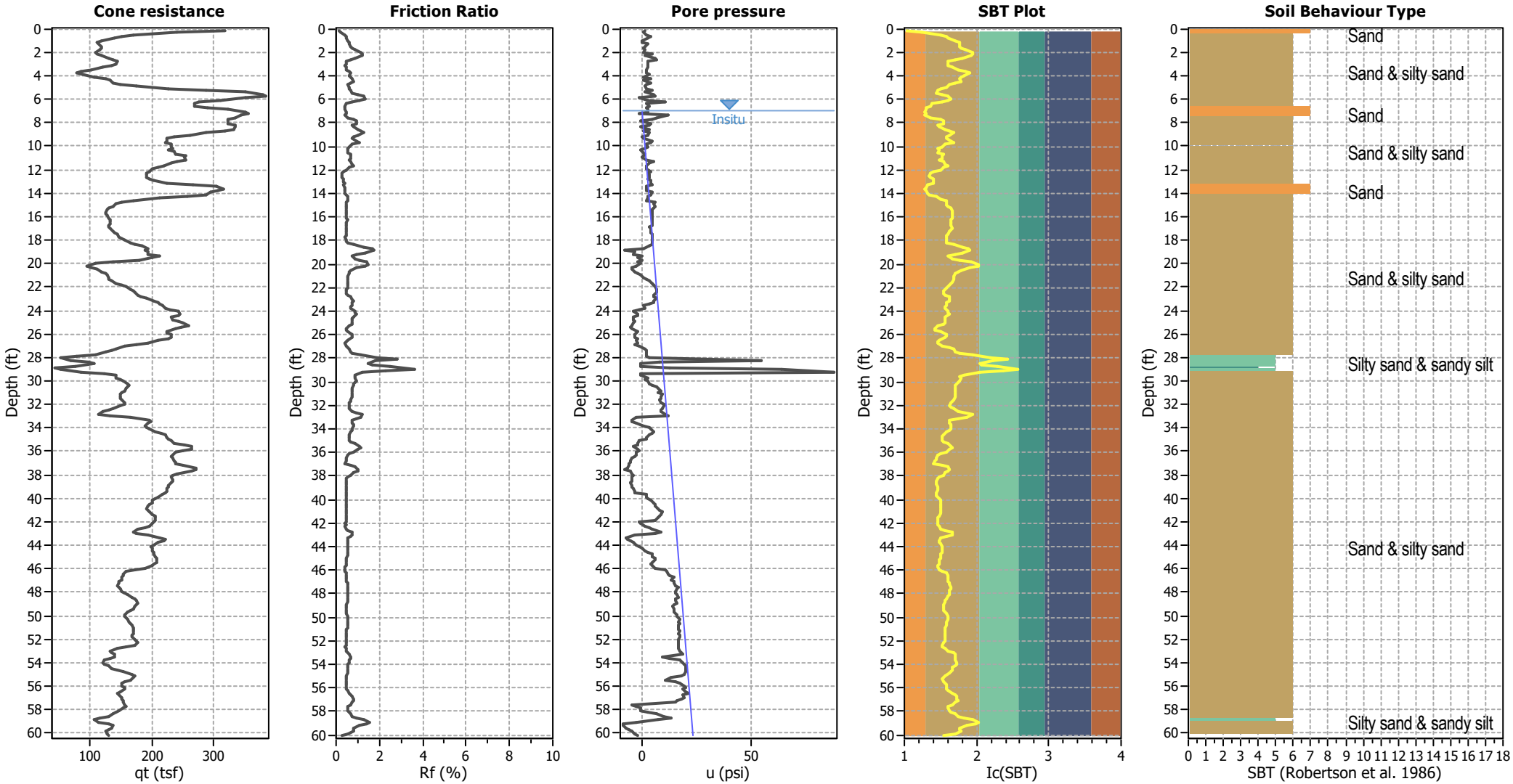






Zone A_1: Cyclic liquefaction likely depending on size and duration of cyclic loading
Zone A_2: Cyclic liquefaction and strength loss likely depending on loading and ground geometry
Zone B: Liquefaction and post-earthquake strength loss unlikely, check cyclic softening
Zone C: Cyclic liquefaction and strength loss possible depending on soil plasticity, brittleness/sensitivity, strain to peak undrained strength and ground geometry

CPT basic interpretation plots



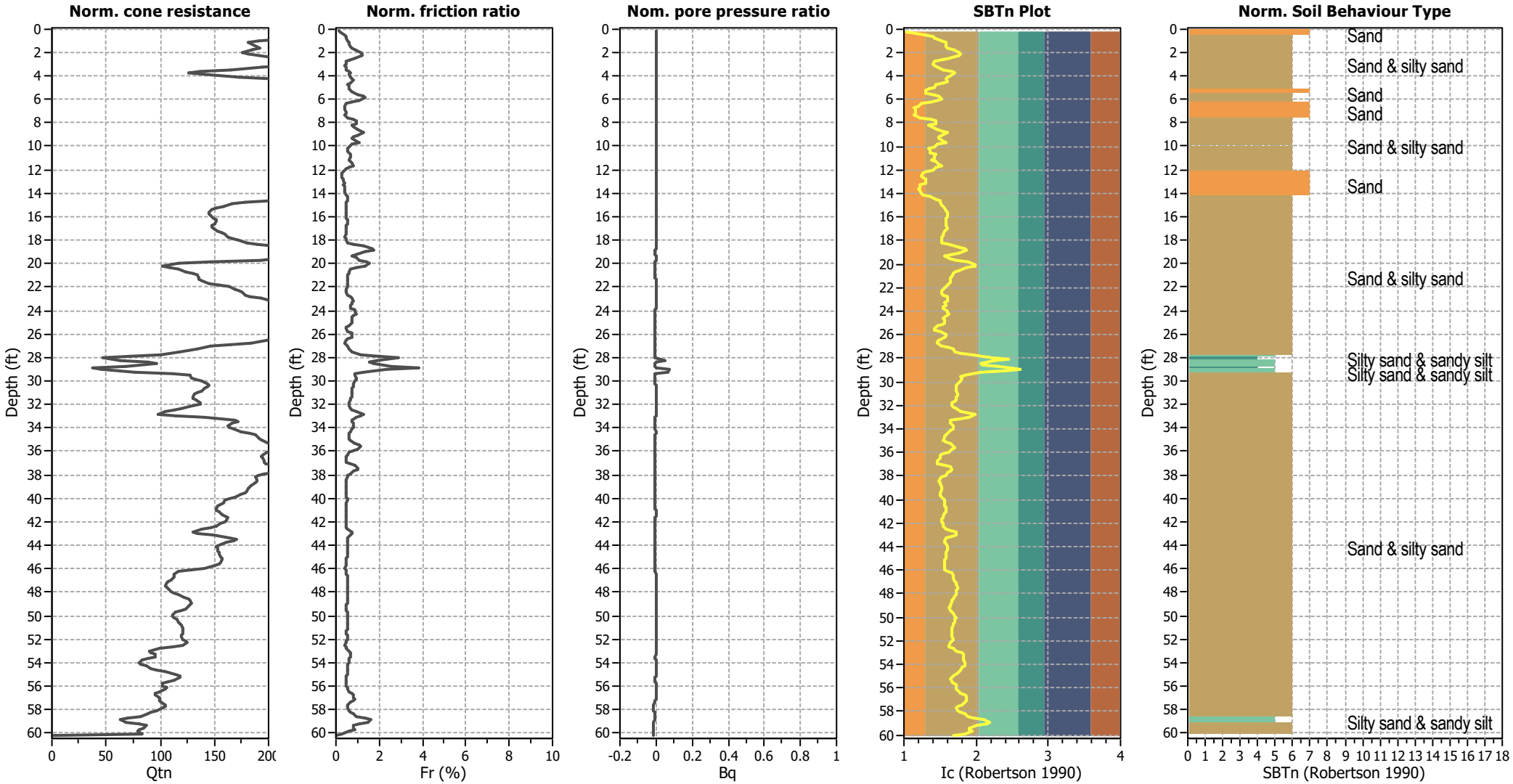
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.03	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.52	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	7.00 ft	Fill height:	N/A	Limit depth:	N/A

SBT legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

CPT basic interpretation plots (normalized)



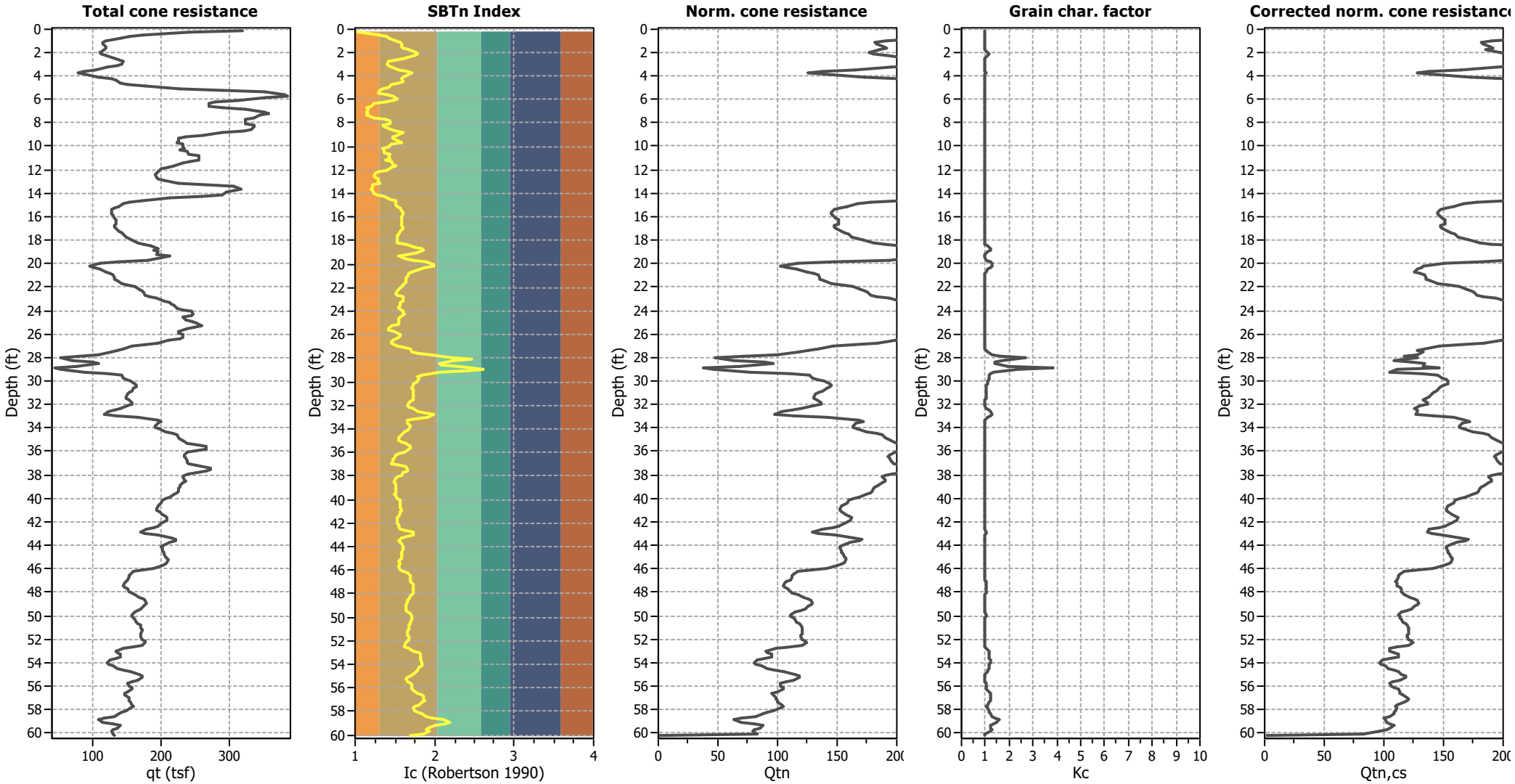
Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.03	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.52	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	7.00 ft	Fill height:	N/A	Limit depth:	N/A

SBTn legend

1. Sensitive fine grained
2. Organic material
3. Clay to silty clay
4. Clayey silt to silty
5. Silty sand to sandy silt
6. Clean sand to silty sand
7. Gravely sand to sand
8. Very stiff sand to
9. Very stiff fine grained

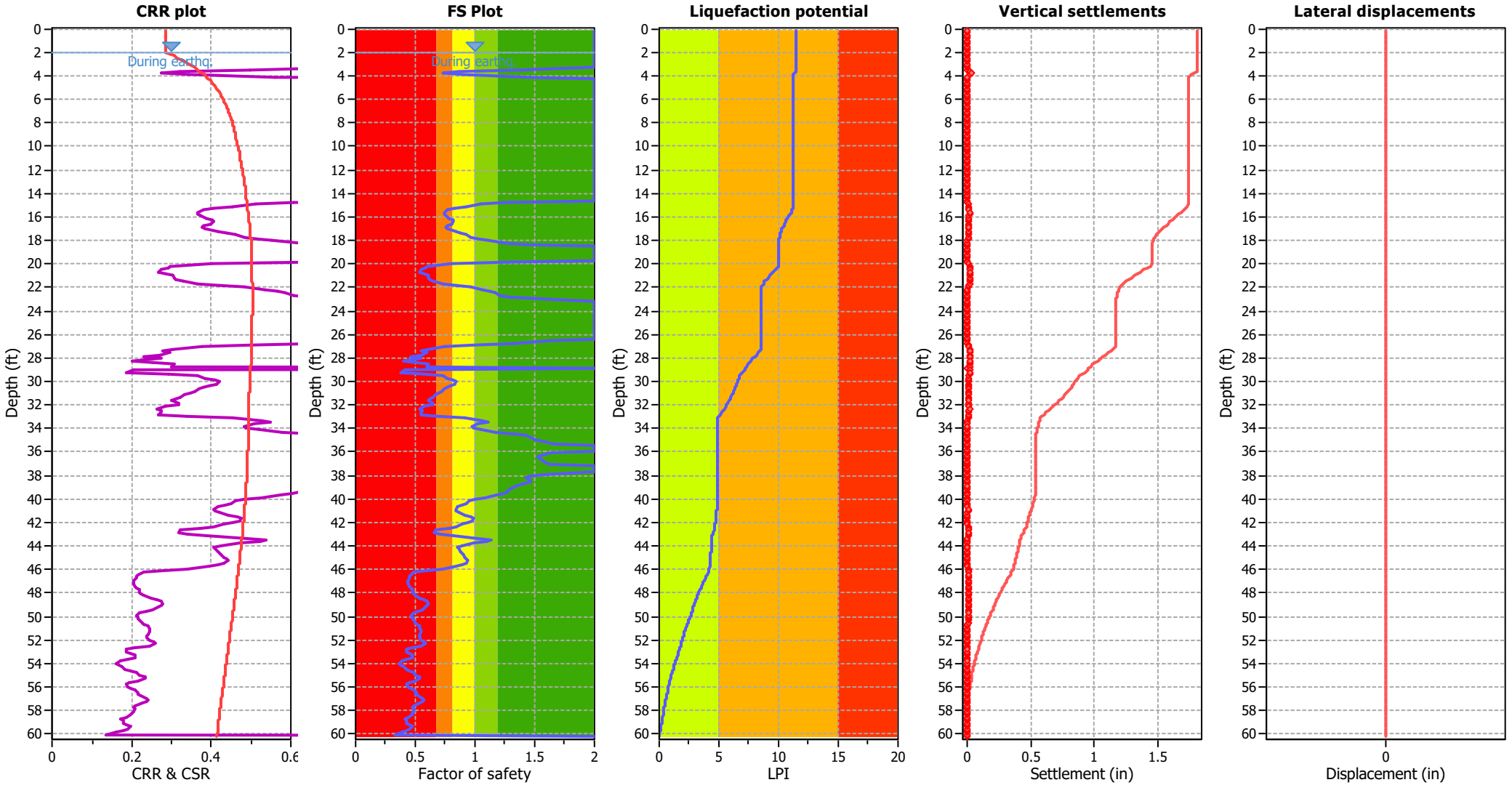
Liquefaction analysis overall plots (intermediate results)



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.03	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.52	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	7.00 ft	Fill height:	N/A	Limit depth:	N/A

Liquefaction analysis overall plots



Input parameters and analysis data

Analysis method:	NCEER (1998)	Depth to water table (erthq.):	2.00 ft	Fill weight:	N/A
Fines correction method:	NCEER (1998)	Average results interval:	3	Transition detect. applied:	No
Points to test:	Based on Ic value	Ic cut-off value:	2.60	K_σ applied:	Yes
Earthquake magnitude M_w:	7.03	Unit weight calculation:	Based on SBT	Clay like behavior applied:	Sands only
Peak ground acceleration:	0.52	Use fill:	No	Limit depth applied:	No
Depth to water table (insitu):	7.00 ft	Fill height:	N/A	Limit depth:	N/A

F.S. color scheme

- Almost certain it will liquefy
- Very likely to liquefy
- Liquefaction and no liq. are equally likely
- Unlike to liquefy
- Almost certain it will not liquefy

LPI color scheme

- Very high risk
- High risk
- Low risk