Stormwater Site Plan
Plat of Squalicum Heights
Bellingham, Washington

TPN. 380316 504243

Prepared For:
Squalicum Heights, LLC
2950 Newmarket Street
#101-254
Bellingham, WA 98226

Prepared By:
Freeland & Associates, Inc.
220 W. Champion Street;
Suite 200
Bellingham, WA 98225
(360) 650-1408

June 2023

FREELAND
& ASSOCIATES
CIVIL ENGINEERS

Table of Contents

ENGINEER'S DECLARATION

"I, Jean-Paul Slagle, a Professional Engineer registered in the State of Washington as a Civil Engineer, do hereby declare that the Plat of Squalicum Heights dated June 2023 was prepared by, or under my personal supervision, and that said Report was prepared in accordance with generally accepted engineering practices. I hereby affirm that, to the best of my knowledge, information and belief, subject Report was prepared in full compliance with the 2019 Washington State Department of Ecology Stormwater Management Manual for Western Washington (2019 DOE SWMM), City of Bellingham Municipal Code 15.42.060, and all Technical Standards adopted there under.

Jean-Paul Salomé Slagle
WA P.E. #43224

This report is not intended to be a final site plan for this project or any individual proposed improvements, and is not intended for use as part of any review of critical area. Existing drainage and site conditions or improvements not mentioned are beyond the scope of this report.

STORMWATER SITE PLAN

The Stormwater Site Plan (SSP) is the comprehensive report containing all the technical information and analysis necessary for regulatory agencies to evaluate the proposed development for compliance with stormwater requirements.

Existing Conditions Summary

The subject property is located along the 2500 Block of E Mcleod Road in Bellingham, Washington (TPN: 380316 504243). The parcel occupies 5.59 acres of land and forms an irregular shape. The site is situated in the Barkley Neighborhood Subarea 2 and zoned Residential Multi. Adjacent land use includes single family residential to the south, east, and west, and Squalicum High School campus directly to the north. Refer to *Figure 1 - Vicinity Map* for the project location.

The site is currently undeveloped and forested with a few indications of historic logging including stumps and downed trees. Mature trees on the site include fir, cedar, alder, and maple. The site is accessible from E Mcleod Road to the north, Magrath Road to the northeast, and Pebble Place to the southwest. The North Ridge Park walking trail runs along the site's southern and eastern property boundaries. Refer to *Figure 2 – Aerial Photograph* for the existing site conditions.

Topography of the site appears to descend from the southeastern corner of the site to the northwestern corner with grades commonly at or less than 30%. The existing stormwater runoff onsite appears to either infiltrate where it lands or sheet flow northwest along the surface to the municipal stormwater system located within the E Mcleod right-of-way. Stormwater collected in the municipal stormwater system is ultimately conveyed to Squalicum Creek. See the *Offsite Analysis* section of this report for a detailed description of the existing drainage system downstream from the project.

Project Overview

The project includes development of a 36-lot residential plat (Plat of Squalicum Heights). The proposed residential lots will range in size from approximately 4,00 to 6,000 square feet. Access to the development is proposed from Pebble Place to the southwest and Magrath Road to the northeast. Associated improvements include municipal utility connections, interior plat roads, parking, and stormwater management facilities. A common space tract as well as residential landscaping are planned to enhance the development.

This project site is separated into two separate threshold discharge areas (TDAs): the West TDA and East TDA. The East TDA proposed development remains below both the flow control and treatment thresholds and will not require specific stormwater management facilities. The West TDA triggers both the treatment and flow control requirements, so applicable stormwater management methods were analyzed. Onsite infiltration is infeasible due to the presence of restrictive soils, underlying bedrock, and indications of shallow perched groundwater conditions in the wet season. Additionally, onsite dispersion is infeasible due to the steep onsite slopes and the total onsite impervious surface cover eliminating sufficient flow paths. Therefore, an Aquaswirl treatment facility is proposed for stormwater pretreatment and a Combined Detention and Wetpool Facility per BMP T40.10 is proposed for stormwater detention and enhanced treatment. These management facilities will be constructed in a separate tract located in the northwest corner of the proposed Plat.

Refer to *Minimum Requirement #5 - On-site Stormwater Management, Minimum Requirement #6 - Runoff Treatment,* and *Minimum Requirement #7 - Flow Control* within this report for further discussion about the applicable stormwater management requirements. See the *Calculations* section for the specific design of the facilities and sizing discussion.

Onsite Soils Analysis

According to the Natural Resource Conservation System Online Soil Survey, soils on the site are mapped as Squalicum-Urban land complex (#156). Squalicum-urban land soils are described as gravely ashy loam derived from volcanic ash and loess over glaciomarine deposits. Squalicum-Urban land complex soils belong to hydrologic group ‘B’ which are moderately well drained. See the *Figures* section of the report for the regional soil mapping, and the *Calculations* section of the report for a discussion of how the hydrologic soil group is used in the hydraulic calculations.

Onsite Soils Testing

GeoTest Services, Inc. (herein referred to as GeoTest) completed a geotechnical engineering investigation on the project site and summarized their findings in a report dated June 17, 2020 (GeoTest Report). The primary purpose of the investigation was to assess the soils on the site for potential stormwater infiltration.

Subsurface conditions were investigated in May 2020 by excavation of 9 test pits (TP-1 to TP-9). Subsurface conditions were relatively consistent among the nine test pit locations. Subsurface conditions consisted of approximately 0.5 to 1 foot of organic topsoil. Below the surface topsoil, a thin medium stiff, reddish medium brown moist, sandy silt subsoil horizon was observed in several test pit locations. Below topsoil and subsoil, glaciomarine drift deposits were sandy silt to very silty sand with trace fine gravel and ranged in consistency from stiff to hard or medium dense to dense. Glacial drift deposits were moist, light brown to gray and exhibited orange mottling at the upper interface.

In TP-2 through TP-9, Chuckanut Formation bedrock was found to underlying glaciomarine drift deposits. Bedrock ranged from massive sandstone to thinly bedded and fractured siltstone. Depths to bedrock ranged from approximately 2 feet below ground surface (BGS) to approximately 4 feet BGS. Slight to moderate mottling and oxidation was observed within the shallow glaciomarine drift soils which typically indicates prolonged exposure to perched water conditions.

Based on the presence of glaciomarine drift soils, underlying Chuckanut Formation bedrock, and the indication of shallow perched groundwater conditions in the wet season, GeoTest does not recommend that on-site infiltration be incorporated as part of stormwater design for the proposed development. A copy of the full GeoTest Report is provided in the *Appendix* section for reference.

Offsite Analysis

West TDA

Stormwater runoff from the West Basin flows along the surface downhill to the northwest where it is collected in the municipal stormwater system located in the E Mcleod Road right-of-way. Once collected in the municipal stormwater system, runoff flows west in 12-inch and 15-inch CPP pipes for approximately 1,600 feet along E Mcleod Road. Runoff is then directed northwest in a 24-inch CMP pipe for approximately 300 feet along Mt. Baker Highway. Stormwater runoff is diverted northwest beneath Mt. Baker Highway in a 36-inch PVC pipe for approximately 75 feet and is discharged into the Trickle Creek Wetland Open Space on the north side of the highway. Excess runoff from the Trickle Creek Wetland area drains out of the wetland through a 36-inch culvert located in the northwest corner. This culvert connects to an adjacent forested area that ultimately drains to Squalicum Creek. Squalicum Creek continues west and south for approximately 3.5 miles before its final outfall into Bellingham Bay.

East TDA

Stormwater runoff from the East Basin flows along the surface to the northeast corner of the property where it is collected in the municipal stormwater system located at the corner of E Mcleod Road and Magrath Road. From there, the runoff is conveyed to the east along the E Mcleod Road right-of-way in a 10-inch PVC pipe for approximately 2,750 feet. The municipal stormwater system then diverts the runoff to the north along the Britton Road right-of-way for approximately 1,000 feet in a series of ditches and 18-inch concrete culverts. Finally, the stormwater runoff leaves the municipal stormwater system and outfalls into Toad Creek, which is a tributary of Squalicum Creek. Toad Creek flows for approximately 1.5 miles to the northwest before connecting with Squalicum Creek, which then flows approximately 6 miles southwest before discharging to the Bellingham Bay.

Using topographic maps, CityIQ, field investigation, and experience with similar projects in the vicinity, no erosion or flooding problems have been identified within 1/4 mile downstream from the project site for both TDAs. In review of the City of Bellingham 2020 and 2007 Stormwater Comprehensive Plans, no drainage features downstream of the proposed project have been identified as needing improvement. The proposed project is not anticipated to affect the capacity of any existing conveyance system downstream from the site by implementing flow control facilities or limiting the impervious surface cover to remain below the flow control threshold. Downstream flow paths are graphically depicted in *Figure 4.a - Downstream Drainage Map: West TDA* and *Figure 4.b - Downstream Drainage Map: East TDA.*

Receiving Water Analysis

Stormwater runoff from the project site drains to Squalicum Creek and, ultimately, Bellingham Bay. Downstream from the project site, Squalicum Creek is listed as an impaired water body in Department of Ecology's Water Quality Assessment 303(d) list for Washington. According to the department's online Assessment tool, Squalicum Creek is listed for Bacteria (Category 5), Dissolved Oxygen (Category 5), and Temperature (Category 2). See *Table 1* below for the full list of impairments and *Figure 5 - Water Quality Assessment Map* for additional information.

Table 1 DOE Water Quality Assessment				
Name	**Parameter**	**Medium**	**Category**	**Waterbody ID**
Squalicum Creek	Bacteria	Water	5	17110004014452
Squalicum Creek	Dissolved Oxygen	Water	5	17110004014452
Squalicum Creek	Temperature	Water	4A	17110004014452

The proposed residential development is not expected to create new pollutant sources. No sources of bacteria are known to exist on site or are proposed, and the project will include a connection to the municipal sewer system. Furthermore, chemicals for grounds and landscape maintenance, including detergents, cleaning products, and fertilizers will be stored indoors to prevent contact with stormwater. Stormwater will also be treated using a stormwater treatment system prior to discharging from the site.

DOE AND CITY OF BELLINGHAM MINIMUM REQUIREMENTS

Minimum stormwater management requirements for this project have been determined using BMC 15.42.060 and the 2019 Department of Ecology Stormwater Management Manual for Western Washington (2019 DOE SWMM or DOE Manual). With more than 5,000 square feet new plus replaced hard surface area, the project is subject to Minimum Requirements 1 through 9 in BMC 15.42.060.

For each Minimum Requirement that is applicable to the project per information above, the Threshold Discharge Area (TDA) must be analyzed to determine which, if any, BMP(s) must be constructed within each TDA to satisfy that Minimum Requirement. Thresholds that apply to each TDA are identified within BMC 15.42.060 or the 2019 DOE SWMM.

Minimum Requirements #1, #2, #3, #4, #5, and #9 do not have separate TDA Thresholds, and must be applied to the entire project if they are applicable to the project. Minimum Requirements #6, #7, and #8 have TDA Thresholds that describe when and/or what type(s) of BMP(s) must be constructed within each TDA, if they are applicable to the project.

It is possible for a project to require Minimum Requirements #6, #7, and #8 per the Project Thresholds, but then not require construction of BMPs in individual TDAs to comply with Minimum Requirement #6, #7, and/or #8. By documenting that the TDA Thresholds requiring construction of a BMP have not been triggered for an individual TDA, the project proponent is in compliance with that Minimum Requirement for that TDA.

MINIMUM REQUIREMENT SUMMARY NEW DEVELOPMENT					
Minimum Requirement		**Not Applicable**	**Variance Requested**	**Standard Requirements Incorporated**	**Comments (Report Section Reference or BMP Identifier)**
#	Description				
1	Preparation of Stormwater Site Plans			✓	
2	Construction Stormwater Pollution Prevention Plan			✓	See "Additional Comments"
3	Source Control of Pollution			✓	
4	Preservation of Natural Drainage Systems and Outfalls			✓	
5	On-Site Stormwater Management			✓	
6	Runoff Treatment			✓	
7	Flow Control			✓	
8	Wetlands Protection	✓			No wetlands identified on or near the site.
9	Operation and Maintenance			✓	
#	**Additional Comments**				
2	The Construction SWPPP is included in the civil construction drawings.				

Minimum Requirement #1 - Preparation of Stormwater Site Plans ("SSP")

This report serves as a preliminary Stormwater Site Plan (SSP). All stormwater management systems have been preliminarily designed according to the Department of Ecology (DOE) and City of Bellingham standards. A construction Stormwater Pollution Prevention Plan (SWPPP) will also be prepared and incorporated in the future construction documents.

Minimum Requirement #2 - Construction Stormwater Pollution Prevention Plan (SWPPP)

A SWPPP narrative will be provided with the future civil site plan drawings to ensure that the SWPPP is on site during construction. Each of the thirteen elements of a SWPPP (as identified in BMC 15.42.060(F)(2)(e)) must be considered and included in a Construction SWPPP unless site conditions render the element unnecessary and the exemption from that element is clearly justified in the narrative of the SWPPP. The SWPPP shall include, at a minimum, the narrative and copies of Best Management Practice detail sheets that will be utilized as a part of the SWPPP.

During construction, the contractor shall maintain a copy of the SWPPP on site and shall update or modify the SWPPP as necessary for the current conditions on site. The contractor's schedule and available crew, equipment, and materials will be determined after the project is submitted for permits, but prior to the start of construction. Accordingly, some BMPs that have been specified may not be necessary, while other additional BMPs may be required.

This project will disturb more than one acre of soil and will require a Construction General Stormwater NPDES permit from Washington State Department of Ecology. As such, the project shall retain a Certified Erosion and Sediment Control Lead (CESCL) to determine which BMPs are necessary as site conditions change during construction. The contractor and/or CESCL shall add any BMP specifications are not included in the SWPPP prepared with the future construction documents.

Minimum Requirement #3 - Source Control of Pollution

Pollutant sources for residential projects include vehicular traffic, fertilizers, and other detergents or chemicals typical to residential building maintenance activities. Pollution will be controlled at the source to the maximum extent possible. All known, available, and reasonable source control BMPs have been applied to the design and layout of the site and stormwater plans.

Vehicular traffic is anticipated to be a primary source of potential pollutants. A portion of the parking for the development will be located outside of the proposed building footprints, and any stormwater runoff from this surface will receive stormwater treatment prior to discharge.

Secondary sources of pollutants include garbage and recycling enclosures and landscape areas. Garbage and recycling will be collected in individual covered bins. To minimize landscaping

maintenance and to reduce potential erosion, BMP T5.13 will be applied to all landscaped areas to promote healthy plans and appropriate groundcover.

The following BMPs have been reviewed for this project.

- S406 BMPs for Streets and Highways
- S410 BMPs for Correcting Illicit Discharges to Storm Drains
- S411 BMPs for Landscaping and Lawn / Vegetation Management
- S415 BMPs for Maintenance of Public and Private Utility Corridors and Facilities
- S417 BMPs for Maintenance of Stormwater Drainage and Treatment Systems
- S421 BMPs for Parking and Storage of Vehicles and Equipment
- S453 BMPs for Formation of a Pollution Prevention Team
- S454 BMPs for Preventive Maintenance / Good Housekeeping
- S455 BMPs for Spill Prevention and Cleanup
- S456 BMPs for Employee/Resident Training
- S457 BMPS for Inspections
- S458 BMPs for Record Keeping

See additional details in the project's operations and maintenance manual and in the 2019 Department of Ecology Stormwater Management Manual for Western Washington: *https://fortress.wa.gov/ecy/ezshare/wq/Permits/Flare/2019SWMMWW/2019SWMMWW.htm*

Minimum Requirement #4 - Preservation of Natural Drainage Systems and Outfalls

The project site is fully contained within the Squalicum Creek Watershed. No significant stormwater diversions are proposed as a part of this project. Natural drainage patterns will be maintained by discharging stormwater to Squalicum Creek or Toad Creek (a tributary of Squalicum Creek).

Minimum Requirement #5 - On-site Stormwater Management

BMC 15.42.060(F)(5) states, "Projects shall employ On-site Stormwater Management BMPs to infiltrate, disperse, and retain stormwater runoff onsite to the maximum extent feasible without causing flooding or erosion impacts. On-site Stormwater Management BMPs shall be designed and provided in accordance with the Ecology Manual."

As a project that triggers Minimum Requirements #1 through #9, is located inside the City of Bellingham Urban Growth Area (UGA), and does not discharge to a flow control exempt water body, this project may use On-site Stormwater Management BMPs from List #2 for all surfaces

within each type of surface in List #2 or demonstrate compliance with the LID Performance Standards. This project will meet the requirements outlined in List #2 to the maximum extent feasible, shown in *Table 3* below.

Projects choosing to utilize List #2 of the 2019 DOE Manual to meet the requirements for Minimum Requirement #5 - On-site Stormwater Management must consider the BMPs in the order listed for each type of surface. The first BMP that is considered feasible for each surface must be used, and then no other On-site Stormwater Management BMPs are necessary for that surface. The following table identifies all the required BMPs in List #2 and their feasibility. Additional discussion of the feasibility criteria is outlined after the following table.

TABLE 3 - MINIMUM REQUIREMENT #5 LIST #2				
Minimum Requirement		**Feasible**	**Infeasible**	**Criteria Comments**
#	**Lawn & Landscaped Area**			
1	Post-Construction Soil Quality and Depth - BMP T5.13	✓		This BMP will be applied to all areas outside of roofs or hard surfaces disturbed during construction.
#	**Roofs**			
1	Full Dispersion - BMP T5.30 Full Infiltration - BMP T5.10A		✓	Full dispersion is infeasible due to hard surface coverage and steep topography. Full infiltration is infeasible per geotechnical advisement.
2	Bioretention – BMP T5.70		✓	Infeasible due to limited infiltration per geotechnical advisement.
3	Downspout Dispersion BMP T5.10B		✓	Infeasible due to steep slopes and insufficient space for a flow path down gradient of proposed buildings.
4	Perforated Stub-out Connection BMP T5.10C		✓	Infeasible due to the steep slopes on the site and insufficient space for a flow path down gradient of proposed buildings.
#	**Other Hard Surfaces**			
1	Full Dispersion BMP T5.30		✓	Infeasible due to hard surface coverage and insufficient space for a flow path down gradient of proposed buildings.
2	Permeable Pavement - BMP T5.15		✓	Infeasible per geotechnical advisement.
3	Bioretention – BMP T5.70		✓	Infeasible due to perched groundwater and limited infiltration per geotechnical advisement.
4	Sheet Flow Dispersion BMP T5.12 Concentrated Flow Dispersion BMP T5.11		✓	Infeasible due to insufficient space for a flow path down gradient of proposed buildings and steep slopes.

As noted previously in this report, stormwater dispersion and infiltration systems were analyzed for use with this project. Fully dispersing stormwater runoff from the improvements is infeasible due to the large quantity of proposed impervious surfaces and steep slopes down gradient of this project. Infiltration potential of the site was also considered; however, per geotechnical advisement, shallow restrictive soil layers and underlying bedrock eliminate the use of infiltration facilities. Therefore, no dispersion or infiltration BMPs will be utilized with this project. All disturbed lawn and landscaping areas will meet topsoil quality and depth requirements per BMP T5.13.

Minimum Requirement #6 - Runoff Treatment

Per BMC 15.42.060(F)(6), stormwater treatment is required for "projects in which the total of new, replaced, or new plus replaced effective pollution generating hard surface (PGHS) is 5,000 square feet or more in a threshold discharge area." The 2019 DOE SWMM specifies, "Each TDA within a project that requires Minimum Requirement #6 must be reviewed to determine if Runoff Treatment BMPs are required for the TDA to be in compliance with MR #6." Since this project contains two TDAs, each basin will be analyzed for treatment individually in accordance with the 2019 DOE SWMM.

West TDA: This TDA will create more than 5,000 square feet of effective PGHS and will require stormwater runoff treatment. Proposed PGHS onsite includes portions of the proposed interior plat roads, residential driveways, and parking areas. This project will receive enhanced treatment by using an Aquaswirl facility and a Combined Detention and Wetpool Facility per BMP T10.40. Specifically, the first wetpool cell of the Combined Detention and Wetpool Facility will be replaced with the Aquaswirl facility for pretreatment, which will then discharge into the second wetpool cell for detention and additional treatment. See the *Calculations* section of this report for the sizing of the proposed system.

East TDA: Proposed PGHS for this TDA include portions of the proposed interior plat roads and residential driveways. These surfaces create less than 5,000 square feet of effective PGHS and do not require stormwater runoff treatment.

Minimum Requirement #7 - Flow Control

The 2019 DOE SWMM specifies, "Each TDA within a project that requires Minimum Requirement #7 must be reviewed to determine if Runoff Treatment BMPs are required for the TDA to be in compliance with MR #7." Since this project contains two TDAs, each basin will be analyzed for flow control individually in accordance with the 2019 DOE SWMM.

West TDA: This TDA will create more than 10,000 square feet of effective hard surface and, therefore, must provide stormwater flow control in accordance with BMC 15.42.060(F)(7). As noted earlier in this report, stormwater dispersion and infiltration systems are not feasible for use on site. Therefore, flow control systems are proposed to mimic forested conditions on site in accordance with design requirements in BMC 15.42.060(F)(7). A Combined Detention and

Wetpool Facility per BMP T10.40 will be installed to provide detention for the runoff from the proposed hard surfaces. See the *Calculations* section of this report for the sizing of the proposed facility.

East TDA: This TDA will not develop more than 10,000 square feet of impervious surface area, will not increase the 100-year flow frequency by more than 0.15 cfs, and will not convert more than ¾ acres of native vegetation to lawn. Thus, no stormwater flow control BMPs are required for the hard surfaces in this basin. See stormwater calculations analyzing the 100-year flow frequency located in the *Calculations* section of this report.

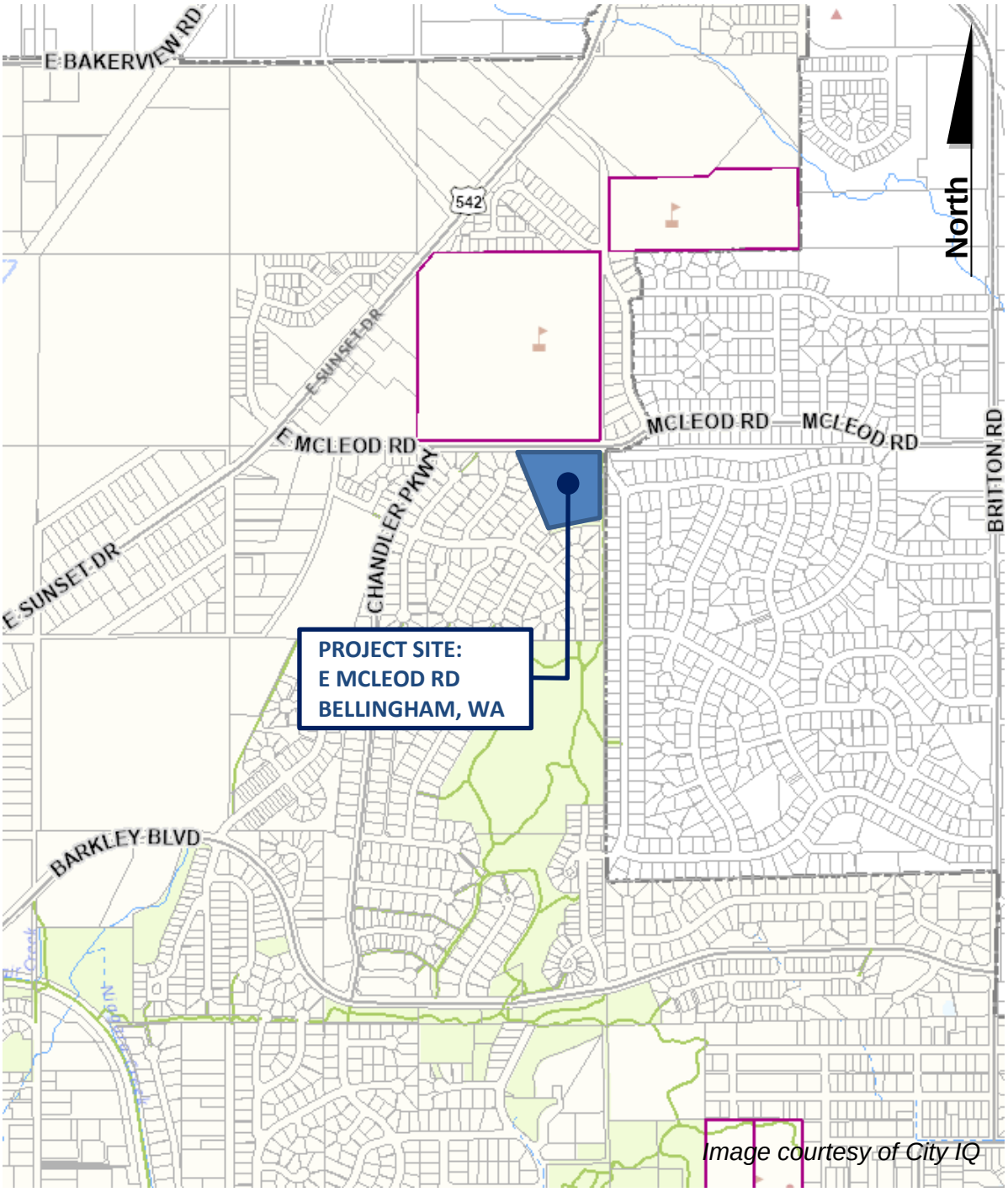
Minimum Requirement #8 - Wetlands Protection

No wetlands have been identified on the project site, or in the immediate vicinity. Therefore, no additional wetland protection requirements will apply to this project.

Minimum Requirement #9 - Operation & Maintenance

Proposed storm drainage improvements consist of a series of catch basins, pipes, and flow control and treatment facilities. A separate operations and maintenance manual will be prepared for the proposed storm drainage improvements and included with the future construction documents. The manual will contain a description of the facilities, what the facilities do, and how they work. The manual will also identify and describe maintenance tasks for each component of the facilities and the required frequency of each task. Refer to the *Stormwater Operations and Maintenance Manual* prepared with the future construction documents for further detail regarding maintenance tasks and frequencies.

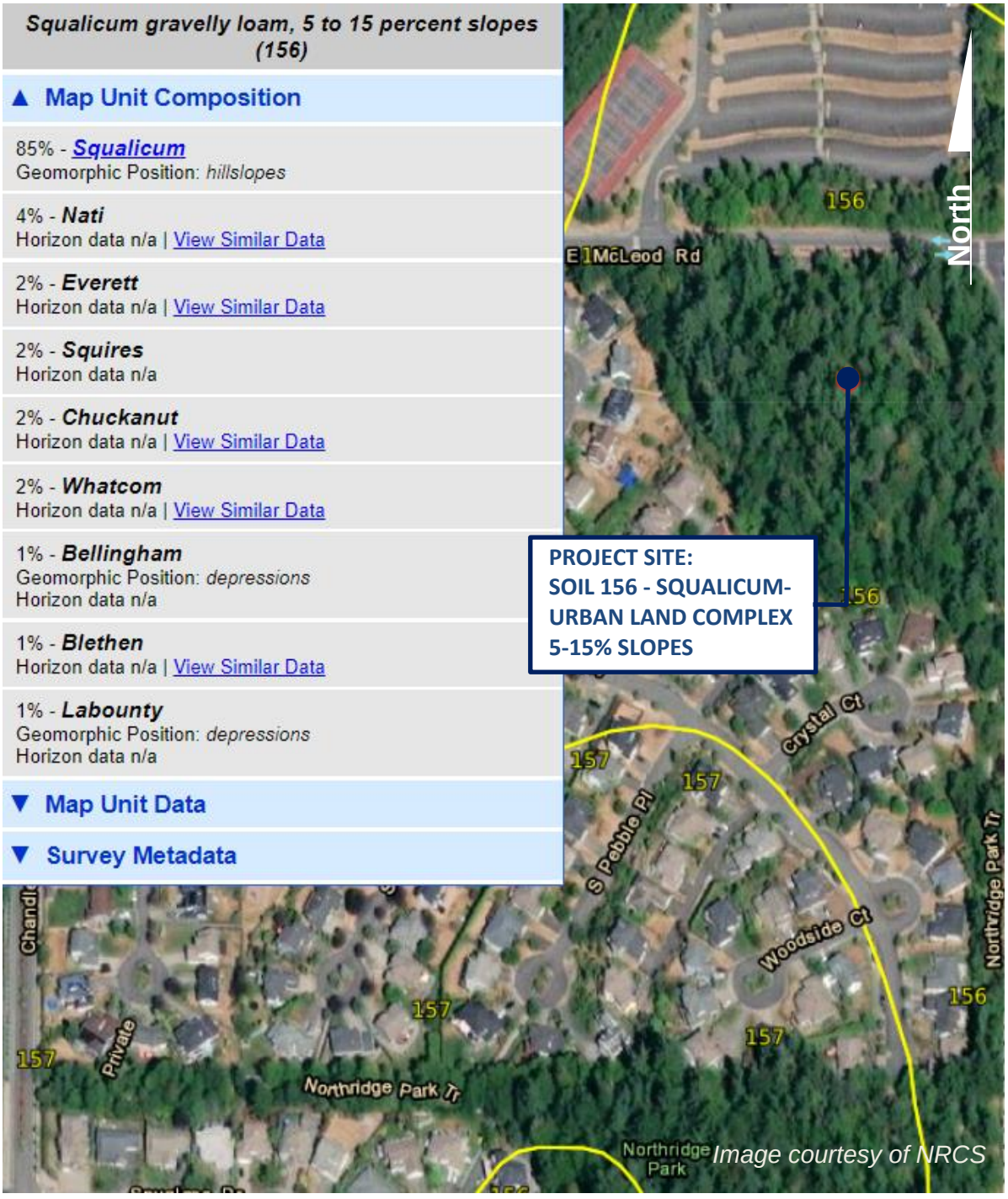
FIGURES



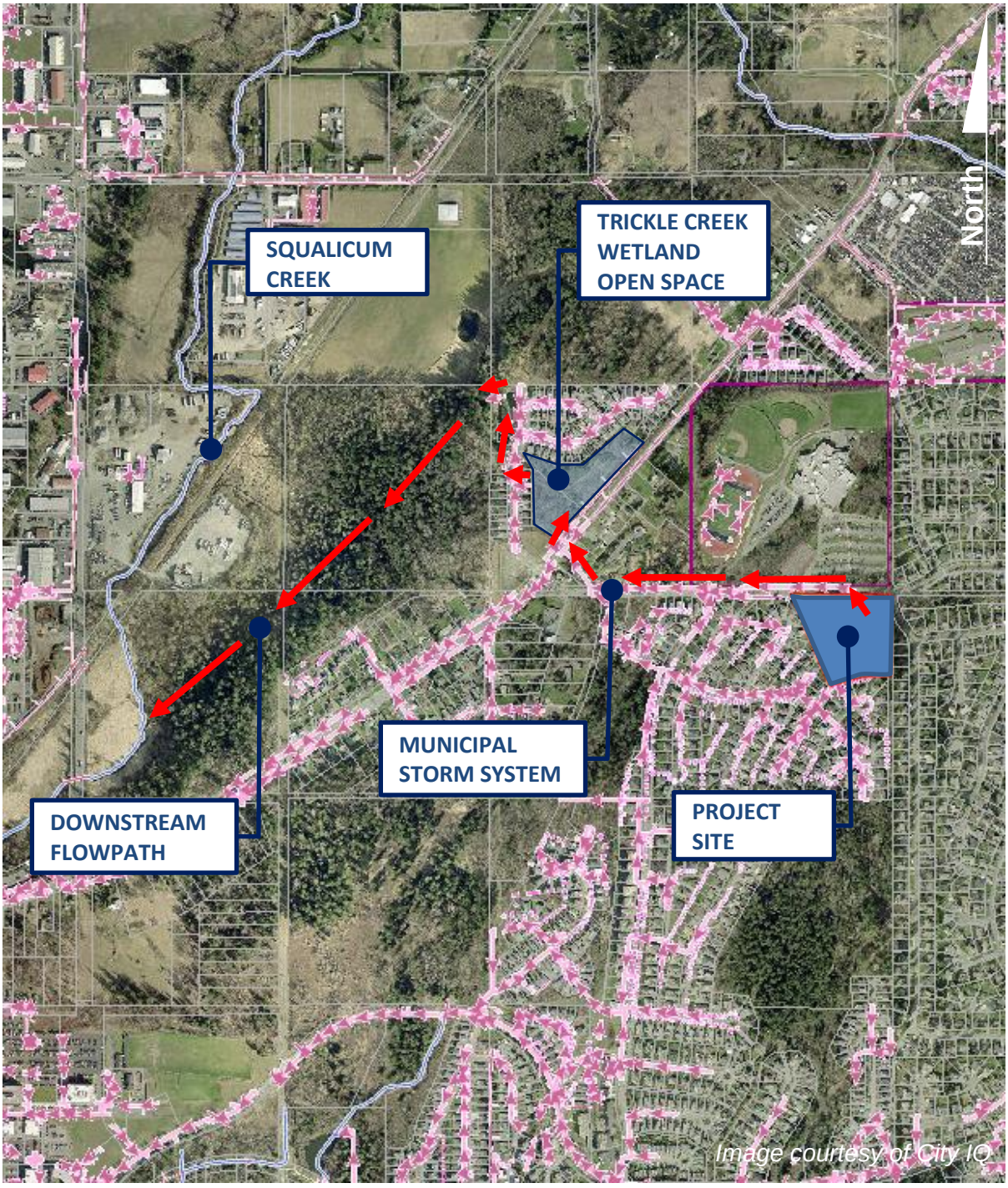
Vicinity Map

Figure 1

	Aerial Imagery	**Figure 2**

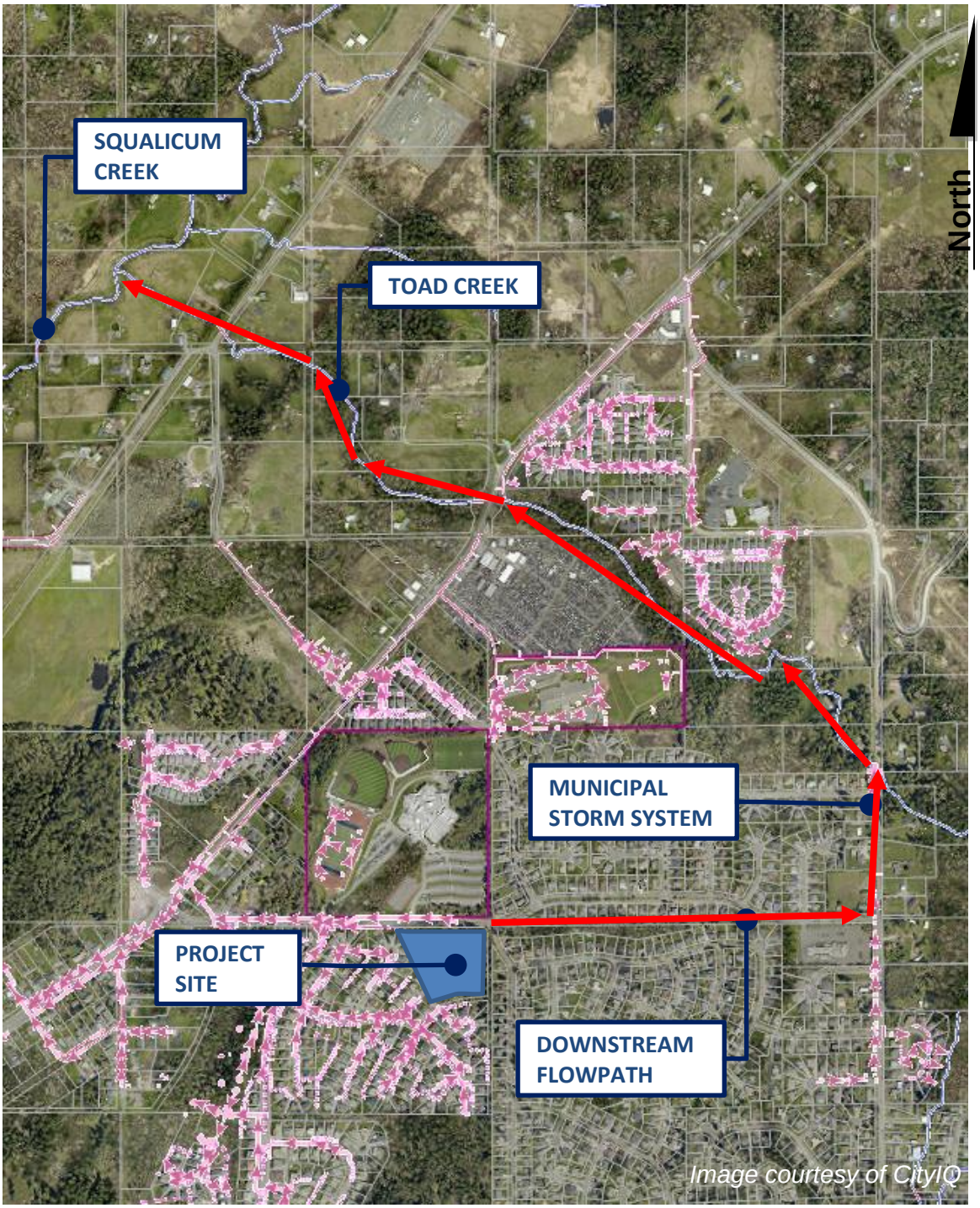


	NRCS Soil Survey Map	**Figure 3**



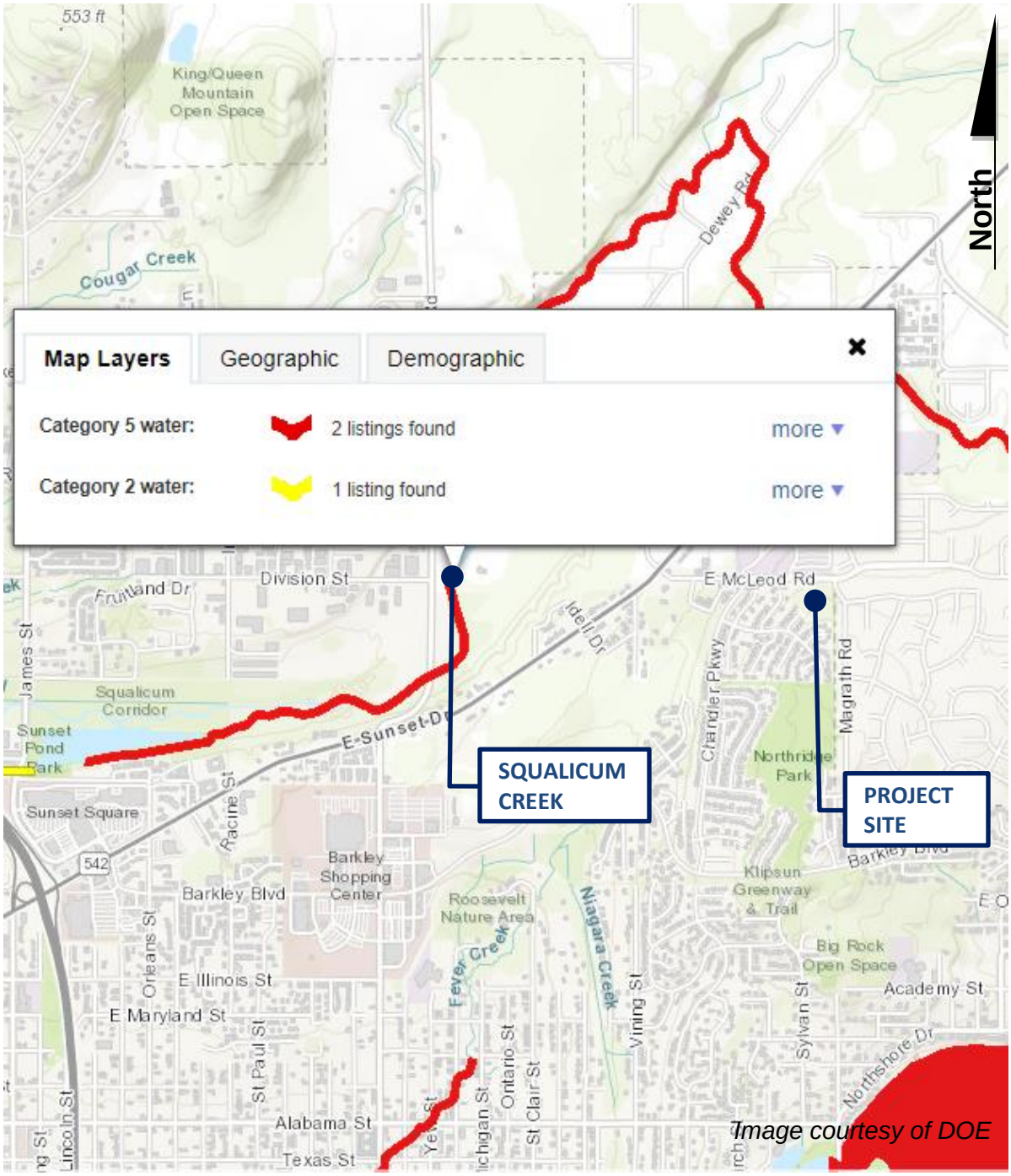
Downstream Drainage Map: West TDA

Figure 4.a



Downstream Drainage Map: East TDA

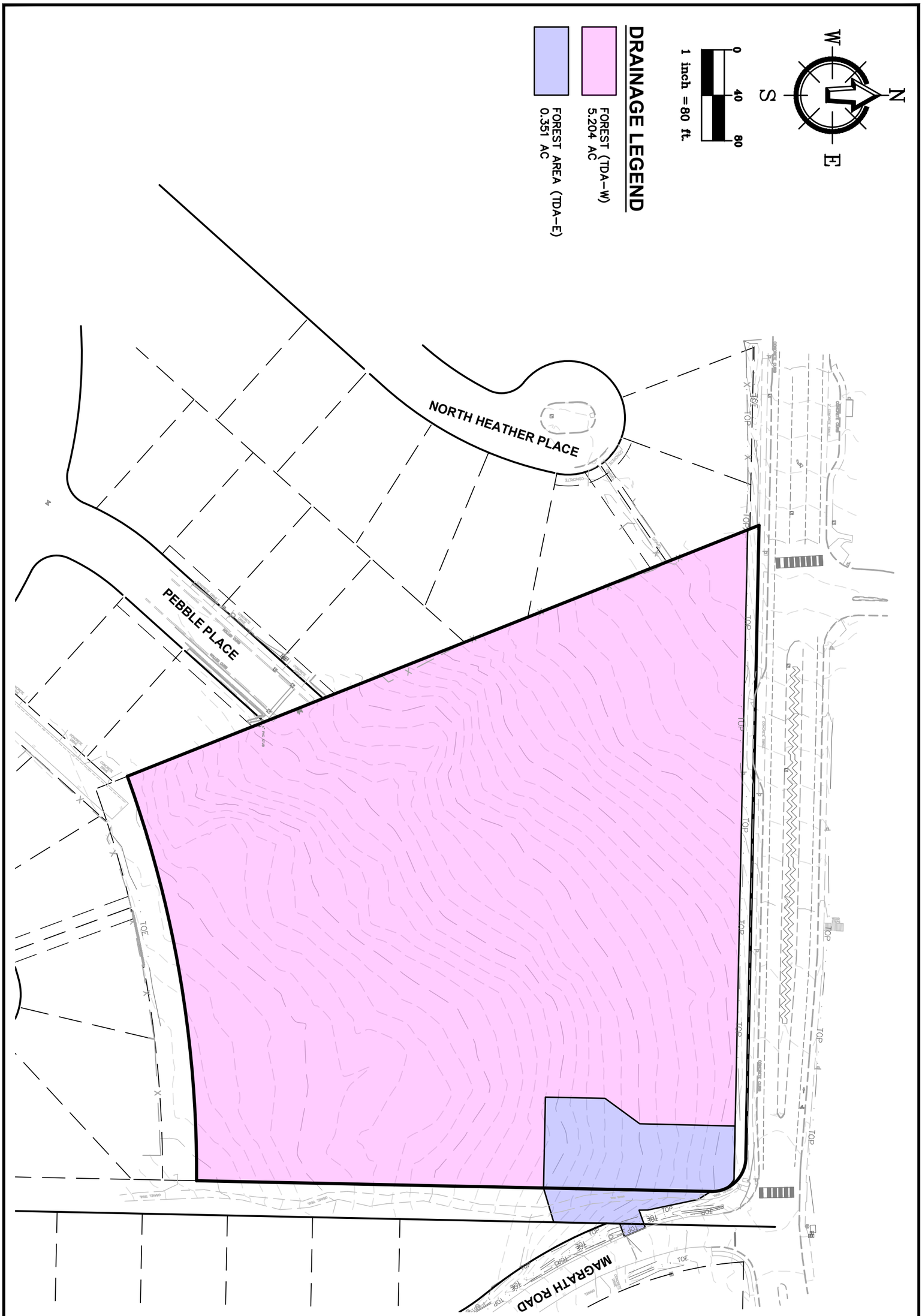
Figure 4.b



Water Quality Assessment Map

Figure 5

Figure 6 - Pre-development Stormwater Basin Map



220 W. Champion Street, Suite 200
Bellingham, WA 98225
t: 360.650.1408
f: 360.650.1401
FREELAND & ASSOCIATES

SHEET CONTENTS

PRE-DEVELOPMENT BASIN MAP

JOB #	DATE
20001	JUNE, 2023
DRAWING #	SHEET NAME
20001SP11.DWG	FIG 6

Figure 7 - Post-development Stormwater Basin Map

N

W E

S

0 40 80

1 inch = 80 ft.

DRAINAGE LEGEND

TDA-WEST

- HARD SURFACE
  1.434 AC
- LOT IMPERVIOUS ALLOWANCE
  (2,500 SF/PER LOT)
  1.951 AC
- LANDSCAPE
  1.589 AC
- POND
  0.230 AC

TDA TOTAL: 5.204 AC

TDA-EAST

- HARD SURFACE
  0.064 AC
- LOT IMPERVIOUS ALLOWANCE
  (2,500 SF/PER LOT)
  0.115 AC
- LANDSCAPE
  0.172 AC

TDA TOTAL: 0.351 AC

DATE JUNE, 2023

SHEET NAME FIG 7

JOB # 20001

DRAWING # 20001SP11.DWG

POST-DEVELOPMENT BASIN MAP

SHEET CONTENTS

FREELAND & ASSOCIATES

220 W. Champion Street, Suite 200
Bellingham, WA 98225

t: 360.650.1408
f: 360.650.1401

CALCULATIONS

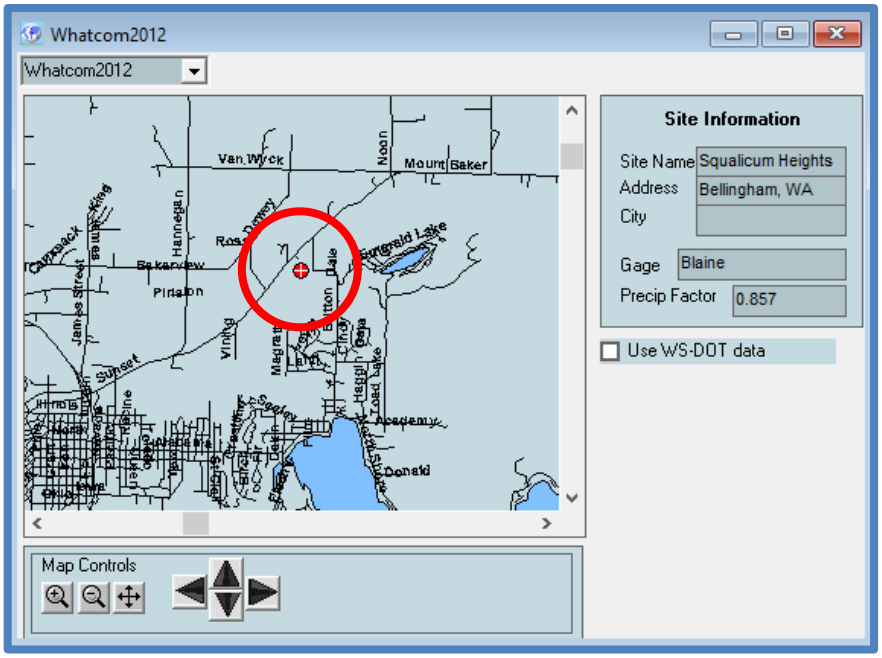
Stormwater Modeling Overview

In accordance with BMC 15.42.060(F)(7)(c), Western Washington Hydrology Model v2012 (WWHM2012) software is used to model the anticipated stormwater flows and durations from the site. WWHM2012 software uses HSPF continuous simulation methodology to compare pre-development discharge rates to post development discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow.

WWHM2012 has three categories for slopes: 0-5% flat, 5%-15% moderate, 15%+ steep. Slopes on the site average between 6-15% and are modeled as moderate. Soils on the site belong to hydrologic group 'B', as mapped by the Natural Resources Conservation Service (NRCS), described previously in this report. However, per the GeoTest Report, the presence of glaciomarine drift soils, underlying bedrock, and shallow perched groundwater indicate minimal infiltration capabilities. Therefore, the soils are modeled as a part of hydrologic group 'C' per the "Soil Data" section of the 2019 DOE SWMM III-2.2.

A 15-minute timestep will be used for this analysis. Precipitation data for the design uses the rain gage from the City of Blaine. Figure C1 below identifies the location of the project and WWHM2012 calculates the difference in rainfall with a precipitation scaling factor of 0.857.

Figure C1 - Rain Gage Scaling



This project is considered to be new development in accordance with the definition for "new development" in Bellingham Municipal Code 15.42.060. Therefore, this project is required to provide flow control for the ***new and replaced*** impervious and ***converted*** pervious surfaces. Per City of Bellingham Municipal code, this project will consider the project site as forested in the pre-development stormwater condition.

This project will utilize both an aquaswirl treatment facility and a combined detention and wetpool treatment pond for flow control and treatment for all surfaces. WWHM2012 software is used to determine the required size of the systems to meet the threshold standards in the Bellingham Municipal Code. Stormwater treatment will occur prior and within the detention pond.

Existing Conditions (Pre-developed)

Flow control and treatment requirements have been triggered for the West TDA but are not triggered for the East TDA. Therefore, the proposed development areas used to size the proposed treatment and detention facilities are representative of the West TDA. All proposed areas are modeled as forested in the pre-development scenario. Refer to *Table C1* below for a summary of the pre-developed modeling conditions for the project and *Figure 6* in the *Figures* section of this SSP for a depiction of the pre-developed basins.

Table C1
Pre-development Modeling Characteristics

Type	Area (Acres)
West TDA Forest Area	5.204
East TDA Forest Area	0.351
Total	**5.555**

Proposed Conditions (Post-developed)

Proposed stormwater management for the West TDA includes the installation of an Aquaswirl facility for pretreatment and a Combined Detention and Wetpool Facility for flow control and treatment. These facilities are designed to provide flow control and treatment for stormwater runoff from the proposed roof, driveway, road, sidewalk, and landscape surfaces.

As stated above, the East TDA does not require flow control since it consists of less than 10,000 square feet of impervious surface area and will not increase the 100-year flow frequency by more than 0.15 cfs. Additionally, the East TDA will develop less than 5,000 square feet of pollution-generating hard surfaces and will not require stormwater treatment.

Refer to *Table C2* below for a summary of the post-development modeling conditions for the project and *Figure 7* in the *Figures* section of this SSP for a depiction of the post-development basins.

Table C2
Post-development Modeling Characteristics

Type	Area (Acres)
West TDA	
Hard Surface Area	3.385
Landscape Area	1.589
Pond Area	0.230
Sub-Total Basin	**5.204**
East TDA	
Hard Surface Area	0.179
Landscape Area	0.172
Sub-Total Basin	**0.351**
Total Basin	**5.555**

Stormwater Modeling Input & Output

Screenshots of the software model are provided below. The left half of each screenshot shows the entire pre- or post-development stormwater model layout with a single component selected. The right half of each screenshot provides input information for the selected component of the model.

Figure C2 - Pre-Development Treatment Basin: West TDA

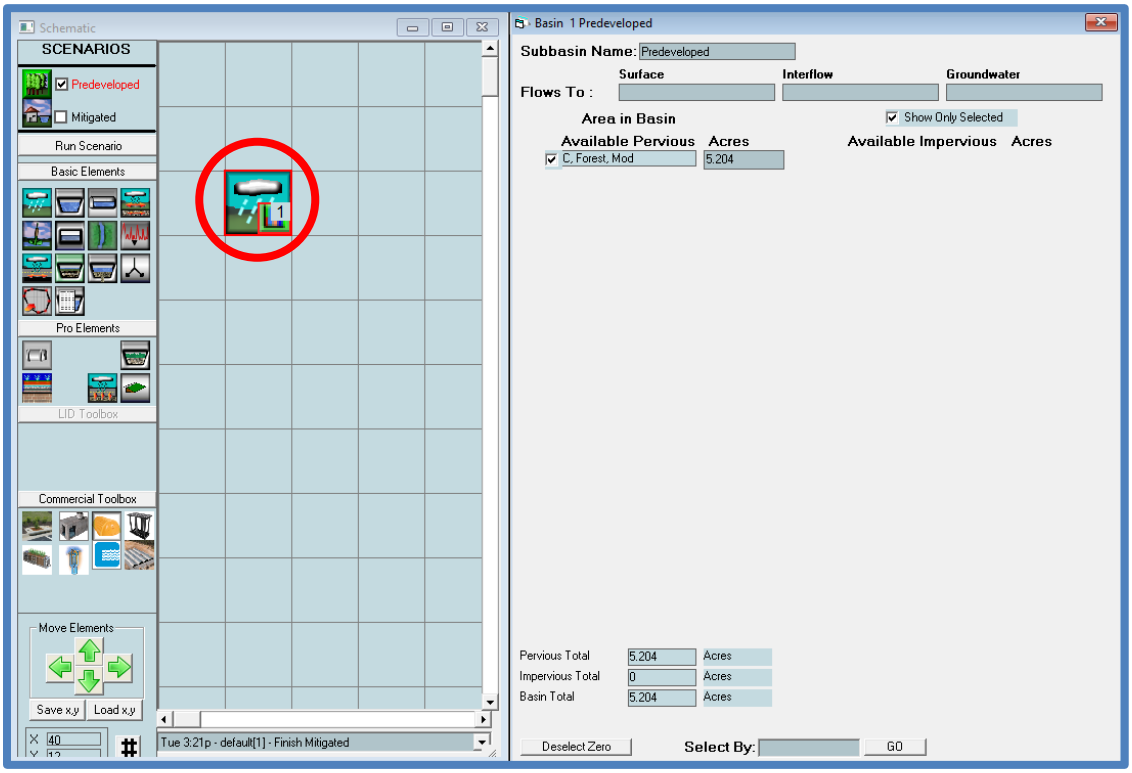


Figure C3 - Post-Development Treatment Basin: West TDA

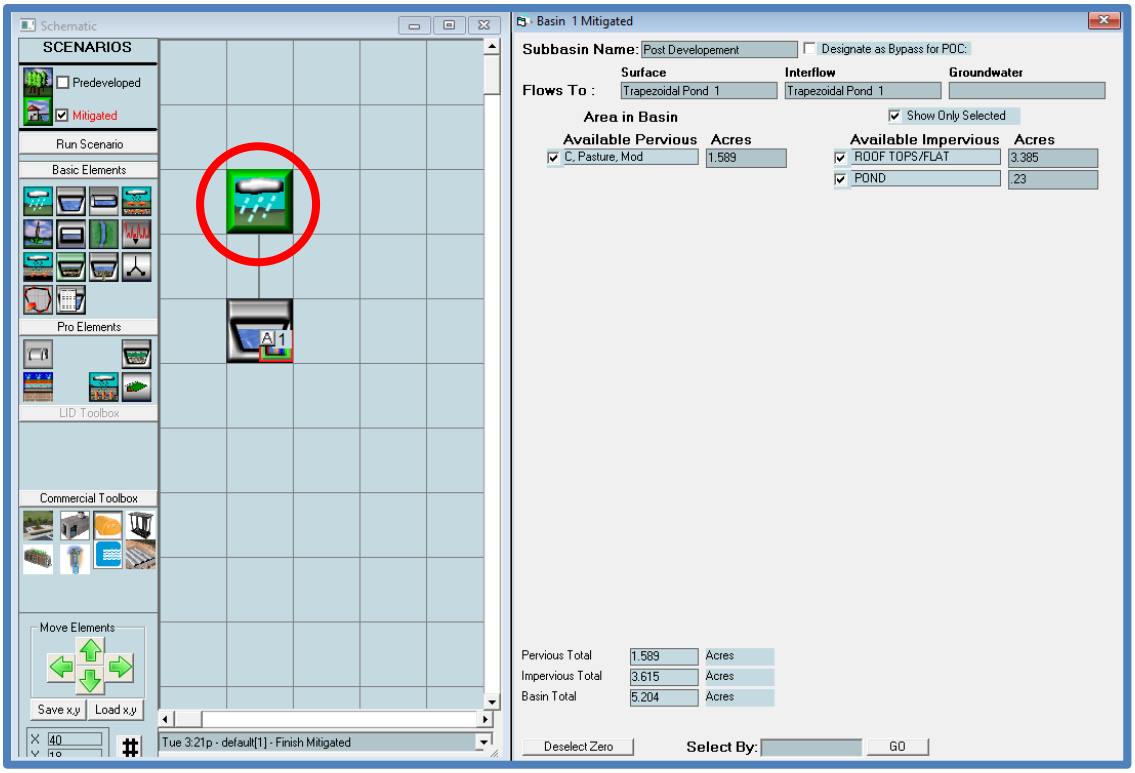


Figure C4 - Detention Facility Design: West TDA

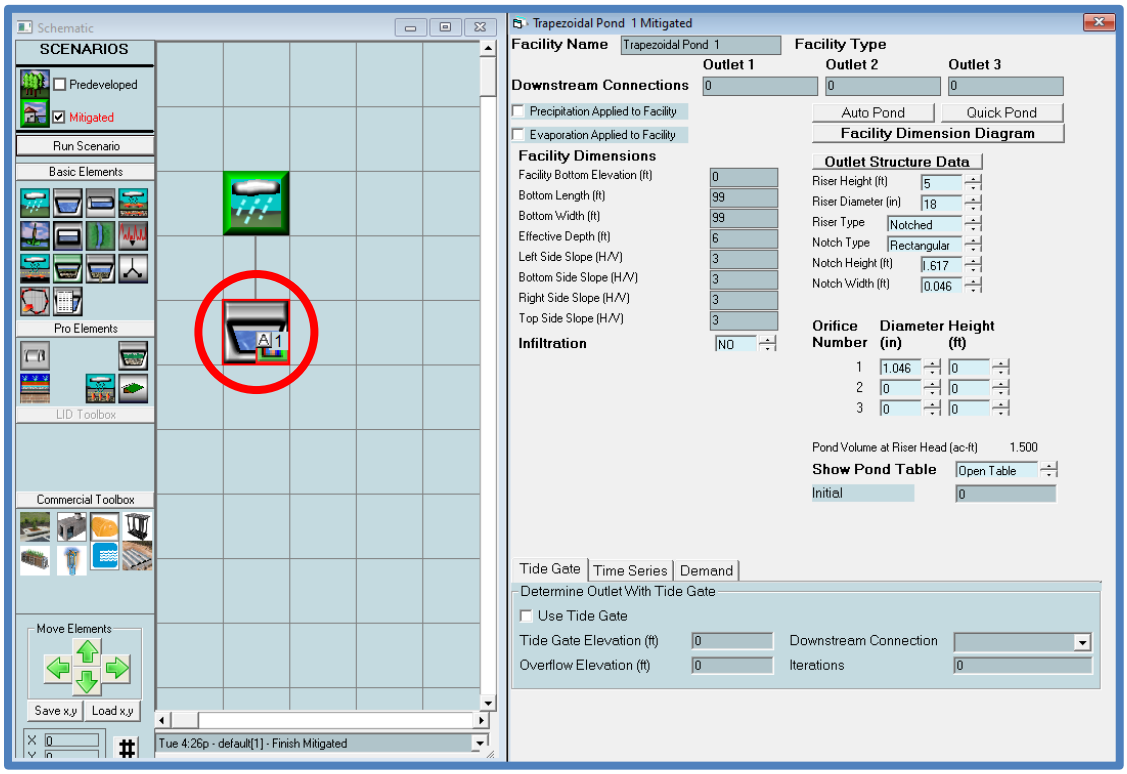


Figure C5 - Stream Protection Duration Analysis: West TDA

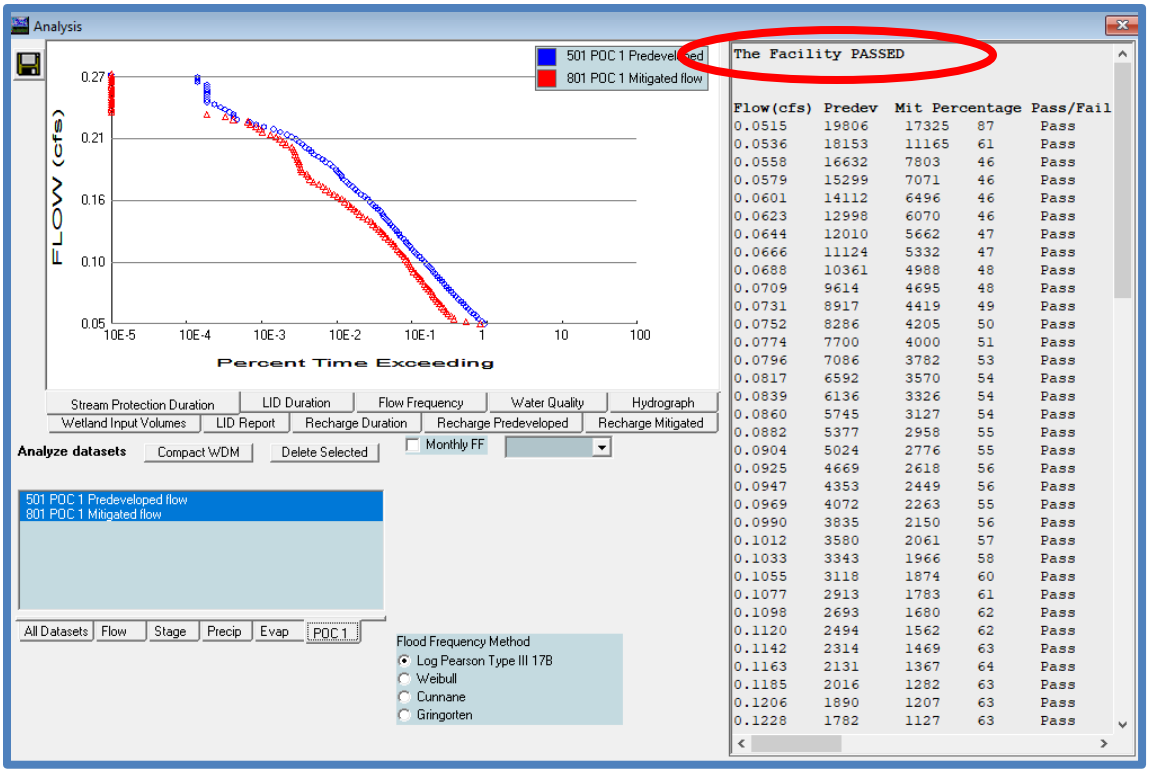


Figure C6 - Flow Frequency Analysis: West TDA

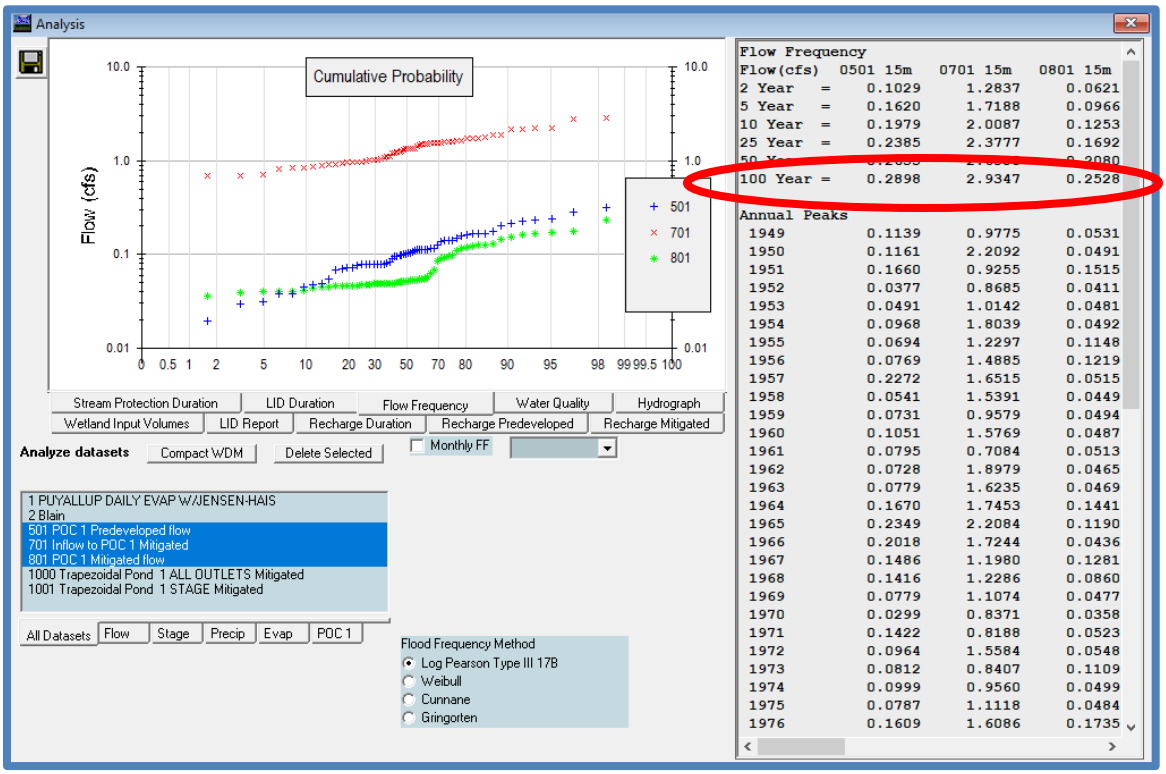


Figure C7 - Pre-Developed Basin: East TDA

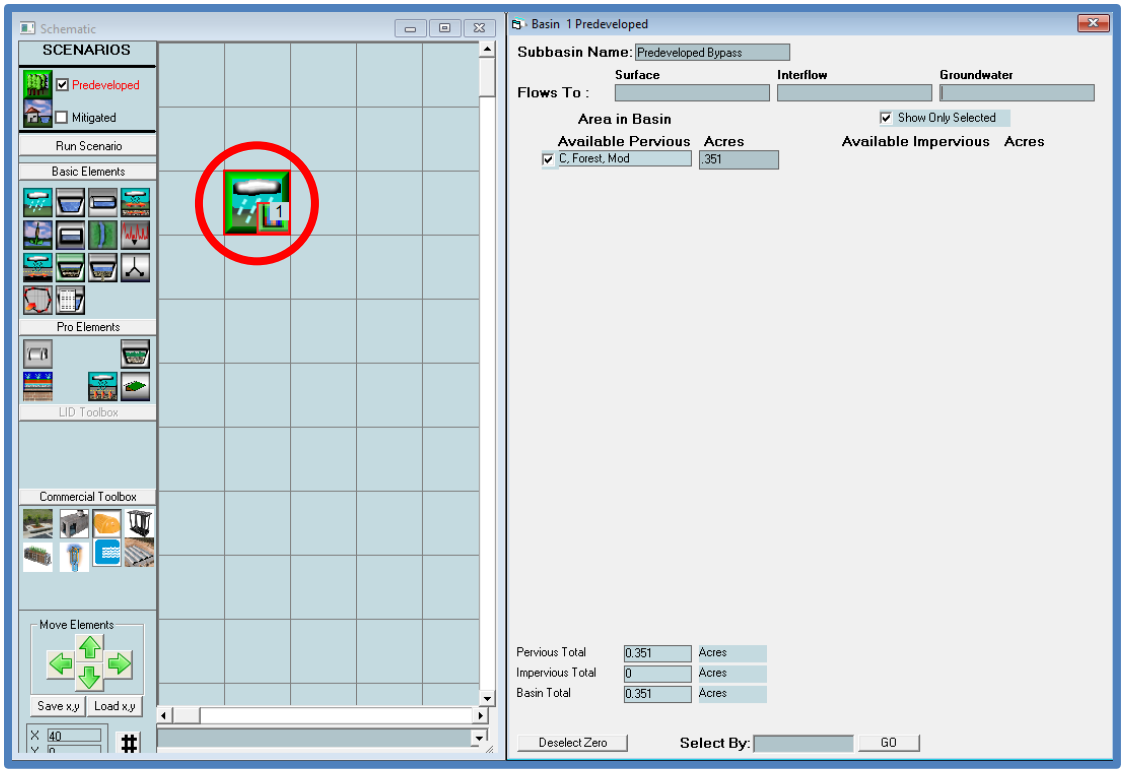


Figure C8 - Post-Developed Basin: East TDA

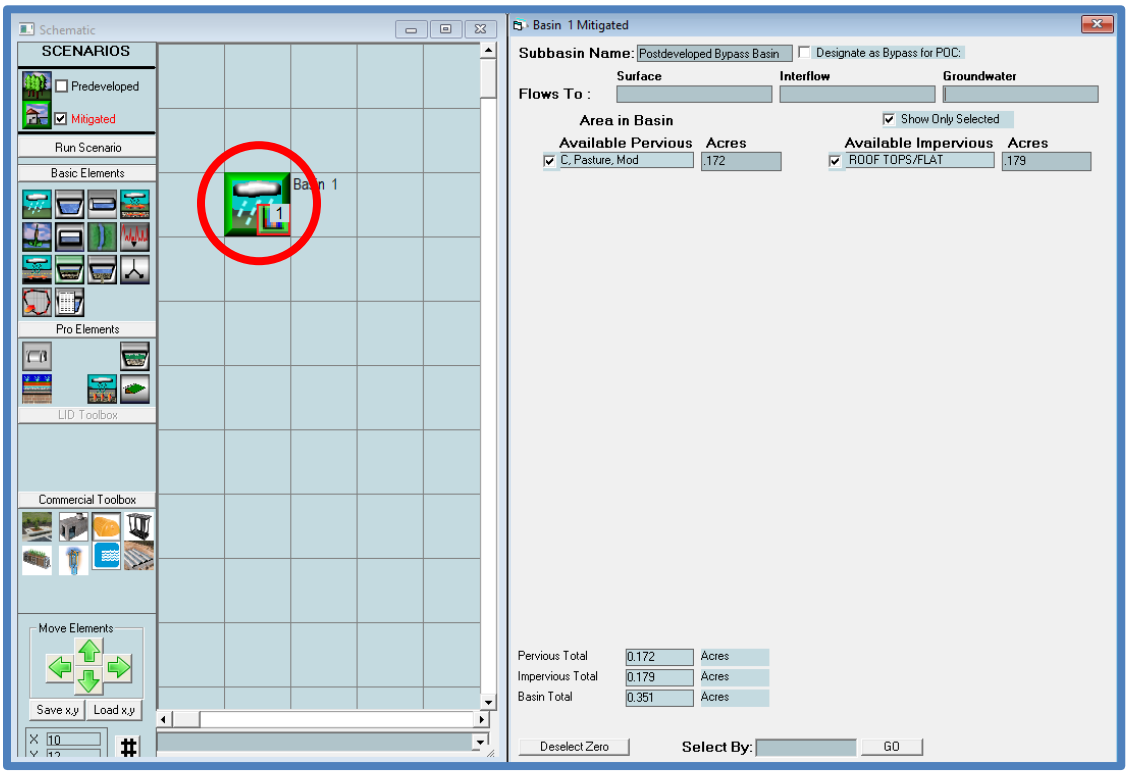
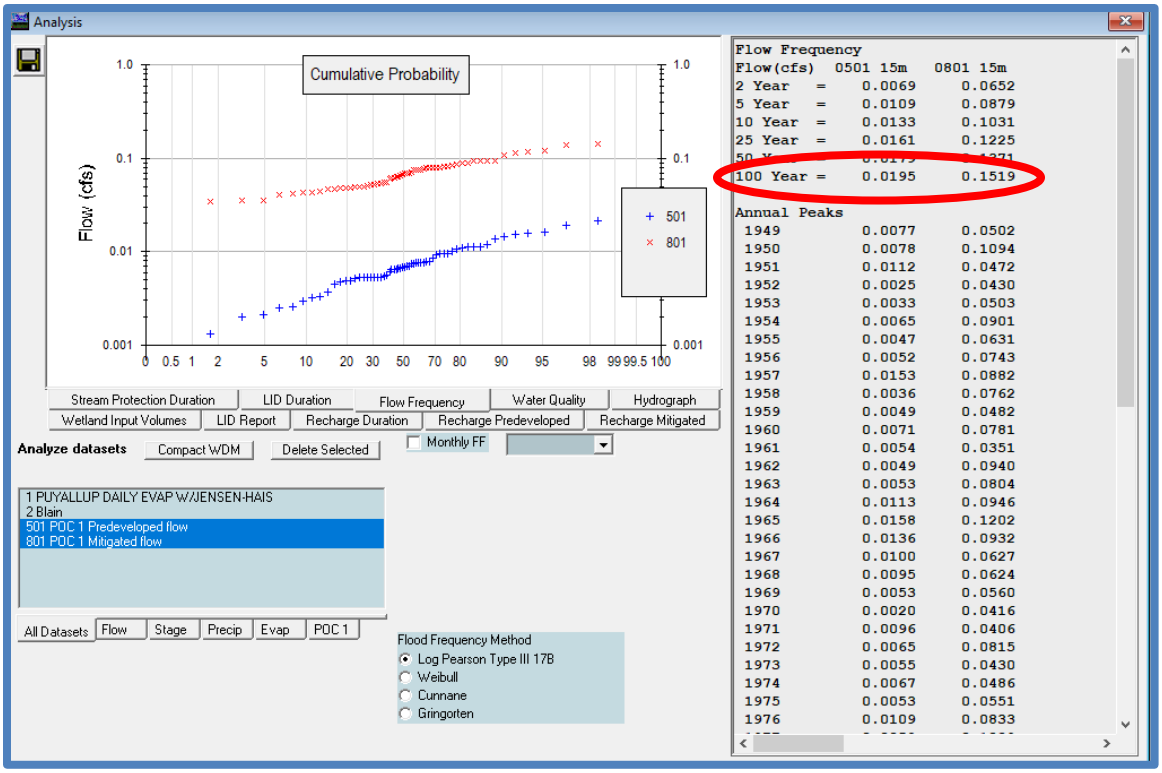


Figure C9 - Flow Frequency Analysis: East TDA



BMP T10.40: Combined Detention and Wetpool Facility

A single stormwater detention pond with a stormwater treatment wetland will be constructed on the northwest corner of the property to provide flow control mitigation per Minimum Requirement #7 and stormwater treatment per Minimum Requirement #6 of the City of Bellingham Municipal Code 15.42.060. The design criteria are provided in Volume V of the 2019 DOE SWMM. A detailed discussion of the project facility design will be provided with the future project construction documents.

APPENDIX

Soils Report - GeoTest

June 17, 2020
Project No. 20-0424

Rod Schenk
Profile Construction, Inc.
2950 Newmarket St, Suite 101-254
Bellingham, WA 98226

Cc: **Jack Bloss**
AVT Consulting

Regarding: Stormwater Infiltration Feasibility Letter
2500 Block E McLeod Rd
(TPN: 3803165042430000)
Bellingham, WA 98226

Dear Mr. Schenk:

As requested, GeoTest Services, Inc. (GeoTest) is pleased to submit the following geotechnical letter concerning the feasibility of stormwater infiltration for the proposed residential plat development located at the 2500 Block of East McLeod Road in Bellingham, Washington. This letter has been prepared in general accordance with the terms and conditions established in our professional services agreement dated April 2, 2020.

PROJECT DESCRIPTION

The subject property contains 5.5 acres of densely forested land within a single, roughly wedge-shaped parcel on the eastern margins of Bellingham, WA. Topography is relatively gently dipping to the northwest from the southeast corner of the property. Based on topographic surveys and *City of Bellingham CityIQ* mapping, gradients are commonly at or less than 30% trending to the northwest. The property is surround by residential developments on the south, east, and west sides, with Squalicum High School directly to the north.

The owner intends to develop the site with a 36-lot residential plat including associated exterior improvements such as a central activity court, access roadways and flatworks, and other landscape features. The project design team has informed GeoTest that the project requires investigation and evaluation for onsite stormwater controls under modern Department of Ecology Stormwater Management Manual for Western Washington (SMMWW 2019) requirements. Based on the preliminary stormwater plan, we understand that stormwater management will likely include the use of a detention pond and possible LID infiltration features, depending on feasibility results to be addressed in this study. The project team have also

requested that GeoTest evaluate the property for potential geological hazard concerns and address these concerns if present.

Our current work has been conducted in order to assess the feasibility of incorporating stormwater infiltration facilities into the planned site development. GeoTest Services performed this infiltration feasibility assessment in accordance with the Washington State Department of Ecology *Stormwater Management Manual of Western Washington* (SMMWW 2019) requirement for site suitability characterization.

SITE CONDITIONS

This section discusses the general surface and subsurface conditions observed at the project site at the time of our field investigation. Interpretations of the site conditions are based on our observations at the time of our field investigation and a review of the available information.

Surface Conditions

The vacant subject property is among a residential neighborhood, located to the northwest of the Barkley area in Bellingham, WA. The property is bound to the north by East McLeod Road with Squalicum High School property farther north. The south and western boundaries of the property are adjacent to residential subdivision developments with increased population density toward the southwest. The east side of the property is bordered by a public trail that provides access to a park to the south with moderate density residential development farther to the east. Within the property, land is completely undeveloped and forested with few indications of historic logging including stumps and downed trees. Mature trees include fir, cedar, alder and maple with numerous vine maples and other juvenile tree growth. The understory of the site includes dense native growth of ferns, oceanspray, and blackberry brambles. The site is crossed in multiple locations by footpaths from animals and human activity. Topography on the property generally descends from the southeastern corner of the site to the northwestern corner at the low point. Several small undulations were observed among the site but in general gradient was consistent and was approximately 30% or less on average. Surface conditions were generally moist and no surface water ponding was observed throughout the property during our site visit in early May 2020.

Subsurface Conditions

Subsurface conditions were investigated on May 5th, 2020 by excavation of 9 machine-assisted test pits broadly spaced throughout the project site to evaluate stormwater infiltration feasibility. Test pit locations were selected by the project team and were field located by GeoTest personnel during our field investigation. Test pits TP-1, TP-2, and TP-3 were excavated along the southern portion of the site. Test pits TP-4 and TP-5 were excavated on the eastern boundary and northeastern corner respectively. Test pit PT-6 was excavated along the north-central boundary and TP-7 was excavated near the center of the project site. Test pit TP-8 was excavated near the

western boundary and TP-9 was excavated near the northwest corner of the site, in the vicinity of the planned stormwater tract. These explorations were advanced to maximum equipment reach or until contact with stiff to hard native soil conditions or bedrock.

Subsurface conditions were relatively consistent among the among the nine test pit locations with variations in relative thickness of the units observed. Subsurface conditions among the site consisted of approximately 0.5 to 1 foot of organic topsoil. Shallow topsoil was typically sandy silt with trace to no gravel content, moist, and dark brown in color. Below the surface topsoil, a thin medium stiff, reddish medium brown moist, sandy silt subsoil horizon was observed in several test pit locations. Below topsoil and subsoil, where present, glaciomarine drift deposits were sandy silt to very silty sand with trace fine gravel and ranged in consistency from stiff to hard or medium dense to dense. Glacial drift deposits were moist, light brown to gray and exhibited orange mottling at the upper interface. At the location of TP-1, the weathered glaciomarine horizon was observed to be slightly thicker, over 1-foot. The glaciomarine drift soils were typically semi-consolidated and were blocky in hand sample. Atterberg Limits analysis performed on glaciomarine drift soils resulted in non-plastic results on the two samples run.

At all test locations, excepting TP-1, Chuckanut Formation bedrock was found to underlying glaciomarine drift deposits. Bedrock ranged from massive sandstone to thinly bedded and fractured siltstone. Chuckanut bedrock was consistently moderately hard, medium to light brown, and dry with slightly elevated moisture at the upper interface. Depths to bedrock ranged from approximately 2 feet below ground surface (BGS) to approximately 4 feet BGS and was not observed at the location of TP-1 to depths of 6.5 feet BGS.

No perched or pervasive groundwater horizons were observed during our field investigation conducted in early May, following a period of dry weather. Slight to moderate orange colored mottling and oxidation was observed within shallow glaciomarine drift soils that typically indicates prolonged exposure to perched water conditions.

Image 1 *– Typical surface conditions of site interior. View facing north with test pit TP-9 in progress.*

General Geologic Conditions

Geologic information for the subject property was obtained from the *Geologic Map of Bellingham 1:100,000 quadrangle, Washington* (Lapen, 2000), published by the Washington State Department of Natural Resources. According to the referenced map, the site falls wholly within the Padden Member of the Eocene Chuckanut Formation (Ec_{cp}). Although Glaciomarine Drift ($Qgdm_e$) was not mapped on the project site, it is common to have relatively thin mantling of glacial soils overlying Chuckanut Sandstone within the lower foothills of Western Washington.

The Padden Member of the Chuckanut Formation is a continental sedimentary deposit formed in the Tertiary. This unit is commonly observed as massive sandstone to thinly bedded siltstone with local coal seams. The glaciomarine drift in the vicinity of the subject site generally consists of unsorted, unstratified pebbly, sandy silt and clay with common dropstones up to boulder size. Glaciomarine drift soils are derived from rock debris melted out of floating ice and deposited in still ocean waters. Observed conditions were consistent with mantling Glacial Drift deposits with underlying sandstone bedrock at depths ranging from less than 2 feet to greater than 6 feet.

Geohazard Review

City of Bellingham Municipal Code (BMC) Section 16.55.410 designates geologically hazardous areas for the use of critical area review and investigation. Erosion hazard areas are defined by this section as "Specifically these areas include any area where the soil type is predominantly (greater than 50 percent) comprised of sand, clay, silt, and/or organic matter and slope is greater than 30 percent". Based on our site investigation, the general gradient of the project site is less than the 30 percent threshold with very minor areas that undulate over 30 percent. In addition, ground surfaces throughout the property are covered with well established vegetation and dense understory growth with a developed topsoil horizon as seen in all test locations. Based on the BMC code definitions and observations among the project site, it is our opinion that the site does need meet the designation as an erosion hazard area.

Stormwater Infiltration Potential

Based on the presence of relatively shallow stiff to hard Glaciomarine Drift soils, underlying Chuckanut Formation bedrock, and the indication of shallow perched groundwater conditions in the wet season, GeoTest does not recommend that on-site infiltration be incorporated as part of stormwater design for the proposed development. It is our opinion that the on-site native soils meet the criteria for a shallow restrictive horizon per the SMMWW (2012, 2019). On-site infiltration of stormwater on this site is not considered feasible through traditional measures. We recommend that the design team consider implementing surface dispersion or detention features as permitted by local municipalities. We understand that preliminary civil design includes the implementation of a stormwater detention pond within the northwest corner of the project site.

Detention Pond Liner Considerations

Due to the lack of onsite infiltration potential at the project site, we understand that detention may be implemented in the project design. Shallow bedrock surfaces through the property and among the potential detention area in the northwest corner may present challenges for detention pond construction and functionality. The Chuckanut Formation commonly expresses as large, variably porous and fractured sandstone and siltstone and hence would need to be lined in order to limit pond leakage and potential failure. Mantling glaciomarine drift deposits found shallowly throughout the project site were assessed via laboratory analysis for qualification in use as low-permeability pond liners.

Pond liner specifications are controlled by SMMWW 2019 guidelines and include either clay or low permeability (Till) liners. Atterberg Limits plasticity analysis of onsite glaciomarine soils yielded non-plastic results for all samples, therefore clay liner specifications are not applicable. Section V-1.3.3 of the SMMWW (2019) contains design criteria for low permeability liners with compacted till liners being applicable to the subject property. Table V-1.3 below shows the gradation requirements for compacted till liners.

Table V-1.3: Soil Gradation for Compacted Till Liners

Sieve Size	Percent Passing
6-inch	100
4-inch	90
#4	70 - 100
#200	20

Grain size analysis performed on glaciomarine drift soils found shallowly throughout the project site indicate that the soils are adequate for use as compacted till liner. In addition to gradation requirements the following are required for proper installation of compacted till liners.

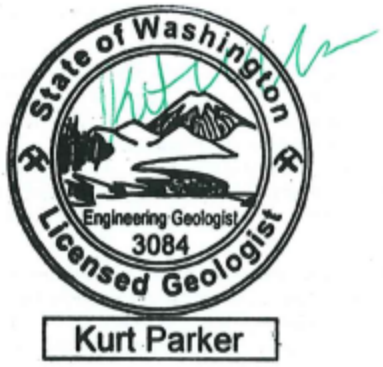
- Liner thickness shall be 18 inches after compaction.
- Soil shall be compacted to 95% minimum dry density, modified proctor method (ASTM D 1557).
- A different depth and density sufficient to retard the infiltration rate to 2.4 x 10^{-5} inches per minute (1 x 10^{-6} cm/s) may also be used instead of bullets 1 and 2 above.
- Soil should be placed in 6-inch lifts.

USE OF THIS REPORT

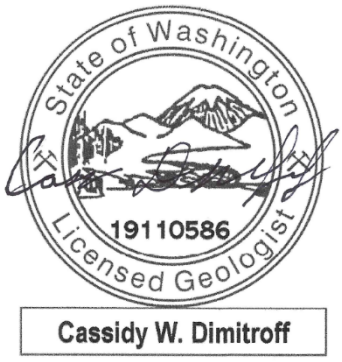
GeoTest Services Inc. has prepared this report for the exclusive use of Rod Schenk and his consultants for specific application to the design of the proposed residential plat development located on East McLeod Road in Bellingham, Washington. Use of this report by others is at the user's sole risk. This report is not applicable to other site locations. Our services are conducted in accordance with accepted practices of the geotechnical engineering profession; no other warranty, express or implied, is made as to the professional advice included in this report.

We appreciate the opportunity to provide geotechnical services for this project and look forward to assisting you further during the design and construction phase. Should you have any further questions regarding the information contained within the letter, or if we may be of service in other regards, please contact the undersigned.

Respectfully,
GeoTest Services, Inc.



6/17/2020



6/17/2020

Kurt Parker, L.E.G.
Geotechnical Department Manager

Cass Dimitroff, L.G.
Geotechnical Project Manager

Attachments:

Figure 1	Vicinity Map
Figure 2	Site and Exploration Plan
Figure 3	Soil Classification System and Key
Figures 4-8	Test Pit Logs
Figure 9	Grain Size Test Data
Attached	Report Limitations and Guidelines

References

Bakeman, S., Dan, G., Howie, D., Killelea, J., Labib, F., & Ed, O. (n.d.) 2012. *Stormwater Management Manual for Western Washington*, as Amended in December 2014 (2012/2014 SWMMWW) (pp. 1-1042) (United States, Washington State Department of Ecology).

Bellingham Municipal Code – Critical Areas Ordinance, §§ 16.55.410 (2020).

City of Bellingham *City IQ Viewer.* Retrieved May 2020 from https://maps.cob.org/geviewer/Html5Viewer/Index.html?viewer=cityiq

Easterbrook, D. J. (1976). *Geologic Map of Western Whatcom County, Washington* [map]. 1:62,500. Miscellaneous investigations series, map 1-854-B. Reston, VA: U.S. Geological Survey.

Gariepy, D., Graul, C. Heye, A., Howie, D., Labib, F. & Song, K. (n.d.) 2019. *Stormwater Management Manual for Western Washington* (2019 SMMWW) (pp. 1-1108) (United States, Washington Department of Ecology).

Lapen, Thomas J., 2000. *Geologic Map of the Bellingham 1:100,000 Quadrangle, Washington.* Washington State Department of Natural Resources, Division of Geology and Earth Resources, Open File Report 2000-5, scale 1:100,000.

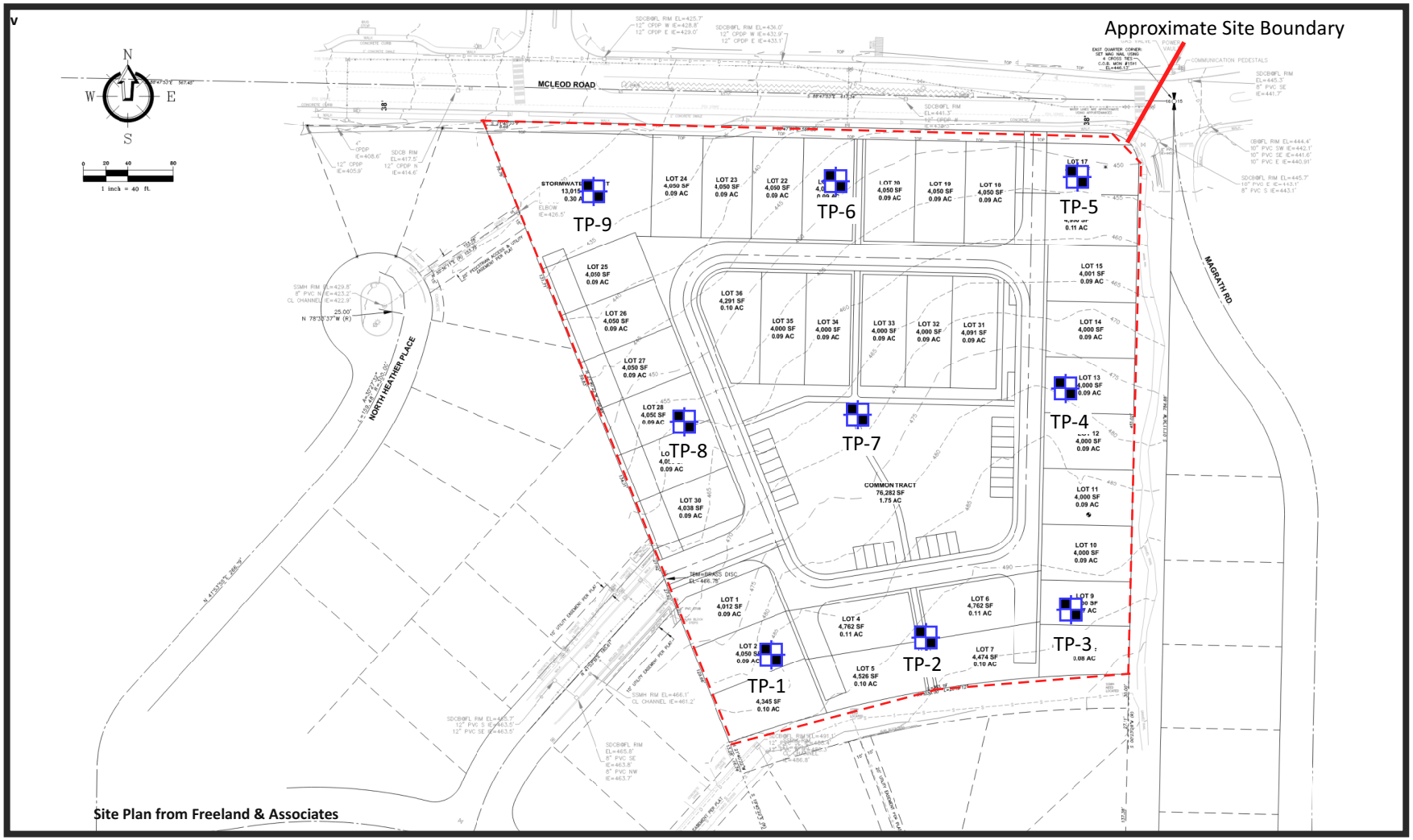
Washington State Department of Natural Resources *Geologic Information Portal.* Retrieved May 2020 from https://geologyportal.dnr.wa.gov/.

GEOTEST	Date: 5-15-20	By: CD	Scale: As Shown

VICINITY MAP
E McLeod Rd Stormwater Feasibilty
2500 Block E McLeod Rd
Bellingham, WA

Project
20-0424

Figure
1



TP-# = Approximate Test Pit Location

N

150 Feet

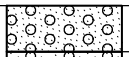
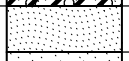
GEOTEST

Date: 5-15-2020	By: CD	Scale: As Shown	Project 20-0424

SITE AND EXPLORATION PLAN
E MCLEOD RD STORMWATER FEASIBILITY
2500 BLOCK E MCLEOD RD
BELLINGHAM, WA

Figure 2

Soil Classification System

MAJOR DIVISIONS			GRAPHIC SYMBOL	USCS LETTER SYMBOL	TYPICAL DESCRIPTIONS[1][2]
COARSE-GRAINED SOIL (More than 50% of material is larger than No. 200 sieve size)	GRAVEL AND GRAVELLY SOIL (More than 50% of coarse fraction retained on No. 4 sieve)	CLEAN GRAVEL (Little or no fines)		GW	Well-graded gravel; gravel/sand mixture(s); little or no fines
				GP	Poorly graded gravel; gravel/sand mixture(s); little or no fines
		GRAVEL WITH FINES (Appreciable amount of fines)		GM	Silty gravel; gravel/sand/silt mixture(s)
				GC	Clayey gravel; gravel/sand/clay mixture(s)
	SAND AND SANDY SOIL (More than 50% of coarse fraction passed through No. 4 sieve)	CLEAN SAND (Little or no fines)		SW	Well-graded sand; gravelly sand; little or no fines
				SP	Poorly graded sand; gravelly sand; little or no fines
		SAND WITH FINES (Appreciable amount of fines)		SM	Silty sand; sand/silt mixture(s)
				SC	Clayey sand; sand/clay mixture(s)
FINE-GRAINED SOIL (More than 50% of material is smaller than No. 200 sieve size)	SILT AND CLAY (Liquid limit less than 50)			ML	Inorganic silt and very fine sand; rock flour; silty or clayey fine sand or clayey silt with slight plasticity
				CL	Inorganic clay of low to medium plasticity; gravelly clay; sandy clay; silty clay; lean clay
				OL	Organic silt; organic, silty clay of low plasticity
	SILT AND CLAY (Liquid limit greater than 50)			MH	Inorganic silt; micaceous or diatomaceous fine sand
				CH	Inorganic clay of high plasticity; fat clay
				OH	Organic clay of medium to high plasticity; organic silt
	HIGHLY ORGANIC SOIL			PT	Peat; humus; swamp soil with high organic content

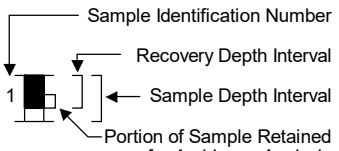
OTHER MATERIALS	GRAPHIC SYMBOL	LETTER SYMBOL	TYPICAL DESCRIPTIONS
PAVEMENT		AC or PC	Asphalt concrete pavement or Portland cement pavement
ROCK		RK	Rock (See Rock Classification)
WOOD		WD	Wood, lumber, wood chips
DEBRIS		DB	Construction debris, garbage

Notes:
1. Soil descriptions are based on the general approach presented in the *Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*, as outlined in ASTM D 2488. Where laboratory index testing has been conducted, soil classifications are based on the *Standard Test Method for Classification of Soils for Engineering Purposes*, as outlined in ASTM D 2487.
2. Soil description terminology is based on visual estimates (in the absence of laboratory test data) of the percentages of each soil type and is defined as follows:

Primary Constituent: > 50% - "GRAVEL," "SAND," "SILT," "CLAY," etc.
Secondary Constituents: > 30% and ≤ 50% - "very gravelly," "very sandy," "very silty," etc.
> 12% and ≤ 30% - "gravelly," "sandy," "silty," etc.
Additional Constituents: > 5% and ≤ 12% - "slightly gravelly," "slightly sandy," "slightly silty," etc.
≤ 5% - "trace gravel," "trace sand," "trace silt," etc., or not noted.

Drilling and Sampling Key

SAMPLE NUMBER & INTERVAL



SAMPLER TYPE

Code	Description
a	3.25-inch O.D., 2.42-inch I.D. Split Spoon
b	2.00-inch O.D., 1.50-inch I.D. Split Spoon
c	Shelby Tube
d	Grab Sample
e	Other - See text if applicable
1	300-lb Hammer, 30-inch Drop
2	140-lb Hammer, 30-inch Drop
3	Pushed
4	Other - See text if applicable

Groundwater

▽ ATD — Approximate water elevation at time of drilling (ATD) or on date noted. Groundwater levels can fluctuate due to precipitation, seasonal conditions, and other factors.

Field and Lab Test Data

Code	Description
PP = 1.0	Pocket Penetrometer, tsf
TV = 0.5	Torvane, tsf
PID = 100	Photoionization Detector VOC screening, ppm
W = 10	Moisture Content, %
D = 120	Dry Density, pcf
-200 = 60	Material smaller than No. 200 sieve, %
GS	Grain Size - See separate figure for data
AL	Atterberg Limits - See separate figure for data
GT	Other Geotechnical Testing
CA	Chemical Analysis

GEOTEST

E McLeod Rd Stormwater Feasibility
2500 Block E McLeod Rd
Bellingham, WA

Soil Classification System and Key

Figure 3

TP-1

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type / Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0				ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics (Topsoil)	Groundwater not encountered.
				ML	Medium stiff, reddish brown, moist, sandy SILT, trace gravel, scattered organics (Subsoil)	
2	1			SM	Medium dense, light brown to gray, mottled, moist, gravelly, very silty SAND, trace boulders (Weathered Glaciomarine Drift)	
				ML	Very stiff to hard, light gray, moist, very sandy SILT, trace fine gravel, blocky (Glaciomarine Drift)	
4	2	W = 25 GS				
6						
8						

Test Pit Completed 05/05/20
Total Depth of Test Pit = 6.5 ft.

TP-2

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type / Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0				ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics (Topsoil)	Groundwater not encountered.
				ML	Very stiff to hard, light gray, slight mottling, moist, very sandy SILT, trace fine gravel, blocky (Glaciomarine Drift)	
2	3			SLS	Moderately hard, medium to light brown, dry, SILTSTONE, small blocky fracture (Chuckanut Bedrock)	
4						
6						
8						

Test Pit Completed 05/05/20
Total Depth of Test Pit = 3.0 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

GEOTEST

E McLeod Rd Stormwater Feasibility
2500 Block E McLeod Rd
Bellingham, WA

Log of Test Pits

Figure 4

TP-3

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics (Topsoil)	Groundwater not encountered.
2	4 5		W = 13 GS		SM	Medium dense, light gray to brown, slight mottling, moist, gravelly, very silty SAND, scattered thin roots (Glaciomarine Drift)	
4					SNS	Moderately hard, medium to light brown, dry, SANDSTONE, large blocky fracture (Chuckanut Bedrock)	
6						Test Pit Completed 05/05/20 Total Depth of Test Pit = 5.0 ft.	
8							

TP-4

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics (Topsoil)	Groundwater not encountered.
					ML	Medium stiff, reddish brown, moist, sandy SILT, trace gravel, scattered organics (Subsoil)	
2	6 7				ML	Very stiff to hard, light gray, slight mottling, moist, very sandy SILT, trace fine gravel, blocky (Glaciomarine Drift)	
					SNS	Non-plastic per Atterberg analysis	
4						Test Pit Completed 05/05/20 Total Depth of Test Pit = 3.5 ft.	
						Moderately hard, medium to light brown, dry, SANDSTONE, massive, minimal fracture (Chuckanut Bedrock)	
6							
8							

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

GEOTEST

E McLeod Rd Stormwater Feasibility
2500 Block E McLeod Rd
Bellingham, WA

Log of Test Pits

Figure 5

TP-5

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics - forest duff (Topsoil)	Groundwater not encountered.
					ML		
					ML	Medium stiff, reddish brown, moist, sandy SILT, trace gravel, scattered organics (Subsoil)	
2	8				SNS	Very stiff to hard, light gray, slight mottling, moist, very sandy SILT, trace fine gravel, blocky (Glaciomarine Drift)	
						Moderately hard, medium to light brown, dry, SANDSTONE, massive, minimal fracture (Chuckanut Bedrock)	
4							
6							
8							

Test Pit Completed 05/05/20
Total Depth of Test Pit = 3.0 ft.

TP-6

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics (Topsoil)	Groundwater not encountered.
	9				ML	Medium stiff, reddish brown, moist, sandy SILT, trace gravel, scattered organics (Subsoil)	
					ML		
2	10				SNS	Very stiff to hard, light gray, slight mottling, moist, very sandy SILT, trace fine gravel, blocky (Glaciomarine Drift)	
						Moderately hard, medium to light brown, dry, SANDSTONE, massive, minimal fracture (Chuckanut Bedrock)	
4							
6							
8							

Test Pit Completed 05/05/20
Total Depth of Test Pit = 2.8 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

GEOTEST

E McLeod Rd Stormwater Feasibility
2500 Block E McLeod Rd
Bellingham, WA

Log of Test Pits

Figure 6

TP-7

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type / Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0				ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics (Topsoil)	Groundwater not encountered.
				ML	Medium stiff, reddish brown, moist, sandy SILT, trace gravel, scattered organics (Subsoil)	
2	11	W = 17 GS		ML		
				SLS	Very stiff to hard, light gray, slight mottling, moist, very sandy SILT, trace fine gravel, minor thin roots (Glaciomarine Drift)	
					Moderately hard, medium to light brown, dry, SILTSTONE, flakey fracture (Chuckanut Bedrock)	
4						
6						
8						

Test Pit Completed 05/05/20
Total Depth of Test Pit = 3.0 ft.

TP-8

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type / Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0				ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics (Topsoil)	Groundwater not encountered.
				ML	Medium stiff, reddish brown, moist, sandy SILT, trace gravel, scattered organics (Subsoil)	
2	12			ML		
	13				Very stiff to hard, light gray, slight mottling, moist, gravelly, very sandy SILT, trace boulders (Glaciomarine Drift)	
4				SNS	Moderately hard, medium to light brown, dry, SANDSTONE, massive, minimal fracture (Chuckanut Bedrock)	
6						
8						

Test Pit Completed 05/05/20
Total Depth of Test Pit = 4.5 ft.

Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

GEOTEST

E McLeod Rd Stormwater Feasibility
2500 Block E McLeod Rd
Bellingham, WA

Log of Test Pits

Figure 7

TP-9

SAMPLE DATA			SOIL PROFILE			GROUNDWATER
Depth (ft)	Sample Number & Interval	Sampler Type	Test Data	Graphic Symbol	USCS Symbol	Excavation Method: Tracked Excavator Ground Elevation (ft): Undetermined	
0					ML	Soft, dark brown, moist, sandy SILT, trace gravel, abundant organics (Topsoil)	Groundwater not encountered.
					ML	Medium stiff, reddish brown, moist, sandy SILT, trace gravel, scattered organics (Subsoil)	
2	14				ML	Very stiff to hard, light gray, slight mottling, moist, gravelly, very sandy SILT, trace cobbles (Glaciomarine Drift)	
					SNS	Non-plastic per Atterberg analysis	
4						Moderately hard, medium to light brown, dry, SANDSTONE, massive, minimal fracture (Chuckanut Bedrock)	
6							
8							

Test Pit Completed 05/05/20
Total Depth of Test Pit = 3.8 ft.

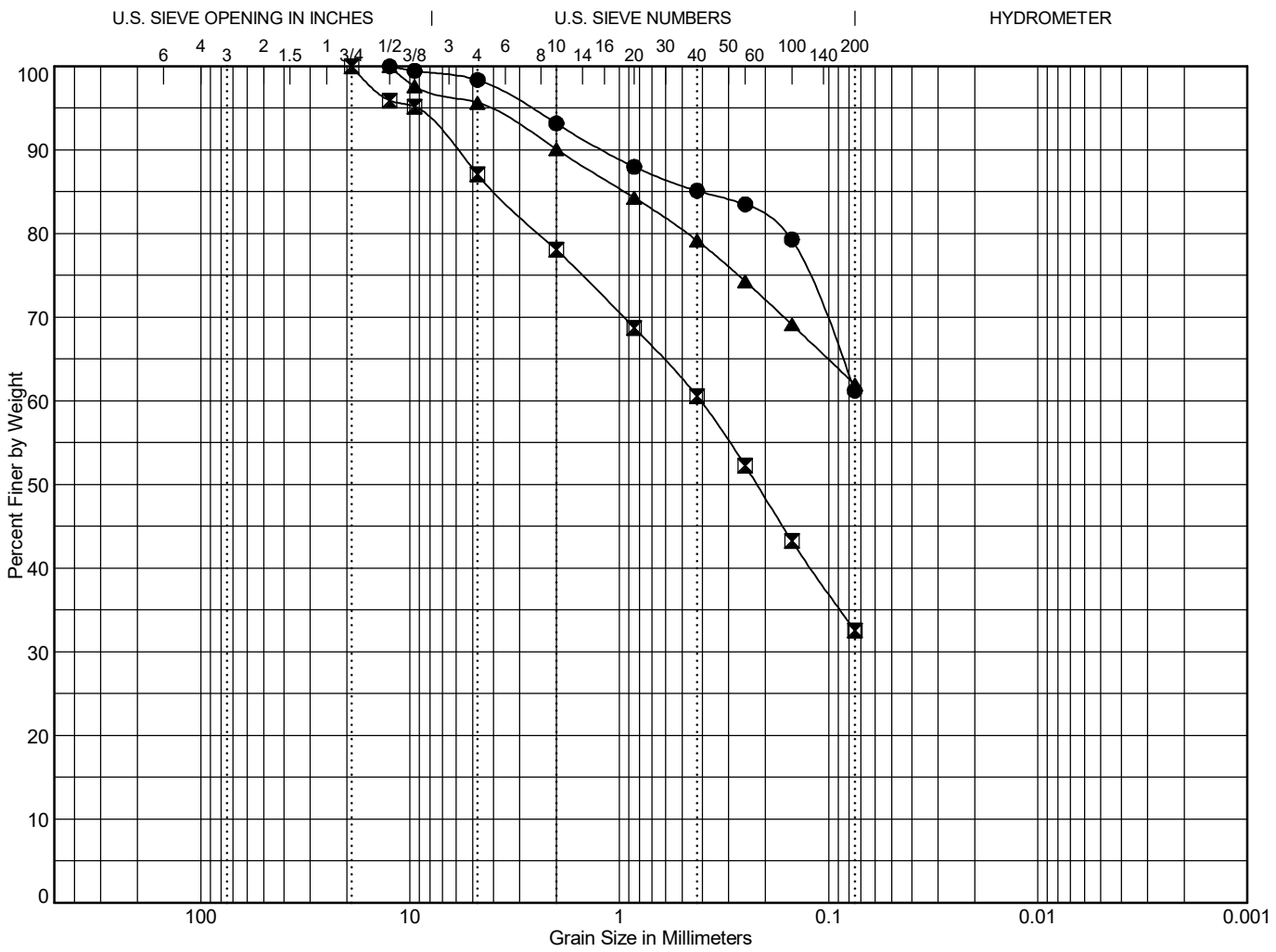
Notes:
1. Stratigraphic contacts are based on field interpretations and are approximate.
2. Reference to the text of this report is necessary for a proper understanding of subsurface conditions.
3. Refer to "Soil Classification System and Key" figure for explanation of graphics and symbols.

GEOTEST

E McLeod Rd Stormwater Feasibility
2500 Block E McLeod Rd
Bellingham, WA

Log of Test Pits

Figure 8



Cobbles	Gravel		Sand			Silt or Clay
	coarse	fine	coarse	medium	fine	

Point		Depth	Classification	LL	PL	PI	C_c	C_u
●	TP-1	4.5	Very sandy SILT, trace fine gravel (ML)					
⊠	TP-3	2.0	Gravelly, very silty SAND (SM)					
▲	TP-7	1.8	Very sandy SILT, trace fine gravel (ML)					

Point		Depth	D_{90}	D_{60}	D_{50}	D_{30}	D_{10}	%Coarse Gravel	% Fine Gravel	% Coarse Sand	% Medium Sand	% Fine Sand	% Fines
●	TP-1	4.5	1.184	0.072*	0.049*	0.023*	0.011*	0.0	1.6	5.2	8.1	23.9	61.2
⊠	TP-3	2.0	6.1	0.41	0.22	0.063*	0.017*	0.0	12.9	9.0	17.5	28.0	32.6
▲	TP-7	1.8	1.972	0.062*	0.024*	0.003*	0*	0.0	4.3	5.6	10.9	17.2	62.0

*Extrapolated from data

$C_c = D_{30}^2/(D_{60} * D_{10})$

$C_u = D_{60}/D_{10}$

To be well graded: $1 < C_c < 3$ and $C_u > 4$ for GW or $C_u > 6$ for SW

GEOTEST

E McLeod Rd Stormwater Feasibility
2500 Block E McLeod Rd
Bellingham, WA

Grain Size Test Data

Figure 9

REPORT LIMITATIONS AND GUIDELINES FOR ITS USE[1]

Subsurface issues may cause construction delays, cost overruns, claims, and disputes. While you cannot eliminate all such risks, you can manage them. The following information is provided to help:

Geotechnical Services are Performed for Specific Purposes, Persons, and Projects

At GeoTest our geotechnical engineers and geologists structure their services to meet specific needs of our clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of an owner, a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared solely for the client. No one except you should rely on your geotechnical engineer who prepared it. And no one – not even you – should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

Serious problems have occurred because those relying on a geotechnical engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

A Geotechnical Engineering Report is Based on a Unique Set of Project-Specific Factors

GeoTest's geotechnical engineers consider a number of unique, project-specific factors when establishing the scope of a study. Typical factors include: the clients goals, objectives, and risk management preferences; the general nature of the structure involved its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless GeoTest, who conducted the study specifically states otherwise, do not rely on a geotechnical engineering report that was:

- not prepared for you,
- not prepared for your project,
- not prepared for the specific site explored, or
- completed before important project changes were made.

1Information in this document is based upon material developed by ASFE, Professional Firms Practicing in the Geosciences(asfe.org)

Typical changes that can erode the reliability of an existing geotechnical engineering report include those that affect:

- the function of the proposed structure, as when it's changed, for example, from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed construction,
- alterations in drainage designs; or
- composition of the design team; the passage of time; man-made alterations and construction whether on or adjacent to the site; or by natural alterations and events, such as floods, earthquakes or groundwater fluctuations; or project ownership.

Always inform GeoTest's geotechnical engineer of project changes – even minor ones – and request an assessment of their impact. Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.

Subsurface Conditions Can Change

This geotechnical or geologic report is based on conditions that existed at the time the study was performed. Do not rely on the findings and conclusions of this report, whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. Always contact GeoTest before applying the report to determine if it is still relevant. A minor amount of additional testing or analysis will help determine if the report remains applicable.

Most Geotechnical and Geologic Findings are Professional Opinions

Our site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. GeoTest's engineers and geologists review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ – sometimes significantly – from those indicated in your report. Retaining GeoTest who developed this report to provide construction observation is the most effective method of managing the risks associated with anticipated or unanticipated conditions.

1Information in this document is based upon material developed by ASFE, Professional Firms Practicing in the Geosciences(asfe.org)

A Report's Recommendations are Not Final

Do not over-rely on the construction recommendations included in this report. Those recommendations are not final, because geotechnical engineers or geologists develop them principally from judgment and opinion. GeoTest's geotechnical engineers or geologists can finalize their recommendations only by observing actual subsurface conditions revealed during construction. GeoTest cannot assume responsibility or liability for the report's recommendations if our firm does not perform the construction observation.

A Geotechnical Engineering or Geologic Report may be Subject to Misinterpretation

Misinterpretation of this report by other design team members can result in costly problems. Lower that risk by having GeoTest confer with appropriate members of the design team after submitting the report. Also, we suggest retaining GeoTest to review pertinent elements of the design teams plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having GeoTest participate in pre-bid and preconstruction conferences, and by providing construction observation.

Do not Redraw the Exploration Logs

Our geotechnical engineers and geologists prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors of omissions, the logs included in this report should never be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable; but recognizes that separating logs from the report can elevate risk.

Give Contractors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make contractors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give contractors the complete geotechnical engineering report, but preface it with a clearly written letter of transmittal. In that letter, consider advising the contractors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with GeoTest and/or to conduct additional study to obtain the specific types of information they need or prefer. A pre-bid conference can also be valuable. Be sure contractors have sufficient time to perform additional study. Only then might you be in a position to give contractors the best information available, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

1Information in this document is based upon material developed by ASFE, Professional Firms Practicing in the Geosciences(asfe.org)

In addition, it is recommended that a contingency for unanticipated conditions be included in your project budget and schedule.

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering or geology is far less exact than other engineering disciplines. This lack of understanding can create unrealistic expectations that can lead to disappointments, claims, and disputes. To help reduce risk, GeoTest includes an explanatory limitations section in our reports. Read these provisions closely. Ask questions and we encourage our clients or their representative to contact our office if you are unclear as to how these provisions apply to your project.

Environmental Concerns Are Not Covered in this Geotechnical or Geologic Report

The equipment, techniques, and personnel used to perform an environmental study differ significantly from those used to perform a geotechnical or geologic study. For that reason, a geotechnical engineering or geologic report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated containments, etc. If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk management guidance. Do not rely on environmental report prepared for some one else.

Obtain Professional Assistance to Deal with Biological Pollutants

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts biological pollutants from growing on indoor surfaces. Biological pollutants includes but is not limited to molds, fungi, spores, bacteria and viruses. To be effective, all such strategies should be devised for the express purpose of prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional biological pollutant prevention consultant. Because just a small amount of water or moisture can lead to the development of severe biological infestations, a number of prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of this study, the geotechnical engineer or geologist in charge of this project is not a biological pollutant prevention consultant; none of the services preformed in connection with this geotechnical engineering or geological study were designed or conducted for the purpose of preventing biological infestations.

1Information in this document is based upon material developed by ASFE, Professional Firms Practicing in the Geosciences(asfe.org)