Stormwater Site Plan Report

PREPARED FOR:

Department of Social and
Health Services
PO Box 45848
Olympia, WA 98597

PROJECT:

Fircrest School Master
Development Plan
Shoreline, WA 98155
2180088.10

PREPARED BY:

Casey Jeszeck, PE
Project Engineer

REVIEWED BY:

Bethany P. Steadman, PE
Project Manager

DATE:

August 2022

Stormwater Site Plan Report

PREPARED FOR:

Department of Social and
Health Services
PO Box 45848
Olympia, WA 98597

PROJECT:

Fircrest School Master
Development Plan
Shoreline, WA 98155
2180088.10

PREPARED BY:

Casey Jeszeck, PE
Project Engineer

REVIEWED BY:

Bethany P. Steadman, PE
Project Manager

DATE:

August 2022

DOUGLAS G. TAPP
STATE OF WASHINGTON
35702
REGISTERED PROFESSIONAL ENGINEER

05/11/2022

I hereby state that this Stormwater Site Plan Report for Fircrest School Master Development Plan has been prepared by me or under my supervision and meets the standard of care and expertise that is usual and customary in this community for professional engineers. I understand that City of Shoreline does not and will not assume liability for the sufficiency, suitability, or performance of drainage facilities prepared by me.

Table of Contents

Section **Page**

Appendices

Appendix A

Maps

Appendix B

Critical Areas Report – Fircrest School Campus Master Plan Shoreline, Washington
Herrera Environmental Consultants, Inc.
March 7, 2022

Report of Geotechnical Engineering Services – Fircrest Adult Training Program Renovation
GeoDesign, Inc.
March 22, 2021

Appendix C

Permanent Stormwater Control Calculations

1.0 Project Overview

1.1 General Description of Project

The project site is located on the existing Fircrest School Campus site (1902 NE 150th Street, Shoreline, Washington) and is encompassed by one tax parcel (1626049010). The parcel is bounded by Hamlin Park to the north, 15th Avenue NE to the west, Shorecrest High School and the South Woods Open Space to the east, and NE 150th Street to the south.

The project proposes to demolish select existing structures and pavement onsite and construct new nursing, educational, and residential buildings with supporting access and utility infrastructure. Demolition includes existing pavement, landscaping, and parking lots. Refer to Appendix A-1 for the Site Vicinity Map.

The project site is subject to the 2019 Washington State Department of Ecology (Ecology) *Stormwater Management Manual for Western Washington (Drainage Manual)*, City of Shoreline Standard Plans, and Shoreline Municipal Code (SMC) 13.10.200, which adopts the 2019 version of the *Drainage Manual*. This report has been prepared to document how the project meets Minimum Requirements 1 through 9, as outlined in the *Drainage Manual*.

1.2 Existing Conditions

The campus site currently contains buildings, access drives, parking areas, and areas of mature vegetation, including stands of trees along the northwestern quadrant and in the north-central portion of the campus. Vehicular access is from the west and south, as well as from Hamlin Park to the north. Existing frontage improvements include curb, gutter, and partial sidewalk along 15th Avenue NE, with rockery walls along the north portion. To the south, a bike lane, curb, gutter, and sidewalk are located along NE 150th Street.

Topographically, the campus consists of two parallel north-south ridges bordering a relatively flat valley that broadens out toward the southern portion of the campus. The western portion of the campus consists of a series of plateaus that step down to relatively flat terrain in the southwestern portion of the campus. The majority of the project site is paved with asphalt, with occasional lawn and trees.

According to the geotechnical subsurface exploration borings, fill consisting of medium dense silty sand was found generally to a depth of about 0 to 2 feet. Glacial Till was generally found at depths of 2 to 10 feet, below which Advance Outwash was found. No groundwater was observed. Infiltration rates were tested using a small-scale Pilot Infiltration Test (PIT) in accordance with the City of Shoreline Engineering Development Manual. These PITs found long-term infiltration rates to be 0.25 inch per hour. Borings and the Geotechnical Report can be found in Appendix B.

The project site drainage is considered under a single Threshold Discharge Area (TDA) and drains southeast via sheet flow and catch basins to a piped stream (Hamlin Creek), which runs underground within NE 160th Street and eventually connecting to NE 150th Street. Minor connections are made to a diverged leg of Hamlin Creek, which runs in a swale along the east property line. However, the majority of the site drains to the piped drainage previously described. The diverged leg becomes piped and outlets to NE 150th Street, where it combines with the main piped drainage.

1.3 Developed Conditions

The project proposes to demolish portions of the existing Fircrest Campus, including buildings, surrounding asphalt and concrete access, parking lots, and supporting utilities. The southerly end of the parcel is to be preserved during construction.

The project proposes construction of numerous new buildings, including a new nursing facility, laundry building, educational buildings, and residential housing buildings. Vehicular and pedestrian access and parking will be provided, as necessary, based on demand. Onsite stormwater management will be provided to the maximum extent feasible using bioretention, permeable pavements, vegetated filter strips, and post-construction soil quality and depth. These facilities will be sized and placed to provide both runoff treatment for pollution generating surfaces and Low Impact Development (LID) standards.

Flow control will be evaluated and provided on a per building scale, rather than installing a regional facility. The project will be required to meet historical land cover discharge requirements per the City of Shoreline Engineering Development Manual. This will be achieved using underground storage facilities, such as galvanized CMP tanks, precast concrete vaults, or chamber systems with control structures to limit outflow from project site.

Refer to Appendix A-3 for the Developed Conditions Map.

1.4 Project Classification

Per the *Drainage Manual*, the project is classified as a Redevelopment Project, and all Minimum Requirements apply to the new and replaced hard surfaces and converted vegetation areas.

2.0 Minimum Requirements

The TDA for Fircrest School campus is subject to Minimum Requirements (MRs) 1 through 9 for all new and replaced hard surfaces and converted vegetation areas. Refer to Appendix A-3, Developed Conditions Map, for areas.

Below is a summary of how the project will meet MRs 1 through 9 for the TDA.

- MR 1 – Preparation of Stormwater Site Plans: This Stormwater Site Plan Report provides the narrative and analysis for the stormwater site plan and accompanies engineered drawings. Both will be developed by a licensed civil engineer and per Volume I, Chapter 3 of the *Drainage Manual*.

- MR 2 – Construction Stormwater Pollution Prevention: A Construction Stormwater Pollution Prevention Plan (CSWPPP) is prepared in conformance to Volume II of the *Drainage Manual*. The CSWPPP narrative is provided in a separate report. The contractor will be responsible for maintaining the CSWPPP during construction and conforming to the National Pollutant Discharge Elimination Systems (NPDES) Construction Stormwater General Permit (CSGP) requirements.

- MR 3 – Source Control of Pollution: Source Control of Pollution Best Management Practices (BMPs) have been selected for use post construction and are discussed in Section 4.1. Source Control BMPs are to be included in an Operation and Maintenance Manual for the owner’s reference.

- MR 4 – Preservation of Natural Drainage Systems and Outfalls: The existing drainage patterns will be preserved to the maximum extent feasible. The developed threshold discharge is to be preserved and not divided, which will match the existing threshold discharge basins as closely as possible.

- MR 5 – Onsite Stormwater Management (OSM): The project has provided OSM to the maximum extent feasible, as required by List 2, found in Section 2.5.5 of the *Drainage Manual.* Refer to Section 3.2 of this report for more detailed information.

- MR 6 – Runoff Treatment: This project does not meet the requirements of a high-use site, and therefore does not need to provide treatment per the Oil Control Treatment Menu. The project does not drain to a phosphorus sensitive lake and does not need to provide treatment per the Phosphorus Treatment Menu. The project is tributary to a fish bearing waterbody and is required to provide stormwater treatment per the Enhanced Treatment Menu. Refer to Section 3.3 for analysis of how the project will meet these performance standards.

- MR 7 – Flow Control: Flow control is required to match historical discharge durations to the pre-developed durations for the range of pre-developed discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow. The pre-developed condition to be matched shall be the historical land cover condition, per Section J.1 of Division 3 of the City of Shoreline Engineering Development Manual.

- MR 8 – Wetlands Protection: No wetlands are located within the site. Stormwater from the site is tributary to several classified wetlands. The natural discharge location is being matched; flow control, water quality, and source controls are being provided. A CSWPPP will be in effect during construction. The project will not aggravate or create any negative downstream conditions.

- MR 9 – Operation and Maintenance: An Operation and Maintenance Manual will be provided.

3.0 Permanent Stormwater Control Plan

This project meets MRs 5 through 7 by providing a Permanent Stormwater Control Plan, which includes water quality treatment and OSM BMPs. The stormwater modeling software, MGSFlood, will be used to size facilities and confirm compliance with the *Drainage Manual*.

3.1 Site Hydrology

The site hydrology is determined by the type of land coverage and soil type. Per the Geotechnical Report, the site is underlain with Glacial Till and Advance Outwash Deposits and is found to have estimated infiltration rates of roughly 0.25 inch per hour. Because of the low infiltration potential and that soils are considered Till, soils were modeled as C in MGSFlood. Historical forested land cover conditions will be used.

Refer to Appendix A-3 for the total developed conditions and for the water quality areas delineated.

3.2 Onsite Stormwater Management (OSM)

The project is subject to MR 5, OSM. Projects that trigger MRs 1 through 9 within the Urban Growth Area are required to use the List 2 approach for evaluating OSM BMPs. For typical surfaces, BMPs area considered in the order listed for that surface type. The chosen BMP is subject to change and the below feasibility criteria are preliminary.

Table 1 – OSM BMP Feasibility Review

Surface Type	List 2 Feasibility Review (~~Strikeout Determined Infeasible~~ and **Bold Determined Feasible and Provided**)	Infeasibility Justification
Landscaping	**1. Post Construction Soil (BMP T5.13)**	**1. BMP T5.13 is to be provided for all proposed landscaped areas.**
Concrete Walks (onsite)	~~1. Full Dispersion~~ **2. Permeable Pavement** **3. Bioretention or Filter Strip** 4. Sheet Flow Dispersion	1. Full Dispersion is not feasible because 65% native growth area is not available downstream of impervious areas. **2. Permeable Pavement may be provided.** **3. A bioretention cell may be provided.**
Parking Lots	~~1. Full Dispersion~~ **2. Permeable Pavement** **3. Bioretention or Filter Strip** 4. Sheet Flow Dispersion	1. Full Dispersion is not feasible because 65% native growth area is not available downstream of impervious areas. **2. Permeable Pavement may be provided.** **3. A bioretention cell may be provided.**
Fire Lane and Roadways	~~1. Full Dispersion~~ ~~2. Permeable Pavement~~ 3. **Bioretention or Filter Strip** 4. Sheet Flow Dispersion	1. Full Dispersion is not feasible because 65% native growth area is not available downstream of impervious areas. 2. Location is made up of fill soils that may become unstable when saturated. **3. A bioretention cell may be provided if runoff is able to be feasibly routed.**
Roof	~~1. Full Dispersion or Downspout Full Infiltration Systems~~ 2. **Bioretention or Filter Strip** 3. Downspout Dispersion 4. Perforated Stub-out Connections	1. Full Dispersion is not feasible because 65% native growth area is not available downstream of impervious areas. Full Infiltration is not feasible due to low long-term infiltration rates found by the geotechnical engineer to be typically 0.25 inch per hour. **2. A bioretention cell may be provided if runoff is able to be feasibly routed.**

Typical Bioretention OSM Sizing

Bioretention areas provided for meeting OSM are sized per BMP T5.14B. The design guidelines recommend that the ponding area be sized as 5 percent of the total impervious surface area and 2 percent of the total pervious surface area draining to it. If any area also has permeable pavement draining to it, these areas will be calculated as half impervious and half pervious per Appendix III-C of the *Drainage Manual*.

3.3 Water Quality Treatment

Because of the project site encompassing more than 5,000 square feet of pollution generating impervious surface (PGIS), enhanced water quality treatment is required for all proposed PGIS per the City of Shoreline Engineering Development Manual, Chapter 19, Section F.1. Refer to Appendix A-3 and Table 2 below for the estimated PGIS target areas.

Water quality target areas include PGIS within the project site, including the fire lane, roadway, and parking lots, as well as any non-pollution generating areas that drain onto PGIS, including adjacent sidewalks and landscaping. The proposed treatment methods for these areas include bioretention cells and filter strips, in addition to underground treatment facilities such as BioPods or Modular Wetlands where surface facilities are infeasible. Refer to Appendix C for calculations showing the typical calculation for sizing for water quality facilities.

Table 2 – Water Quality Facilities Summary

Typical Bioretention	Facility Type	Bioretention
	Required Infiltration %	91%
	Required Bottom Area	Sizing based on MGSFlood typical filter strip sizing calculated in Appendix C-2.
Underground Structure (BioPod / Modular Wetland)	Facility Type	Underground Water Quality Treatment Structure
	Required Infiltration %	91%
	Required Sizing	Sized based on water quality flow rate calculated in Appendix C-2.
	Required Infiltration	91%
Compost Amended Vegetated Filter Strip (CAVFS)	Facility Type	CAVFS
	Required Infiltration %	91%
	Required Length	Sizing based on MGSFlood calculation and varies in width, depth, and length.

3.4 Flow Control

Flow control is required to match developed discharge durations to the historical durations for the range of historical discharge rates from 50 percent of the 2-year peak flow up to the full 50-year peak flow. The condition to be matched shall be the historical land cover condition per the City of Shoreline Engineering Development Manual, Chapter 19, Section J-1.

The project will meet the requirements above using underground stormwater storage facilities, such as aluminized steel CMP tanks, precast or cast-in-place concrete vaults, or prefabricated stormwater arch chambers. Refer to Appendix C-1 and Table 3 below for the typical Flow Control MGSFlood calculation used to size flow control systems based on a ratio of acreage captured to cubic feet of storage required. Depth of system is preliminarily determined based on existing stormwater system depth and conveyance routing feasibility.

Table 3 – Flow Control Facilities Summary

Typical Flow Control	Facility Type	Flow Control Storage with Control Structure
	Required Storage Volume	30,000 CF per acre of impervious surface
	Required Footprint	Determined by depth of storage system, with a 20% sizing factor applied. Required Volume / Available Depth x 1.2

Refer to Appendix A-3 for delineation of areas. Refer to Appendix C for typical flow control calculation showing that the project intends to meet the flow control standard at the point of compliance.

3.5 Stormwater Conveyance Analysis and Design

Conveyance analysis and design will be performed using King County Backwater Analysis (KCBW) or Storm and Sanitary Sewer Analysis (SSA) Software and the outputs from the MGSFlood model.

4.0 Stormwater Pollution Prevention

The project will require a CSGP from Ecology. The Contractor will provide temporary BMPs per the CSWPPP report and engineering drawings. A separate CSWPPP report will be provided.

4.1 Source Control of Pollution BMPs

In addition to the temporary construction BMPs outlined in the CSWPPP report, the project will provide the following permanent Source Control of Pollution BMPs per Volume IV of the *Drainage Manual*.

Source Control BMPs:

- BMPs for Landscaping and Lawn/Vegetation Management.
- BMPs for Maintenance of Stormwater Drainage and Treatment Systems.
- BMPs for Parking and Storage of Vehicles and Equipment.
- BMPs for Roof/Building Drains at Manufacturing and Commercial Buildings.

5.0 Special Reports and Studies

Refer to Appendix B for the following information:

- Critical Areas Report – Fircrest School Campus Master Plan, Shoreline, Washington, by Herrera Environmental Consultants, Inc., March 7, 2022.

- Report of Geotechnical Engineering Services – Fircrest Adult Training Program Renovation, by GeoDesign, Inc., dated March 22, 2021.

6.0 Operation and Maintenance Manual

Onsite stormwater management, water quality, and conveyance systems are maintained and operated by the owner. An Operation and Maintenance Manual will be developed for the permanent stormwater controls included in the project.

7.0 Declaration of Covenant for Privately Maintained Stormwater Facilities

A Declaration of Covenant will be provided.

8.0 Conclusion

This analysis is based on data and records either supplied to or obtained by AHBL. These documents are referenced within the text of the analysis. The analysis has been prepared using procedures and practices within the standard accepted practices of the industry.

AHBL, Inc.

Casey Jeszeck, PE
Project Engineer

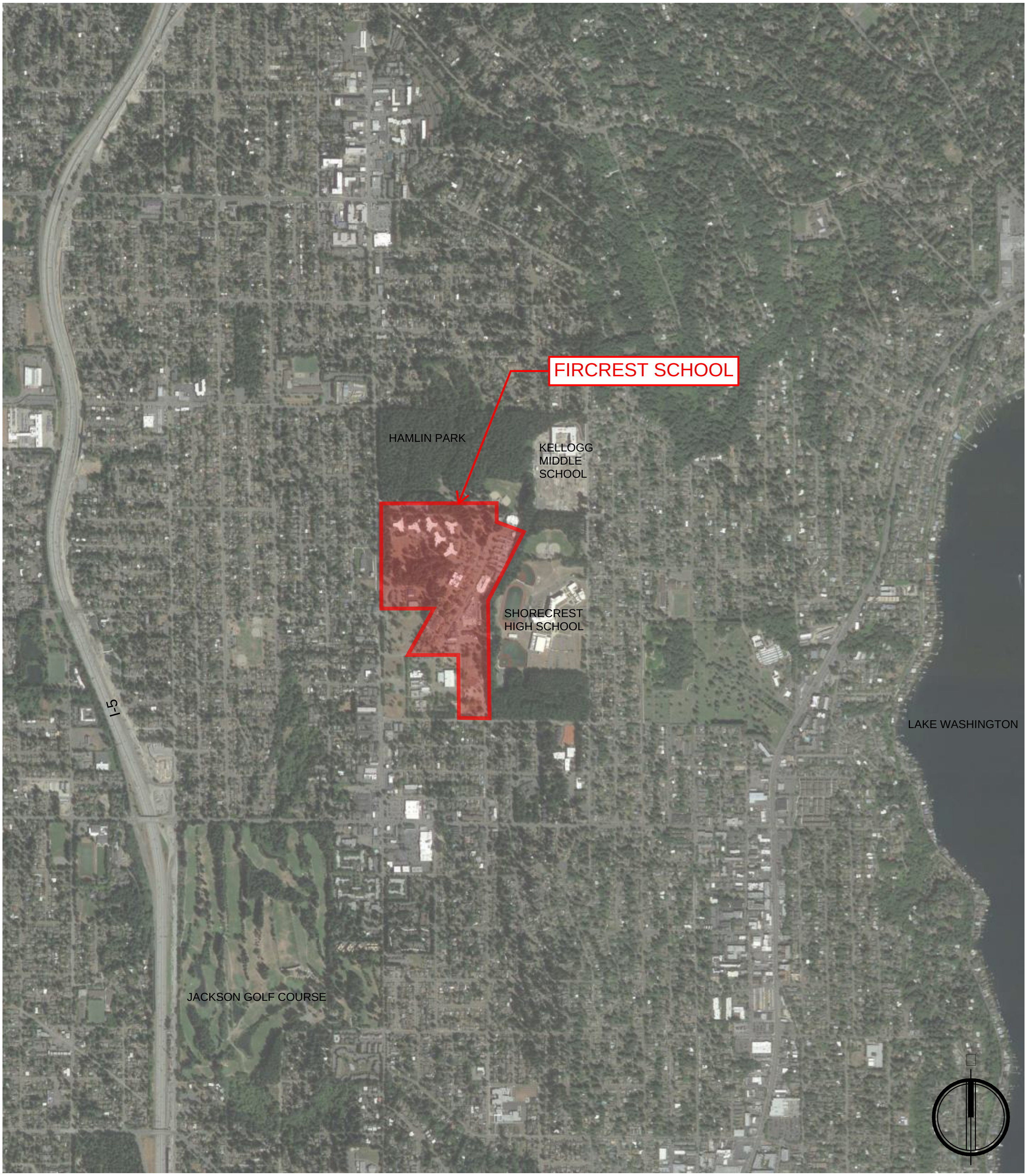
CTJ/lsk

August 2022

Q:\2018\2180088\WORDPROC\Reports\20220511 Rpt (SSP) 2180088.10.docx

Appendix A

Maps

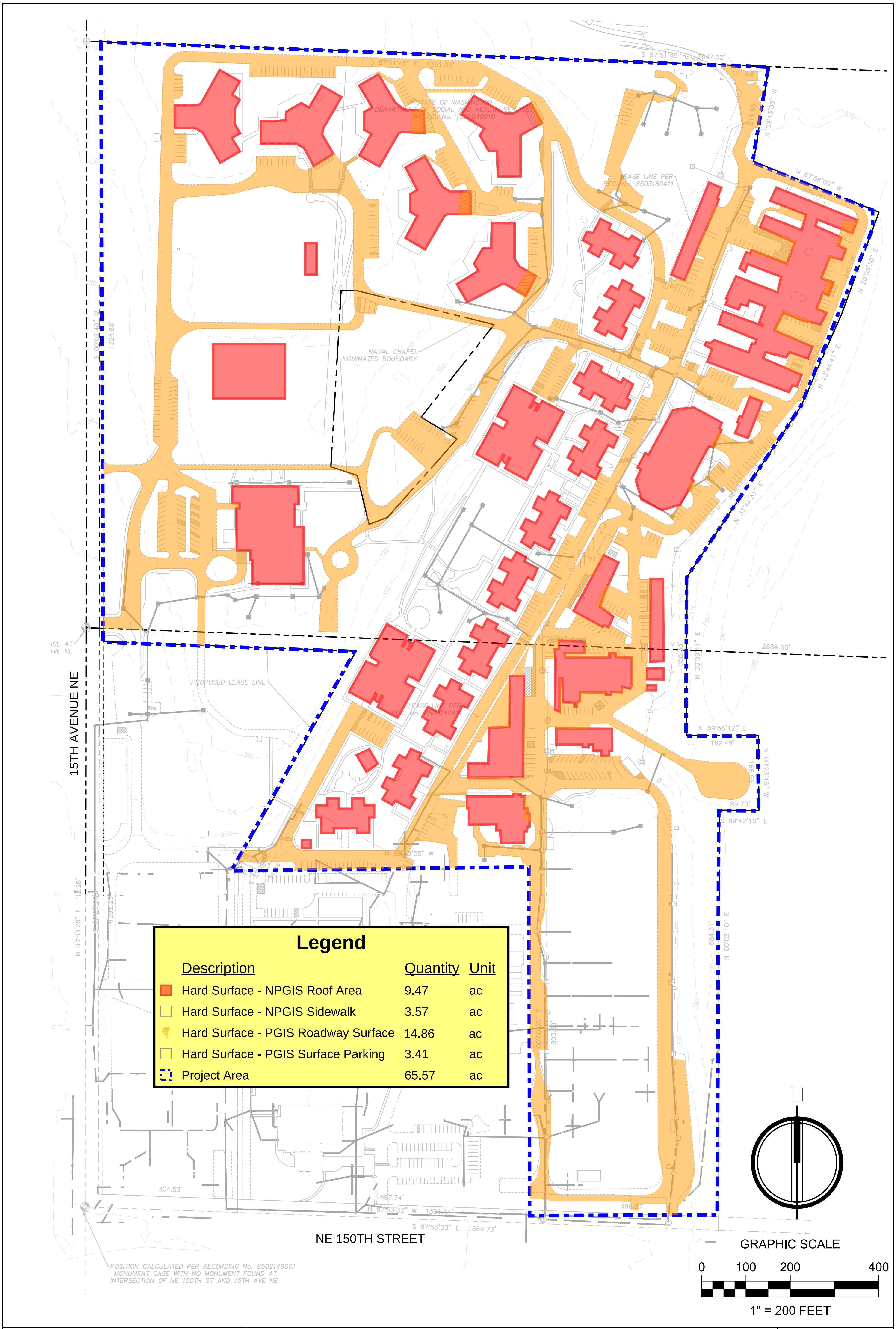


1200 6th Avenue
Suite 1620
Seattle, WA 98101
206.267.2425 TEL
206.267.2429 FAX

FIRCREST SCHOOL

SITE VICINITY MAP

FIG. A-1



Legend

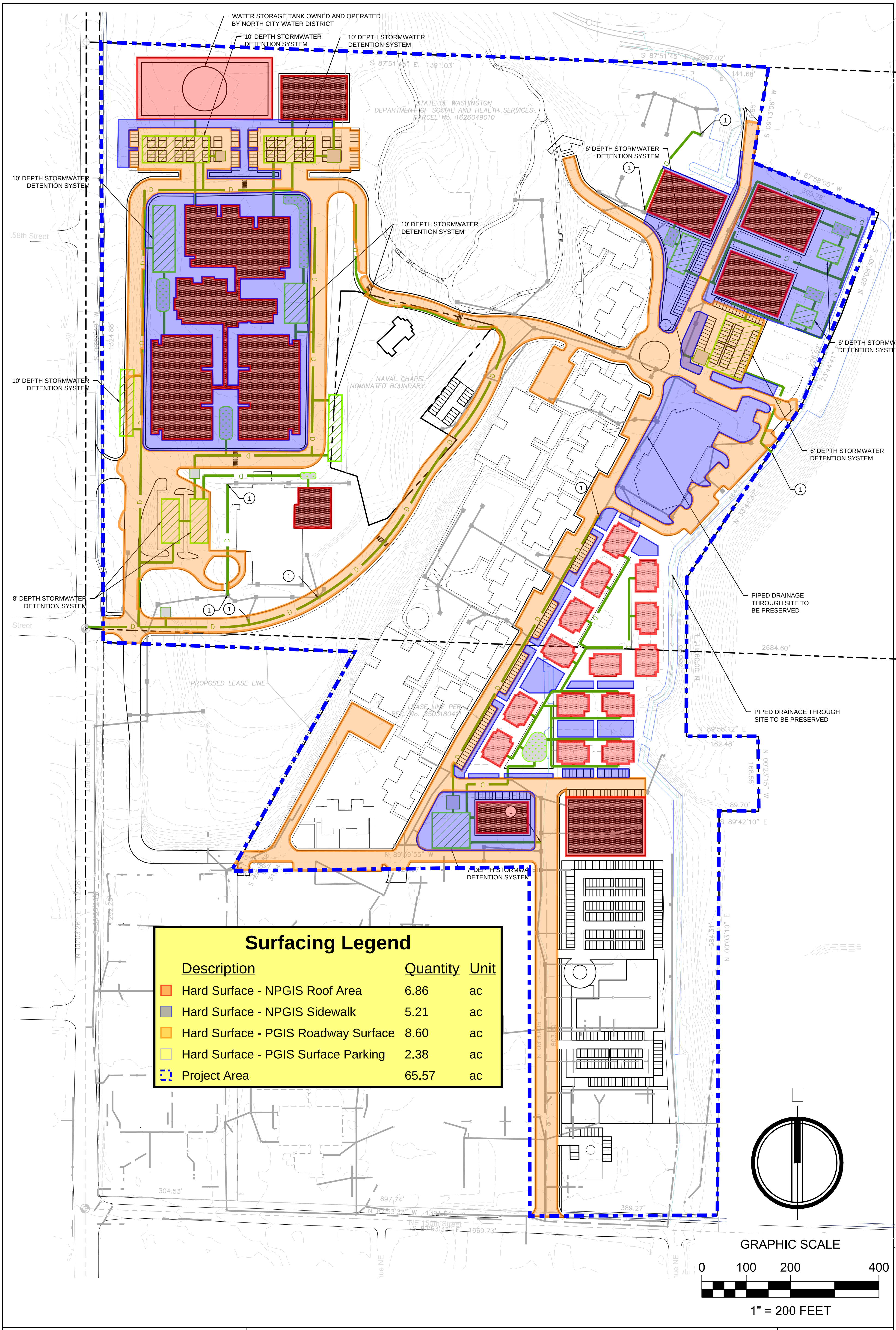
	Description	Quantity	Unit
🟥	Hard Surface - NPGIS Roof Area	9.47	ac
☐	Hard Surface - NPGIS Sidewalk	3.57	ac
🟧	Hard Surface - PGIS Roadway Surface	14.86	ac
☐	Hard Surface - PGIS Surface Parking	3.41	ac
⬚	Project Area	65.57	ac

AHBL
1200 6th Avenue
Suite 1620
Seattle, WA 98101
206.267.2425 TEL
206.267.2429 FAX

FIRCREST SCHOOL

EXISTING CONDITIONS MAP

Fig. A-2



Surfacing Legend

	Description	Quantity	Unit
🟥	Hard Surface - NPGIS Roof Area	6.86	ac
▨	Hard Surface - NPGIS Sidewalk	5.21	ac
🟧	Hard Surface - PGIS Roadway Surface	8.60	ac
☐	Hard Surface - PGIS Surface Parking	2.38	ac
⬚	Project Area	65.57	ac

AHBL

1200 6th Avenue
Suite 1620
Seattle, WA 98101
206.267.2425 TEL
206.267.2429 FAX

FIRCREST SCHOOL

DEVELOPED CONDITIONS MAP

Fig. A-3

Appendix B

Critical Areas Report – Fircrest School Campus Master Plan Shoreline, Washington

Herrera Environmental Consultants, Inc.
March 7, 2022

Report of Geotechnical Engineering Services – Fircrest Adult Training Program Renovation

GeoDesign, Inc.
March 22, 2021

DRAFT
CRITICAL AREAS REPORT

FIRCREST SCHOOL CAMPUS MASTER PLAN
SHORELINE, WASHINGTON

Prepared for
City of Shoreline
and
AHBL, Inc.

Prepared by
Herrera Environmental Consultants, Inc.

CRITICAL AREAS REPORT

FIRCREST SCHOOL CAMPUS MASTER PLAN
SHORELINE, WASHINGTON

Prepared for
City of Shoreline
and
AHBL, Inc.
Tacoma, Washington 98403

Prepared by
Herrera Environmental Consultants, Inc.
2200 Sixth Avenue, Suite 1100
Seattle, Washington 98121
Telephone: 206-441-9080

DRAFT
March 7, 2022

CONTENTS

APPENDICES

TABLES

FIGURES

DISCLAIMER

Herrera Environmental Consultants, Inc., has prepared this report for use by AHBL, Inc., and the City of Shoreline. The results and conclusions in this report represent the professional opinion of Herrera Environmental Consultants, Inc. They are based upon examination of public domain information concerning the study area, site reconnaissance, and data analysis.

The work was performed according to accepted standards in the field of jurisdictional wetland determination and delineation using the *Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987) and the *Regional Supplement to the Corps of Engineers Wetlands Delineation Manual: Western Mountains, Valleys, and Coast Region* (Environmental Laboratory 2010). However, final determination of jurisdictional wetland boundaries pertinent to Section 404 of the Clean Water Act is the responsibility of the Seattle District of the US Army Corps of Engineers. Various agencies of the State of Washington and local jurisdictions may require a review of final site development plans that could potentially affect zoning, buffer requirements, water quality, or habitat functions of lands in question. Therefore, the findings and conclusions in this report should be reviewed by appropriate regulatory agencies before any detailed site planning or construction activities.

HERRERA QUALIFICATIONS

Established in 1980, Herrera Environmental Consultants, Inc. is an innovative, employee-owned, consulting firm focused on three practice areas: water, restoration, and sustainable development. The following staff authored this report and conducted field work in support of this report. A summary of their qualifications is provided.

Rayna Gleason, ISA Arborist

Rayna Gleason is an arborist and landscape designer with 11 years of experience in urban forestry, native habitat restoration, forest and meadow restoration, environmental design, and invasive species management. Rayna provides tree inventories, tree risk assessments, planting plans, vegetation monitoring surveys, wetland delineation, and native Pacific Northwest habitat restoration consulting. Rayna writes tree assessment reports, critical areas reports, wetland and stream delineation reports, and vegetation monitoring reports. Rayna creates JARPA permitting and mitigation planting plans for Washington municipalities.

Credentials

- ISA Arborist, NY-5710A, PNW Chapter, 2011
- ISA TRAQ Qualification, 2019

Eliza Spear, PWS

Eliza Spear is an ecologist and permitting specialist with 6 years of experience in wetland, forest, and meadow restoration; wetland delineation; environmental permitting; and invasive species control. Eliza delineates wetlands and ordinary high water marks of streams and shorelines, and prepares wetland and stream delineation reports, critical areas reports, and mitigation plans for impacts to wetlands, streams, and buffers. Eliza coordinates with local, state, and federal agencies; completes applications; and obtains permits and approvals for project compliance with regulations including local critical area ordinances, the State Hydraulic Code, SEPA, and Clean Water Act Sections 401 and 404.

Credentials

- BS, Environmental Science and Ecology, College of William and Mary, 2013
- Certificate in Wetland Science and Management, University of Washington, 2018
- PWS, Professional Wetland Scientist, Society of Wetland Scientists, 2021
- WSDOT Junior Biological Assessment Author, 2020

EXECUTIVE SUMMARY

This critical areas and significant tree investigation was performed as a subconsultant for AHBL, Inc. (AHBL) in support of the Fircrest School Campus Master Plan. This report presents the results of a wetlands and stream investigation conducted by Herrera Environmental Consultants, Inc. (Herrera) in May 2018, a significant tree survey conducted by Herrera in 2018, and a landslide and erosion hazard assessment conducted by South Sound Geotechnical Consulting in February 2022. Critical areas present on the site include two non-fish-bearing streams and one priority habitat (critical roosting habitat for little brown bat). The project is not expected to directly impact the streams, but may impact stream buffers. Mitigation for impacts on stream buffers must be mitigated according to City of Shoreline Critical Areas code.

The significant tree survey found that most of the trees measured on the site met the City of Shoreline definition of a significant tree. Any significant trees removed for the project are required to be replaced according to City of Shoreline replacement ratios.

No wetlands were found on the site, and no landslide hazard areas or areas of erosion were identified.

Most of the trees measured on site met the City of Shoreline definition of a significant tree.

INTRODUCTION

The critical areas investigation and significant tree survey described in this report was performed as a subconsultant for AHBL, in support of the Fircrest School Campus Master Plan (hereafter referred to as the project). AHBL is proposing to create a campus master plan to improve modifications to facilities and campus layout. Critical areas regulated by the City of Shoreline and relevant to this project include wetlands, fish and wildlife habitat conservation areas (streams, priority habitats, and species), and geologic hazard areas. Significant trees are regulated under the City's development standards. This report documents baseline conditions of significant trees and critical areas in the study area and applicable regulations and guidance regarding potential project impacts on these resources.

PROJECT SETTING

The Fircrest School campus is located at 15230 15th Avenue Northeast, Shoreline, Washington 98155 (Figure 1). The approximately 53-acre area, investigated for the presence of wetlands and streams (the study area), is located at latitude 47.5968633, longitude -122.3236344 in Sections S5 T24N and R4E, Township T24N North, Range R4E East of the Willamette Meridian (WDFW 2009).

The study area Is in the Cedar River/Lake Washington portion of Water Resource Inventory Area (WRIA) Cedar-Sammamish (WRIA 8). The study area is within the subbasin referred to as the North Branch Thornton Creek drainage basin, which discharges into Lake Washington.

STUDY OBJECTIVES

The objectives of the study were to:

- Identify any wetlands and fish and wildlife habitat conservation areas (FWHCAs) in the study area.
- Identify all significant trees within the study area.
- Identify geologic hazards in the study area.
- Identify regulations and guidance applicable to project impacts on wetlands, FWHCAs, significant trees, and buffers set forth by local, state, and federal authorities.

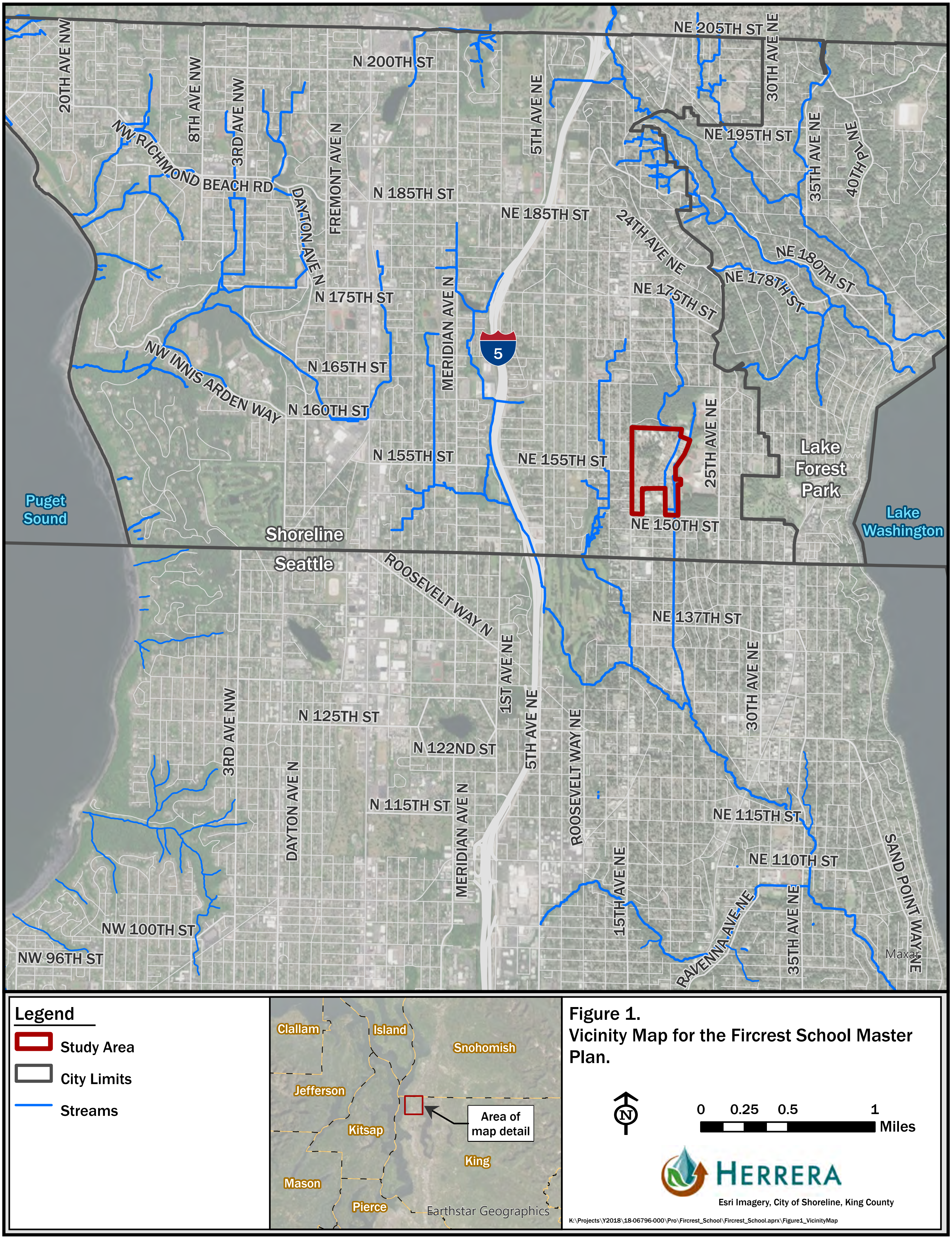


Figure 1.
Vicinity Map for the Fircrest School Master Plan.

HERRERA

Esri Imagery, City of Shoreline, King County

K:\Projects\Y2018\18-06796-000\Pro\Fircrest_School\Fircrest_School.aprx\Figure1_VicinityMap

METHODS AND MATERIALS

Evaluating the presence, extent, and type of critical areas and significant trees requires a review of available information about the site (e.g., surveys, studies), followed by an onsite wetland investigation. The following sections describe the research methods and field protocols for the evaluations.

REVIEW OF AVAILABLE INFORMATION

A literature review was performed to determine the historical and current presence of critical areas in and near the study area. Sources of information included:

- Aerial photographs of the study area (Google Earth 2022)
- National Wetlands Inventory map of wetland areas in the study area (USFWS 2022)
- King County wetland inventory (King County 2022)
- Hydrographic data (stream locations) for King County (King County 2022)
- SalmonScape online mapping (WDFW 2022b)
- Washington State priority habitat and species (PHS) data (WDFW 2022c).
- Washington State Natural Heritage data (DNR 2022)
- Soil survey maps for the study area (NRCS 2022)
- Landslide and Erosion Hazard Assessment (Appendix A)
- Thornton Creek and West Lake Washington Basin Characterizations Report (Tetra Tech 2004)

WETLAND INVESTIGATION

The wetland investigation was performed in accordance with the *Regional Supplement to the US Army Corps of Engineers Wetlands Delineation Manual: Western Mountains, Valleys, and Coast Region* (Environmental Laboratory 2010) , which is consistent with the *1987 Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratory 1987).

The methods in the guidance manuals listed above use a three-parameter approach for identifying and delineating wetlands and rely on the presence of field indicators for hydrophytic vegetation, hydric soils, and hydrology.

FISH AND WILDLIFE HABITAT CONSERVATION AREA DELINEATION AND CLASSIFICATION

A Fish and Wildlife Habitat Conservation Areas (FHWCA) is an area that supports regulated fish or wildlife species or habitats, typically identified by known point locations of specific species, habitat areas, or both. Streams and piped stream segments are FHWCAs according to Shoreline Municipal Code (SMC) 20.80.270(B)(5). SMC defines streams as "those areas where surface waters produce a defined channel or bed, not including irrigation ditches, canals, storm or surface water runoff devices or other entirely artificial watercourses, unless they are used by fish or are used to convey streams naturally occurring prior to construction." FHWCAs also include Washington Department of Fish and Wildlife (WDFW) Priority Habitats and Species.

In accordance with the City of Shoreline, streams on the site were classified using the Washington State Department of Natural Resources (DNR) water typing system based on WAC 222-16-030.

Stream locations and conditions, and potential wildlife presence and habitats, were evaluated through the review of available information and onsite investigations.

SIGNIFICANT TREE INVESTIGATION

In 2018 a Herrera arborist and a biologist inventoried the entire Fircrest Campus project area, measuring 176 significant trees or tree groves that met the minimum circumference per the City of Shoreline Municipal Code, *Chapter 22.62 Landscaping Regulations*. Within the code, *Chapter 22.62.009 Retention and protection of significant trees,* states that "*significant trees are healthy evergreen trees with a minimum 12-inch DBH and healthy deciduous trees with a minimum nine-inch DBH* (diameter at breast height)."

Prior to the initial site visit, a desktop analysis was done for the campus property, private buildings, and access points. Once in the field, tree circumference was measured at 4.5 feet above grade (dbh), identified by genus and species, and mapped by hand with a unique tree number and location within the project area. Trees that were dead, damaged, in decline, or hazardous were noted at the time.

The tree inventory of the Fircrest Campus is grouped into two categories: specimen trees and tree groves. Specimen trees are categorized as trees of significant size or approximately significant size that are planted on site. Tree groves are larger groups of trees that may have been planted or generated naturally. They tend to have a mixture of sizes and species, and often a mature native canopy with invasive species in the understory. Tree groves are also defined by a complex understory (versus grass or a planting bed for specimen trees). Understory species are listed in the comments section of the tree inventory for each grove. Constraints on the project timeline did not allow each tree in a tree grove to be measured. Instead, the species diversity was identified, and the dbh range was provided based on measurements taken of the high and low end of the spectrum of tree sizes. Tree groves receive one unique Tree ID Number, although they have multiple trees in each grove.

The final tree inventory spreadsheet (see Appendix B) shows the Tree ID Number, Species, Common Name, DBH, Significant Tree per City Standards (Yes or No), whether the tree species is native, nonnative, on the Washington State Noxious Weed Board's invasive monitor list or its invasive list, Tree Grove vs Tree Specimen, General Tree Health (Good, Fair, Poor), Risk of Physical Failure (Low, Medium, High), Location by Building Number, and Notes.[1]

Notes detail dead trees present, justifications for a "Fair" or "Poor" General Tree Health rating, or Risk of Physical Failure Rating of "Medium" or greater.

The Fircrest School Campus Master Plan project was put on hold, and the original tree inventory was not delivered to the City upon completion in 2018. The completed tree inventory and corresponding map (see Figure 2) reflects the health and size of significant species inventoried in 2018. Trees that have died, become damaged, grown into significant size per City standards, or have been removed since 2018 have not been noted.

---

[1] General Tree Health and Risk of Physical Failure refer to the Type 1 Tree Risk Assessment (TRAQ) standards set by the International Society of Arboriculture (ISA).

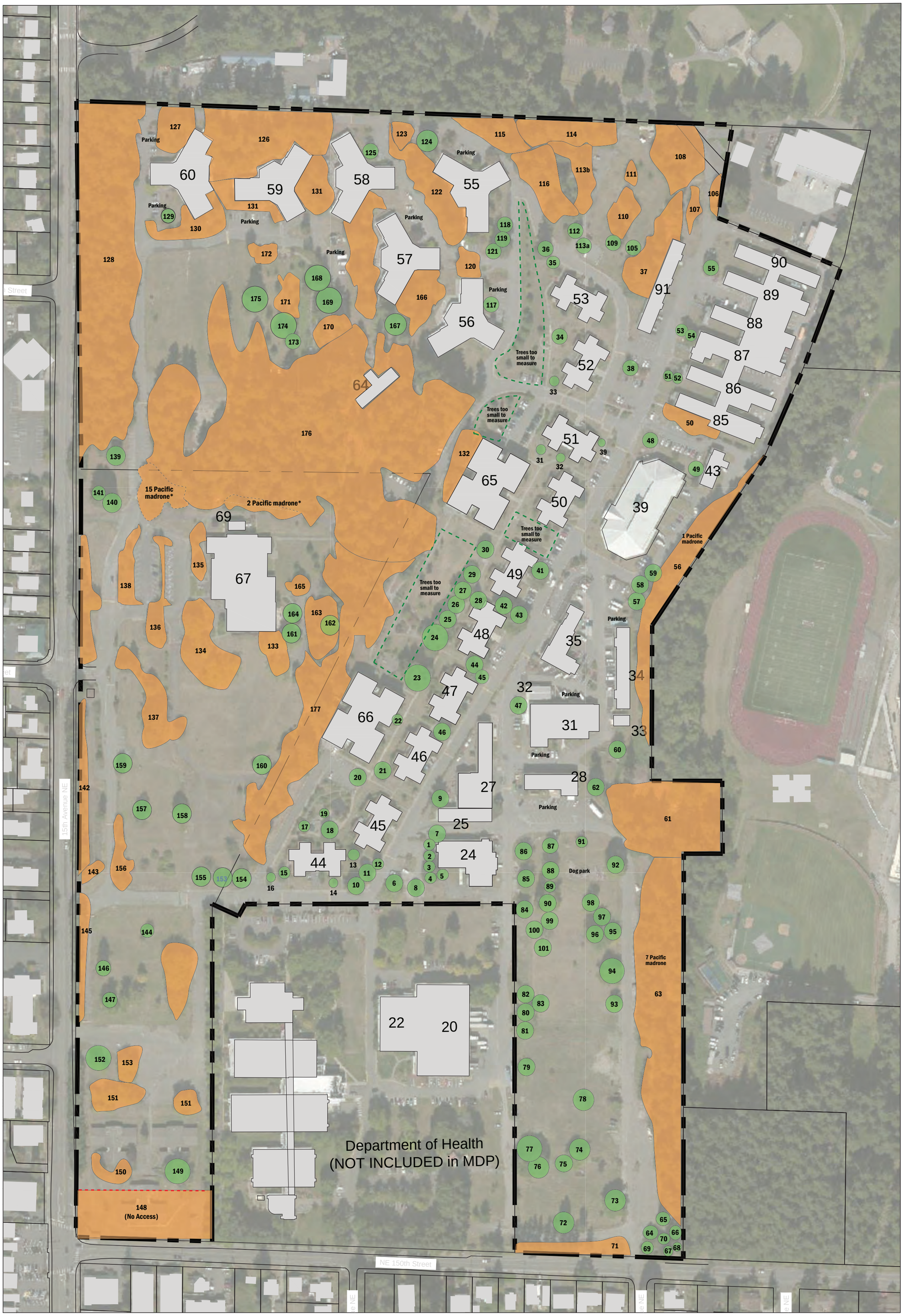


Figure 2. Fircrest Campus Tree Inventory – 2018.

HERRERA

RESULTS

This section discusses the results of the site investigations, including a review of information obtained from various references, and an analysis of critical area conditions in the study area as observed during field investigations.

ANALYSIS OF AVAILABLE INFORMATION

The available existing information compiled for the critical areas investigation is summarized in the following subsections.

Previously Mapped Wetlands and Streams

The National Wetlands Inventory (NWI) does not map any wetlands in the study area. NWI maps show West Hamlin Creek flowing under Northeast 160th Street from Hamlin Park to the north. West Hamlin Creek is then conveyed through pipes to the eastern boundary of the study area, where it joins with East Hamlin Creek and flows out of the study area to the south before joining the main Thornton Creek system south of the Shoreline city limits boundary (Tetra Tech 2004).

East Hamlin Creek is also mapped flowing through a mixed open channel conveyance and piped system on the eastern boundary of the study area. East Hamlin Creek collects drainage from primarily single-family residential areas before flowing south into Thornton Creek downstream of the study area (Tetra Tech 2004).

Fish Habitat Use

Based on WDFW's SalmonScape and PHS mapping, there is no fish use in West or East Hamlin Creek (WDFW 2022b, 2022c). SalmonScape mapping shows multiple fish passage barriers downstream of the study area, including multiple natural barriers due to excessive slopes for fish passage.

Wildlife Habitat Use

According to WDFW PHS data (WDFW 2022c), the Fircrest Campus is potential habitat for the little brown bat (*Myotis lucifugus*), similar to the entire Shoreline city limits. The little brown bat is one of the most common bat species in Washington and is found throughout forested habitats. The species is a habitat generalist and occurs most commonly in both conifer and hardwood forests and forest margins (WDFW 2022a).

The little brown bat is not federally regulated or regulated within Washington State. Critical roosting habitat preservation is encouraged, but not enforced. Critical roosting habitat per the WDFW are remnant forest patches, large snags, hollow trees, and large-diameter trees in areas that are heavily managed (i.e., the Fircrest Campus). As of the 2018 site visit, no critical little brown bat roost habitat was identified.

RESULTS OF FIELD INVESTIGATIONS

This section presents the results of the 2018 significant tree survey and wetland investigation, the 2022 FWHCA investigation, and the February 2022 geologic hazard investigation.

Wetlands

Herrera biologists found no evidence of hydrophytic vegetation or wetland hydrology during the site investigation and determined that no wetlands are present in the study area.

Fish and Wildlife Habitat Conservation Areas

Streams

The small segment of West Hamlin Creek that was not piped in the study area did not have any bed or bank characteristics and instead was observed to be a vegetated swale that conveys the stream flows from mapped piped stream segments to the north and south. A majority of the small segment of East Hamlin Creek that was not piped in the study area displayed characteristics consistent with those observed in West Hamlin Creek; however, a small segment of the vegetated swale appeared to have been maintained, resulting in bed and bank characteristics likely caused by human intervention, rather than by natural flow processes. Piped stream segments and segments without OHWM but that convey naturally occurring streams are regulated as FWHCAs per SMC 20.80.270(B)(5) and SMC 20.80.270(B)(5)(E). Stream conditions are summarized in Tables 1 and 2.

Table 1. Stream Summary Table—West Hamlin Creek.

Stream Name	West Hamlin Creek
	Photo showing the non-piped section of West Hamlin Creek lacking OHWM at the northern boundary of the study area.
Local Jurisdiction	City of Shoreline
DNR Stream Type	Type Ns
Local Stream Rating	Type Ns
City of Shoreline Buffer Width	45-foot buffer on non-piped section, 10-foot buffer on piped sections
Documented Fish Use	No known fish use (WDFW 2022b and 2022c). Mapped natural barriers downstream.
Location of Stream Relative to Project Corridor	Stream flows south from Hamlin Park through the eastern portion of the study area. At the southeastern corner of the study area, West Hamlin Creek flows into East Hamlin Creek.
Riparian/Buffer Condition	The buffer in the northernmost portion of the study area where West Hamlin Creek is conveyed through an open channel consists of mature trees and a mowed, grassy understory. West Hamlin Creek is then conveyed through pipes that are within the paved development of the Fircrest School Campus.

Table 2. Stream Summary Table—East Hamlin Creek.

Stream Name	East Hamlin Creek
	Photo showing the non-piped section of East Hamlin Creek lacking OHWM at the eastern boundary of the study area.
Local Jurisdiction	City of Shoreline
DNR Stream Type	Type Ns
Local Stream Rating	Type Ns
City of Shoreline Buffer Width	45-foot buffer on non-piped section, 10-foot buffer on piped sections
Documented Fish Use	No known fish use (WDFW 2022b, 2022c). Mapped natural barriers downstream.
Location of Stream Relative to Project Corridor	East Hamlin Creek flows south into the study area at its northeast corner. East Hamlin Creek flows south out of the study area at its southeast corner after joining with West Hamlin Creek.
Riparian/Buffer Condition	The buffer within the study area consists of narrow strips of managed, upland lawn. Beyond this vegetation, the buffer is comprised of paved surfaces associated with the buildings on the Fircrest School Campus.

Wildlife

During field reconnaissance, a large number of domesticated rabbits and raptors, predominantly red-tailed hawk (*Buteo jamaicensis*), were observed on site. It is probable the domesticated rabbits are feral offspring of pets. No other wildlife were observed during the site visit.

Significant Trees

The current tree canopy within the Fircrest Campus is a mixture of mature native tree species and ornamental species, many from the eastern United States. On average, trees within the project area were about 23 inches dbh in 2018. Most of the trees measured on site met the City of Shoreline definition of a significant tree.

Specimen Trees

Ornamental and native trees are located around each of the buildings and along the roadways, within the off-leash dog park, and within an open field along the southeastern portion of the campus. The predominant ornamental/specimen trees species are American sycamore *(Platanus occidentalis*), horse chestnut (*Aesculus hippocastanum*), Norway maple (*Acer platanoides*), sycamore maple (*Acer pseudoplatanus*), Port Orford cedar (*Chamaecyparis lawsoniana*), Northern red oak (*Quercus rubra*) and Scots pine (*Pinus sylvestris).*

Most specimen trees around the campus appear healthy and provide significant benefits to the look of the campus. A few specimen trees were dead or had obvious health problems. A few trees had experienced structural damage. Dead, damaged, or trees in decline were noted within the Notes section of the 2018 tree inventory.

Tree Groves

Tree Groves are predominantly along the edges of the property line, along with a large grove of trees around the Naval Hospital Chapel. Healthy, large stands of Pacific madrone (*Arbutus menziesii*) and mature native conifers such as Douglas fir (*Pseudotsuga menziesii*), Western white pine *(Pinus monticola*), Western hemlock (*Tsuga heterophylla*), Western redcedar (*Thuja plicata*) are prominent throughout. Other native species found within the tree groves are bigleaf maple (*Acer macrophyllum*), Ponderosa pine (*Pinus ponderosa*), quaking aspen (*Populus tremuloides*), black cottonwood (*Populus balsamifera* ssp *trichocarpa*), red alder (*Alnus rubra*), Pacific dogwood (*Cornus nuttallii*), and bitter cherry (*Prunus emarginata*). Nonnative species found within the tree groves are Scots pine and horse chestnut. Species within the tree groves on the Washington State Noxious Species Board's list of Invasive of Invasive Monitor are Norway maple, English laurel (*Prunus laurocerasus*), and English holly (*Ilex aquifolium*).

Native species within the tree grove understory often consisted of bracken fern (*Pteridium aquilinum*), salal (*Gaultheria shallon*), Western swordfern (*Polystichum munitum*), dull Oregon grape (*Mahonia nervosa*), red huckleberry (*Vaccinium parvifolium*), Pacific blackberry (*Rubus *ursinus*), osoberry (*Oemleria cerasiformis*), beaked hazelnut (*Corylus cornuta*), common snowberry (*Symphoricarpos albus*) and small native tree saplings.

Invasive understory species within the tree groves are: Himalayan blackberry (*Rubus armeniacus*), common hawthorn (*Crataegus monogyna*), English ivy (*Hedera helix*), English holly, and herb Robert, (*Geranium robertianum*), English laurel, creeping buttercup (*Ranunculus repens*), field bindweed (*Convolvulus arvensis*), and Norway maple saplings.

Landslide and Erosion Hazard Assessment

A complete description of the landslide and erosion hazard assessment is included in Appendix A of this report. This assessment indicated that the study area does not include a Landslide Hazard Area. The study area is anticipated to have a slight to moderate potential for erosion and Best Management Practices for erosion control should be applied to limit the risk of offsite transport of sediment during construction.

REGULATORY IMPLICATIONS

Critical areas are subject to a variety of federal, state, and local regulations that will apply to any future activities planned for the project. Federal laws regulating wetlands and streams include Sections 404 and 401 of the Clean Water Act (United States Code, Title 33, Chapter 1344 and 1251 [33 USC 1344 and 1251]) and the Navigable Waters Protection Rule (33 Code of Federal Regulations [CFR] Part 328). Washington State laws and programs designed to control the loss of wetland acreage include the State Environmental Policy Act (SEPA) and Section 401 of the Clean Water Act (administered in the State of Washington by the Washington State Department of Ecology [Ecology], as mandated by the Washington State Water Pollution Control Act). In addition, Washington State laws include the state Hydraulic Code (Washington Administrative Code [WAC] 220-110). SMC 20.80 specifies wetland categories, required wetland buffer widths, development standards, and wetland mitigation requirements for critical areas in its jurisdiction. Federal, state, and county regulations require mitigation for impacts on wetlands and streams.

Clean Water Act Sections 404 and 401

The project is not anticipated to require Section 404 or 401 permitting because there are no anticipated direct impacts to a water of the United States.

Section 404 of the federal Clean Water Act regulates the placement or removal of soil or other fill, grading, or alteration (hydrologic or vegetative) in waters of the United States, including wetlands and streams (33 USC 1344). The Seattle District of the US Army Corps of Engineers (USACE) administers the permitting program under the act. The permits include nationwide (general) permits for projects involving small areas of fill, grading or alteration and individual permits for projects that require larger areas of wetland disturbance. USACE does not regulate wetland buffers.

Section 401 of the Clean Water Act requires that proposed dredge (removal) and fill activities permitted under Section 404 be reviewed and certified to ensure that such activities meet state water quality standards. State 401 certification is administered by Ecology for all Section 404 permits. State 401 certification is granted without the need for a separate permit from Ecology for projects that qualify for a Section 404 nationwide permit, meet specific 401 certification conditions of the nationwide permit, and meet Ecology 401 General Conditions. If that is not the case, an Individual 401 Water Quality Certification permit is required by Ecology.

Washington State Laws

The project is not anticipated to require a Hydraulic Project Approval (HPA) because there is no work proposed that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state.

Washington State laws and programs designed to control the loss of wetland acreage include SEPA and Section 401 of the Clean Water Act (a federal law that is implemented in the state by Ecology as noted above and as mandated by the Washington State Water Pollution Control Act).

The WDFW administers the Hydraulic Project Approval (HPA) program under the state Hydraulic Code (WAC 220-110), which was specifically designed to protect fish life. An HPA is required for projects that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state.

City of Shoreline Municipal Code

FWHCAs

The open conveyances are regulated as streams because they “are used to convey streams naturally occurring prior to construction” (SMC 20.80.270(5)). West and East Hamlin Creek convey flows in an area where historical aerial photographs indicate the presence of multiple streams (Tetra Tech 2004), indicating this system is part of a historical stream network that existed prior to human intervention in this area.

In accordance with the City of Shoreline, streams on the site were classified using the Washington State Department of Natural Resources water typing system based on WAC 222-16-030. This system is based primarily on fish, wildlife, and human use, and consists of four stream types: Type S, F, Np, or Ns. Type S streams are those surface waters that are inventoried as “Shorelines of the State” under the Shoreline Management Master Program for the City, pursuant to Revised Code of Washington (RCW) Chapter 90.58.030. Type F streams and water bodies are those known to be used by fish or meet the physical criteria to be potentially used by fish. Fish streams may or may not have flowing water all year; they may be perennial or seasonal. Physical criteria for fish use include stream segments having a defined channel of 2 feet or greater within the bankfull width in Western Washington; and having a gradient of

16 percent or less. Type Np streams have flow year-round and may have spatially intermittent dry reaches downstream of perennial flow. Type Np streams do not meet the physical criteria of a Type F stream and have been proven not to contain fish. Type Ns streams do not have surface flow during at least some portion of the year, and do not meet the physical criteria of a Type F stream.

The piped segments of these streams are afforded a 10-foot standard buffer width and the open conveyances are afforded a 45-foot standard buffer width per SMC 20.80.280(C)(1). Per SMC 20.80.280(D)(7), areas that are functionally isolated and physically separated from streams due to existing, legally established roadways or paved areas 8 feet or more in width shall be considered physically isolated and functionally separated stream buffers. Development proposals are allowed in these areas as approved by the City of Shoreline. Mitigation will be required for impacts to stream buffers that are not physically separated or functionally isolated from West and East Hamlin Creek (Figure 3).

Significant Trees

The City of Shoreline defines a significant tree as 8 inches in diameter or larger for evergreen conifers, and 12 inches in diameter for other trees. The City’s tree regulations, SMC 20.50.290–370 Significant Sized Trees, state that “up to six significant trees may be removed during a 3-year period based on the parcel sizes below. Trees over 30 inches in diameter (94.2” in circumference) are not exempt and will need a permit to remove.” Trees that are dead, a high risk, or dying may be removed as they are not counted as a significant tree. Critical root zones (CRZs) of each tree that remains must be protected during the length of construction; and prior to construction, an arborist must approve a tree protection plan.

Per City of Shoreline code, landscaping credit may be given for significant trees retained, especially if trees that provide screening, habitat, buffering, or extend canopy coverage are maintained.

City of Shoreline Replacement Requirements (SMC 20.50.360.D) for all significant trees removed on site are as follows: One existing significant tree of 8 inches in diameter at breast height for conifers or 12 inches in diameter at breast height for all others equals one new tree.

1. Each additional 3 inches in diameter at breast height equals one additional new tree, up to three trees per significant tree removed.

2. Minimum size requirements for replacement trees under this provision: Deciduous trees shall be at least 1.5 inches in caliper and evergreens 6 feet in height.

Prior to the construction phase of the Master Plan, it is recommended that an updated tree survey be generated for all trees that will be removed. Tree sizes, health, and replacement ratios should be updated; and an in-depth analysis of all tree groves may be required per City code.

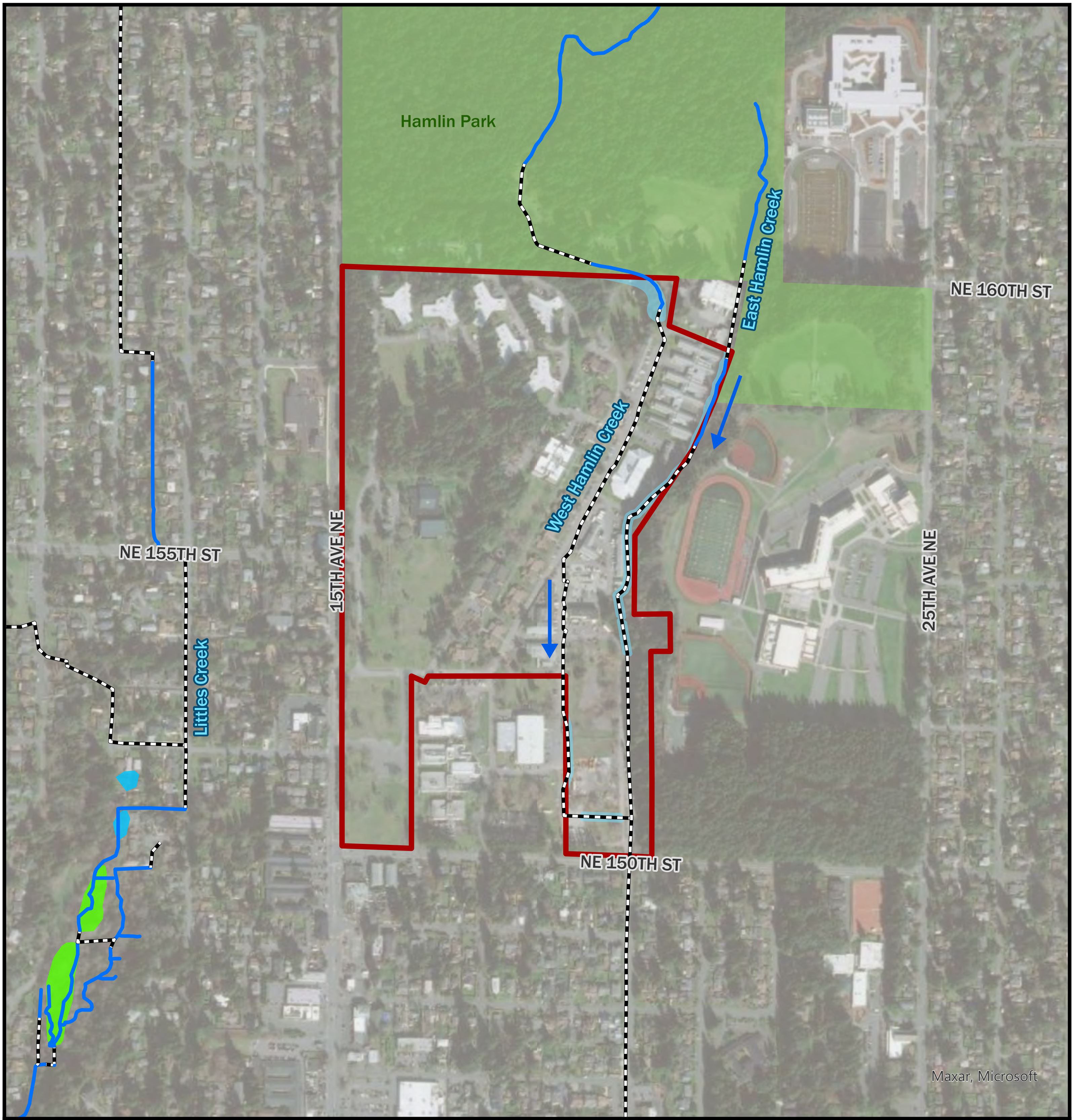


Figure 3.
Previously Mapped Wetlands and Streams in the Vicinity of the Study Area for the Fircrest School Master Plan.

HERRERA

Esri Imagery, City of Shoreline, USFWS

K:\Projects\Y2018\18-06796-000\Pro\Fircrest_School\Fircrest_School.aprx\Figure2_PrevMappedWetlandsStreams

REFERENCES

Brinson, M.M. 1993. A Hydrogeomorphic Classification for Wetlands. Technical Report WRP-DE-4. US Army Engineer Waterways Experiment Station, Vicksburg, Mississippi. August.

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual. Technical Report Y-87-1. US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Mississippi. January.

Environmental Laboratory. 2010. Regional Supplement to the Corps of Engineers Wetlands Delineation Manual: Western Mountains, Valleys, and Coast Region. Technical Report TR-08-13. US Army Corps of Engineers, Engineer Research and Development Center, Wetlands Regulatory Assistance Program, Vicksburg, Mississippi.

King County. 2022. King County iMap Interactive Mapping Tool. Updated August 22, 2018. Accessed January 22, 2022. <https://kingcounty.gov/services/gis/Maps/imap.aspx>.

NRCS. 2022. WebSoil Survey. Natural Resources Conservation Services, US Department of Agriculture. Accessed January 22, 2022. <https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm>.

Shoreline, City of. Development Code SMC 20.503290-370. Accessed January 6, 2022. <Tree Regulations for Private Property Development Handout (champtreecare.com)>.

Tetra Tech. 2004. Thornton Creek and West Lake Washington Basins Characterization Report. Prepared for the City of Shoreline. Tetra Tech, Seattle, Washington. May.

USFWS. 2022. Raster scan data of National Wetlands Inventory wetlands maps. US Fish and Wildlife Service. Accessed January 22, 2022. <http://www.fws.gov/wetlands/index.html>.

WDFW. 2022a. Little brown bat (*Myotis lucifugus*). Accessed January 22, 2022. https://wdfw.wa.gov/species-habitats/species/myotis-lucifugus#desc-range

WDFW. 2022b. SalmonScape mapping system. Washington Department of Fish and Wildlife. Accessed January 22, 2022. <http://wdfw.wa.gov/mapping/salmonscape/index.html>.

WDFW. 2022c. Priority Species and Habitat Database. Provided by Washington Department of Fish and Wildlife. Accessed January 22, 2022. <http://wdfw.wa.gov/mapping/phs/>.

APPENDIX A

Landslide and Erosion Hazard Assessment

South Sound Geotechnical Consulting

February 4, 2022

AHBL
2215 North 30th Street, Suite 200
Tacoma, Washington 98403-3350

Attention: Ms. Brittany Port

Subject: Landslide and Erosion Hazard Assessment
Fircrest School Master Plan
Shoreline, Washington
SSGC Project No. 22012

Ms. Port,

South Sound Geotechnical Consulting (SSGC) has prepared this landslide and erosion hazard assessment at the DSHS Fircrest School in Shoreline, Washington. Our services have been completed in general conformance with our proposal P21160 (dated December 21, 2021) and authorized per AHBL subconsultant agreement. Our scope of services included a site visit, review of available geologic, soil, topographic, and geologic hazard maps, and preparation of this report.

PROJECT INFORMATION

The project area is on the east side of the Fircrest campus. Construction of new residential cottages is planned in the central portion of the campus near the east boundary. This area is near the base of a west-facing slope that extends up to the ballfields of Shorecrest High School. We understand the City of Shoreline is requesting a landslide hazard assessment of the slope regarding future development plans.

DOCUMENT REVIEW

The following documents were reviewed as part of our assessment of this site:

- Shoreline Municipal Code (SMC).
- USGS "Geologic Map of Northeastern Seattle (Part of the Seattle North 7.5' x 15'Quadrangle), King County", 2009.
- USDA NRCS Soil Survey of King County Area, Washington.
- King County iMap System.
- Washington State DNR Geologic Information Portal Web Site.

Document Summary

Native soil on the west-facing slope have been classified on the referenced USGS map as Vashon Stade glacial till. Ice-contact deposits are mapped at the top of the slope on the Shorecrest High School grounds. Till is described as a compact diamict of silt, sand, and gravel deposited directly under the last advancing glacial ice-sheet.

Native soil on the slope is mapped as “Alderwood gravelly sandy loam” per the USDA Soil Conservation Service map of King County. Alderwood soils reportedly formed in glacial till/drift.

Slopes on the property are not shown as having landslide susceptibility on the DNR Geologic Information portal or King County iMap system. Portions of the slope in the northern side of the Fircrest campus are shown on the King County iMap system as a potential soil erosion hazard. The slope near the planned cottages is not mapped as an erosion hazard.

Topography of the west-facing slope shows an elevation change of about 50 feet per King County GIS topographic information. Average slope inclination is on the order of 30 to 35 percent.

SITE CONDITIONS

SSGC completed a reconnaissance of the west-facing slope on February 1, 2022. Site observations include:

- The west-facing slope is vegetated with a mixture of young and mature deciduous and conifer trees with an understory of vines, ferns, grasses, and brush. Mature fir trees exhibited generally straight trunks.

- A drainage ditch and culvert system is at the base of the slope. North of the planned cottage building area, the lower portion of the slope above the ditch has been previously graded to a near vertical cut-face. Exposed soils in the cut-face appeared to be glacial till. No excessive erosion or evidence of slope movement was observed in the cut-face.

- A rockery extends across a portion of the slope base on the east side of the existing parking lot. The tallest portion of the rockery is on the order of 7 (+/-) feet tall. No evidence of deformation (e.g. bulging of rocks) was observed.

- Evidence of recent slope movement (such as slumps, slides, tension cracks, head scarps, etc.) was not observed on the slope.

- No evidence of excessive erosion was observed on the slope.

- The presence of seeps or springs was not observed on the slope at the time of our site visit. Wet soil vegetation (such as horsetail, rushes, or other) was not observed on or at the base of the slope.

GEOLOGIC HAZARD AREAS DISCUSSION

Chapter 20.80.210 of the SMC addresses geologic hazards. Based upon our review of the referenced documents and our field observations, we offer the following statements regarding the geologic hazard areas as described in the SMC.

Landslide Hazard

The SMC utilizes landslide hazard indicators that include the combination of slope inclinations and heights, soil conditions, groundwater conditions, and surface expressions of past or ongoing slope movement. The west-facing slope has an average inclination between about 30 to 35 percent. Locally steeper cut-slopes have inclinations near vertical. No evidence of recent landslide activity was apparent on the slope or on neighboring properties at the time of our site visit.

Based on our site observations and document review, this parcel is not considered a Landslide Hazard Area. The slope appears to consist of dense, glacially consolidated till. We understand planned cottage development is west of the base of the slope and existing parking lot. Construction of the cottages should not adversely affect stability of the west-facing slope.

Erosion Hazard

Native soils are reported to have slight to moderate potential for erosion per the USDA Soil Conservation Service. Evidence of natural erosion was not observed on slopes during our site visit. Excessive erosion was not observed in graded cut slopes.

Regarding construction of the planned development, it is our opinion Best Management Practices (BMP) for erosion control (silt fencing, straw bales, etc) can be utilized such that the risk of off-site transport of sediment is limited during construction. Additional erosion control measures may be necessary if earthwork is scheduled during the wetter seasons. All erosion control provisions should follow City of Shoreline regulations to reduce the risk of off-site transport of sediments. Exposed soils following any construction should be vegetated as soon as possible. Irrigation should be minimized on or near slopes. Temporary and permanent stormwater control measures should prevent concentrated flow onto site slopes.

REPORT CONDITIONS

This letter has been prepared for the exclusive use of AHBL, Inc. for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices in the area. No warranties, either express or implied, are intended or made. The opinions and recommendations contained in this letter are based on surface and subsurface conditions observed during our February 1, 2022 site visit and the referenced documents. Should site conditions presented in this document change, or new information become available, the conclusions and recommendations contained herein shall not be considered valid unless SSGC reviews the new/revised information and either verifies or modifies the conclusions in writing. Additional geotechnical evaluations may be necessary based on future development of the site.

We appreciate the opportunity to work with you on this project. Please contact us if we can be of further assistance.

Respectfully,

South Sound Geotechnical Consulting

43126

2-4-22

Timothy H. Roberts, P.E.
Member/Geotechnical Engineer

APPENDIX B

Tree Inventory

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
1	*Chamaecyparis lawsoniana*	Port Orford cedar	26.4	Y	N		x	G	L	Blg 24	
2	*Pseudotsuga menziesii*	Douglas fir	28	Y	N		x	G	L	Blg 24	
3	*Chamaecyparis lawsoniana*	Port Orford cedar	na	N	N		x	P	L/M	Blg 24	Dead, no obvious signs of decay
4	*Chamaecyparis lawsoniana*	Port Orford cedar	na	N	N		x	P	L/M	Blg 24	Dead, no obvious signs of decay
5	*Chamaecyparis lawsoniana*	Port Orford cedar	28.75	Y	N		x	G	L	Blg 24	Double leader
6	*Catalpa sp.*	Catalpa	33	Y	NN		x	G	L	Blg 24	Significant tree
7	*Acer japonica*	Japanese maple	17.5	Y	NN		x	G	L	Blg 24	
8	*Pinus sylvestris*	Scots pine	15.75	Y	NN		x	G	L	Blg 24	
9	*Pseudotsuga menziesii*	Douglas fir	26.5	Y	N		x	G	L	Blg 25	
10	*Aesculus hippocastanum*	Horse chestnut	23.5	Y	NN		x	G	L	Blg 44	Invasive species in WA
11	*Liquidambar styraciflua*	Sweetgum	21	Y	NN		x	G	L	Blg 44	
12	*Chamaecyparis lawsoniana*	Port Orford cedar	18	Y	N		x	G	L	Blg 44	
13	*Acer platanoides*	Norway maple	14.75	Y	IM		x	G	L	Blg 44/45	Species of concern in WA
14	*Juniperus sp.*	Cultivar juniper	11	N	NN		x	G	L	Blg 44	Cultivar unknown
15	*Cedrus atlantica* 'Glauca'	Blue Atlas cedar	22	Y	NN		x	G	L	Blg 44	
16	*Chamaecyparis obtusa*	Hinoki cypress	19.5	Y	NN		x	G	L	Blg 44	Double leader
17	*Chamaecyparis lawsoniana*	Port Orford cedar	18.25	Y	N		x	G	L	Blg 44 (Garden)	Double leader
18	*Acer pseudoplatanus*	Sycamore maple	21	Y	NN		x	G	L	Blg 44 (Garden)	
19	*Metasequoia glyptostroboides*	Dawn redwood	15	Y	NN		x	G	L	Blg 44 (Garden)	
20	*Acer pseudoplatanus*	Sycamore maple	28.5	Y	NN		x	G	L	Blg 66	Triple leader, species of concern in WA
21	*Pinus sylvestris*	Scots pine	16	Y	NN		x	G	L	Blg 66	
22	*Acer circinatum*	Vine maple	30	Y	N		x	F	L	Blg 64	Quadruple leader; dieback on one leader
23	*Platanus occidentalis*	American sycamore	54	Y	NN		x	G	L	Blg 47	Significant tree
24	*Acer platanoides*	Norway maple	18.5	Y	IM		x	G	L	Blg 47/48	Species of concern in WA
25	*Platanus occidentalis*	American sycamore	45	Y	NN		x	G	L	Blg 48	Significant tree
26	*Acer pseudoplatanus*	Sycamore maple	20	Y	NN		x	G	L	Blg 48	Species of concern in WA
27	*Platanus occidentalis*	American sycamore	23	Y	NN		x	G	L	Blg 48/49	
28	*Pinus ponderosa*	Ponderosa pine	18	Y	N		x	G	L	Blg 48/49	
29	*Acer platanoides*	Norway maple	18	Y	IM		x	G	L	Blg 49	Species of concern in WA
30	*Acer platanoides*	Norway maple	20	Y	IM		x	G	L	Blg 49	Species of concern in WA
31	*Cedrus atlantica 'Glauca'*	Blue Atlas cedar	13.5	Y	NN		x	G	L	Blg 65/51	
32	*Prunus serrulata 'Kwanzan'*	Kwanzan cherry	15	Y	NN		x	F/P	L/M	Blg 51/50	Tree very stressed
33	*Pyrus calleryana*	Callery pear	14	Y	NN		x	G/F	L	Blg 52	Poor branch structure
34	*Cedrus atlantica 'Glauca'*	Blue Atlas cedar	13.5	Y	NN		x	G	L	Blg 53	
35	*Pseudotsuga menziesii*	Douglas fir	20	Y	N		x	G	L	Blg 53	
36	*Pseudotsuga menziesii*	Douglas fir	37	Y	N		x	G	L	Blg 53	

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
37	*Populus balsamifera ssp. trichocarpa*	Black cottonwood	13–20	Y	N	x		G	L	Blg 91	Understory: Natives: *Gaultheria shallon, Pteridium aquilinum, Mahonia nervosa, Rubus ursinus, Tsuga heterophylla* Invasives: *Hedera helix, Ilex aquifolium, Rubus armeniacus , Crataegus monogyna, Prunus*
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Acer platanoides	Norway maple		Y	IM						
	Arbutus menziesii	Pacific madrone		Y	N						
	Tsuga heterophylla	Western hemlock		Y	N						
	Thuja plicata	Western redcedar		Y	N						
38	*Pinus monticola*	Western white pine	12.5	Y	N		x	G	L	Blg 91 Parking area	
39	*Picea pungens*	Colorado blue spruce	9	N	NN		x	G	L	Blg 51	
40	*Cedrus deodara*	Deodar cedar	28	Y	NN		x	G	L	Blg 50	
41	*Acer rubrum*	Red maple	32	Y	NN		x	P	M	Blg 49	Mostly dead. Recommend removal.
42	*Platanus occidentalis*	American sycamore	41	Y	NN		x	G	L	Blg 49/48	Significant tree
43	*Platanus occidentalis*	American sycamore	39	Y	NN		x	G	L	Blg 49/48	Significant tree
44	*Acer platanoides*	Norway maple	22.5	Y	IM		x	G	L	Blg 48	Species of concern in WA
45	*Acer pseudoplatanus*	Sycamore maple	19	Y	NN		x	G	L	Blg 47	
46	*Acer pseudoplatanus*	Sycamore maple	22	Y	NN		x	G	L	Bldg 47/46	
47	*Aesculus hippocastanum*	Horse chestnut	15.5	Y	NN		x	G	L	Bldg 32/31	Invasive species in WA
48	*Prunus serrulata 'Kwanzan'*	Kwanzan cherry	15	Y	NN		x	G	L	Blg 39	
49	*Prunus serrulata 'Kwanzan'*	Kwanzan cherry	11	Y	NN		x	G	L	Blg 39	
50	*Acer platanoides*	Norway maple	14–25	Y	IM	x		G	L	Blg 85	9 trees total, 1 large beaked hazelnut shrub (*Corylus cornuta*) also in the grove.
	Acer platanoides	Norway maple		Y	IM						
	Acer platanoides	Norway maple		Y	IM						
	Acer platanoides	Norway maple		Y	IM						
	Acer platanoides	Norway maple		Y	IM						
	Aesculus hippocastanum	Horse chestnut		Y	NN						
	Aesculus hippocastanum	Horse chestnut		Y	NN						
	Malus spp.	Fruiting apple		Y	NN						
	Pyrus calleryana	Callery pear		N	NN						
51	*Ilex aquifolium*	English holly	~30	Y	IM		x	G	L	Blg 85	Invasive species in WA. Many leader tree
52	*Ilex aquifolium*	English holly	~30	Y	IM		x	G	L	Blg 85	Invasive species in WA. Many leader tree
53	*Acer platanoides*	Norway maple	18	Y	IM		x	G/F	L	Blg 85/86	Species of concern in WA
54	*Aesculus hippocastanum*	Horse chestnut	20	Y	NN		x	G	L	Blg 85/86	Invasive species in WA
55	*Acer platanoides*	Norway maple	19.5	Y	IM		x	G	L	Blg 89/90	Species of concern in WA
56	*Acer platanoides*	Norway maple	8–15	N	IM	x		G	L	Edge of property along Blg 34–39	Understory: *Rubus armeniacus, Hedera helix, Mahonia nervosa, Prunus laurocerasus, Gaultheria shallon, Symphoricarpos albus, Polystichum munitum, Thuja plicata* (sapling), *Geranium robertianum*
	Acer pseudoplatanus	Sycamore maple		N	NN						
	Aesculus hippocastanum	Horse chestnut		Y	NN						
	Arbutus menziesii	Pacific madrone		Y	N						
	Picea spp.	Spruce		Y	NN						
	Pseudotsuga menziesii	Douglas fir		Y	N						

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
57	*Pseudotsuga menziesii*	Douglas fir	26	Y	N		x	G	L	Blg 39 edge	
58	*Pseudotsuga menziesii*	Douglas fir	31	Y	N		x	G	L	Blg 39 edge	
59	*Pseudotsuga menziesii*	Douglas fir	28	Y	N		x	G	L	Blg 39 edge	
60	*Acer macrophyllum*	Bigleaf maple	30	Y	N		x	G	L		
61	*Acer platanoides*	Norway maple	12–35	Y	IM	x		G	L	Edge of property adjacent to Blg 28	Understory: *Rubus armeniacus, Convolvulus arvensis, Ranunculus repens, Pteridium aquilinum, Geranium robertianum, Epilobium ciliatum, Hedera helix, Rumex crispus*
	Acer pseudoplatanus	Sycamore maple		Y	NN						
	Aesculus hippocastanum	Horse chestnut		Y	NN						
	Arbutus menziesii	Pacific madrone		Y	N						
	Prunus emarginata	Bitter cherry		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western hemlock		Y	N						
62	*Pseudotsuga menziesii*	Douglas fir	14	Y	N		x	G	L	Blg 28	
63	*Acer macrophyllum*	Bigleaf maple	8–35	Y	N	x				Edge of property adjacent to open field	Multistem madrones. Some are partially dead. Madrones ~14" dbh. Understory: *Symphoricarpos albus, Rubus armeniacus, Rubus ursinus, Ilex aquifolium, Dactylis glomerata, Hedera helix, Mahonia nervosa, Crataegus monogyna, Mahonia aquifoium, Plantago lanceolata*
	Alnus rubra	Red alder		Y	N						
	Arbutus menziesii	Pacific madrone		Y	N						
	Arbutus menziesii	Pacific madrone		Y	N						
	Arbutus menziesii	Pacific madrone		Y	N						
	Arbutus menziesii	Pacific madrone		Y	N						
	Cornus nuttalli	Pacific dogwood		Y	N						
	Cornus nuttalli	Pacific dogwood		Y	N						
	Cornus nuttalli	Pacific dogwood		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western redcedar		Y	N						
64	*Thuja plicata*	Western redcedar	28.5	Y	N		x	G	L	Parking lot in south	
65	*Ilex aquifolium*	English holly	19	Y	IM		x	G	L		Double leader. Invasive species in WA.
66	*Ilex aquifolium*	English holly	20	Y	IM		x	G	L		Double leader. Invasive species in WA.
67	*Pseudotsuga menziesii*	Douglas fir	26	Y	N		x	G	L		
68	*Arbutus menziesii*	Pacific madrone	12	Y	N		x	G	L		Significant tree
69	*Alnus rubra*	Red alder	40	Y	N		x	G	L		~7 leaders
70	*Prunus emarginata*	Bitter cherry	30	Y	N		x	G	L		~6 leaders, thicket

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
71	*Pseudotsuga menziesii*	Douglas fir	~20	Y	N	x		G	L		10 Douglas fir and 1 Western redcedar in grove. Understory: *Ilex aquifolium, Juniperus* sp (shrub), *Acer platanoides* (sapling), ornamental rose
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western redcedar		Y	N						
72	*Populus balsamifera ssp. trichocarpa*	Black cottonwood	18	Y	N		x	G/F	L		Suckering at base
73	*Platanus occidentalis*	American sycamore	39	Y	NN		x	G	L		Significant tree
74	*Platanus occidentalis*	American sycamore	24	Y	NN		x	G	L		Some dead branches. Recommend pruning.
75	*Prunus serrulata 'Kwanzan'*	Kwanzan cherry	15	Y	NN		x	F	L		Overtaken by Himalayan blackberry
76	*Quercus rubra*	Northern red oak	30	Y	NN		x	G	L		
77	*Platanus occidentalis*	American sycamore	~80	Y	NN		x	G	L		4 leaders
78	*Prunus serrulata 'Kwanzan'*	Kwanzan cherry	24	Y	NN		x	G/F	L		Drought stress, some dieback
79	*Acer pseudoplatanus*	Sycamore maple	22	Y	NN		x	F	L		Branch dieback
80	*Platanus occidentalis*	American sycamore	28	Y	NN		x	G	L		
81	*Ulmus spp.*	Elm	25	Y	NN		x	F	L		Dieback on the crown. Surrounded by dense invasive species.
82	*Aesculus hippocastanum*	Horse chestnut	17.5	Y	NN		x	F	L		Dieback on the crown.
83	*Acer pseudoplatanus*	Sycamore maple	28	Y	NN		x	G	L		Multistem
84	*Acer platanoides*	Norway maple	22	Y	IM		x	G	L		
85	*Acer pseudoplatanus*	Sycamore maple	25	Y	NN		x	G/F	L		Some crown dieback
86	*Acer pseudoplatanus*	Sycamore maple	35	Y	NN		x	G	L		Multistem
87	*Acer pseudoplatanus*	Sycamore maple	40	Y	NN		x	G	L		7 leaders
88	*Acer pseudoplatanus*	Sycamore maple	35	Y	NN		x	G	L		6 leaders
89	*Acer pseudoplatanus*	Sycamore maple	15	Y	NN		x	G	L		2 leaders
90	*Acer pseudoplatanus*	Sycamore maple	35	Y	NN		x	G	L		5 leaders
91	*Aesculus hippocastanum*	Horse chestnut	17	Y	NN		x	G	L		Invasive species in WA.
92	*Acer macrophyllum*	Bigleaf maple	39	Y	N		x	G	L		3 leaders
93	*Aesculus hippocastanum*	Horse chestnut	17	Y	NN		x	G	L	Located in dog park.	Invasive species in WA.

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
94	*Platanus occidentalis*	American sycamore	38	Y	NN		x	G	L	Located in dog park.	
95	*Aesculus hippocastanum*	Horse chestnut	18.5	Y	NN		x	G	L	Located in dog park.	Invasive species in WA.
96	*Quercus rubra*	Northern red oak	24.5	Y	NN		x	G/F	L	Located in dog park.	Small branch dieback
97	*Quercus rubra*	Northern red oak	24	Y	NN		x	G/F	L	Located in dog park.	Small branch dieback. Recommend pruning to reduce risk of branches falling in dog park.
98	*Platanus occidentalis*	American sycamore	20	Y	NN		x	G	L	Located in dog park.	
99	*Platanus occidentalis*	American sycamore	34	Y	NN		x	G	L	Located in dog park.	
100	*Chamaecyparis lawsoniana*	Port Orford cedar	26	Y	N		x	G	L	Located in dog park.	
101	*Chamaecyparis lawsoniana*	Port Orford cedar	26	Y	N		x	F	L	Located in dog park.	Interior branches are dead (close to other tree)
102–104	*Missed using these numbers in the field*										
105	*Thuja plicata*	Western redcedar	24	Y	N		x	G	L		
106	*Acer platanoides*	Norway maple	32	Y	IM	x		G	L	NE Corner of the property	
	Acer platanoides	Norway maple	12.5–30	Y	IM						
	Chamaecyparis cultivar	Yellow-leaved cypress		Y	NN						
	Picea sylvestris	Scots pine		Y	NN						
	Prunus emarginata	Bitter cherry		Y	N						
107	*Ilex aquifolium*	English holly	~18–23	Y	IM	x		G	L	NE Corner of the property	Understory: *Corylus cornuta, Pteridium aquilinum, Gaultheria shallon*
	Pinus monticola	Western white pine		Y	N						
	Pinus sylvestris	Scots pine		Y	NN						
	Prunus emarginata	Bitter cherry		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
108	*Acer platanoides*	Norway maple	~18–27	Y	IM	x		G	L	NE Corner of the Property	Understory: *Rubus armeniacus, Pteridium aquilinum*
	Arbutus menziesii	Pacific madrone		Y	N						
	Crataegus monogyna	Common hawthorn		Y	I						
	Pseudotsuga menziesii	Douglas fir		Y	N						
109	*Arbutus menziesii*	Pacific madrone	23	Y	N		x	G	L		
110	*Pseudotsuga menziesii*	Douglas fir	10	N	N		x	G	L		
	Pinus ponderosa	Ponderosa pine	25-Nov	Y	N		x	G	L	Back strip along road	Understory: *Rubus ursinus, Hedera helix, Rubus armeniacus, Gaultheria shallon, Oemleria cerasiformis*
111	*Acer platanoides*	Norway maple	12–30	Y	IM	x		G	L		
	Thuja plicata	Western redcedar		Y	N						

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
112	*Tsuga heterophylla*	Western hemlock	20	Y	N		x	G	L		
113a	*Pseudotsuga menziesii*	Douglas fir	32	Y	N	x		G	L		Duplicate entry of 113 in the field. Have been
113b	*Thuja plicata*	Western redcedar	36.5	Y	N	x		G	L		Duplicate entry of 113 in the field. Have been relabeled as 113a and 113b to differentiate groups.
	Pinus monticola	Western white pine	20–36	Y	N			G	L		
	Alnus rubra	Red alder		Y	N			G	L		
114	*Arbutus menziesii*	Pacific madrone	22	Y	N	x		G	L	Back fence	Understory: *Gaultheria shallon*
	Thuja plicata	Western redcedar	12+	Y	N			G	L		
	Pinus ponderosa	Ponderosa pine		Y	N			G	L		
115	*Thuja plicata*	Western redcedar	15–24	Y	N	x		G	L	Woodshed area	Understory: *Vaccinium parvifolium, Pteridium aquilinum, Mahonia nervosa, Polystichum*
	Tsuga heterophylla	Western hemlock		Y	N						
116	*Arbutus menziesii*	Pacific madrone	8–25	Y	N	x		G	L		Understory: *Mahonia nervosa, Gaultheria shallon*
	Ilex aquifolium	English holly		N	IM						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western redcedar		Y	N						
	Tsuga heterophylla	Western hemlock		Y	N						
117	*Cedrus deodara*	Deodar cedar	20	Y	NN		x	G	L		
118	*Tsuga heterophylla*	Western hemlock	25	Y	N		x	G	L		
119	*Pseudotsuga menziesii*	Douglas fir	25	Y	N		x	G	L		
120	*Pinus monticola*	Western white pine	9–14	Y	N	x		G/F	L	North of Blg 56	Planted too close together and scraggly
	Pinus monticola	Western white pine		N	N						
	Pinus monticola	Western white pine		N	N						
	Pinus monticola	Western white pine		N	N						
	Pinus monticola	Western white pine		Y	N						
121	*Pinus sylvestris*	Scots pine		Y	NN						
122	*Acer platanoides*	Norway maple	14–25	Y	IM	x				West of Blg 55	About 35 trees. Understory: *Gaultheria shallon, Pteridium aquilinum*
	Populus balsamifera ssp. trichocarpa	Black cottonwood		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
123	*Arbutus menziesii*	Pacific madrone		Y	N	x				NW of BLg 55	Understory: *Gaultheria shallon*
	Pinus sylvestris	Scots pine		Y	NN						
	Pseudotsuga menziesii	Douglas fir			N						
124	*Pinus sylvestris*	Scots pine	30	Y	NN		x	G	L		Around 10 leaders
125	*Prunus serrulata 'Kwanzan'*	Kwanzan cherry	15	Y	NN						
126	*Alnus rubra*	Red alder	~8–28	N	N	x				NW of BLg 59	Madrones are in good condition. Large conifers. Understory: *Gaultheria shallon, Pteridium aquilinum*
	Arbutus menziesii	Pacific madrone		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western redcedar		Y	N						

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
127	*Arbutus menziesii*	Pacific madrone	~8–25	Y	N	x		F/P	M	North of Blg 60	Pines not doing well. Branch dieback around 30' up. Very large madrone.
	Pinus monticola	Western white pine		Y	N						
128	*Acer macrophyllum*	Bigleaf maple	~8–25	Y	N	x		G	L	Many large ARME at the base of the hill	Understory: *Crataegus monogyna, Rubus armeniacus, Pteridium aquilinum, Gaultheria shallon, Prunus laurocerasus*
	Aesculus hippocastanum	Horse chestnut		N	NN						
	Arbutus menziesii	Pacific madrone		Y	N						
	Ilex aquifolium	English holly		N	IM						
	Pinus monticola	Western white pine		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western redcedar		Y	N						
	Tsuga heterophylla	Western hemlock		Y	N						
129	*Prunus laurocerasus*	English laurel	24	N	IM		x				4 leaders. Invasive species.
130	*Cercis canadensis*	Eastern redbud	12	Y	NN	x		G/F	L	South of Blg 60	1 dead, 4 live POTR.
	Picea pungens	Colorado blue spruce		Y	NN						
	Populus tremuloides	Quaking aspen		Y	N						
	Pseudotsuga menziesii	Douglas fir	~31	Y	N						
131	*Arbutus menziesii*	Pacific madrone	~10–30+	Y	N	x		G	L		
	Pinus monticola	Western white pine		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
132	*Arbutus menziesii*	Pacific madrone	~15–30	Y	N	x		G	L	Blg 65	Adjacent to the largest grove (176). No understory.
	Pinus monticola	Western white pine		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western redcedar		Y	N						
133	*Acer pseudoplatanus*	Sycamore maple	8–22	N	NN	x				Field	Maple is dead
	Aesculus hippocastanum	Horse chestnut		N	NN						
	Platanus occidentalis	American sycamore		Y	NN						
	Thuja plicata	Western redcedar		Y	N						
134	*Quercus rubra*	Northern red oak	27.5	Y	NN		x			Field	
	Platanus occidentalis	American sycamore	12–24	Y	NN		x			Field	
135	*Platanus occidentalis*	American sycamore	25	Y	NN						
	Acer platanoides 'Crimson King'	Crimson King Norway maple	20	Y	IM						
	Pinus sylvestris	Scots pine	21	Y	NN						
	Pinus ponderosa	Ponderosa pine	20	Y	N						
136	*Abies concolor*	White fir	12	Y	NN		x	F/P	L	Planting median	Declining
	Pinus strobus	Eastern white pine	15	Y	NN	x		G	L	Planting median	4 trees
137	*Arbutus menziesii*	Pacific madrone	12	Y	N		x	G	L		
	Betula pendula	Weeping silver birch	12	Y	NN		x	G	L		
	Betula pendula	Weeping silver birch	12	Y	NN		x	G	L		
	Pinus monticola	Western white pine	24–30	Y	N	x		G	L		3 trees

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
138	*Pinus sylvestris*	Scots pine	11.5	N	NN		x	G	L	Parking median	
	Pinus sylvestris	Scots pine	11	N	NN		x	G	L		
	Pinus sylvestris	Scots pine	11	N	NN		x	G	L		
139	*Pinus contorta*	Shore pine	24	Y	N		x	F/P	L/M		Declining
140	*Chamaecyparis lawsoniana*	Port Orford cedar	20	Y	N			G	L	Little grove	
141	*Pinus monticola*	Western white pine	38	Y	N		x	G	L		
142	*Pseudotsuga menziesii*	Douglas fir	~8–25	N/Y	N	x		G	L		18 trees
	Aesculus hippocastanum	Horse chestnut	~22–24	Y	NN	x		G	L		3 trees
143	*Liquidambar styraciflua*	Sweetgum	22	Y	NN		x	G	L		
	Pinus ponderosa	Ponderosa pine	25	Y	N		x	G	L		
144	*Pinus ponderosa*	Ponderosa pine	26	Y	N		x	G	L		
145	*Acer macrophyllum*	Bigleaf maple	23	Y	N		x	G	L	Edge hedge	
	Acer macrophyllum	Bigleaf maple	30+	Y	N	x		G	L		4 trees
	Aesculus hippocastanum	Horse chestnut	20	Y	NN		x	G	L		Invasive species in WA
	Platanus occidentalis	American sycamore	15	Y	NN		x	G	L		
	Pseudotsuga menziesii	Douglas fir	12–25	Y	N	x		G	L		40+ trees
146	*Thuja plicata*	Western redcedar	18	Y	N		x	G	L		
147	*Aesculus hippocastanum*	Horse chestnut	16	Y	NN		x	G	L		Invasive species in WA
148	*Abies sp.*	Fir	24	Y	N		x	F	L	No access, end of site	Declining
	Acer platanoides 'Crimson King'	Crimson King Norway maple	15	Y	IM		x	G	L		1 dead tree in 148 grove
	Aesculus hippocastanum	Horse chestnut		Y	N		x	G	L		
	Betula pendula	European white birch		Y	N		x	G	L		
	Pinus monticola	Western white pine		Y	N		x	G	L		
	Platanus occidentalis	American sycamore	26.5	Y	NN		x	G	L		Significant tree, 3 trees total
149	*Platanus occidentalis*	American sycamore	41.5	Y	NN		x	G	L		Significant tree
150	*Acer pseudoplatanus*	Sycamore maple		Y	NN	x		G	L		13 total
	Aesculus hippocastanum	Horse chestnut	12	Y	NN		x	G	L		
	Platanus occidentalis	American sycamore	26.5	Y	NN		x	G	L		Significant tree
	Ulmus spp.	Elm		Y	NN		x	F/P	L		Dead leader, declining
151	*Acer rubrum*	Red maple	33	Y	NN		x	G	L		
	Platanus occidentalis	American sycamore	14	Y	NN		x	G/F	L		Branch dieback
	Platanus occidentalis	American sycamore	30	Y	NN		x	G	L		
	Platanus occidentalis	American sycamore	30	Y	NN		x	G	L		
	Quercus rubra	Northern red oak	22	Y	NN		x	G/F	L		Branch dieback
152	*Betula pendula*	European white birch	15	Y	NN		x	G	L		
153	*Pseudotsuga menziesii*	Douglas fir	13	Y	N		x	G	L	at stairs	
	Arbutus menziesii	Pacific madrone	12	Y	N		x	G	L		
154	*Acer macrophyllum*	Bigleaf maple	30	Y	N		x	G	L		Understory: *Hedera helix, Cistus scoparius*
155	*Robinia pseudoacacia*	Black locust	28	Y	NN		x	G	L		Invasive species in WA

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
156	*Aesculus hippocastanum*	Horse chestnut	16	Y	NN		x	G	L	lot	
	Arbutus menziesii	Pacific madrone	25	Y	N		x	G	L		
	Juniperus virginiana	Eastern red cedar	30	Y	NN		x	G	L		
	Malus spp.	Fruiting apple		N	NN		x	G	L		
	Pseudotsuga menziesii	Douglas fir	25	Y	N		x	G	L		
	Robinia pseudoacacia	Black locust		N	NN		x	G	L		
157	*Populus balsamifera ssp. trichocarpa*	Black cottonwood	~90	Y	N		x	G	L	retaining wall	
158	*Acer pseudoplatanus*	Sycamore maple	17	Y	NN		x	G	L		
159	*Pinus monticola*	Western white pine	26	Y	N		x	G	L		
160	*Acer macrophyllum*	Bigleaf maple	25	Y	N		x	G	L		
161	*Arbutus menziesii*	Pacific madrone	22	Y	N		x	G	L		
162	*Aesculus hippocastanum*	Horse chestnut	23	Y	NN		x	G	L		
163	*Pseudotsuga menziesii*	Douglas fir	9.5–10	N	N	x		G	L		4 trees
164	*Pseudotsuga menziesii*	Douglas fir	23	Y	N		x	G	L	Small path median	
165	*Thuja plicata*	Western redcedar	16–21	Y	N	x		G	L		7 trees
	Tsuga heterophylla	Western hemlock		Y	N						
166	*Pinus monticola*	Western white pine		Y	N	x		G	L		Understory: *Rubus armeniacus, Gaultheria shallon*
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western redcedar		Y	N						
167	*Pseudotsuga menziesii*	Douglas fir	22	Y	N		x	G	L		
168	*Tsuga heterophylla*	Western hemlock	26.5	Y	N		x	G	L		
169	*Pinus monticola*	Western white pine	38	Y	N		x	G	L		
170	*Pseudotsuga menziesii*	Douglas fir	18–24	Y	N	x		G	L		3 trees
	Thuja plicata	Western redcedar	24	Y	N		x	G	L		
	Prunus serrulata 'Kwanzan'	Kwanzan cherry	19	Y	NN		x	G	L		
171	*Arbutus menziesii*	Pacific madrone	20	Y	N						
	Chamaecyparis lawsoniana	Port Orford cedar	20	Y	N						
	Chamaecyparis lawsoniana	Port Orford cedar	18	Y	N						
	Paulownia tomentosa	Princess tree	12	Y	NN		x				
	Pinus sylvestris	Scots pine	12	Y	NN						
	Pinus sylvestris	Scots pine	10	N	NN						
	Pseudotsuga menziesii	Douglas fir	12	Y	N	x					3 trees
	Thuja plicata	Western redcedar	41	Y	N						
	Tsuga heterophylla	Western hemlock	23	Y	N		x				
	Tsuga heterophylla	Western hemlock	37	Y	N		x				
	Zelkova serrata	Japanese zelkova	12	Y	NN		x	G	L		

Fircrest Tree Survey – 2018

Tree ID Number	*Species*	Common Name	Diameter at Breast Height (DBH	Significant Tree?	Native, Nonnative, Invasive Monitor*, Invasive	Tree Grove	Tree Specimen	Health (Good, Fair, Poor)	Risk (Low, Medium, High)	Location (By Building [Blg] Number)	Notes
172	*Populus tremuloides*	Quaking aspen	24	Y	N		x	G	L		multi-stem
	Populus tremuloides	Quaking aspen	20	Y	N		x	G	L		multi-stem
	Populus tremuloides	Quaking aspen	18	Y	N		x	G	L		
	Populus tremuloides	Quaking aspen	14	Y	N		x	G	L		
	Populus tremuloides	Quaking aspen	12	Y	N		x	G	L		
	Populus tremuloides	Quaking aspen	12	Y	N		x	G	L		
173	*Populus tremuloides*	Quaking aspen	14	Y	N		x	G	L		
174	*Pinus monticola*	western white pine	37	Y	N		x	G	L		
175	*Thuja plicata*	Western redcedar	36	Y	N		x	G	L		
176	*Acer macrophyllum*	Bigleaf maple	12–30+	Y	N	x		G	L	Very large grove, around chapel/ Blg 64. Pacific madrones of significant size.	Understory: *Pteridium aquilinum, Rubus armeniacus, Gaultheria shallon, Sorbus sp., Vaccinium parvifolium, Polystichum munitum*
	Arbutus menziesii	Pacific madrone		Y	N						
	Pinus monticola	Western white pine		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Thuja plicata	Western redcedar		Y	N						
177	*Acer macrophyllum*	Bigleaf maple	12–30+	Y	N	x		G	L	Along Blg 66	Understory: *Pteridium aquilinum, Rubus armeniacus, Gaultheria shallon, Polystichum munitum*
	Arbutus menziesii	Pacific madrone		Y	N						
	Pinus monticola	Western white pine		Y	N						
	Pseudotsuga menziesii	Douglas fir		Y	N						
	Tsuga heterophylla	Western hemlock		Y	N						
	Thuja plicata	Western redcedar		Y	N						

* **Invasive Monitor (IM)** refers to WA State Noxious Weed Guidelines for species that should be monitored for invasive tendencies, but it not yet listed as noxious.

APPENDIX C

Photographic Log

CRITICAL AREAS REPORT:
FIRCREST SCHOOL CAMPUS MASTER PLAN—
PHOTOGRAPHIC LOG

Photo Number	Photo Description
1	Fircrest campus overview
2	East Hamlin Creek site investigation
3	East Hamlin Creek site investigation
4	Typical specimen tree—London planetree (*Platanus x acerifolia*) on campus
5	Typical tree grove—mix of species and sizes with an understory
6	Example of a specimen tree growing close to campus buildings
7	Typical tree grove with Pacific madrone (*Arbutus menziesii*) and Scotch pine (*Pinus sylvestris*)
8	Population of domesticated rabbits that are feral on campus
9	Typical specimen trees adjacent to buildings
10	Specimen trees and tree groves in the outer campus

1

2

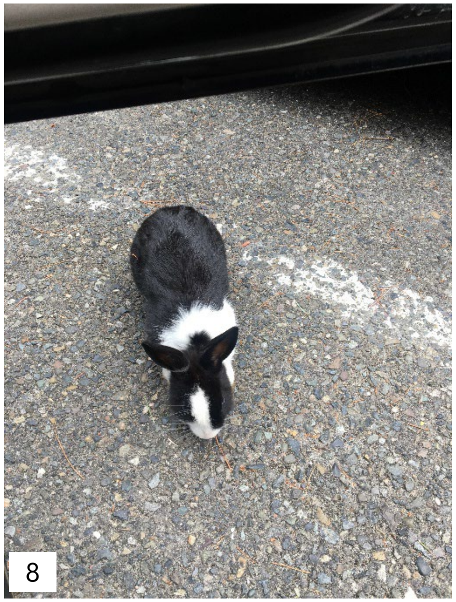
3

4

5

6

7



8

9

10

DRAFT

REPORT OF GEOTECHNICAL ENGINEERING SERVICES

Fircrest Adult Training Program Renovation
1902 NE 150th Street
Shoreline, Washington

For
Trinity NAC
March 22, 2021

Project: NAC-1-02

March 22, 2021

Trinity NAC
2502 1st Avenue, Suite 200
Seattle, WA 98121-3131

Attention: Bill Rash, AIA, NCARB

Report of Geotechnical Engineering Services
Fircrest Adult Training Program Renovation
1902 NE 150th Street
Shoreline, Washington
Project: NAC-1-02

GeoDesign, Inc., DBA NV5 (GeoDesign) is pleased to submit our report of geotechnical engineering services for the planned improvements to the Fircrest Adult Training Program (ATP) renovation project. The project is located at the Washington State Department of Social and Health Services Fircrest facility in Shoreline, Washington. Our services for this project were conducted in accordance with our proposal dated December 9, 2020.

We appreciate the opportunity to be of continued service to you. Please call if you have questions regarding this report.

Sincerely,

GeoDesign, Inc., DBA NV5

DRAFT

Kevin J. Lamb, P.E.
Principal Engineer

JTW:KJL:kt
Attachments
One copy submitted (via email only)
Document ID: NAC-1-02-032221-geor-DRAFT.docx

TABLE OF CONTENTS **PAGE NO.**

TABLE OF CONTENTS **PAGE NO.**

APPENDICES (continued)

ACRONYMS AND ABBREVIATIONS

AC	asphalt concrete
ASCE	American Society of Civil Engineers
ATP	Adult Training Program
ASTM	American Society for Testing and Materials
BGS	below ground surface
BMP	best management practice
CEC	cation exchange capacity
CSBC	crushed surfacing base course
g	gravitational acceleration (32.2 feet/second^2)
H:V	horizontal to vertical
IBC	International Building Code
LID	low-impact development
MCE	maximum considered earthquake
meq/100 g	milliequivalent per 100 grams
OSHA	Occupational Safety and Health Administration
PCC	portland cement concrete
pcf	pounds per cubic foot
pci	pounds per cubic inch
PIT	pilot infiltration test
psf	pounds per square foot
SFZ	Seattle fault zone
SPT	standard penetration test
WSS	Washington Standard Specifications for Road, Bridge, and Municipal Construction (2020)

1.0 INTRODUCTION

This report presents the results of GeoDesign's geotechnical investigation to support the planned improvements to the Fircrest ATP renovations project. The project is located at the Washington State Department of Social and Health Services Fircrest facility in Shoreline, Washington. The project includes interior improvements to the existing ATP building and construction of a new parking area.

The site location relative to surrounding physical features is shown on Figure 1. The proposed parking area and locations of our explorations are shown on Figure 2. The existing ATP building and locations of subsurface borings completed by others is shown on Figure 3. The logs of our explorations at the site are presented in Appendix A. The analytical laboratory report of the CEC and organic content test results is presented in Appendix B. An as-built plan for the existing ATP building, which includes logs of geotechnical borings drilled at the northeast and southeast corners of the building (borings B-3 and B-4), is presented in Appendix C.

Acronyms and abbreviations used herein are defined above, immediately following the Table of Contents.

2.0 PROJECT UNDERSTANDING

We understand the proposed improvements are generally limited to interior renovations to the existing ATP building and construction of a new parking area east of the building and on the east side of Circle Drive at the former laundry building location(Figure 2, and Appendix C). The ATP building is located west of 20th Avenue NE and the first floor of the building has been benched into the toe of an east-facing slope. The west wall of the first floor is a retaining wall. Portions of the slope meet the definitions of a geologic hazard area as defined in the City of Shoreline Municipal Code (SMC) 20.80 Critical Areas. Structural improvements and a new elevator are planned for the interior of the building and updated retaining wall parameters and seismic design parameters have been requested.

We reviewed as-built plans for the existing ATP building, which also includes logs of geotechnical borings drilled at the northeast and southeast corners of the building (presented in Appendix C). The general notes on the structural sheets indicate the foundation design is based on an allowable bearing pressure of 4,000 psf and lateral earth pressures are based on an equivalent fluid density of 30 pcf. Subsurface conditions encountered in the borings generally consist of loose to medium dense, silty sand with gravel extending to depths of 5 to 6 feet BGS underlain by glacially consolidated deposits of coarse sand and gravel to silty sand with gravel (glacial till). Groundwater, likely perched above the glacial till layer, was encountered in previous boring B-3 drilled at the northeast corner of the existing ATP building.

3.0 PURPOSE AND SCOPE

The purpose of our geotechnical engineering services was to provide geotechnical information and recommendations to support design and construction of the interior and frontage improvements and parking area as well as support evaluation of the existing retaining wall and the capacity for infiltration of stormwater below the proposed parking area. The specific scope of our services is summarized as follows:

- Reviewed existing information, including plans for the improvements and as-built plans for the existing building that include four existing borings at the existing ATP location.
- Coordinated and managed the field explorations, including public and private utility locates and scheduling of contractors and GeoDesign staff.
- Drilled one boring to a depth of 31 feet BGS and installed a monitoring well in the boring.
- Excavated three test pits to depths between 14 and 14.5 feet BGS. Completed small-scale PITs in each of the test pits at depths requested by the design team.
- Completed laboratory analysis to assist in characterization of physical parameters and water quality treatment characteristics of the soil.
- Performed engineering analysis and evaluated data derived from the subsurface investigation.
- Provided this geotechnical report that summarizes our findings and provides recommendations to support the proposed improvements.

4.0 SITE CONDITIONS

4.1 GENERAL

The site is located at the Washington State Department of Social and Health Services Fircrest facility in Shoreline, Washington. The ATP building is located west of 20th Avenue NE. The proposed parking area is located at the former location of the laundry building on the west side of 20th Avenue NE (Figure 2). Surficial conditions were determined during several visits to the site. Subsurface conditions were evaluated by reviewing existing boring logs, drilling one boring, and excavating three test pits. The soil boring and test pit explorations completed for this study were completed in the proposed parking area (Figure 2).

4.2 SURFACE CONDITIONS

The existing ATP building is located west of 20th Avenue NE and the first floor of the building has been benched into the toe of an east-facing slope. The surrounding area on the northwest and south sides of the building is relatively level. The area north of the building is s landscaped lawn area with a hardscape-surfaced area and planters and is where the geothermal well field is proposed. East the ATP building are residential units with landscaped lawn areas between them. South of the ATP building is a small AC-paved parking area. The west wall of the first floor is a retaining wall and the engineered steep slope above the retaining wall is covered with landscaping and mature evergreen trees. Concrete walkways traverse the slope northwest of the ATP building.

The proposed new parking area is located east of the ATP building on the east side of Circle Drive at the former laundry building location. The laundry building burned down in 2018 and all that remains is the concrete floor slab. Around the perimeter of the slab are AC- and gravel-covered parking areas.

4.3 SLOPES

West of the ATP building the ground surface slopes up to the upland area on the western half of the Fircrest campus. The slope varies from 20 percent to approximately 50 percent, with the steeper slope areas west of the central and southern portions of the ATP building. The vertical elevation change from the ATP building up to the top of the slope is approximately 30 feet.

The slope is well vegetated with brush and trees. Surficial indications of erosion were not observed. The slope appears stable and surficial indicators of deep or shallow slope instability were not observed.

The slope meets the City of Shoreline SMC 20.80.220 classification for Moderate to High Risk geologic hazard areas. The proposed ATP building improvements are not expected to extend into the geologic hazard area and no impacts are anticipated or will require mitigation.

4.4 SUBSURFACE CONDITIONS

4.4.1 General

Our subsurface exploration program consisted of drilling one boring (B-1) to a depth of 31 feet BGS and excavating three test pits (TP-1 through TP-3) to depths between 14 and 14.5 feet BGS. The approximate locations of our explorations are shown on Figure 2. A description of the field exploration program and the exploration logs are presented in Appendix A. We also reviewed as-built plans for the existing ATP building, which include logs of geotechnical borings drilled at the northeast and southeast corners of the building. The as-built plans with the logs are presented in Appendix C.

The test pits were completed around the perimeter of the former laundry building and the boring was completed near the center of the former building area. We encountered approximately 7 inches of concrete in the boring (existing slab) and approximately 6 inches of aggregate base in the test pits.

Fill consisting of medium dense, silty sand with gravel was encountered to depths between approximately 1 foot and 2 feet BGS.

Glacial till consisting of dense to very dense, silty sand with gravel and variable amounts of cobbles was encountered below the fill to depths between 8 and 10 feet BGS. The upper 2 to 3.5 feet of the glacial till in the test pits has been weathered and is distinguished on the logs as "weathered glacial till." It is similar in character to the underlying glacial till but is less dense due to weathering and disturbance. Based on SPT blow counts and excavation difficulty, the glacial till is generally dense to very dense and increases in density with depth.

Advance outwash, generally consisting of dense to very dense, silty sand with some gravel, is present below the glacial till at our exploration locations to the maximum depth in the test pits of 14.5 feet BGS and to 25 feet BGS in boring B-1.

For the existing ATP building, the existing borings generally indicate the subsurface conditions are loose to medium dense, silty sand with gravel extending to depths between 5 and 6 feet BGS underlying glacially consolidated deposits consisting of coarse sand and gravel to silty sand with gravel (glacial till) (Appendix C).

Environmental screening for the presence of volatile organic compounds was completed during excavation of the test pits. Odors or sheens were not noted or observed at the exploration locations.

4.4.2 Groundwater

Groundwater, likely perched above the glacial till layer, was encountered in the existing boring B-3 completed near the northeast corner of the ATP building at depths between 8 and 10 feet BGS.

In our explorations in the proposed parking area, groundwater seepage was not observed in the test pit explorations to the maximum depth explored of 14.5 feet BGS. Groundwater was encountered in boring B-1 at a depth of approximately 20 feet BGS during drilling. A 2-inch-diameter standpipe piezometer was installed in boring B-1 to monitor groundwater levels.

A data logger was installed in the well at a depth of approximately 29.5 feet BGS to record regular groundwater measurements. Depth to groundwater varied from approximately 19 to 20 feet BGS during the monitoring period that extended from February 3, 2021 through March 10, 2021. Groundwater measurements obtained from the well for the monitoring period are shown on Figure 4.

5.0 INFILTRATION TESTING

Small-scale PITs were performed in the three test pits in general accordance with the 2016 City of Shoreline Engineering Development Manual (City of Shoreline, 2016). The test pits were excavated using a mini excavator. The size of test pits was generally rectangular and approximately 2.5 feet wide by 6 feet long. The PITs were performed near the anticipated bottom of the infiltration/detention system at a depth of 8 feet BGS. Soil conditions encountered at the base of the infiltration tests consist generally of dense, silty sand with gravel glacial till (TP-1) or advance outwash (TP-2 and TP-3) material.

An electronic pressure transducer and data logger were placed in the test pits to measure groundwater levels at regular short-term intervals throughout the saturation period and during the test. The test was repeated as time and the infiltration rate permitted. Up to approximately 12 to 18 inches of water was established in the test pit during the test. The infiltration rate measured near the end of the test, which allows for the longest saturation period, is used to calculate the short-term infiltration rate, as summarized in Table 1.

Table 1. Soil Infiltration Rate Analysis

Infiltration Location	Soil Type	Test Depth (feet BGS)	Averaged Measured Short-Term Infiltration Rate (inches per hour)
TP-1	Dense, silty SAND with gravel	8	1.3
TP-2	Dense, silty SAND, trace gravel	8	2.2
TP-3	Dense, silty SAND, minor gravel	8	0.7

6.0 DESIGN RECOMMENDATIONS AND CONCLUSIONS

6.1 GENERAL

Based on our review of the proposed preliminary development plans and the results of our exploration and analyses, it is our opinion that the proposed development is geotechnically feasible. Our recommendations are provided in the following sections.

6.2 SEISMIC DESIGN CRITERIA

6.2.1 Seismicity

Washington State is situated at a convergent continental margin and is susceptible to subduction zone, intraplate, and shallow crustal source earthquakes. We reviewed published geologic maps for the site vicinity to evaluate seismic hazards. The site is approximately 10 miles north of the SFZ.

The SFZ represents a 2- to 4-mile-wide zone, extending from the Kitsap Peninsula near Bremerton to the Sammamish Plateau. Within the SFZ are several east to west-trending fault splays of the Seattle fault (Johnson et al., 1999). The Seattle fault is thought to be a reverse fault, with the south side "shoved up." The SFZ is considered an active major fault and can produce earthquakes of Magnitude ~7 with associated surface rupture and ground motions, posing a significant hazard to the Puget Sound Region (Sherrod et al., 2008). Geologic evidence indicates at least three episodes of movement on the fault within the last 10,000 years, with the most recent earthquake with surface rupture approximately 1,100 years ago (Nelson et al., 2000).

6.2.2 IBC Parameters

Boring B-1 encountered very dense, glacially consolidated soil within 2 feet of the ground surface with SPT blow counts exceeding 50 blows per foot. Similar conditions were encountered in the previous borings drilled for the ATP building and similar conditions are expected to extend to over 100 feet BGS, as confirmed in the geothermal test boring. We believe these conditions support classification of the site as Site Class C. Based on our explorations and analysis, the following design parameters can be applied if the building is designed using the applicable provisions of ASCE 7-16. The parameters in Table 2 should be used to compute seismic base shear forces (ASCE 7-16).

Table 2. ASCE 7-16 Seismic Design Parameters

Parameter	Short Period	1 Second
MCE Spectral Acceleration	S_s = 1.268 g	S_1 = 0.442 g
Site Class	C	
Site Coefficient	F_a = 1.2	F_v = 1.858
Adjusted Spectral Acceleration	S_{MS} = 1.521 g	S_{M1} = 0.664 g
Design Spectral Response Acceleration Parameters	S_{DS} = 1.014 g	S_{D1} = 0.442 g

6.2.3 Landslide Hazards

The site is relatively flat and underlain by dense/hard glacial till deposits. Landslide hazard risk for the site is very low.

6.2.4 Liquefaction

Liquefaction is a phenomenon caused by a rapid increase in pore water pressure that reduces the effective stress between soil particles to near zero. The excessive buildup of pore water pressure results in the sudden loss of shear strength in a soil. Granular soil, which relies on interparticle friction for strength, is susceptible to liquefaction until the excess pore pressures can dissipate.

Based on the results of our explorations, the site in underlain by dense to very dense/hard glacial till consisting of silty sand and sandy silt. We anticipate the potential for liquefaction is very low for this site.

6.2.5 Lateral Spreading

Lateral spreading is a liquefaction-related seismic hazard and occurs on gently sloping or flat sites underlain by liquefiable sediment adjacent to an open face (such as riverbanks). Liquefied soil adjacent to an open face will tend to flow, resulting in surface cracking and lateral displacement towards the open face. The magnitude of lateral spreading decreases with distance from the open face. Based on the soil encountered at the site and distance from an open face, lateral spreading is not considered a hazard at this site.

6.2.6 Surficial Rupture

The site is approximately 10 miles north of the SFZ. The risk of surficial rupture for the site is low.

6.3 SHALLOW FOUNDATIONS

6.3.1 General

The existing ATP building foundations were design using an allowable bearing pressure of 4,000 psf based on the as-built plans. The site is underlain by dense glacial till. New foundations for upgrades within the ATP building, such as the elevator pit, and elsewhere, supported on undisturbed glacial till or outwash soil may be designed using an allowable bearing pressure of 4,000 psf. Where new foundations are located adjacent to an existing foundation, they should bear at similar bottom of foundation elevations as the existing foundations.

6.3.2 Bearing Capacity

Foundations bearing on the dense glacial till or compacted stabilization material placed over it may be sized based on an allowable bearing pressure of 4,000 psf. This is a net bearing pressure; the weight of the footing and overlying backfill can be ignored in calculating footing sizes. The recommended allowable bearing pressure applies to the total of dead plus long-term live loads and may be increased by one-third for short-term loads, such as those resulting from wind or seismic forces. Continuous wall and spread footings should be at least 18 inches wide. The bottom of exterior footings should be at least 18 inches below the lowest adjacent final grade. The bottom of interior footings should be placed at least 12 inches below the base of the floor slab.

6.3.3 Resistance to Sliding

Lateral loads on footings can be resisted by passive earth pressure on the sides of the foundation and by friction on the base of the footings. Passive earth pressure may be estimated using an equivalent fluid density of 350 pcf. Adjacent floor slabs, pavement, or the upper 12-inch depth of adjacent, unpaved areas should not be considered when calculating passive resistance. A coefficient of friction equal to 0.35 may be used when calculating resistance to sliding for footings in direct contact with the glacial till or structural fill. A safety factor of 1.5 has been applied to the recommended sliding friction and passive pressure.

6.3.4 Settlement

For foundations designed in accordance with the recommendations provided above, total post-construction settlement should be less than ½ inch and differential settlement less than ¼ inch.

6.4 FLOOR SLABS

Satisfactory subgrade support for building floor slabs supporting up to 350 psf areal loading can be obtained on subgrade that is scarified and compacted to 95 percent of the maximum dry density, as determined by ASTM D1557.

A minimum 6-inch-thick layer of crushed surfacing base course, WSS 9-03.9(3) – Crushed Surfacing, should be placed and compacted over the prepared subgrade to provide uniform support beneath the slab.

A subgrade modulus of 200 pci may be used to design the floor slab.

The near-surface soil typically has a fines content in excess of 15 percent. In areas where moisture-sensitive floor slab and flooring will be installed, the installation of a vapor barrier is warranted to reduce the potential for moisture transmission through and efflorescence growth on the slab and flooring.

6.5 RETAINING STRUCTURES

6.5.1 Conventional Below-Grade or Retaining Structures

We understand additional analysis is required to evaluate the existing retaining wall. We reviewed as-built plans for the existing ATP building. The general notes on the structural sheets indicate that lateral earth pressures for retaining wall design are based on an equivalent fluid density of 30 pcf. This value is suitable for the dense glacial till soil encountered in the boring and for walls that are free to rotate about their base. Braced walls should be designed for at-rest conditions. Additional recommendations for below-grade walls are provided below.

6.5.1.2 Wall Design Parameters

For unrestrained retaining walls, an equivalent fluid density of 30 pcf is appropriate for design assuming drained conditions and that active earth pressure conditions develop behind the wall as a result of wall deflection. Where retaining walls are restrained from rotation prior to being backfilled, an equivalent fluid density of 45 pcf should be used for design for the at-rest condition.

A superimposed seismic lateral force should be calculated based on a dynamic force of $6.5H^2$ pounds per lineal foot of wall (where H is the height of the wall in feet) and applied a distance of 0.6H above the base of the wall.

If surcharges (e.g., building foundations, vehicles, etc.) are located within a horizontal distance from the back of a wall equal to twice the height of the wall, additional pressures will need to be accounted for in the wall design. Our office should be contacted for appropriate wall surcharges based on the actual magnitude and configuration of the applied loads.

The base of the wall footing excavations should extend a minimum of 12 inches below the lowest adjacent grade and be designed in accordance with the recommendations provided in the "Shallow Foundations" section.

6.5.1.3 Wall Backfill

Backfill material placed behind retaining walls and extending a horizontal distance of ½H (where H is the height of the retaining wall) should consist of select granular material that meets the specifications provided in WSS 9-03.12(2) – Gravel Backfill for Walls. We recommend the select granular wall backfill be separated from general fill, native soil, and/or topsoil using a geotextile fabric that meets the specifications provided in WSS 9-33.2 – Geosynthetic Properties for drainage geotextiles.

Backfill should be placed and compacted as recommended for structural fill, except for backfill placed immediately adjacent to walls. Backfill adjacent to walls should be compacted to a lesser standard to reduce the potential for generation of excessive pressure on the walls. Backfill located within a horizontal distance of 3 feet from the retaining walls should be compacted to approximately 90 percent of the maximum dry density, as determined by ASTM D1557. Backfill placed within 3 feet of the wall should be compacted in lifts less than 6 inches thick using hand-operated tamping equipment (such as a jumping jack or vibratory plate compactor). If flatwork (slabs, sidewalk, or pavement) will be placed adjacent to the wall, we recommend the upper 2 feet of fill be compacted to 95 percent of the maximum dry density, as determined by ASTM D1557.

6.5.1.4 Wall Drainage

The above design parameters have been provided assuming back-of-wall drains will be installed to prevent buildup of hydrostatic pressures behind all walls. If a drainage system is not installed, our office should be contacted for revised design forces.

Positive drainage should be provided behind below-grade walls and retaining walls by placing a minimum 1-foot-wide zone of free-draining backfill directly behind the wall. The free-draining backfill should meet the criteria for WSS 9-03.12(4) – Gravel Backfill for Drains. The free-draining backfill zone should extend from the base of the wall to within 2 feet of the finished ground surface. The top 2 feet of fill should consist of relatively impermeable or native soil to prevent infiltration of surface water into the wall drainage zone.

Perforated collector pipes should be placed at the base of the walls. The pipe should be embedded in a minimum 2-foot-wide zone of drain rock. The drain rock should meet specifications provided in the "Materials" section. The drain rock should be wrapped in a geotextile fabric that meets the specifications for drainage geotextiles as described in the "Materials" section. The collector pipes should discharge at an appropriate location away from the base of the wall. Unless measures are taken to prevent backflow into the drainage system of the wall, the discharge pipe should not be tied directly into stormwater drain systems.

6.6 INFILTRATION

6.6.1 Design Infiltration Rate

As discussed in the "Subsurface Conditions" section, the soil encountered near the base of the anticipated stormwater management systems consists of dense, glacially consolidated material generally composed of silty sand with varying gravel content.

The infiltration rate determined using the PIT procedure is a short-term infiltration rate. A correction factor is necessary to account for the small scale of the test. Additional correction factors are necessary to account for testing uncertainties, site variability, and long-term reduction in permeability due to biological activity and accumulation of fines. The recommended correction factors to be applied to the "short-term" rate measured in the tests are summarized as follows:

- Correction factor $F_{testing}$ accounts for uncertainties in testing methods. A correction factor of 0.5 is typically applied to rates from small-scale PITs.
- Correction factor $F_{variability}$ accounts for site subsurface variability and the number of locations tested. We recommend a correction factor $F_{variability}$ of 0.45.
- Correction factor F_m accounts for reduction in infiltration rates over the long term due to siltation and bio-buildup. We recommend a correction factor of 0.9.

The total correction factor to be applied is obtained by multiplying the individual correction factors. A cumulative correction factor of 0.20 should be applied to the measured infiltration rate. Table 3 summarizes the infiltration test results along with the correction factor.

Table 3. Soil Infiltration Rate Analysis[1]

Infiltration Location	Soil Type	Averaged Short-Term Infiltration Rate (inches per hour)	Recommended Long-Term Design Infiltration Rate[1] (inches per hour)
TP-1	Dense, silty SAND with gravel	1.3	0.26
TP-2	Dense, silty SAND, trace gravel	2.2	0.44
TP-3	Dense, silty SAND, minor gravel	0.7	0.14

1. Based on the recommended combined correction factor of 0.20.

We recommend the facility in the proposed parking area be designed using an average long-term infiltration rate of 0.25 inch per hour.

6.6.2 Soil Suitability for Treatment

CEC and organic content testing were also completed on samples collected at the base of the test pits to evaluate soil capacity for water quality treatment. Our subcontracted laboratory, AMTest Laboratories, performed the testing. The test results are presented in Appendix B and the results are summarized in Table 4.

Table 4. CEC and Organic Content Analytical Results Summary[1]

Exploration	Sample Depth (feet BGS)	Soil Type	CEC (meq/100 g)	Organic Content (percent)
TP-1	8	Dense, silty SAND with gravel	1.8	1.2
TP-2	1	Dense, silty SAND, trace gravel	1.0	0.7
TP-3	1	Dense, silty SAND, minor gravel	1.5	0.8

1. Suitability for Water Quality Treatment: CEC greater than 5 meq/100 g and organic content a minimum of 1.0 percent

The results of the tests indicate that the CEC for the soil at a depth of 8 feet BGS is typically less than 2 meq/100 g, which is less than the required 5 meq/100 g. The organic content of the soil ranges between 0.7 and 1.2 percent, with an average value of 0.9 percent, which is less than the 1 percent required for water quality treatment.

Based on the available test results, soil amendment will be necessary to address water quality treatment.

6.6.3 Groundwater Separation

We anticipate the depth of LID infiltration elements will be approximately 8 feet BGS. Stormwater Standards require a minimum of 5 feet of separation between the bottom of infiltration facilities or areas and groundwater. Groundwater measurements in the monitoring well on site indicate that 10-feet of separation exists.

6.7 GEOLOGIC HAZARD AREAS

As discussed in the "Slopes" section, portions of the slope west and south of the ATP building meet the City of Shoreline SMC 20.80.220 classification for Moderate to High Risk geologic hazard areas. Indications of instability were not observed in the areas and the proposed work is expected to be outside of the geologic critical area. The building is located along the toe of the slope and the proposed work will not impact existing slope stability nor impact adjacent properties.

Soil in the area generally meets the classification of "severe" erosion hazard, particularly on slopes that exceed 15 percent. The temporary increase in erosion hazard during construction, due to activities that disturb the ground surface, can be mitigated through appropriate BMPs such as stabilized construction entrances and haul roads, silt fencing, and straw wattles and by placing sediment socks in catch basins. The appropriate BMPs should be maintained after the site is restored while the permanent landscaping or surface finishes become established.

7.0 CONSTRUCTION

The proposed parking area was previously developed and what remains is a concrete floor slab surrounded with gravel or AC pavement hardscape areas. Earthwork site preparation activities will include removing the existing PCC floor slab and surrounding AC. It should include removal of previously installed utilities or foundation elements to avoid variations in subgrade consistency.

The soil to be exposed during grading operations has a high fines content, is moisture sensitive, and will deteriorate rapidly in wet weather where left exposed. If earthwork construction is expected to extend into the wet season, we recommend stabilizing exposed areas with a 12-inch-thick layer of CSBC material.

During excavation of the test pits, spoils were monitored for volatile organic compounds. Although no odors or sheens, indicating contamination, were detected, the previous development history and use as a laundry facility should be considered and impacted soil may be encountered.

7.1 SUBGRADE VERIFICATION

Exposed subgrades should be evaluated by a representative from GeoDesign to verify conditions are as anticipated and will provide the required support. Subgrade evaluation should be performed by probing with a foundation probe beneath foundations. If soft or loose zones are identified, these areas should be excavated to the extent indicated by the engineer or technician and replaced with structural fill or stabilization material.

7.2 EXCAVATION

7.2.1 General

The soil at the site can be excavated with conventional earthwork equipment. Excavations should stand vertical to a depth of approximately 4 feet, provided groundwater seepage is not observed in the trench walls.

Open excavation techniques may be used to excavate utility trenches with depths greater than 4 feet, provided the walls of the excavation are cut at appropriate cut slopes determined by the contractor. Approved temporary shoring is recommended where sloping is not possible. If a conventional shield is used, the contractor should limit the length of open trench. If shoring is used, we recommend that the type and design of the shoring system be the responsibility of the contractor, who is in the best position to choose a system that fits the overall plan of operation and the subsurface conditions. All excavations should be made in accordance with applicable OSHA, local, and state regulations.

7.2.2 Temporary Slopes

Based on soil conditions encountered during our explorations, temporary slopes for excavations of 1.25H:1V may be used to vertical depths of 15 feet or less, provided groundwater seepage is not significant, groundwater remains below the base of the excavation, surcharge loads are not present within 10 feet of the top of the slope, and the slopes are observed by the geotechnical engineer on a regular basis during construction. At this inclination, the slopes may ravel and require some on-going repair.

If seepage is encountered, it may be necessary to flatten the slopes to protect the surface from raveling or provide dewatering. All cut slopes should be protected from erosion by covering them with plastic sheeting or other stabilizing cover during the rainy season. If sloughing or instability is observed, the slope may need to be flattened or the cut supported by shoring.

Excavations should not undermine adjacent utilities, foundations, walkways, streets, or other hardscapes unless special shoring or underpinned support is provided. Unsupported excavations should not be conducted within a downward and outward 1H:1V projection starting at least 10 feet outside the edge of an adjacent structural feature.

7.2.3 Dewatering

Shallow excavations (less than 5 feet) may encounter limited seepage from perched water. In our opinion, significant dewatering operations will not likely be necessary. Dewatering systems are best designed by the contractor; however, it is our opinion that it should be possible to remove groundwater encountered by pumping from a sump. More intense use of pumps may be required at certain times of the year and where more intense seepage occurs. Removed water should be routed to a suitable discharge point.

If significant groundwater is present at the base of utility excavations, we recommend placing up to 6 inches of stabilization material at the base of the excavation.

7.3 MATERIALS

Fill material will be required for site grading, backfilling over-excavations, pavement support, installation of utilities, and drainage. Recommended fill materials are discussed below.

7.3.1 General

All material used as structural fill should be free of organic material or other unsuitable materials and (except where modified below) have a maximum particle size of 3 inches. A brief characterization of some of the acceptable material and our recommendations for their use as structural fill are provided below.

7.3.2 On-Site Soil

The on-site material encountered in our explorations has a high fines content, is sensitive to changes in moisture content, and will deteriorate under construction traffic and/or when exposed to wet weather. Although the on-site material does not meet the gradation requirements for imported structural fill, as defined below, we anticipate that some of the on-site material identified as silty sand with gravel can be used for fill but will be limited to use during the dry season and it will require moisture conditioning prior to use.

Deleterious material (such as wood, organics, and man-made material) should be removed from native soil prior to use as fill. The use of on-site soil as fill should be subject to review and approval by GeoDesign. It will be prudent to provide a 12-inch-thick cap of imported structural fill over areas where on-site soil is exposed or used as fill.

When used as structural fill, the on-site soil should be placed in lifts with a maximum uncompacted thickness of 10 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

7.3.3 Imported Granular Material

Structural fill placed for general site grading in improved areas should consist of clean, free-draining granular soil (sand and gravel) that is free from organic material or other deleterious and man-made materials, with a maximum particle size of 3 inches and a maximum fines content of 5 percent by dry weight passing the U.S. Standard No. 200 sieve. The use of granular, free-draining material will increase the workability of the material during the wet season and the likelihood that the material can be placed and adequately compacted.

Imported granular material used for structural fill should be naturally occurring pit- or quarry-run rock, crushed rock, or crushed gravel and sand and should meet the specifications provided in WSS 9-03.14(1) – Gravel Borrow, with the exception that the percentage passing the U.S. Standard No. 200 sieve does not exceed 5 percent by dry weight. Structural fill should be placed in lifts with a maximum uncompacted thickness of 12 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

7.3.4 Stabilization Material

Stabilization material used to backfill over-excavations below structures should consist of imported shot rock, quarry spalls, or crushed ballast. The material should have a maximum particle size of 6 inches, should have less than 5 percent by dry weight passing the U.S. Standard

No. 4 sieve, and should have at least two mechanically fractured faces. The material should be free of organic material and other deleterious materials. Materials that meet the specifications provided in WSS 9-13.7(2) – Backfill for Rock Wall, WSS 9-13.1(5) – Quarry Spalls, or WSS 9-27.3(6) – Stone are generally acceptable for use. Stabilization material should be placed in lifts between 12 and 18 inches thick and compacted to a firm condition with the bucket of an excavator.

7.3.5 Drain Rock

Drain rock used in subsurface drains or against retaining walls should consist of granular material with a maximum particle size of 1 inch and should meet the specifications provided in WSS 9-03.12(4) – Gravel Backfill for Drains. The material should be free of roots, organic material, and other unsuitable materials; should have less than 2 percent by dry weight passing the U.S. Standard No. 200 sieve (washed analysis); and should have at least two mechanically fractured faces.

7.3.6 Floor Slab and Pavement Base Rock

Imported granular material used as aggregate base for floor slabs, pavement, and beneath hardscape areas should consist of 1½-inch-minus material meeting the specifications provided in WSS 9-03.9(3) – Crushed Surfacing, Base Course, with the exception that the aggregate should have less than 5 percent by dry weight passing the U.S. Standard No. 200 sieve and at least two mechanically fractured faces. It should be placed in lifts with a maximum uncompacted thickness of 12 inches and compacted to not less than 95 percent of the maximum dry density, as determined by ASTM D1557.

7.3.7 Retaining Wall Select Backfill

Retaining wall select backfill should consist of well-graded sand or gravel with not more than 5 percent by dry weight passing the U.S. Standard No. 200 sieve and meeting WSS 9-03.12(2) – Gravel Backfill for Walls. Retaining wall backfill should be compacted in accordance with recommendations provided in the "Wall Backfill" section.

7.3.8 Geotextiles

7.3.8.1 Separation and Drainage Geotextile

We recommend using a non-woven geotextile drainage material around subsurface drains to separate drain rock from adjacent materials. The geotextile should conform to the specifications for non-woven separation material provided in WSS 9-33.2(1) – Geotextile Properties, Table 3 Geotextile for Separation or Soil Stabilization. A suitable non-woven material meeting these recommendations is Tencate Mirafi 160N.

8.0 OBSERVATION OF CONSTRUCTION

Recommendations provided in this report assume that GeoDesign will be retained to provide geotechnical consultation and observation services during construction. Satisfactory earthwork and foundation performance depends to a large degree on the quality of construction. Subsurface conditions observed during construction should be compared with those encountered during the subsurface explorations. Recognition of changed conditions requires experience with the site conditions and an understanding of the geotechnical recommendations; therefore, GeoDesign personnel should visit the site with sufficient frequency to detect whether subsurface conditions change significantly from those anticipated and to verify that the work is completed in accordance with the construction drawings and specifications.

Sufficient observation of the contractor's activities is a key part of determining that the work is completed in accordance with the construction drawings, project specifications, and our recommendations.

We recommend that GeoDesign be retained to observe all earthwork activities, including the following:

- Excavation activities
- Subgrade preparation prior to fill placement or foundation construction
- Placement and compaction of fill, including fill placed in utility trenches, around buried structures, and around the stormwater management system
- Laboratory compaction and field moisture-density tests

9.0 LIMITATIONS

We have prepared this report for use by Trinity NAC and the design and construction team for the proposed development. The data and report can be used for bidding or estimating purposes, but our report, conclusions, and interpretations should not be construed as warranty of the subsurface conditions and are not applicable to other sites.

Exploration observations indicate soil conditions only at specific locations and only to the depths penetrated. They do not necessarily reflect soil strata or water level variations that may exist between exploration locations. If subsurface conditions differing from those described are noted during excavation and construction, re-evaluation will be necessary.

The site development plans and design details were preliminary at the time this report was prepared. When the design has been finalized and if there are changes in the site grades or location, configuration, design loads, or type of construction, the conclusions and recommendations presented may not be applicable. If design changes are made, we request that we be retained to review our conclusions and recommendations and to provide a written modification or verification.

The scope of our services does not include services related to construction safety precautions, and our recommendations are not intended to direct the contractor's methods, techniques, sequences, or procedures, except as specifically described in this report for consideration in design.

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

◆ ◆ ◆

We appreciate the opportunity to be of continued service to you. Please call if you have questions concerning this report or if we can provide additional services.

Sincerely,

GeoDesign, Inc., DBA NV5

DRAFT

Kevin J. Lamb, P.E.
Principal Engineer

REFERENCES

ASTM, 2020. *Annual Book of ASTM Standards*, Vol. 4.08, Soil and Rock (1): D420-D4914, Philadelphia: ASTM.

City of Shoreline, 2016, Engineering Development Manual, Public Works Department, City of Shoreline, 303 p.

City of Shoreline Municipal Code Chapter 20.80 Critical Areas, March 2020.

Johnson, S., Childs, J., Stanley, W., Dadisman, S. (1999). Active Tectonics of the Seattle Fault and Central Puget Sound, Washington: Implications for earthquake hazards. GSA Bulletin, v. 111(no. 7), 1042-1053.

King County Surface Water Design Manual, April 24, 2014, King County Department of Natural Resources and Parks.

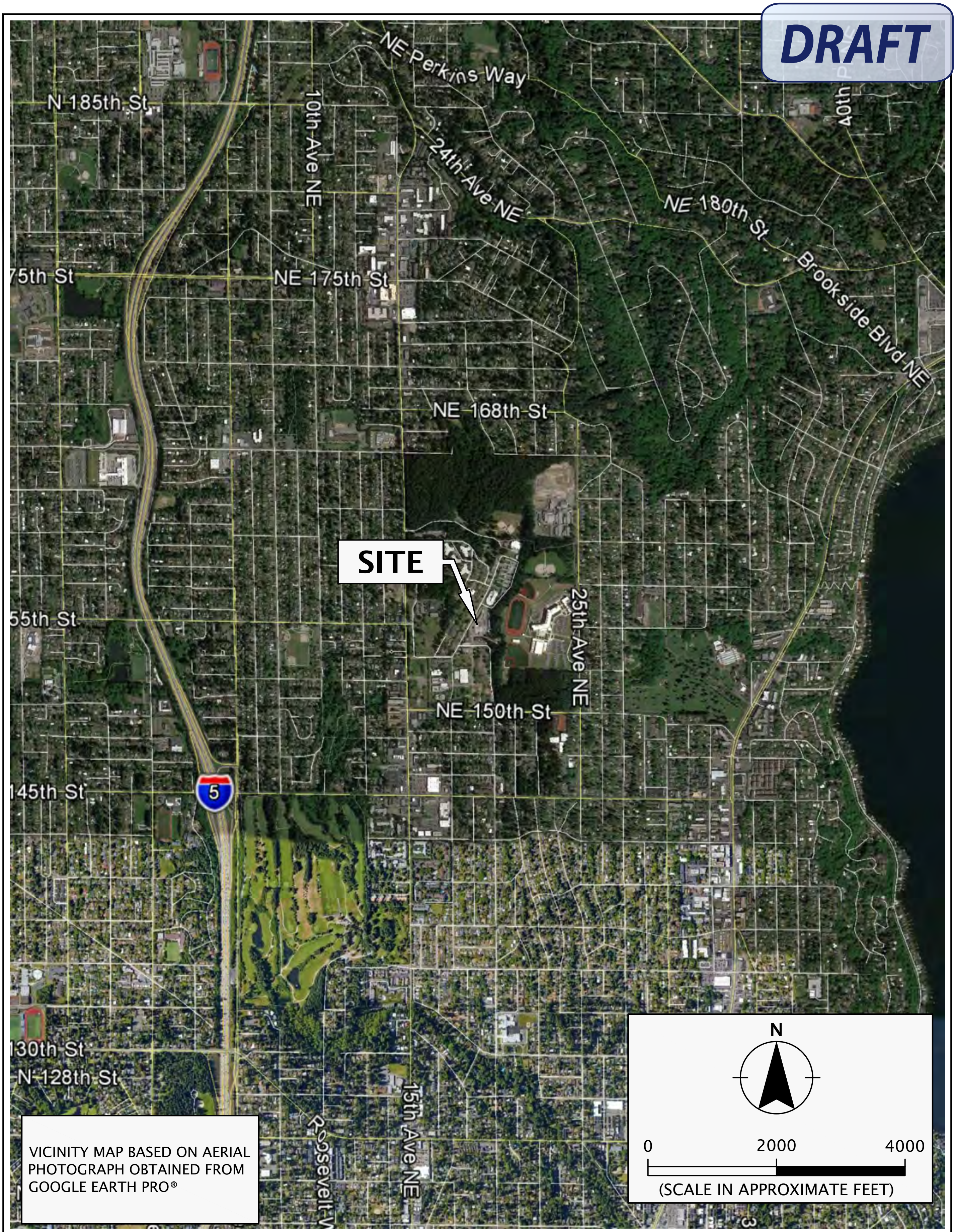
Nelson, A., Johnson, S., Pezzopane, S., Wells, R., Kelsey, H., Sherrod, B., Narwolds, C. (2000). Postglacial and Late Holocene earthquakes on the Toe Jam Strand of the Seattle Fault, Bainbridge Island, Washington. GSA Cordilleran Section Meeting. Vancouver, Canada.

Sherrod, B. L., Blakely, R. J., Weaver, C. S., Kelsey, H. M., Barnett, E., Liberty, L., . . . Pape, K. (2008). Finding Concealed Active Faults: Extending the Southern Whidbey Island Fault across the Puget Lowland, Washington. Journal of Geophysical Research: Solid Earth. Retrieved from https://scholarworks.boisestate.edu/cgi/viewcontent.cgi?article=1055&context=cgiss_facpubs.

Washington State Department of Natural Resources, 2020. Subsurface Geology Information System. Retrieved from Division of Geology and Earth Resources - Washington's Geologic Survey Database: https://geologyportal.dnr.wa.gov/.

Washington State Department of Transportation, 2020. Standard Specifications for Road, Bridge, and Municipal Construction. M 41-10.

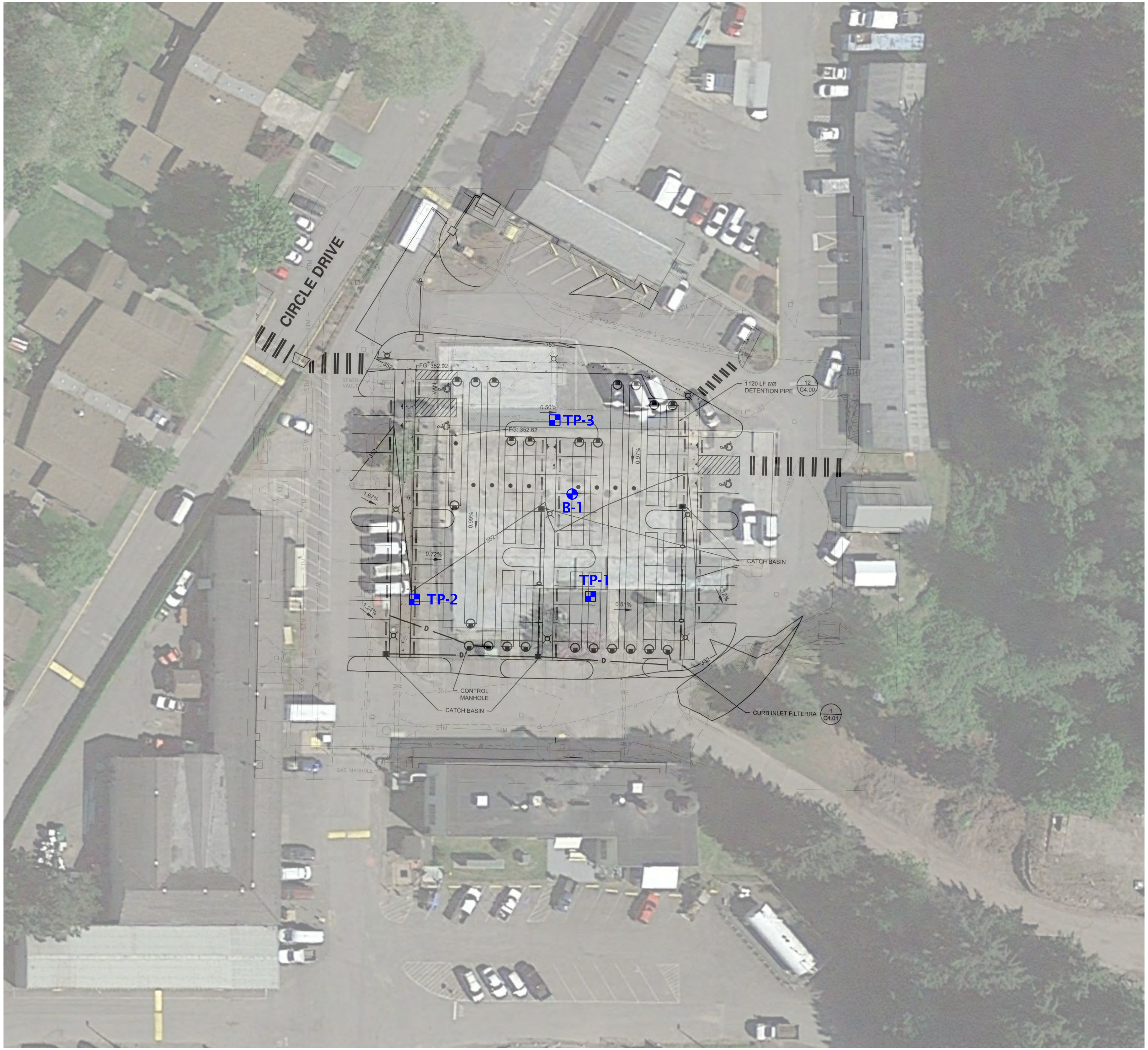
FIGURES



VICINITY MAP BASED ON AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO®

Printed By: mmiller | Print Date: 3/22/2021 8:13:17 AM
File Name: J:\M-R\NAC\NAC-1\NAC-1-02\Figures\CAD\NAC-1-02-VM01.dwg | Layout: FIGURE 1

GEODESIGN INC AN NV5 COMPANY	NAC-1-02	**VICINITY MAP**	
	MARCH 2021	FIRCREST ATP RENOVATION SHORELINE, WA	**FIGURE 1**



DRAFT

LEGEND:

— — —	SITE BOUNDARY
B-1 ◕	BORING
TP-1 ▣	TEST PIT

N

0 50 100

(SCALE IN FEET)

NOTES:

1. SITE PLAN BASED ON IMAGE OF SHEET C1.01 GRADING AND DRAINAGE PLAN EAST DATED NOVEMBER 11, 2020 PREPARED BY NAC ARCHITECTURE.
2. AERIAL PHOTOGRAPH OBTAINED FROM GOOGLE EARTH PRO FEBRUARY 2, 2021.

FIGURE 2

SITE PLAN
PROPOSED PARKING AREA

FIRCREST ATP RENOVATION
SHORELINE, WA

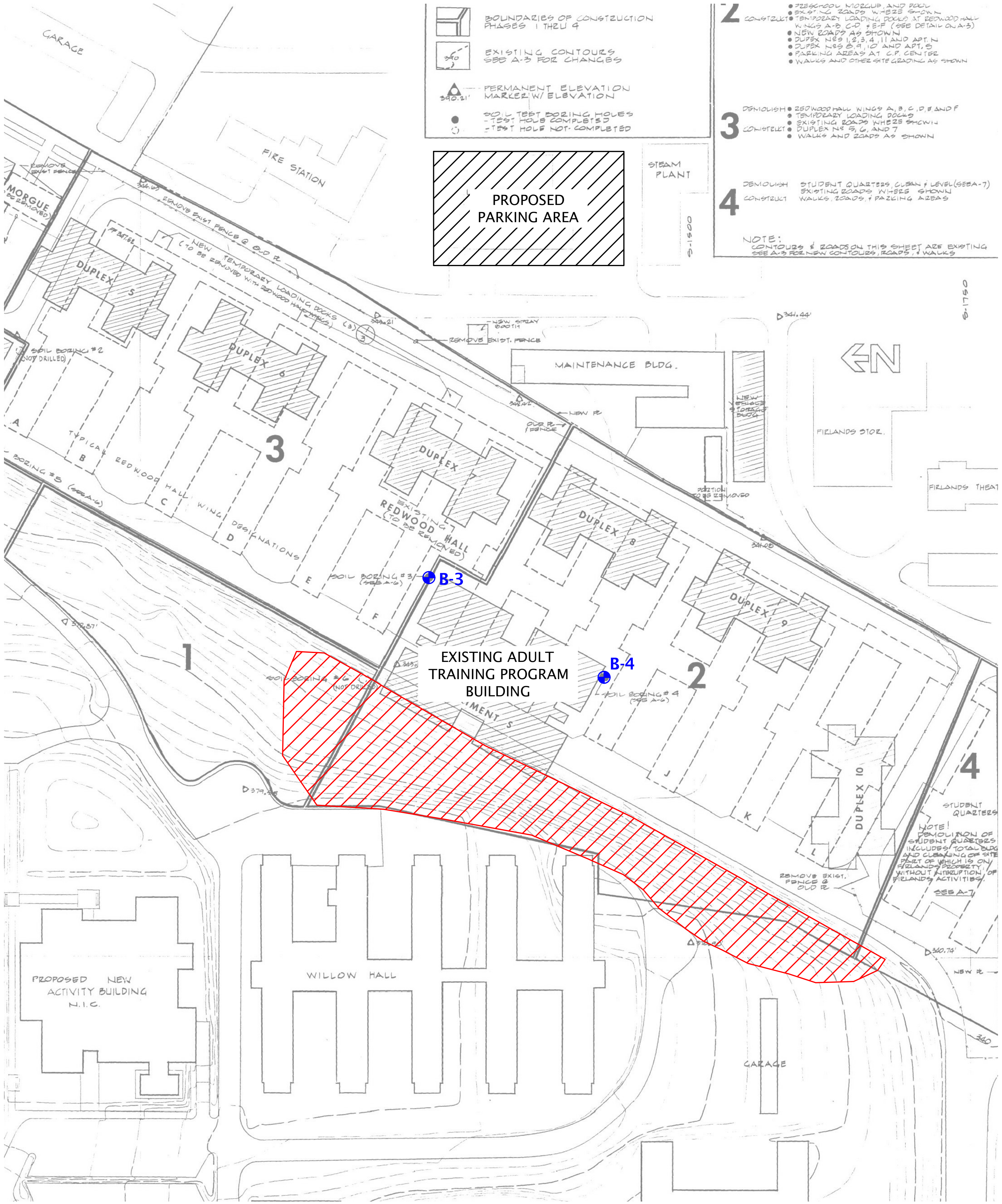
NAC-1-02

MARCH 2021

GEODESIGN^NV
AN NV5 COMPANY

Printed By: mmiller | Print Date: 3/22/2021 8:13:24 AM
File Name: J:\M-R\NAC\NAC-1\NAC-1-02\Figures\CAD\NAC-1-02-SP01.dwg | Layout: FIGURE 2

DRAFT



LEGEND:

▨ MODERATE TO HIGH LANDSLIDE HAZARD AREA

B-3 ● EXISTING BORING DRILLED BY OTHERS

N

(NOT TO SCALE)

NOTE:

1. SITE PLAN BASED ON IMAGE OF SHEET A2 DATED JULY 1, 1970 PREPARED BY SHAVEY & SCHMIDT A.I.A., ARCHITECTS.

SITE PLAN

EXISTING ADULT TRAINING PROGRAM BUILDING

FIRCREST ATP RENOVATION
SHORELINE, WA

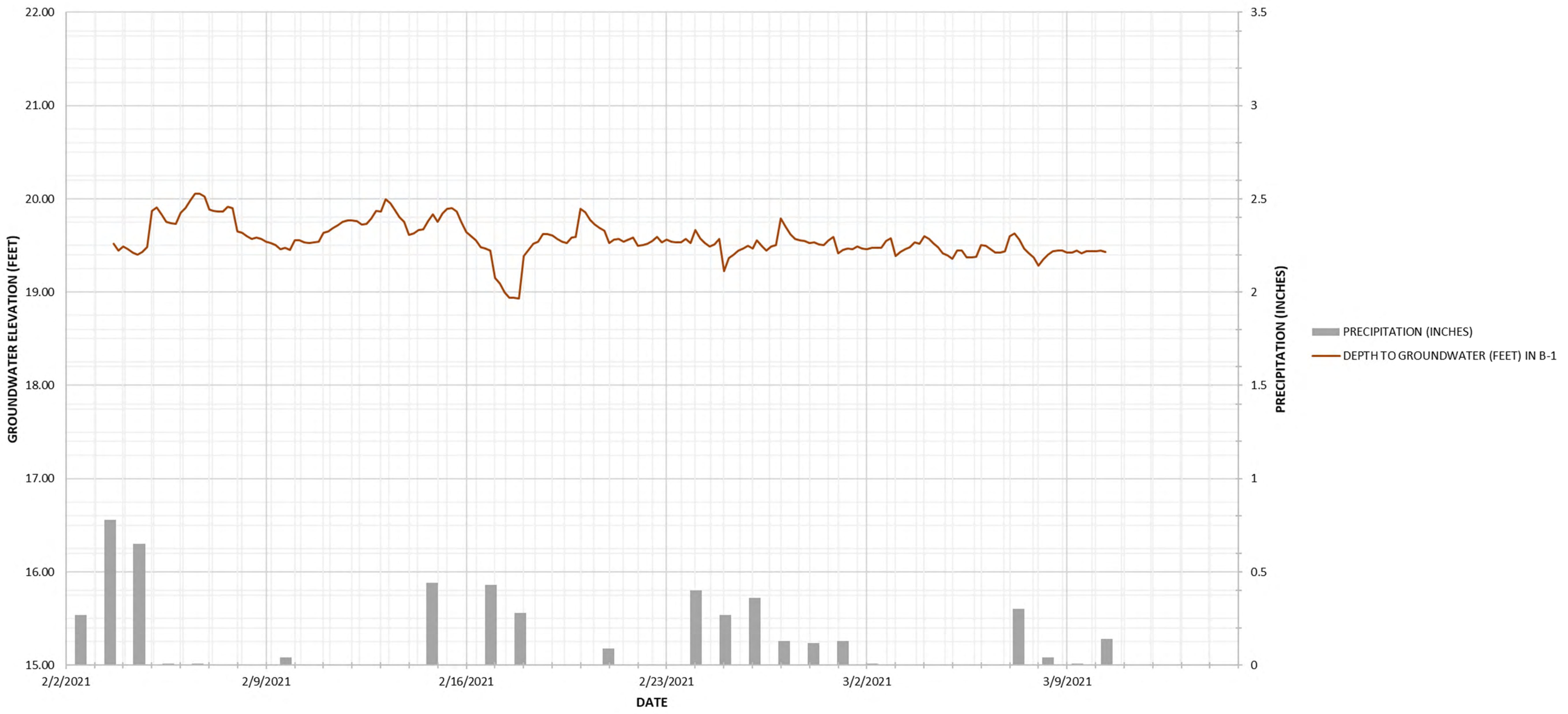
FIGURE 3

NAC-1-02

MARCH 2021

GEODESIGN℠
AN NV5 COMPANY

Printed By: mmiller | Print Date: 3/22/2021 8:13:32 AM
File Name: J:\M-R\NAC\NAC-1\NAC-1-02\Figures\CAD\NAC-1-02-Landslide-Haz01.dwg | Layout: FIGURE 3



GROUNDWATER MEASUREMENTS

FIRCREST ATP RENOVATION
SHORELINE, WA

FIGURE 4

NAC-1-02

MARCH 2021

APPENDIX A

APPENDIX A

FIELD EXPLORATIONS

GENERAL

Subsurface conditions at the site were explored by drilling one boring (B-1) to a depth of 31 feet BGS on January 25, 2021 and excavating three test pits (TP-1 through TP-3) to depths of up to 14.5 feet BGS on January 19, 2021. The boring was drilled by Boretec1 using hollow-stem auger drilling methods. The test pits were completed by Continental Dirt Contractors using a Komatsu PC88 rubber-tracked excavator. The exploration logs are presented in this appendix.

The approximate locations of our explorations are shown on Figure 2. The exploration locations were selected based on our project understanding communicated by the client and adjusted based on accessibility and avoidance of existing underground utilities. This information should be considered accurate only to the degree implied by the methods used.

SOIL SAMPLING

A member of our geotechnical staff observed the explorations. We collected disturbed and relatively undisturbed soil samples from the explorations for geotechnical laboratory testing.

We collected samples from the borings using 1½-inch-inside diameter, split-spoon sampler in general accordance with ASTM D1586. We used a 140-pound hammer free-falling 30 inches to drive the split-spoon samplers into the soil a total distance of 18 inches. We recorded on the exploration logs the number of blows required to drive the sampler the final 12 inches, unless otherwise noted. Representative grab samples of the soils observed in the test pit explorations were collected from the walls and/or base of the test pits using the excavator bucket. Sampling methods and intervals are shown on the exploration logs.

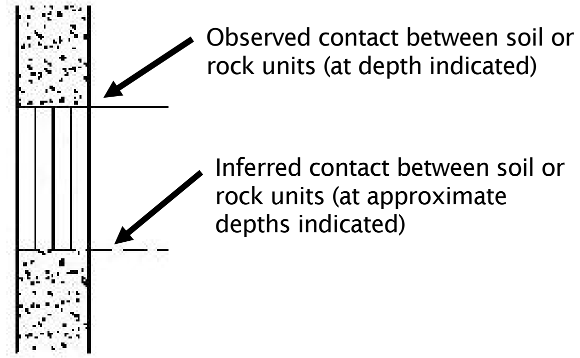
The average efficiency of the automatic SPT hammer used by Boretec1 was 91.9 percent. The calibration testing results are presented at the end of this appendix.

SOIL CLASSIFICATION

The soil samples were classified in accordance with the "Exploration Key" (Table A-1) and "Soil Classification System" (Table A-2), which are presented in this appendix. The exploration logs indicate the depths at which the soils or their characteristics change, although the change could be gradual. A horizontal line between soil types indicates an observed (visual or excavation resistance) change. If the change occurred between sample locations and was not observed or obvious, the depth was interpreted, and the change is indicated using a dashed line. Classifications are shown on the exploration logs.

SYMBOL	SAMPLING DESCRIPTION
▮	Location of sample collected in general accordance with ASTM D1586 using Standard Penetration Test with recovery
▮	Location of sample collected using thin-wall Shelby tube or Geoprobe® sampler in general accordance with ASTM D1587 with recovery
▮	Location of sample collected using Dames & Moore sampler and 300-pound hammer or pushed with recovery
▮	Location of sample collected using Dames & Moore sampler and 140-pound hammer or pushed with recovery
▮	Location of sample collected using 3-inch-O.D. California split-spoon sampler and 140-pound hammer with recovery
☒	Location of grab sample
▮	Rock coring interval
▽	Water level during drilling
▼	Water level taken on date shown

Graphic Log of Soil and Rock Types



GEOTECHNICAL TESTING EXPLANATIONS

ATT	Atterberg Limits	P	Pushed Sample
CBR	California Bearing Ratio	PP	Pocket Penetrometer
CON	Consolidation	P200	Percent Passing U.S. Standard No. 200 Sieve
DD	Dry Density		
DS	Direct Shear	RES	Resilient Modulus
HYD	Hydrometer Gradation	SIEV	Sieve Gradation
MC	Moisture Content	TOR	Torvane
MD	Moisture-Density Relationship	UC	Unconfined Compressive Strength
NP	Non-Plastic	VS	Vane Shear
OC	Organic Content	kPa	Kilopascal

ENVIRONMENTAL TESTING EXPLANATIONS

CA	Sample Submitted for Chemical Analysis	ND	Not Detected
P	Pushed Sample	NS	No Visible Sheen
PID	Photoionization Detector Headspace Analysis	SS	Slight Sheen
		MS	Moderate Sheen
ppm	Parts per Million	HS	Heavy Sheen

GEODESIGN INC AN NV5 COMPANY	EXPLORATION KEY	TABLE A-1

RELATIVE DENSITY - COARSE-GRAINED SOIL

Relative Density	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)
Very Loose	0 – 4	0 – 11	0 – 4
Loose	4 – 10	11 – 26	4 – 10
Medium Dense	10 – 30	26 – 74	10 – 30
Dense	30 – 50	74 – 120	30 – 47
Very Dense	More than 50	More than 120	More than 47

CONSISTENCY - FINE-GRAINED SOIL

Consistency	Standard Penetration Resistance	Dames & Moore Sampler (140-pound hammer)	Dames & Moore Sampler (300-pound hammer)	Unconfined Compressive Strength (tsf)
Very Soft	Less than 2	Less than 3	Less than 2	Less than 0.25
Soft	2 – 4	3 – 6	2 – 5	0.25 – 0.50
Medium Stiff	4 – 8	6 – 12	5 – 9	0.50 – 1.0
Stiff	8 – 15	12 – 25	9 – 19	1.0 – 2.0
Very Stiff	15 – 30	25 – 65	19 – 31	2.0 – 4.0
Hard	More than 30	More than 65	More than 31	More than 4.0

PRIMARY SOIL DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE-GRAINED SOIL (more than 50% retained on No. 200 sieve)	GRAVEL (more than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (< 5% fines)	GW or GP	GRAVEL
		GRAVEL WITH FINES (≥ 5% and ≤ 12% fines)	GW-GM or GP-GM	GRAVEL with silt
			GW-GC or GP-GC	GRAVEL with clay
		GRAVEL WITH FINES (> 12% fines)	GM	silty GRAVEL
			GC	clayey GRAVEL
			GC-GM	silty, clayey GRAVEL
	SAND (50% or more of coarse fraction passing No. 4 sieve)	CLEAN SAND (<5% fines)	SW or SP	SAND
		SAND WITH FINES (≥ 5% and ≤ 12% fines)	SW-SM or SP-SM	SAND with silt
			SW-SC or SP-SC	SAND with clay
		SAND WITH FINES (> 12% fines)	SM	silty SAND
			SC	clayey SAND
			SC-SM	silty, clayey SAND
FINE-GRAINED SOIL (50% or more passing No. 200 sieve)	SILT AND CLAY	Liquid limit less than 50	ML	SILT
			CL	CLAY
			CL-ML	silty CLAY
			OL	ORGANIC SILT or ORGANIC CLAY
		Liquid limit 50 or greater	MH	SILT
			CH	CLAY
			OH	ORGANIC SILT or ORGANIC CLAY
HIGHLY ORGANIC SOIL			PT	PEAT

MOISTURE CLASSIFICATION

Term	Field Test
dry	very low moisture, dry to touch
moist	damp, without visible moisture
wet	visible free water, usually saturated

ADDITIONAL CONSTITUENTS

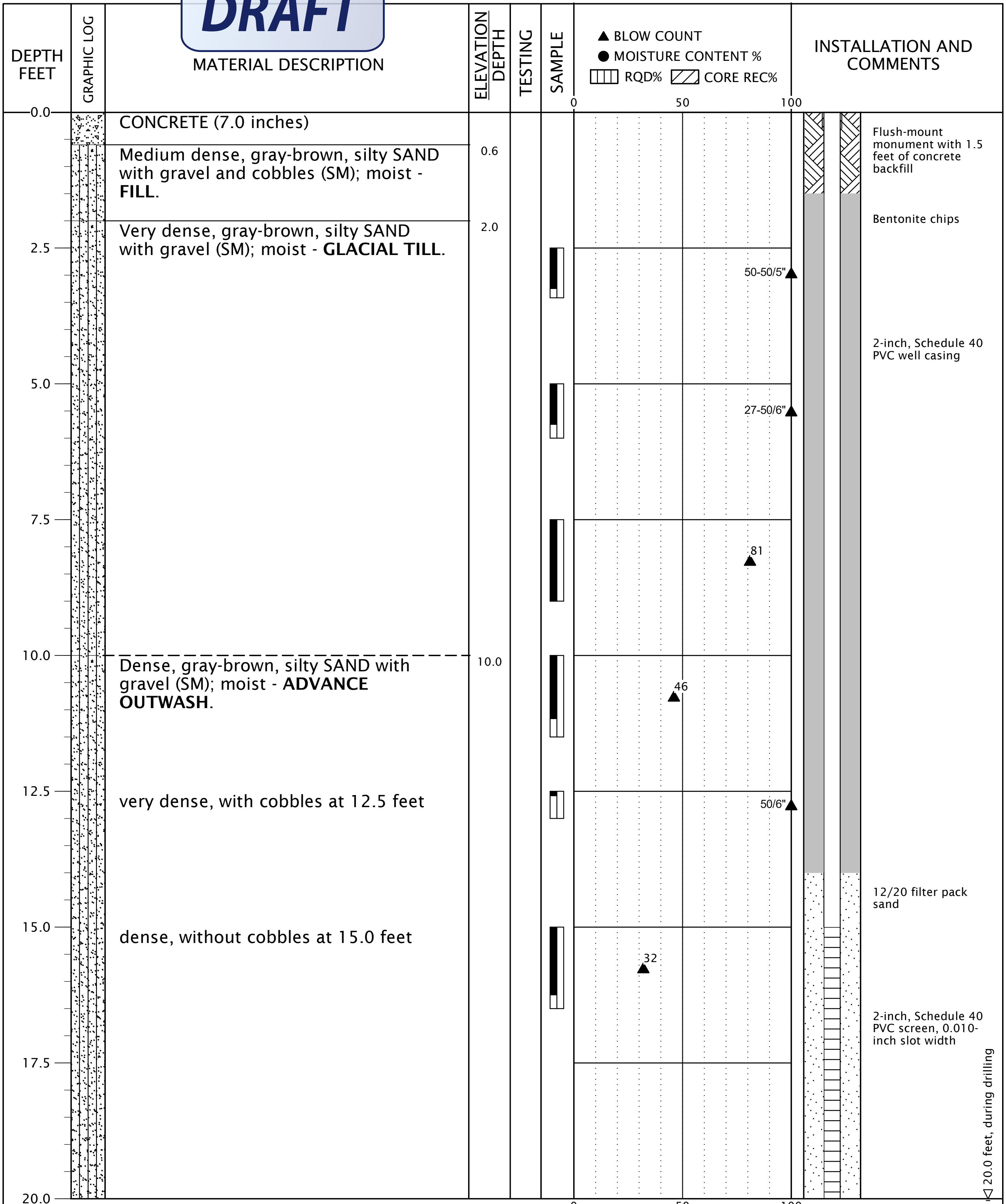
Secondary granular components or other materials such as organics, man-made debris, etc.					
Percent	Silt and Clay In:		Percent	Sand and Gravel In:	
	Fine-Grained Soil	Coarse-Grained Soil		Fine-Grained Soil	Coarse-Grained Soil
< 5	trace	trace	< 5	trace	trace
5 – 12	minor	with	5 – 15	minor	minor
> 12	some	silty/clayey	15 – 30	with	with
			> 30	sandy/gravelly	Indicate %

GEODESIGN INC
AN NV5 COMPANY

SOIL CLASSIFICATION SYSTEM

TABLE A-2

DRAFT



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH
0.0	CONCRETE (7.0 inches)	
	Medium dense, gray-brown, silty SAND with gravel and cobbles (SM); moist - **FILL**.	0.6
	Very dense, gray-brown, silty SAND with gravel (SM); moist - **GLACIAL TILL**.	2.0
10.0	Dense, gray-brown, silty SAND with gravel (SM); moist - **ADVANCE OUTWASH**.	10.0
12.5	very dense, with cobbles at 12.5 feet	
15.0	dense, without cobbles at 15.0 feet	

DRILLED BY: Boretec1

LOGGED BY: R. Hilal

COMPLETED: 01/25/21

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 8 inches

GEODESIGN INC
AN NV5 COMPANY

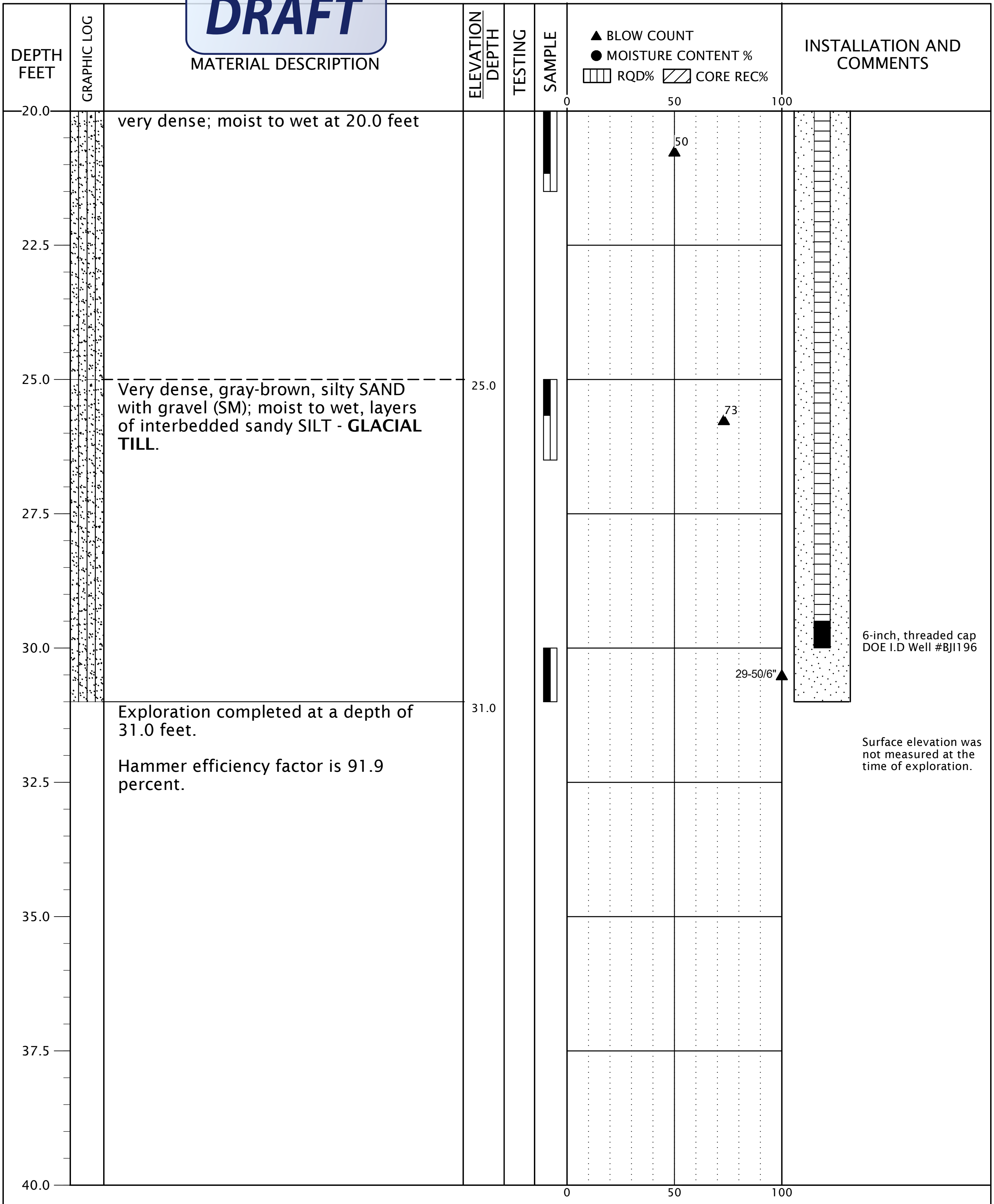
NAC-1-02

MARCH 2021

BORING B-1

FIRCREST ATP RENOVATION
SHORELINE, WA

FIGURE A-1



DRAFT

very dense; moist to wet at 20.0 feet

Very dense, gray-brown, silty SAND with gravel (SM); moist to wet, layers of interbedded sandy SILT - **GLACIAL TILL**.

Exploration completed at a depth of 31.0 feet.

Hammer efficiency factor is 91.9 percent.

6-inch, threaded cap
DOE I.D Well #BJI196

Surface elevation was not measured at the time of exploration.

DRILLED BY: Boretec1

LOGGED BY: R. Hilal

COMPLETED: 01/25/21

BORING METHOD: hollow-stem auger (see document text)

BORING BIT DIAMETER: 8 inches

GEODESIGN INC AN NV5 COMPANY	NAC-1-02	**BORING B-1** (continued)	
	MARCH 2021	FIRCREST ATP RENOVATION SHORELINE, WA	**FIGURE A-1**

DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % (0 50 100)	COMMENTS
0.0	AGGREGATE BASE (6.0 inches).					
	Medium dense, brown, silty SAND with gravel (SM); moist - **FILL**.	0.5		☒		Minor caving observed from 1.0 to 3.0 feet.
	Medium dense, light brown SAND with silt and gravel (SP-SM); moist - **WEATHERED GLACIAL TILL**.	1.5				
2.5				☒		
5.0	Dense, light gray, silty SAND with gravel (SM); moist - **GLACIAL TILL**.	5.0				
7.5				☒		Infiltration test at 8.0 feet.
10.0	Dense, gray-brown, silty SAND with gravel (SM); moist to wet - **ADVANCE OUTWASH**.	10.0				
12.5				☒		
15.0	Exploration completed at a depth of 14.5 feet.	14.5				No groundwater seepage observed to the depth explored. Surface elevation was not measured at the time of exploration.
17.5						
20.0					0 50 100	

EXCAVATED BY: Continental Dirt Contractors

LOGGED BY: R. Hilal

COMPLETED: 01/19/21

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
AN NV5 COMPANY

NAC-1-02

MARCH 2021

TEST PIT TP-1

FIRCREST ATP RENOVATION
SHORELINE, WA

FIGURE A-2

TEST PIT LOG - GDI-NV5 - 1 PER PAGE NAC-1-02-B1-TP1_3.GPJ GDI_NV5.GDT PRINT DATE: 3/22/21:MGL:KT

DEPTH FEET	GRAPHIC LOG	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0		AGGREGATE BASE (6.0 inches)					
		Dense, brown, silty SAND with gravel (SM); moist - **FILL**.	0.5		☒		
		Dense, light brown SAND with silt and gravel (SP-SM); moist - **WEATHERED GLACIAL TILL**.	1.5				Minor caving observed from 2.0 to 4.0 feet.
2.5					☒		
		medium dense at 4.0 feet					
5.0		Dense, light gray, silty SAND with gravel (SM); moist - **GLACIAL TILL**.	5.0				
7.5							
		Dense, gray-brown, silty SAND (SM), trace gravel; moist to wet - **ADVANCE OUTWASH**.	8.0		☒		Infiltration test at 8.0 feet.
10.0					☒		
12.5							
		Exploration completed at a depth of 14.5 feet.	14.5				No groundwater seepage observed to the depth explored. Surface elevation was not measured at the time of exploration.
15.0							
17.5							
20.0						0 50 100	

EXCAVATED BY: Continental Dirt Contractors

LOGGED BY: R. Hilal

COMPLETED: 01/19/21

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC
AN NV5 COMPANY

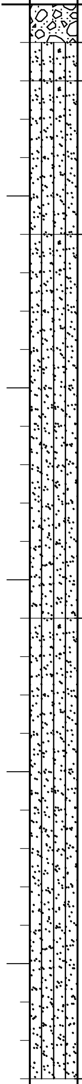
NAC-1-02

MARCH 2021

TEST PIT TP-2

FIRCREST ATP RENOVATION
SHORELINE, WA

FIGURE A-3



DEPTH FEET	MATERIAL DESCRIPTION	ELEVATION DEPTH	TESTING	SAMPLE	● MOISTURE CONTENT % 0 50 100	COMMENTS
0.0	AGGREGATE BASE (6.0 inches).					
	Medium dense, brown, silty SAND with gravel (SM), trace organics; moist - **FILL**.	0.5		☒		
2.5	Medium dense, light brown, silty SAND with gravel (SM); moist - **WEATHERED GLACIAL TILL**.	1.0		☒		
5.0 7.5	Dense, gray, silty SAND with gravel and cobbles (SM); moist - **GLACIAL TILL**.	3.0				
10.0 12.5	Dense, gray-brown, silty SAND (SM), minor gravel; moist to wet - **ADVANCE OUTWASH**.	8.0		☒ ☒		Infiltration test at 8.0 feet.
15.0 17.5 20.0	Exploration completed at a depth of 14.0 feet.	14.0			0 50 100	No groundwater seepage observed to the depth explored. No caving observed to the depth explored. Surface elevation was not measured at the time of exploration.

EXCAVATED BY: Continental Dirt Contractors

LOGGED BY: R. Hilal

COMPLETED: 01/19/21

EXCAVATION METHOD: excavator (see document text)

GEODESIGN INC AN NV5 COMPANY	NAC-1-02	**TEST PIT TP-3**
	MARCH 2021	FIRCREST ATP RENOVATION SHORELINE, WA
		FIGURE A-4

BORETEC-1-01 - B-1 20FT
OP: WMN

TRACK RIG EC-95
Date: 05-October-2015

AR: 1.41 in²
LE: 24.10 ft
WS: 16,807.9 f/s

SP: 0.492 k/ft³
EM: 30,000 ksi
JC: 0.00 []

ETR: Energy Transfer Ratio
EMX: Max Transferred Energy
FVP: Force/Velocity proportionality
CSX: Max Measured Compr. Stress
CSI: Max F1 or F2 Compr. Stress

CSB: Compression Stress at Bottom
BPM: Blows per Minute
VMX: Maximum Velocity
FMX: Maximum Force

BL#	depth ft	BLC bl/ft	ETR (%)	EMX k-ft	FVP []	CSX ksi	CSI ksi	CSB ksi	BPM bpm	VMX f/s	FMX kips
8	20.00	10	93.9	0.3	0.6	25.5	25.9	0.00	56	16.575	35.9
9	20.10	10	88.4	0.3	0.6	25.7	25.9	0.00	57	16.655	36.2
10	20.20	10	90.3	0.3	0.5	25.1	25.4	0.00	54	16.925	35.5
11	20.31	10	93.3	0.3	0.6	25.8	26.2	0.00	56	16.634	36.4
12	20.41	10	86.7	0.3	0.7	26.2	26.7	0.00	56	15.753	36.9
13	20.51	10	82.5	0.3	0.7	26.6	26.6	0.00	55	16.138	37.5
14	20.61	10	89.3	0.3	0.6	23.7	24.7	0.00	55	17.030	33.4
15	20.71	10	84.5	0.3	0.6	23.5	24.9	0.00	56	16.260	33.1
16	20.82	10	86.3	0.3	0.6	23.6	24.5	0.00	56	17.248	33.3
17	20.92	10	88.3	0.3	0.5	26.7	27.1	0.00	55	17.003	37.7
18	21.02	10	90.6	0.3	0.6	26.2	26.2	0.00	56	17.131	36.9
19	21.12	10	90.4	0.3	0.6	25.3	25.6	0.00	56	17.131	35.6
20	21.22	10	91.4	0.3	0.5	24.9	25.6	0.00	57	17.302	35.2
21	21.33	10	92.2	0.3	0.6	25.3	25.7	0.00	55	17.584	35.7
22	21.43	10	86.0	0.3	0.6	24.4	24.5	0.00	56	16.086	34.4
23	21.53	10	89.3	0.3	0.7	25.5	25.7	0.00	55	16.791	35.9
24	21.63	10	90.2	0.3	0.6	24.1	24.5	0.00	55	16.422	34.0
25	21.73	10	82.8	0.3	0.6	24.5	25.8	0.00	56	16.371	34.5
26	21.84	10	84.9	0.3	0.5	24.6	25.6	0.00	56	16.824	34.7
27	21.94	10	91.7	0.3	0.6	25.9	26.9	0.00	55	17.706	36.5
28	22.04	10	89.4	0.3	0.6	25.6	26.9	0.00	56	17.223	36.1
29	22.14	10	84.9	0.3	0.6	25.6	26.7	0.00	56	17.130	36.1
30	22.24	10	88.0	0.3	0.5	25.4	25.9	0.00	56	17.228	35.8
31	22.35	10	89.6	0.3	0.5	26.6	27.3	0.00	55	16.948	37.5
32	22.45	10	89.9	0.3	0.6	25.8	26.5	0.00	56	17.692	36.3
33	22.55	10	92.1	0.3	0.6	25.5	26.0	0.00	55	17.539	36.0
34	22.65	10	91.0	0.3	0.6	24.7	25.2	0.00	55	16.685	34.8
35	22.76	10	90.5	0.3	0.6	25.3	25.7	0.00	57	17.032	35.7
36	22.86	10	91.5	0.3	0.6	25.2	26.7	0.00	56	17.461	35.5
37	22.96	10	87.3	0.3	0.6	25.3	26.8	0.00	56	17.394	35.6
38	23.06	10	89.6	0.3	0.6	24.3	24.9	0.00	56	16.758	34.2
39	23.16	10	90.6	0.3	0.5	24.6	25.9	0.00	56	17.063	34.7
40	23.27	10	86.8	0.3	0.7	25.8	27.4	0.00	56	16.481	36.3
41	23.37	10	88.6	0.3	0.6	25.3	26.9	0.00	55	17.395	35.6
42	23.47	10	88.6	0.3	0.6	25.9	27.2	0.00	57	17.135	36.5
43	23.57	10	91.0	0.3	0.5	26.9	27.7	0.00	56	17.975	37.9
44	23.67	10	89.3	0.3	0.6	25.2	27.0	0.00	56	17.433	35.6
45	23.78	10	84.0	0.3	0.6	26.0	28.4	0.00	55	17.365	36.7
46	23.88	10	87.6	0.3	0.5	25.8	27.7	0.00	57	17.391	36.4
47	23.98	10	88.2	0.3	0.6	26.3	28.6	0.00	56	17.397	37.1
48	24.08	10	84.0	0.3	0.6	26.5	28.4	0.00	55	17.536	37.3
57	25.00	10	103.1	0.4	0.5	27.4	31.1	0.00	55	19.420	38.6
58	25.28	4	87.0	0.3	0.5	27.0	30.5	0.00	56	19.110	38.1
59	25.56	4	87.8	0.3	0.7	26.0	29.5	0.00	55	17.983	36.7
60	25.83	4	85.1	0.3	0.5	26.6	30.9	0.00	57	18.220	37.5

BORETEC-1-01 - B-1 20FT
OP: WMN

TRACK RIG EC-95
Date: 05-October-2015

BL#	depth	BLC	ETR	EMX	FVP	CSX	CSI	CSB	BPM	VMX	FMX
	ft	bl/ft	(%)	k-ft	[]	ksi	ksi	ksi	bpm	f/s	kips
61	26.11	4	86.9	0.3	0.5	26.8	30.5	0.00	56	19.337	37.7
62	26.39	4	89.7	0.3	0.5	27.4	30.3	0.00	55	19.459	38.6
63	26.67	4	88.1	0.3	0.5	27.3	30.9	0.00	56	19.451	38.4
64	26.94	4	88.6	0.3	0.5	26.0	29.3	0.00	56	18.572	36.7
65	27.22	4	95.3	0.3	0.4	26.8	30.2	0.00	56	19.280	37.7
66	27.50	4	92.5	0.3	0.5	26.8	30.7	0.00	56	19.630	37.8
67	27.78	4	87.7	0.3	0.5	27.1	30.7	0.00	56	19.739	38.3
68	28.06	4	88.9	0.3	0.4	27.2	30.3	0.00	55	19.655	38.3
75	30.00	4	89.0	0.3	0.6	30.6	33.9	0.00	56	17.359	43.1
76	30.15	7	97.9	0.3	0.6	30.3	32.7	0.00	55	17.416	42.8
77	30.29	7	92.1	0.3	0.6	31.6	36.1	0.00	56	17.529	44.6
78	30.44	7	93.9	0.3	0.6	31.8	36.1	0.00	55	17.712	44.9
79	30.59	7	98.1	0.3	0.6	30.2	32.9	0.00	56	17.551	42.5
80	30.74	7	94.5	0.3	0.6	31.7	36.3	0.00	55	17.653	44.7
81	30.88	7	97.0	0.3	0.6	31.2	35.2	0.00	56	17.942	43.9
82	31.03	7	97.9	0.3	0.6	31.4	36.1	0.00	55	18.048	44.2
83	31.18	7	92.5	0.3	0.6	31.4	35.6	0.00	57	17.902	44.2
84	31.32	7	95.6	0.3	0.8	28.9	31.3	0.00	55	16.198	40.7
85	31.47	7	95.9	0.3	0.5	31.0	35.3	0.00	55	17.957	43.7
86	31.62	7	100.9	0.4	0.6	31.7	36.0	0.00	55	17.571	44.7
87	31.76	7	95.5	0.3	0.6	31.4	35.6	0.00	57	17.729	44.3
88	31.91	7	101.4	0.4	0.7	30.5	34.1	0.00	55	17.089	43.0
89	32.06	7	95.1	0.3	0.6	32.1	36.4	0.00	56	17.729	45.2
90	32.21	7	93.3	0.3	0.6	31.0	35.1	0.00	55	17.368	43.7
91	32.35	7	94.1	0.3	0.6	31.4	35.1	0.00	56	17.399	44.3
92	32.50	7	93.8	0.3	0.5	30.8	34.8	0.00	56	17.457	43.4
93	32.65	7	96.8	0.3	0.5	31.0	35.6	0.00	55	17.609	43.7
94	32.79	7	96.3	0.3	0.6	31.2	34.7	0.00	56	17.409	43.9
95	32.94	7	96.4	0.3	0.6	31.6	35.8	0.00	55	17.378	44.6
96	33.09	7	96.6	0.3	0.6	31.1	34.4	0.00	55	17.449	43.8
97	33.24	7	93.4	0.3	0.6	32.0	35.7	0.00	55	17.550	45.2
98	33.38	7	94.6	0.3	0.6	30.9	34.1	0.00	56	16.940	43.6
99	33.53	7	93.2	0.3	0.6	32.0	35.8	0.00	56	17.159	45.1
109	35.00	7	86.5	0.3	0.7	31.0	32.9	0.00	56	16.563	43.7
110	35.15	7	99.0	0.3	0.6	30.5	31.1	0.00	55	17.381	42.9
111	35.29	7	95.2	0.3	0.7	30.6	31.8	0.00	58	17.089	43.2
112	35.44	7	89.1	0.3	0.7	30.8	32.1	0.00	56	16.936	43.5
113	35.59	7	94.9	0.3	0.7	31.7	33.0	0.00	56	17.320	44.8
114	35.74	7	87.5	0.3	0.7	31.2	33.3	0.00	57	17.189	44.0
115	35.88	7	101.6	0.4	0.7	30.9	32.3	0.00	55	17.022	43.6
116	36.03	7	92.3	0.3	0.6	32.1	34.8	0.00	56	17.318	45.2
117	36.18	7	108.0	0.4	0.5	31.1	32.8	0.00	55	17.741	43.8
118	36.32	7	98.2	0.3	0.7	29.5	32.4	0.00	56	16.443	41.6
119	36.47	7	97.7	0.3	0.6	30.4	33.2	0.00	56	17.030	42.9
120	36.62	7	102.1	0.4	0.7	28.8	30.1	0.00	56	17.030	40.7
121	36.76	7	99.7	0.3	0.6	29.3	32.6	0.00	56	16.624	41.3
122	36.91	7	95.3	0.3	0.6	29.1	32.2	0.00	56	16.424	41.1
123	37.06	7	87.6	0.3	0.7	28.1	29.9	0.00	56	16.646	39.6
124	37.21	7	96.3	0.3	0.8	26.9	27.6	0.00	55	15.949	38.0
125	37.35	7	96.5	0.3	0.6	29.1	30.5	0.00	55	17.299	41.1
126	37.50	7	93.3	0.3	0.6	29.5	30.9	0.00	56	17.425	41.6
		Average	91.9	0.3	0.6	27.9	30.1	0.00	56	17.398	39.4
		Std. Dev.	4.9	0.0	0.1	2.7	3.8	0.00	1	0.833	3.8

BORETEC-1-01 - B-1 20FT
OP: WMN

TRACK RIG EC-95
Date: 05-October-2015

BL#	depth ft	BLC bl/ft	ETR (%)	EMX k-ft	FVP []	CSX ksi	CSI ksi	CSB ksi	BPM bpm	VMX f/s	FMX kips

Total number of blows analyzed: 96

BL#	Sensors
8-48	F3: [SPT B2] 218.9 (1.00); F4: [SPT B1] 217.8 (1.00); A3: [K0035] 295.0 (1.00); A4: [K5175] 354.0 (1.00)
57-126	F3: [SPT B1] 217.8 (1.00); F4: [SPT B2] 218.9 (1.00); A3: [K5175] 354.0 (1.00); A4: [K0035] 295.0 (1.00)

BL#	Comments
48	N: 6, 11, 28
57	LE = 29.20 ft; WC = 16,778.2 f/s
68	N: 7, 7, 6
75	LE = 34.30 ft; WC = 16,781.6 f/s
99	N: 5, 11, 14
109	LE = 39.30 ft; WC = 16,731.7 f/s
126	N: 8, 8, 10

Time Summary

Drive	43 seconds	2:08 PM - 2:09 PM (10/5/2015) BN 8 - 48
Stop	14 minutes 9 seconds	2:09 PM - 2:23 PM
Drive	11 seconds	2:23 PM - 2:23 PM BN 57 - 68
Stop	12 minutes 12 seconds	2:23 PM - 2:36 PM
Drive	25 seconds	2:36 PM - 2:36 PM BN 75 - 99
Stop	11 minutes 49 seconds	2:36 PM - 2:48 PM
Drive	18 seconds	2:48 PM - 2:48 PM BN 109 - 126

Total time [00:39:50] = (Driving [00:01:38] + Stop [00:38:11])

APPENDIX B

APPENDIX B

LABORATORY TESTING

CEC

CEC tests were completed by AMTest Laboratories in Kirkland, Washington, to help assess the suitability of on-site soil for water quality treatment.

ORGANIC CONTENT

Organic content tests were completed by AMTest Laboratories in Kirkland, Washington, to help assess the suitability of on-site soil for water quality treatment.

Am Test Inc.
13600 NE 126TH PL
Suite C
Kirkland, WA 98034
(425) 885-1664
www.amtestlab.com

Professional Analytical Services

ANALYSIS REPORT

GeoDesign, Inc.
19201 120TH AVE NE
BOTHELL, WA 98011
Attention: ROBBIE HILAL
Project Name: FIRCREST ATP RENNOVATION
Project #: NAC_1_02
PO Number: NAC_1_02
All results reported on an as received basis.

Date Received: 01/22/21
Date Reported: 2/10/21

AMTEST Identification Number **21-A000954**
Client Identification **TP-1 S-3 W8'**
Sampling Date **01/19/21**

Conventionals

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Cation Exchange Capacity	1.8	meq/100g		0.5	SW-846 9081	JDR	02/01/21

Miscellaneous

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANLST	DATE
Organic Matter	1.2	%			SM 2540G	DM	01/25/21

AMTEST Identification Number **21-A000955**
Client Identification **TP-2 S-3 W8'**
Sampling Date **01/19/21**

Conventionals

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Cation Exchange Capacity	1.0	meq/100g		0.5	SW-846 9081	JDR	02/01/21

Miscellaneous

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANLST	DATE
Organic Matter	0.7	%			SM 2540G	DM	01/25/21

AMTEST Identification Number **21-A000956**
Client Identification **TP-3 S-3 W8'**
Sampling Date **01/19/21**

Conventionals

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANALYST	DATE
Cation Exchange Capacity	1.5	meq/100g		0.5	SW-846 9081	JDR	02/01/21

Miscellaneous

PARAMETER	RESULT	UNITS	Q	D.L.	METHOD	ANLST	DATE
Organic Matter	0.8	%			SM 2540G	DM	01/25/21

Kathy Fugiel
President

AmTest Chain of Custody Record

AMTEST LABORATORIES

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

Chain of Custody No.

Client Name & Address: GeoDesign Inc. (NV5 company) 19201 120th Ave NE #201 Bothell, WA 98011	Invoice To: SAME
Contact Person: Robbie Hild	Invoice Contact: Robbie Hild
Phone No: (206)459-4792	PO Number: Job NAC-1-02
Fax No:	Invoice Ph/Fax: (206)459.479
E-mail: robbie.hild@NV5.com	Invoice E-mail: robbie.hild@NV5.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: 11.2

Project Name: Fircrest ATP Remodel

Project Number: NAC-1-02

AmTest ID	Client ID (35 characters max)	Date Sampled	Time Sampled	Matrix	No. of containers	Analysis Requested CEC	Organic matter								QA/QC
954	TP-1 S-3 @ 8'	1/19/21	AM												
55	TP-2 S-3 @ 8'	1/19/21	AM												
56	TP-3 S-3 @ 8'	1/19/21	AM												

Collected/Relinquished By:	Date	Time	Received By:	Date	Time
Robbie Hild	1/22/21	12:30		1/22/21	1230
Relinquished By: Robbie Hild	Date	Time	Received By:	Date	Time
Relinquished By:	Date	Time	Received By:	Date	Time

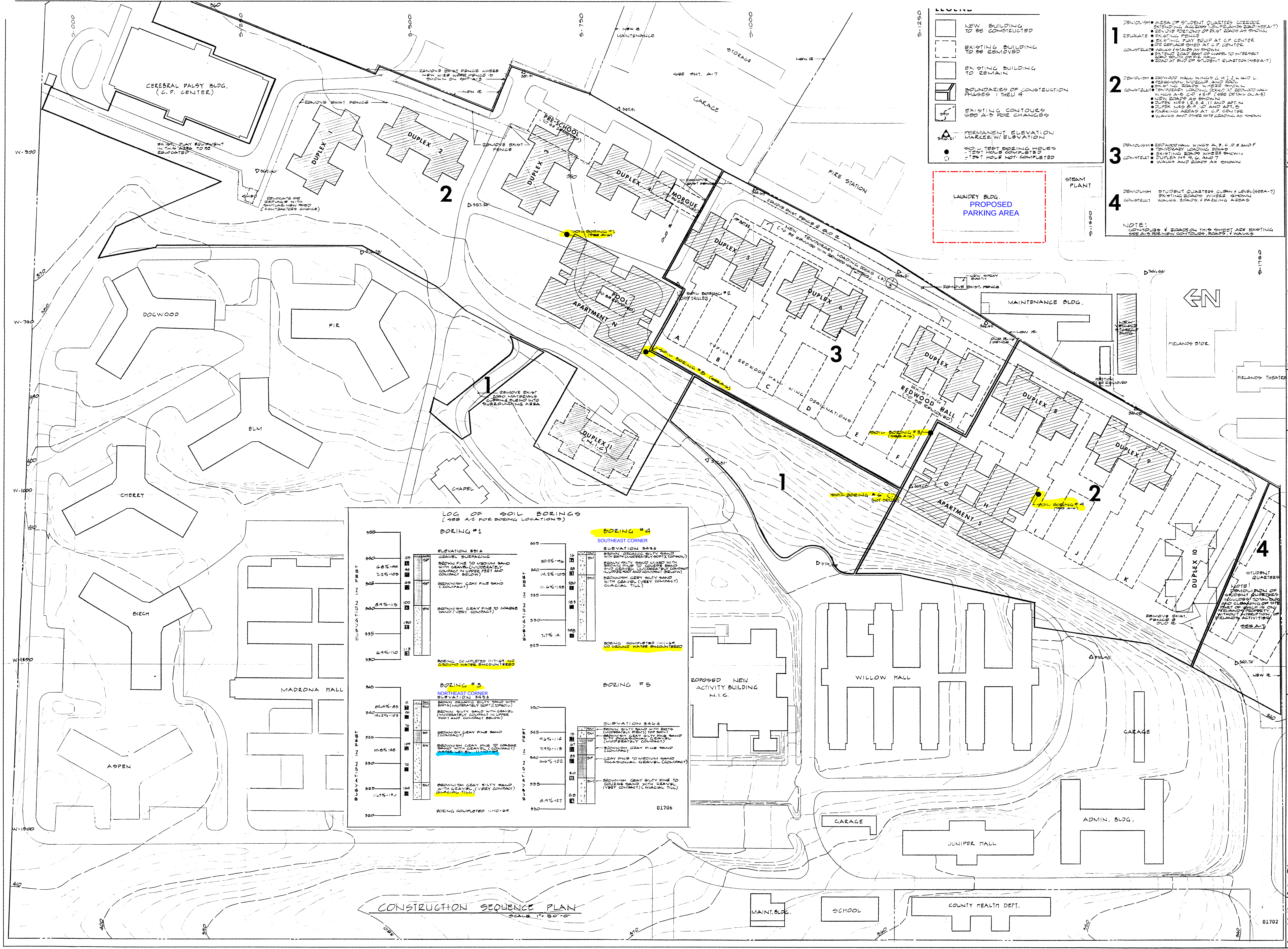
COMMENTS:

client

APPENDIX C

APPENDIX C

ATP BUILDING EXISTING BORING LOGS



LEGEND

☐	NEW BUILDING TO BE CONSTRUCTED
⬚	EXISTING BUILDING TO BE REMOVED
☐	EXISTING BUILDING TO REMAIN
▨	BOUNDARIES OF CONSTRUCTION PHASES 1 THRU 4
340	EXISTING CONTOURS SEE A-3 FOR CHANGES
△ 390.21'	PERMANENT ELEVATION MARKER W/ ELEVATION
●	SOIL TEST BORING HOLES - TEST HOLE COMPLETED
○	- TEST HOLE NOT-COMPLETED

1
DEMOLISH
- AREA OF STUDENT QUARTERS CORRIDOR EXTENDING ACCROSS FIRLANDS ROAD (SEE A-7)
- REMOVE PORTIONS OF EXIST ROADS AS SHOWN

RELOCATE
- EXISTING FENCE
- EXISTING PLAY EQUIP AT C.P. CENTER
- OR REPLACE SHED AT C.P. CENTER

CONSTRUCT
- WALKS & STAIRS AS SHOWN
- EXTEND ROAD EAST OF CHAPEL TO INTERSECT ROAD SOUTH OF FIR HALL
- ROAD AT END OF STUDENT QUARTERS (SEE A-7)

2
DEMOLISH
- REDWOOD HALL WINGS G, H, I, J, K AND L.
- PRESCHOOL, MORGUE, AND POOL
- EXISTING ROADS WHERE SHOWN

CONSTRUCT
- TEMPORARY LOADING DOCKS AT REDWOOD HALL WINGS A-B, C-D, & E-F (SEE DETAIL ON A-3)
- NEW ROADS AS SHOWN
- DUPLEX NOS 1, 2, 3, 4, 11 AND APT. N
- DUPLEX NOS 8, 9, 10 AND APT. S
- PARKING AREAS AT C.P. CENTER
- WALKS AND OTHER SITE GRADING AS SHOWN

3
DEMOLISH
- REDWOOD HALL WINGS A, B, C, D, E AND F
- TEMPORARY LOADING DOCKS
- EXISTING ROADS WHERE SHOWN

CONSTRUCT
- DUPLEX NO 5, 6, AND 7
- WALKS AND ROADS AS SHOWN

4
DEMOLISH STUDENT QUARTERS, CLEAN & LEVEL (SEE A-7)
EXISTING ROADS WHERE SHOWN
CONSTRUCT WALKS, ROADS, & PARKING AREAS

NOTE:
CONTOURS & ROADS ON THIS SHEET ARE EXISTING
SEE A-3 FOR NEW CONTOURS, ROADS, & WALKS

LOG OF SOIL BORINGS
(SEE A-2 FOR BORING LOCATIONS)

BORING #1
ELEVATION 351±

Elevation scale 355–330 (ELEVATION IN FEET); samples: 25, 44, 43, 100, 150, 113; 6.8%-99, 7.2%-105, 8.9%-115, 6.9%-110

- GW — GRAVEL SURFACING
- SP — BROWN FINE TO MEDIUM SAND WITH GRAVEL (MODERATELY COMPACT IN UPPER FEET AND COMPACT BELOW)
- SP — BROWNISH GRAY FINE SAND (COMPACT)
- SW — BROWNISH GRAY FINE TO COARSE SAND (VERY COMPACT)

BORING COMPLETED 11-7-69 NO GROUND WATER ENCOUNTERED

BORING #4
SOUTHEAST CORNER
ELEVATION 343±

Elevation scale 345–325 (ELEVATION IN FEET); samples: 16, 28, 280, 183, 358; 20.2%-96, 19.2%-105, 11.6%-125, 7.7% 141

- SM — BROWN ORGANIC SILTY SAND WITH ROOTS (MODERATELY SOFT)(TOPSOIL)
- SM — BROWN SILTY SAND MIXED WITH BROWN FINE TO COURSE SAND AND GRAVEL (MODERATELY COMPACT IN UPPER FOOT AND COMPACT BELOW)
- SM — BROWNISH GREY SILTY SAND WITH GRAVEL (VERY COMPACT) GLACIAL TILL)

BORING COMPLETED 11-11-69 NO GROUND WATER ENCOUNTERED

BORING #3
NORTHEAST CORNER
ELEVATION 343±

Elevation scale 345–320 (ELEVATION IN FEET); samples: 12, 26, 76, 109, 74, 144; 32.4%-83, 14.2%-103, 10.8% 128, 11.7%-130

- SM — BROWN ORGANIC SILTY SAND WITH ROOTS (MODERATELY SOFT)(TOPSOIL)
- SM — BROWN SILTY SAND WITH GRAVEL (MODERATELY COMPACT IN UPPER FOOT AND COMPACT BELOW)
- SP — BROWNISH GRAY FINE SAND (COMPACT)
- SW — BROWNISH GRAY FINE TO COARSE SAND WITH GRAVEL (COMPACT) WATER LEVEL 11-10-69
- SM — BROWNISH GRAY SILTY SAND WITH GRAVEL (VERY COMPACT) (GLACIAL TILL)

BORING COMPLETED 11-10-69

BORING #5
ELEVATION 346±

Elevation scale 350–330 (ELEVATION IN FEET); samples: 15, 67, 83, 310, 218; 9.6%-114, 7.9%-113, 6.6%-122, 8.9%-127

- SM — BROWN SILTY SAND WITH ROOTS (MODERATELY FIRM)(TOP SOIL)
- SM — BROWNISH GRAY SILTY FINE SAND WITH OCCASIONAL GRAVEL (MODERATELY COMPACT)
- SP — BROWNISH GRAY FINE SAND (COMPACT
- SP — GRAY FINE TO MEDIUM SAND OCCASIONAL GRAVEL (COMPACT)
- SM — BROWNISH GRAY SILTY FINE TO COURSE SAND WITH GRAVEL (VERY COMPACT) (GLACIAL TILL)

01706

CONSTRUCTION SEQUENCE PLAN
SCALE 1" = 50'-0"

01702

Revisions:
5-1-72 DUPLEX II - DELETED PER ALTERNATE
12-27-72 "AS-BUILT" CONDITION

Sheet Contents: CONSTRUCTION SEQUENCE PLAN

Approvals:
Agency: Donald E. Dunlevy
Job Capt.: Jeffrey A. Fong
Section Head: [illegible]
Agency Director: William R. Coates
Supv. of Eng. & Arch.: [illegible]

Drawn: ATWOOD
Traced:
Checked: DeCHASSE
Date: 7-1-70

REGISTERED ARCHITECT
STATE OF WASHINGTON
TL1094
Richard O. Schmidt

Prepared by:
SHAVEY & SCHMIDT A.I.A., ARCHITECTS
710 CHERRY STREET SEATTLE, WASHINGTON 98104

Project Title:
REPLACE REDWOOD HALL
FIRCREST SCHOOL
SEATTLE, WASHINGTON

State Job No.: 67-366
Sheet No.: A2

STATE OF WASHINGTON – DEPARTMENT OF GENERAL ADMINISTRATION – DIV. OF ENGINEERING & ARCHITECTURE

67-366
1702

Appendix C

Permanent Stormwater Control Calculations

C-1 TYPICAL FLOW CONTROL CALCULATION

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.57
Program License Number: 201710010
Project Simulation Performed on: 04/08/2022 3:55 PM
Report Generation Date: 04/08/2022 3:55 PM

Input File Name: Fircrest FC Modeling.fld
Project Name: Fircrest Flow Control
Analysis Title:
Comments:

——————————— PRECIPITATION INPUT ———————————

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 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)	10.810	10.810
Area of Links that Include Precip/Evap (acres)	0.000	0.000
Total (acres)	10.810	10.810

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

---------- Subbasin : Existing Condition ----------

	-------Area (Acres) --------
C, Forest, Mod	10.810
--	
Subbasin Total	10.810

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


  ---------- Subbasin : Developed Condition ----------
                          -------Area (Acres) --------
C, Lawn, Mod                2.360
ROADS/MOD                   2.810
ROOF TOPS/FLAT                        5.640
-------------------------------------------
Subbasin Total              10.810



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

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


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

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


------------------------------------------
Link Name: FC
Link Type:   Structure
Downstream Link: None

Prismatic Pond Option Used
Pond Floor Elevation (ft)           :      100.00
Riser Crest Elevation (ft)                    :      103.00
Max Pond Elevation (ft)             :      104.00
Storage Depth (ft)                  :      3.00
Pond Bottom Length (ft)             :       360.0
Pond Bottom Width (ft)              :       220.0
Pond Side Slopes (ft/ft)            : Z1= 3.00    Z2= 3.00   Z3= 3.00   Z4= 3.00
Bottom Area (sq-ft)                 :      79200.
Area at Riser Crest El (sq-ft)      :      89,964.
                        (acres)     :       2.065
Volume at Riser Crest (cu-ft)       :      253,584.
                        (ac-ft)     :      5.821
Area at Max Elevation   (sq-ft)     :      93696.
                        (acres)     :       2.151
Vol at Max Elevation   (cu-ft)      :     345,408.
                        (ac-ft)     :      7.929

Hydraulic Conductivity (in/hr)     :   0.00
Massmann Regression Used to Estimate Hydralic Gradient
Depth to Water Table (ft)                     : 100.00
Bio-Fouling Potential               : Low
Maintenance                         : Average or Better

Riser Geometry
```

Volume Required for Flow Control Treatment (Total)

Ratio of FC Volume/Impervious Area

= 253,584/(2.81+5.64)

= 30,009.94

~30,000 CF/AC

```
Riser Structure Type              : Circular
Riser Diameter (in)               : 30.00
Common Length (ft)                : 0.210
Riser Crest Elevation             : 103.00 ft

 Hydraulic Structure Geometry

Number of Devices:      2

      ---Device Number    1 ---
Device Type               :   Circular Orifice
Control Elevation (ft)    :   100.00
Diameter (in)             :   1.63
Orientation               : Horizontal
Elbow                     : No

      --- Device Number    2 ---
Device Type               : Vertical Rectangular Orifice
Control Elevation (ft)    :   101.83
Length (in)               :     2.52
Height (in)               :     14.01
Orientation               : Vertical
Elbow                     : No


**********************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

********** Subbasin: Developed Condition **********

 Flood Frequency Data(cfs)
 (Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs)          Flood Peak (cfs)
====================================
   2-Year          3.711
   5-Year          4.918
   10-Year         5.670
   25-Year         7.601
   50-Year         9.024
   100-Year        11.802
   200-Year        12.542
   500-Year        13.476


********** Link: FC                                                   **********       Link Inflow
Frequency Stats
 Flood Frequency Data(cfs)
```

```
 (Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs)           Flood Peak (cfs)
=======================================
    2-Year         3.711
    5-Year         4.918
    10-Year        5.670
    25-Year        7.601
    50-Year        9.024
    100-Year       11.802
    200-Year       12.542
    500-Year       13.476
```

```
********** Link: FC                                                          **********      Link WSEL
Stats
 WSEL Frequency Data(ft)
 (Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs)           WSEL Peak (ft)
=======================================
    1.05-Year      100.969
    1.11-Year      101.132
    1.25-Year      101.239
    2.00-Year      101.680
    3.33-Year      101.976
        5-Year     102.150
       10-Year     102.402
       25-Year     102.594
       50-Year     102.663
    100-Year       102.691
```

*************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: Existing Condition      1864.432
____________________________________________
Total:                                       1864.432

                 Total Post Developed Recharge During Simulation
Model Element                               Recharge Amount (ac-ft)
-----------------------------------------------------------------------------------------
Subbasin: Developed Condition            288.413
Link:       FC                    0.000
____________________________________________
Total:                                                288.413
```

Total Predevelopment Recharge is Greater than Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped: 11.800 ac-ft/year,   Post Developed: 1.825 ac-ft/year

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

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

Number of Links:   0


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

Number of Links:   1


********** Link: FC                                                    **********

 Basic Wet Pond Volume (91% Exceedance):   39778. cu-ft
 Computed Large Wet Pond Volume, 1.5*Basic Volume:   59667. cu-ft

 2-Year Discharge Rate : 0.091 cfs

 15-Minute Timestep, Water Quality Treatment Design Discharge
 On-line Design Discharge Rate (91% Exceedance):   1.28 cfs
 Off-line Design Discharge Rate (91% Exceedance):   0.71 cfs


 Infiltration/Filtration Statistics--------------------
 Inflow Volume (ac-ft):   4266.76
 Inflow Volume Including PPT-Evap (ac-ft):   4266.76
 Total Runoff Infiltrated (ac-ft):   0.00,   0.00%
 Total Runoff Filtered (ac-ft):   0.00,   0.00%
 Primary Outflow To Downstream System (ac-ft):   4265.61
 Secondary Outflow To Downstream System (ac-ft):   0.00
 Volume Lost to ET (ac-ft):   0.00
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 0.00%


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

Scenario Predeveloped Compliance Subbasin: Existing Condition

Scenario Postdeveloped Compliance Link: FC

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

       Predevelopment Runoff                   Postdevelopment Runoff
Tr (Years)        Discharge (cfs)            Tr (Years)      Discharge (cfs)
------------------------------------------------------------------------------
   2-Year                     0.230          2-Year            9.133E-02
   5-Year                     0.375          5-Year                0.205
   10-Year                    0.506          10-Year               0.352
   25-Year                    0.641          25-Year               0.487
   50-Year                    0.819          50-Year               0.540
   100-Year                   0.887          100-Year              0.562
   200-Year                   1.381          200-Year              0.607
   500-Year                   2.044          500-Year              0.667
 ** 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%):	-34.4%	PASS ✓
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):	-25.6%	PASS ✓
Maximum Excursion from Q2 to Q50 (Must be less than 10%):	-9.3%	PASS ✓
Percent Excursion from Q2 to Q50 (Must be less than 50%):	0.0%	PASS ✓

MEETS ALL FLOW DURATION DESIGN CRITERIA: PASS

C-2 TYPICAL WATER QUALITY CALCULATION

MGS FLOOD
PROJECT REPORT

Program Version: MGSFlood 4.57
Program License Number: 201710010
Project Simulation Performed on: 04/08/2022 4:06 PM
Report Generation Date: 04/08/2022 4:07 PM

Input File Name:	Fircrest WQ Modeling.fld
Project Name:	Fircrest Water Quality
Analysis Title:	Bioretention and Water Quality Flow Rates
Comments:	

PRECIPITATION INPUT

Computational Time Step (Minutes): 15

Extended Precipitation Time Series Selected
Climatic Region Number: 15

Full Period of Record Available used for Routing
Precipitation Station : 96004005 Puget East 40 in_5min 10/01/1939-10/01/2097
Evaporation Station : 961040 Puget East 40 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)	1.000	1.000
Area of Links that Include Precip/Evap (acres)	0.000	0.004
Total (acres)	1.000	1.004

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

Number of Subbasins: 1

---------- Subbasin : Existing Condition ----------

	-------Area (Acres) --------
ROADS/MOD	1.000
Subbasin Total	1.000

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


  ---------- Subbasin : PGIS ----------
                         -------Area (Acres) --------
ROADS/MOD                     1.000
--------------------------------------------
Subbasin Total                1.000



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

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


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

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


----------------------------------------
Link Name: Bioretention
Link Type:   Ecology Bioretention Facility
Downstream Link: None

Floor Elevation (ft)                   :     100.00
Riser Crest Elevation (ft)                     :     100.50
Storage Depth (ft)                     :    0.50
Bottom Length (ft)                     :     15.0
Bottom Width (ft)                      :     12.0
Bottom Slope (ft/ft)                   :     0.000
Side Slopes (ft/ft)                    : Z1= 3.00    Z2= 3.00   Z3= 3.00   Z4= 3.00
Bottom Area (sq-ft)                    :     180.
Area at Riser Crest El (sq-ft)         :     270.
                           (acres)     :      0.006
Volume at Riser Crest (cu-ft)          :     223.
                           (ac-ft)     :     0.005

Infiltration on Bottom only Selected

Soil Properties
Layer No   Soil Name                          Thickness (ft)
        1 ASTM 100                      0.250
        2 SMMWW 12 in/hr (Ecol          1.500
        3 GRAVEL                        1.500

KSat Safety Factor: None
Native Soil Infiltration Rate (in/hr)         :        0.00

Underdrain Present
Underdrain Offset (in):                :       6.00
Orifice Diameter (in)                  :       6.000
```

270 SF of Bioretention @ 6" ponding depth
Per 1 acre of PGIS

```
Riser Geometry
Riser Structure Type            : Circular
Riser Diameter (in)             : 6.00
Common Length (ft)              : 0.000
Riser Crest Elevation           : 100.50 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

********** Subbasin: PGIS **********

 Flood Frequency Data(cfs)
 (Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs)           Flood Peak (cfs)
========================================
    2-Year          0.459
    5-Year          0.615
    10-Year         0.775
    25-Year         0.990
    50-Year         1.096
    100-Year        1.460
    200-Year        1.641
    500-Year        1.876



********** Link: Bioretention                                  **********      Link Inflow
Frequency Stats
 Flood Frequency Data(cfs)
 (Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs)           Flood Peak (cfs)
========================================
    2-Year          0.459
    5-Year          0.615
    10-Year         0.775
    25-Year         0.990
    50-Year         1.096
    100-Year        1.460
    200-Year        1.641
    500-Year        1.876
```

```
********** Link: Bioretention                                        **********      Link WSEL Stats
 WSEL Frequency Data(ft)
 (Recurrence Interval Computed Using Gringorten Plotting Position)
Tr (yrs)           WSEL Peak (ft)
=======================================
    1.05-Year     100.613
    1.11-Year     100.620
    1.25-Year     100.639
    2.00-Year     100.690
    3.33-Year     100.751
        5-Year    100.798
      10-Year     100.910
      25-Year     101.063
      50-Year     101.182
    100-Year      101.504



 ***********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: Existing Condition       0.000
________________________________________
Total:                                          0.000

                  Total Post Developed Recharge During Simulation
Model Element                                  Recharge Amount (ac-ft)
-----------------------------------------------------------------------------------------
Subbasin: PGIS                     0.000
Link:        Bioretention          0.000
________________________________________
Total:                                                    0.000

Total Predevelopment Recharge Equals Post Developed
Average Recharge Per Year, (Number of Years= 158)
Predeveloped:     0.000 ac-ft/year,    Post Developed:     0.000 ac-ft/year
```

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

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

Number of Links:   0


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

Number of Links:   1
```

WQ Discharge rates for preliminary sizing of underground treatment structures such as Biopod and Modular Wetland.

```
********** Link: Bioretention                                          **********

 2-Year Discharge Rate : 0.412 cfs

 15-Minute Timestep, Water Quality Treatment Design Discharge
 On-line Design Discharge Rate (91% Exceedance):   0.17 cfs
 Off-line Design Discharge Rate (91% Exceedance):   0.09 cfs

 Infiltration/Filtration Statistics--------------------
 Inflow Volume (ac-ft):   451.51
 Inflow Volume Including PPT-Evap (ac-ft):   452.88
 Total Runoff Infiltrated (ac-ft):   0.00,   0.00%
 Total Runoff Filtered (ac-ft):   413.90,   91.39%✓
 Primary Outflow To Downstream System (ac-ft):   450.87
 Secondary Outflow To Downstream System (ac-ft):   0.00
 Volume Lost to ET (ac-ft):   2.02
 Percent Treated (Infiltrated+Filtered+ET)/Total Volume: 91.84%✓


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

Scenario Predeveloped Compliance Subbasin: Existing Condition

Scenario Postdeveloped Compliance Link: Bioretention

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

        Predevelopment Runoff                      Postdevelopment Runoff
Tr (Years)        Discharge (cfs)            Tr (Years)       Discharge (cfs)
----------------------------------------------------------------------------------------------------
   2-Year                 0.459                2-Year                 0.412
   5-Year                 0.615                5-Year                 0.515
   10-Year                0.775                10-Year                0.592
   25-Year                0.990                25-Year                0.684
   50-Year                1.096                50-Year                0.746
   100-Year               1.460                100-Year               0.897
   200-Year               1.641                200-Year               0.960
   500-Year               1.876                500-Year               1.041
 ** 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%):               -20.3%    PASS
Maximum Excursion from 50%Q2 to Q2 (Must be Less Than or Equal to 0%):             -9.7%    PASS
Maximum Excursion from Q2 to Q50 (Must be less than 10%):                         -19.7%    PASS
Percent Excursion from Q2 to Q50 (Must be less than 50%):                           0.0%    PASS

-------------------------------------------------------------------------------------------
MEETS ALL FLOW DURATION DESIGN CRITERIA:     PASS
-------------------------------------------------------------------------------------------
```