BLUELINE

Harbor Grove

Parcel No. 00611600015901
9110 53rd Ave W
Mukilteo, Washington 98275

Date: May 3rd, 2022
Revision Date: April 20th, 2023

Storm Drainage Report

Prepared for
Sea-Pac Homes, (425) 626-5353
120 SW Everett Mall Way Suite 100
Everett, WA 98204

Blueline Job No. 21-073
Prepared by: Olivia Westmoreland, (425) 250-7236
Reviewed by: Lucas Zirotti, EIT, (425) 250-7223
Jeremy Epley, PE, (425) 250-7269
Kristal Keating, PE, (425) 250-7276

04/21/2023

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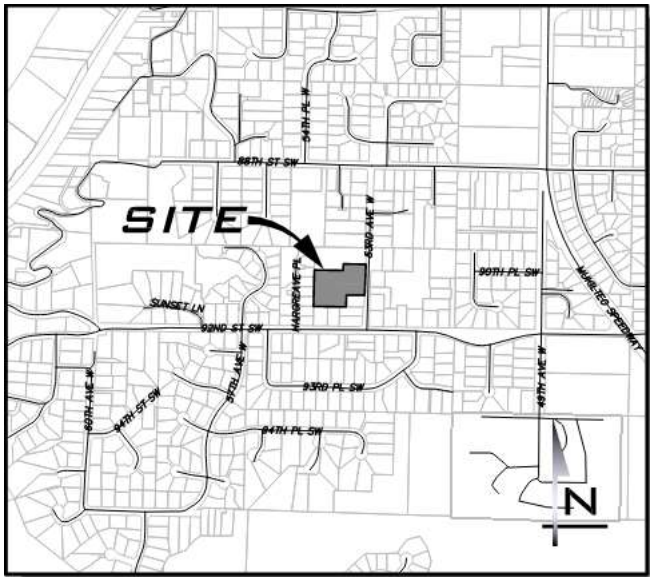
Section 1 Project Overview

The project is located at 9110 53rd Ave W in Mukilteo, WA 98275. More generally, the site is located in NW ¼ of Section 16, Township 28 N, Range 4 E, W.M. Please see the vicinity map below.



Vicinity Map – Not to Scale

The project site consists of a single 2.43-acre parcel (#00611600015901) and frontage improvements along 53rd Ave W. In the developed condition, there will be 0.05 acres of dedicated right-of-way (ROW), leaving the parcel to be 2.38-acres post-dedication. Approximately 0.19 acres of onsite area will remain undisturbed/preserved within a Native Vegetative Area Easement and will therefore be excluded from the flow control and water quality analysis. An additional 0.12 acres of frontage area will be included in the drainage analysis, as well as 0.28 acres of upstream area, for a total targeted area of 2.59 acres. Approximately 0.12 acres of targeted area cannot physically be routed to the proposed detention system and will therefore be considered bypass. The existing lot is generally forested with understory vegetation. The site includes one single family home, garage, and driveway. The existing site consists of an east and west subbasin, where their downstream paths combine within a quarter mile and are ultimately tributary to the Puget Sound. Therefore, the site is subject to one threshold discharge area. Refer to the *Existing Conditions Exhibit* included in Section 4.1. The project proposes the construction of 7 single-family homes with associated access drives, utilities, and landscaping. Refer to the *Developed Conditions Exhibit* included in Section 4.4.

The property is bound to the north, west, and south by single-family residences. The site is bound to the east by 53rd Ave W. An updated critical area study with current site information is provided in Section 6 of this report. There is a significant amount of elevation change across the parcel, with slopes greater than 33 percent in multiple areas.

Given information for project site (including as-builts, GIS, and survey) it is assumed that groundwater wells and septic systems are not present onsite or within 100 feet of the site.

Per the Geotechnical Report prepared by Earth Solutions NW, LLC., dated July 28, 2022, onsite soils consist of medium dense to very dense silty sand. Due to the presence of glacial till soils at shallow depths, onsite infiltration or low impact development (LID) is infeasible. The groundwater elevation per the Groundwater Elevation Evaluation prepared by Cobalt Geosciences, LLC is at an elevation of 375 feet. Technical reports can be found in Section 6.

The existing and developed basins are part of the Smuggler's Gulch drainage basin. In the existing condition, runoff sheet flows to the west and to the east from a natural ridge in the center portion of the property. The downstream paths for both subbasins discharge to Smuggler's Gulch Creek. In the developed condition, the

majority of onsite runoff will be routed to a detention vault. Approximately 0.12 acres of lot, frontage and dedicated right-of-way area cannot physically be routed to the proposed detention vault, thus, considered bypass. The majority of the frontage area will be conveyed to a proposed rain garden within the frontage.
The proposed improvements for this project are greater than 5,000 sf of new impervious area, thus the project, per the Department of Ecology's 2012 Stormwater Management Manual for Western Washington as amended in 2014 (DOE Manual), is categorized as a Large Project and required to meet Minimum Requirements 1 – 9 as detailed in Chapter 2 of the DOE Manual. The project was designed to satisfy the requirements of the DOE Manual as adopted by the City of Mukilteo and the 2019 City of Mukilteo Development Standards (COM Development Standards).

Section 2 Minimum Requirements

The project will comply with Minimum Requirements 1 – 9 of the DOE Manual as adopted by the City of Mukilteo and COM Development Standards, determined by the DOE Flow Chart included at the end of this section. Minimum requirements are listed and met as detailed below.

MINIMUM REQUIREMENT #1: PREPARATION OF STORMWATER SITE PLANS

All projects meeting the thresholds in Section I-3.3 of the DOE Manual shall prepare a stormwater Site Plan for City review. Refer to the Final Engineering Submittal included under separate cover for detailed information about the proposed stormwater design.

MINIMUM REQUIREMENT #2: CONSTRUCTION STORMWATER POLLUTION PREVENTION (SWPP)

See Section 5. A Construction SWPPP is provided under separate cover.

MINIMUM REQUIREMENT #3: SOURCE CONTROL OF POLLUTION

All known, available and reasonable source control BMPs must be applied to all projects. Source control BMPs will be selected, designed, and maintained in accordance with the COM Development Standards and the DOE Manual.

MINIMUM REQUIREMENT #4: PRESERVATION OF NATURAL DRAINAGE SYSTEMS AND OUTFALLS

See Sections 3 and 4. In the existing condition, site drainage ultimately flows west through the storm system within the Plat of Rugosa Ridge and outfalls to Smuggler's Gulch Creek. The developed drainage will be designed to match existing site discharge location. The existing and developed drainage path are both part of the Smuggler's Gulch basin.

MINIMUM REQUIREMENT #5: ON-SITE STORMWATER MANAGEMENT

See Section 4. The project will comply with the Low Impact Development Performance Standards, per Table I-3.1 of the DOE Manual included at the end of this section. The project is required to evaluate the BMPs in the order listed in List #2 for each surface presented in the list and utilize the first BMP considered feasible. The site is proposing to collect onsite runoff and route it to a detention vault to meet flow control requirements.

MINIMUM REQUIREMENT #6: RUNOFF TREATMENT

See Section 4. The project will provide Enhanced Water Quality Treatment Requirements as defined by Section 2.5.6 of the DOE Manual. Water quality requirements will be met by utilizing a Contech Modular Wetland System (MWS).

MINIMUM REQUIREMENT #7: FLOW CONTROL

See Section 4. The project will meet Flow Control Requirements as stated in Section 2.5.7 of the DOE Manual. Flow control requirements will be met through the use of a detention vault.

MINIMUM REQUIREMENT #8: WETLANDS PROTECTION

The project will not discharge stormwater into a wetland either directly or indirectly through a conveyance system. Therefore, this Minimum Requirement is not applicable.

MINIMUM REQUIREMENT #9 OPERATION AND MAINTENANCE

Operations and maintenance information is provided in Section 8 of this report.

Figure I-2.4.1 Flow Chart for Determining Requirements for New Development

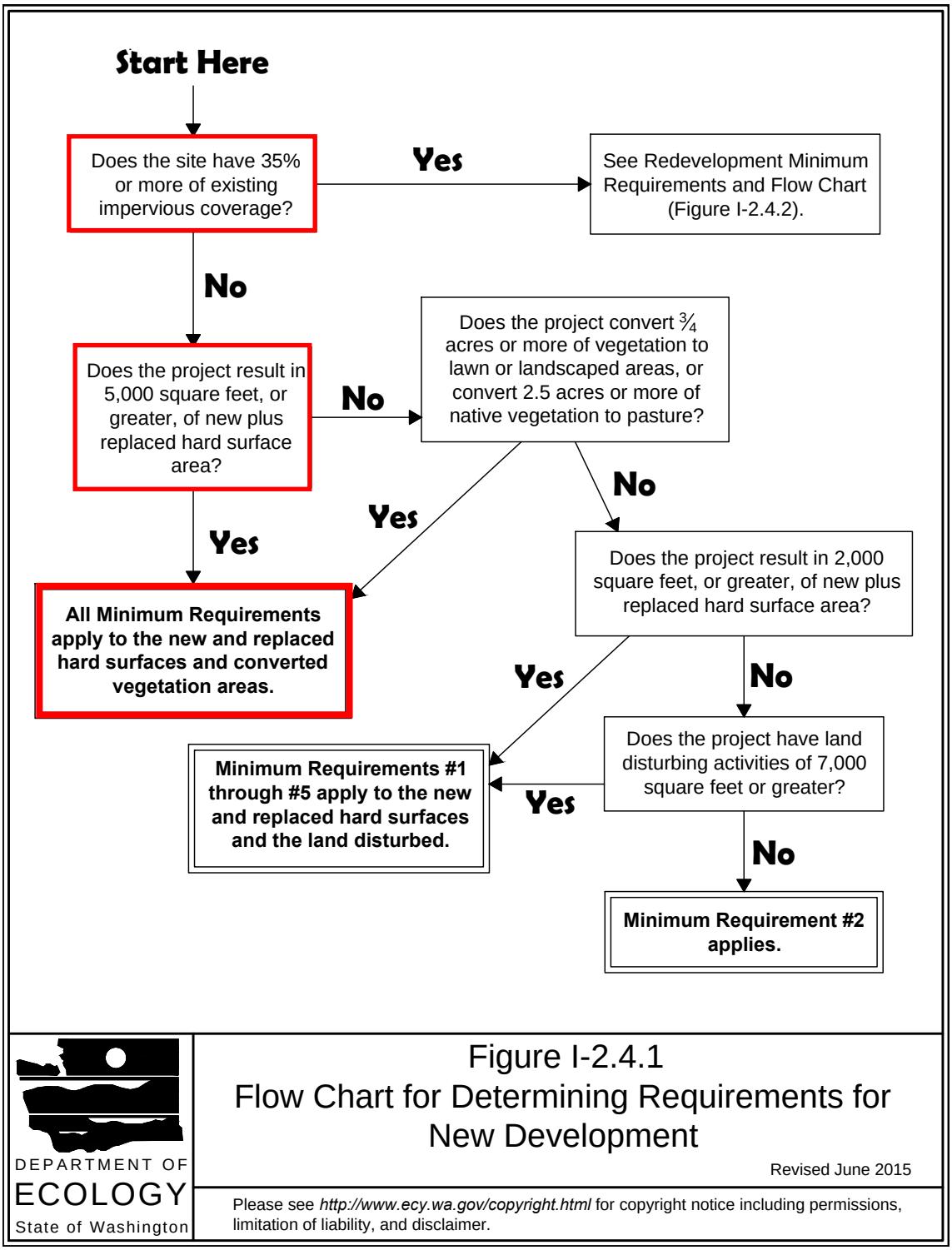


Table I-2.5.1 On-Site Stormwater Management Requirements for Projects Triggering Minimum Requirements #1 - #9

Project Type and Location	Requirement
New development on any parcel inside the UGA, or new development outside the UGA on a parcel less than 5 acres	Low Impact Development Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth (p.911); or List #2 (applicant option).
New development outside the UGA on a parcel of 5 acres or larger	Low Impact Development Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth (p.911).
Redevelopment on any parcel inside the UGA, or redevelopment outside the UGA on a parcel less than 5 acres	Low Impact Development Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth (p.911); or List #2 (applicant option).
Redevelopment outside the UGA on a parcel of 5 acres or larger	Low Impact Development Performance Standard and BMP T5.13: Post-Construction Soil Quality and Depth (p.911).
Note: This table refers to the Urban Growth Area (UGA) as designated under the Growth Management Act (GMA) (Chapter 36.70A RCW) of the State of Washington. If the Permittee is located in a county that is not subject to planning under the GMA, the city limits shall be used.	

Low Impact Development Performance Standard

Stormwater discharges shall match developed discharge durations to pre-developed durations for the range of pre-developed discharge rates from 8% of the 2-year peak flow to 50% of the 2-year peak flow. Refer to the Standard Flow Control Requirement section in Minimum Requirement #7 for information about the assignment of the pre-developed condition. Project sites that must also meet minimum requirement #7 – flow control - must match flow durations between 8% of the 2-year flow through the full 50-year flow.

List #1: On-site Stormwater Management BMPs for Projects Triggering Minimum Requirements #1 through #5

For each surface, consider the BMP's in the order listed for that type of surface. Use the first BMP that is considered feasible. No other On-site Stormwater Management BMP is necessary for that surface. Feasibility shall be determined by evaluation against:

1. **Design criteria, limitations, and infeasibility criteria identified for each BMP in this manual; and**

Section 3 Offsite Analysis

An offsite analysis was conducted on June 4th, 2021, a sunny day with temperatures around 56°F, to observe the downstream flow path of the site.

TASK 1: DEFINE AND MAP THE STUDY AREA

The project is comprised of one parcel (#00611600015901). See Section 4 of this report for the *Existing Conditions Exhibit* and the *Developed Conditions Exhibit.* A Photo Exhibit and Downstream Path Exhibit are provided at the end of this section that show the study area boundaries and the observed stormwater runoff flow path from the site.

TASK 2: RESOURCE REVIEW

The best available resource information was reviewed for existing or potential problems. The following is a summary of the findings from the information used in preparing this report. Technical reports can be found in Section 6 of this report.

- Per the Geotechnical Report provided by Earth Solutions NW, LLC., dated July 28, 2022, soils are dense to very dense silty sand, consistent with glacial till soil classification.
- The groundwater elevation per the Groundwater Elevation Evaluation prepared by Cobalt Geosciences, LLC is at an elevation of 375 feet.
- The site does not contain wetlands (City of Mukilteo Critical Areas Map).
- The site is not located in an Erosion Hazard Area (Snohomish County GIS).
- The site is not located in a Fish and Wildlife Habitat Conservation Area (City of Mukilteo Critical Areas Map).
- The site is not located in a 100-year flood plain or a FEMA floodway (City of Mukilteo Critical Areas Map).
- The site is not located in a Landslide Hazard Area (City of Mukilteo Critical Areas Map).
- The site is located in a Seismic Hazard Area Site Class C (Snohomish County GIS).
- The site is located in the Smuggler's Gulch sub-basin which is located in the Possession Sound Watershed Basin (Snohomish County GIS).

Per email coordination with the City of Mukilteo, there are ongoing drainage complaints concerning Parcel No. 00925600000500, 00925600000600, and 00925600000700. These drainage complaints are located along the frontage basin downstream drainage path. The project is proposing to collect the majority of onsite runoff and route it south bypassing the area of concern. A small portion of area bypassing the proposed detention vault will be tributary to the frontage downstream drainage path. When comparing the existing and the developed conditions, there will be a net decrease in the 100-year peak flow tributary to the frontage system. As such, the project will not impact the existing drainage issues along the frontage downstream drainage path and will not

need to provide a quantitative capacity assessment of the existing conveyance system. Refer to Section 4 of this report for a peak flow analysis between the existing and developed condition tributary to the frontage downstream path.

TASK 3: FIELD INSPECTION:

A field inspection was conducted for the project at 9110 53rd Ave W on June 4th, 2021. The weather was sunny with temperatures around 56°F. See below for detailed descriptions of the onsite and upstream basins. Task 4 of this section contains a detailed description of the downstream drainage path as well as a *Downstream Path Exhibit*.

Onsite Basin

The site contains an existing single-family residence, garage structure, driveway, and associated residential landscaping, including rockery and fencing. The site is bound to the north, west, and south by single-family residences. The site is bound to the east by 53rd Ave W. The site is located in the Smuggler's Gulch drainage basin and onsite runoff is ultimately tributary to the Puget Sound. See *Existing Conditions Exhibit* provided in Section 4.1 of this report.

Per the Geotechnical Report provided by Earth Solutions NW, LLC., dated July 28, 2022, soils are dense to very dense silty sand, consistent with glacial till soil classification.

The site consists of an east and west subbasin, where their downstream paths combine within a quarter mile. Runoff from the site generally sheet flows east and west from the natural ridge onsite located in the center portion of the site. Runoff travelling both east and west sheet flows across existing topography and vegetated landcover before entering conveyance systems on the respective property edges.

Upstream Area

In the existing condition, surface runoff from majority of adjacent properties sheet flow away from the site. It appears that Parcel 00611600015902 outfalls to the subject property and will be collected and routed to the detention vault in the developed condition.

TASK 4: DRAINAGE SYSTEM DESCRIPTION

The downstream drainage path was investigated approximately ¼ mile downstream from the site. At the time of the site investigation, no problems were found with the existing system beyond standard maintenance and cleaning. Existing catch basins and pipes require no immediate corrective maintenance. Refer to the *Downstream Drainage Exhibit* for the path and photo locations referred to in this section.

Existing Downstream Drainage Path

East Subbasin (Frontage Basin)

In the existing condition, portions of runoff from the subject site frontage along 53rd Ave W are collected via drainage swales and routed north along the west side of 53rd Ave W (*Photo E.1*). Flows enter a driveway culvert near the northeast corner of the subject parcel and daylight to a drainage swale that continues north before entering a culvert that directs water to a storm drain manhole (*Photo E.2*). Runoff is conveyed west within the existing tightlined storm system along 92nd St W, before being conveyed north to Hargreaves Pl (*Photo E.3-5*). Runoff travels north along Hargreaves Pl before outfalling to Smuggler's Gulch Creek (*Photo E.6*). Flows travel

west via Smuggler's Gulch Creek before combining with the existing west subbasin path. Flow continue west through the quarter-mile downstream location. In the developed condition, runoff from the frontage will maintain the existing frontage natural discharge location. There are multiple downstream drainage complaints along this downstream path. The project will be reducing the 100-year peak flow tributary to this existing system and will therefore not negatively impact these drainage concerns.

West Subbasin (Onsite Basin)
The majority of the existing onsite runoff sheet flows west across vegetated landcover *(Photo W.1 – 3)*. Runoff travelling west continues across Parcel No. 01116500000600, Parcel No. 01116500000500, Parcel No. 01116500000400, and Parcel No. 01116500000300 before entering a catch basin on the east side of Hargreaves Pl *(Photo W.4 – 5)*. Flow continues west through the existing tightlined storm system, travelling underneath Hargreaves Pl. Flow travels to the west side of Hargreaves Pl, discharging to heavily vegetated understory on the west side of Hargreaves Pl *(Photo W.6 – 7)*. Runoff combines with Smuggler's Gulch creek, where it continues west to the quarter-mile downstream location *(Photo W.8)*.

Developed Downstream Drainage Path
Onsite Basin
In the developed condition, the project proposes to collect majority of onsite runoff via roof drains/yard drains/french drains, route runoff to an onsite detention vault, and eventually outfall to the existing system within 92nd St SW. Flows will be conveyed west along the north side of 92nd St SW via the proposed tightlined storm system *(Photo 1)*. Flows will combine with the existing tightlined storm system at the intersection of 92nd St SW and Hargreaves Pl, before continuing north along the west side of Hargreaves Pl *(Photo 2).* Runoff eventually outfalls to vegetated understory *(Photo 3)*. Runoff combines with Smuggler's Gulch Creek and travels west to the quarter-mile downstream location.

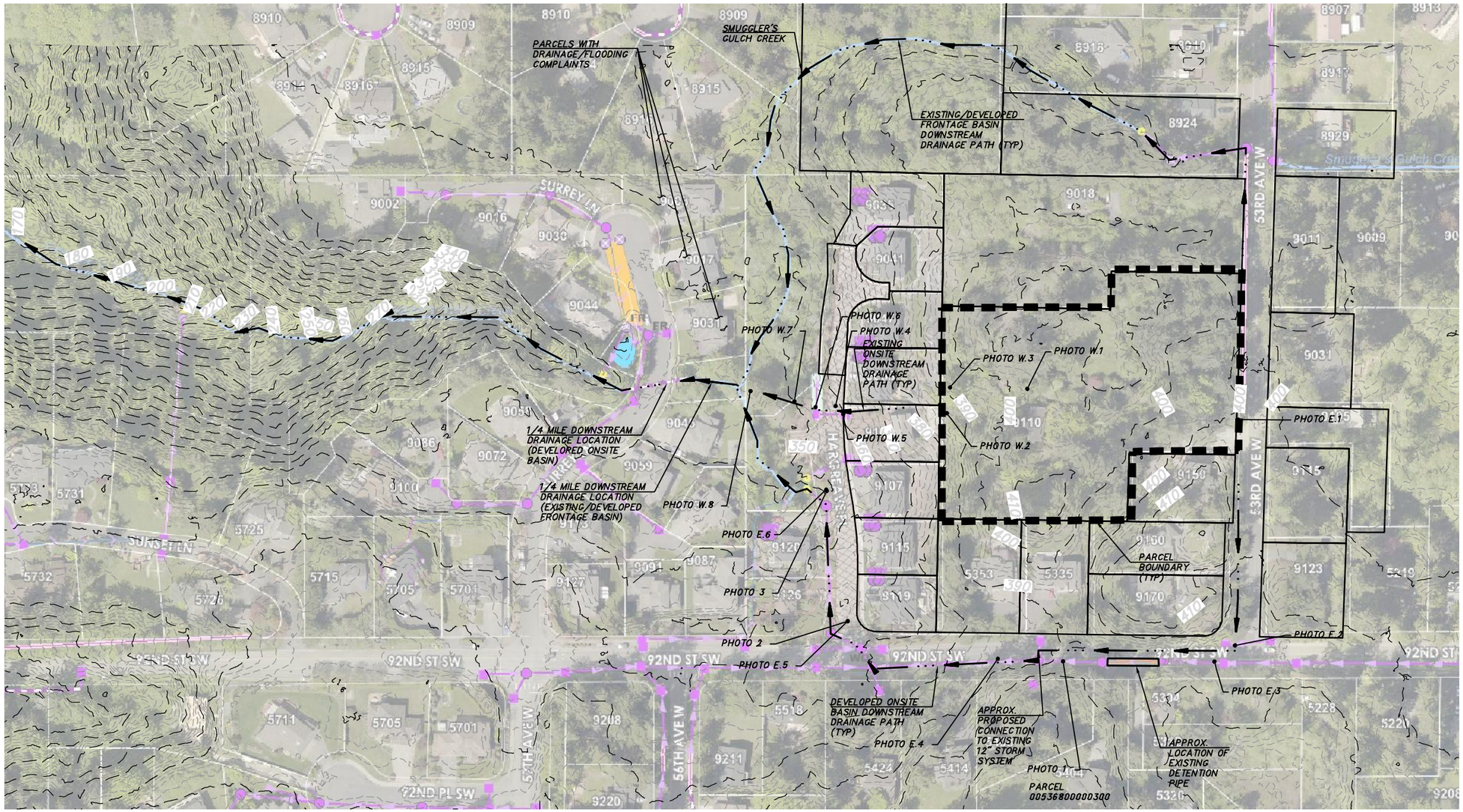
The existing east subbasin, existing west subbasin, and developed basin downstream paths discharge west of Hargreaves Pl and converge at Smuggler's Gulch Creek within a quarter mile downstream of the site, thus, result in one threshold discharge area. The downstream paths are part of the Smuggler's Gulch basin and are eventually tributary to Puget Sound.

DOWNSTREAM DRAINAGE EXHIBIT

N

SCALE: 1" = 150'

0 37.5 75 150



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DOWNSTREAM AREA EXHIBIT
HARBOR GROVE
STORM DRAINAGE REPORT

SCALE	AS NOTED
PROJECT MANAGER	TC COLLERAN
DESIGNED BY	LUCAS ZIROTTI
DRAWN BY	LUCAS ZIROTTI
PLOT DATE	April 20, 2023

JOB NUMBER: 21-073

FIGURE: DS

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DOWNSTREAM DRAINAGE PHOTOGRAPHS – DEVELOPED BASIN

Note: See the Downstream Drainage Exhibit for numbered locations of pictures.

Photo 1 – Facing west from the south side of 92nd St SW. Runoff travels west via the proposed tightlined storm system.

Photo 2 – Facing north on Hargreaves Pl. Runoff combines with the existing system and travels north.

Photo 3 – Facing north adjacent to the west side of Hargreaves Pl. Runoff discharges to heavily vegetated understory. The downstream flow paths of the east and west subbasin combine at this location.

DOWNSTREAM DRAINAGE PHOTOGRAPHS – EXISTING EAST SUBBASIN

Note: See the Downstream Drainage Exhibit for numbered locations of pictures.

Photo E.1 – Facing south from the eastern property edge. Runoff enters drainage swale adjacent to the west side of 53rd Ave W and is conveyed south.

Photo E.2 – Facing north from the east side of 53rd Ave W. Runoff travelling south enters a catch basin and is conveyed west through the existing tightlined storm system.

Photo E.3 – Facing northeast from the south side of 92nd St W. Runoff continues west through the existing tightlined storm system.

Photo E.4 – Facing west from the south side of 92nd St W. Runoff continues west through the existing tightlined storm system.

Photo E.5 – Facing north on Hargreaves Pl. Runoff travels north through existing tightlined storm system.

Photo E.6 – Facing north adjacent to the west side of Hargreaves Pl. Runoff discharges to heavily vegetated understory. The downstream flow paths of the east and west subbasin combine at this location.

DOWNSTREAM DRAINAGE PHOTOGRAPHS – EXISTING WEST SUBBASIN

Note: See the Downstream Drainage Exhibit for numbered locations of pictures.

Photo W.1 – Facing west from the western portion of the site. Runoff sheet flows west across vegetated landcover.

Photo W.2 – Facing south from the western edge of the site. Runoff sheet flows west across sloping terrain.

Photo W.3 – Facing west from the western edge of the site. Runoff sheet flows west across vegetated landcover.

Photo W.4 – Facing north on Hargreaves Pl. Runoff sheet flows west across private residences towards the existing tightlined storm system.

Photo W.5 – Facing east from the east side of Hargreaves Pl. Runoff enters existing catch basin and travels west across Hargreaves Pl.

Photo W.6 – Facing west from the west side of Hargreaves Pl. Runoff continues west through existing tightlined system.

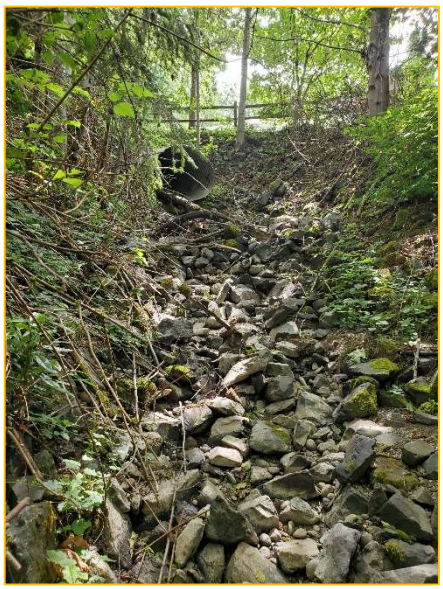


Photo W.7 – Facing east at the downstream end of the culvert just west of Hargreaves Pl. Flows outfall the culvert and continue west through vegetated understory. The downstream flow paths of the east and west subbasin combine at this location.

Photo W.8 – Facing east at the quarter-mile downstream location. Flows merge with existing Smuggler's Gulch Creek and continue west.

Lucas Zirotti

From: Jennifer Adams <jadams@mukilteowa.gov>
Sent: Monday, June 14, 2021 5:18 PM
To: MaKenzie Fockler
Cc: Matthew Geiger
Subject: RE: Downstream Complaints/Concerns Request (Parcel # 00611600015901)

Hi MaKenzie,

Thank you for asking. The city has ongoing drainage/flooding complaints from 9003, 9017 and 9031 Surrey Lane, dating back to 2003 and as recent as 2019. During heavy rains, the stream jumps the channel. There is a 10' private drainage easement on the back of two of these lots. Past service requests indicate there was a mound constructed to help keep water out and a 12" pipe that drains three back yards as part of the original development plan. I don't have that design at my fingertips. However, if you would like that information, please submit a Public Disclosure Request and we will follow up. https://mukilteowa.gov/departments/executive/city-clerk/public-records-requests/

City plat records are available here: https://mukilteo-city.maps.arcgis.com/apps/webappviewer/index.html?id=bb9ee1cb6b9d40a28ec1698b5c8c59e7 , which should show the easement referenced above.

As it relates to the Hargreaves properties (the existing runoff location), I have responded to one property owner's complaint of onsite runoff from the parcel in question, although I don't have a record of that site visit. We didn't observe surface flows, but their property was very wet. No cause was discovered.

Let me know if you have additional questions.

Regards,

Jennifer Adams | Surface Water Programs Manager
Public Works Engineering | City of Mukilteo | 425.263.8083
jadams@mukilteowa.gov | www.mukilteowa.gov

My hours are 7:00am-4:30pm, with every other Thursday off.

From: MaKenzie Fockler <mfockler@thebluelinegroup.com>
Sent: Tuesday, June 8, 2021 2:02 PM
To: Jennifer Adams <jadams@mukilteowa.gov>
Subject: Downstream Complaints/Concerns Request (Parcel # 00611600015901)

[WARNING: THIS MESSAGE HAS COME FROM A SENDER OUTSIDE THE CITY OF MUKILTEO NETWORK,]
Hi Jennifer,

I am working on a project in Mukilteo and would like to determine if there are any drainage complaints or concerns for this project's downstream drainage path. The project is located at 9110 53rd Ave W, Mukilteo, WA (parcel # 00611600015901).

In the attached exhibit, I outlined three different downstream paths that we are investigating. The middle path is the existing condition, where onsite runoff sheet flows unmitigated offsite into the existing system in Hargreave Pl and then continues west in the stream. For the developed conditions, we are looking in to routing the runoff north via the existing storm system in the project parcel frontage. This path joins in to Smuggler's Gulch Creek from the system in 53rd Avenue. Alternatively, we could route the water south to the existing system in 92nd St SW, which also conveys the stormwater west to the stream.

Could you please provide information regarding any downstream drainage complaints along the downstream paths? I have attached an exhibit delineating the downstream paths for reference.

Please let me know if you need additional information or have any questions.

Thanks!

MaKenzie Fockler | ENGINEER
BLUELINE | THEBLUELINEGROUP.COM
DIRECT 425.250.7258 | **MAIN** 425.216.4051

Section 4 Permanent Stormwater Control Plan

The permanent stormwater control plan includes both flow control and water quality treatment facilities designed and sized according to the COM Development Standards and DOE Manual.

4.2 FLOW CONTROL ANALYSIS AND DESIGN

The drainage analysis was modeled using the Western Washington Hydrology Model software program (WWHM2012), which is recognized as an approved model in the COM Development Standards. The project was modeled using a 15-minute timestep. Per the Geotechnical Report provided by Earth Solutions NW, LLC., dated July 28, 2022, soils are dense to very dense silty sand, consistent with glacial till soil classification. The site is subject to one threshold discharge area as the proposed downstream drainage paths combine within a quarter-mile. Refer to the Downstream Drainage Exhibit included in Section 3 of this report.

The project was modeled with the following parameters:

Rainfall Region:	Everett
Scale Factor:	0.80

EXISTING CONDITIONS

The subject parcel is 2.43-acres and is generally forested with understory vegetation. The site contains an existing single-family home, an existing asphalt road, and a portion of an existing adjacent gravel driveway. Approximately 0.19 acres of onsite area will remain undisturbed/preserved within a Native Vegetative Area Easement. According to Figure I-3.1 in the 2014 SWMMWW, "All Minimum Requirements apply to the new and replaced hard surfaces and converted vegetation areas". Areas left unconverted do not need to meet water quality and quantity requirements, thus, not included in the drainage analysis. An additional 0.07 acres of frontage area will be included in the drainage analysis, as well as 0.28 acres of upstream area from Parcel 00611600015902, for a total basin of 2.59 acres. A maximum impervious coverage per zoning, percentage of 55%, is assumed for the upstream area within 00611600015902.

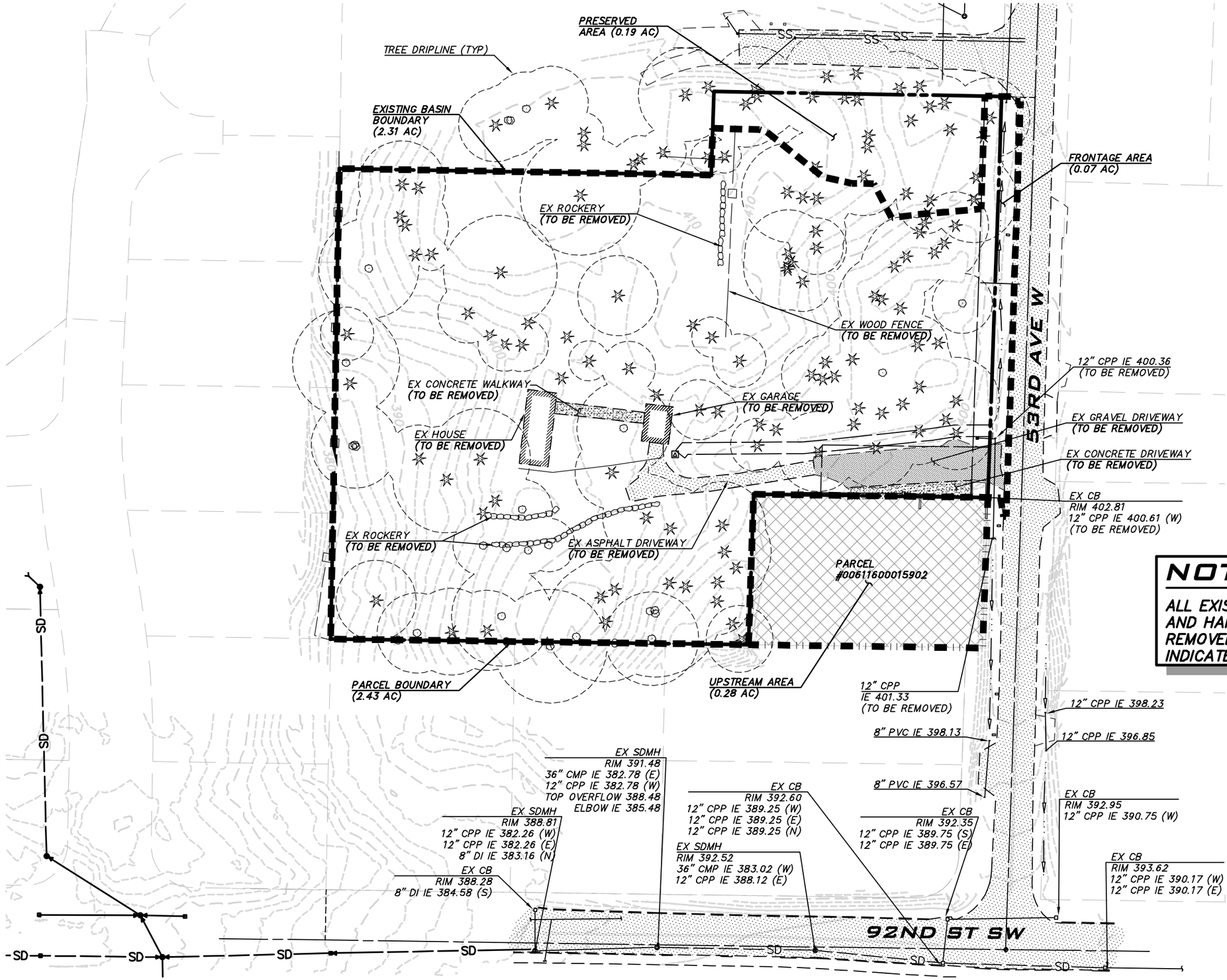
Per Section 3.5.9 of the COM Development Standards, the pre-developed condition to be matched shall be modeled as forested land cover. The areas used to compute the drainage calculations associated with the existing basin conditions, as well as the corresponding WWHM output, are summarized on the following page and included in the Appendix of this report.

EXISTING CONDITIONS

Forest		
Parcel	2.43	ac
Undisturbed/Protected Area*	(0.19)	ac
Frontage	0.07	ac
Total Forest (Soil Group C - Till)	**2.31**	**ac**
Lawn		
Upstream	0.13	ac
Total Lawn (Till - Soil Group C)	0.13	ac
Impervious		
Upstream	0.15	ac
Total Impervious	0.15	ac
TOTAL EXISTING CONDITIONS	**2.59**	**ac**

*Unconverted areas are excluded from drainage analysis per Volume I, Chapter 2 of the DOE Manual. Minimum requirements only apply to new and replaced hard surfaces and land disturbed.

EXISTING CONDITIONS EXHIBIT



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SCALE: 1" = 60'

0 15 30 60

NOTE

ALL EXISTING STRUCTURES, UTILITIES AND HARDSCAPE ONSITE ARE TO BE REMOVED UNLESS OTHERWISE INDICATED.

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EXISTING CONDITIONS EXHIBIT
HARBOR GROVE
STORM DRAINAGE REPORT

SCALE	1" = 50'
PROJECT MANAGER	TC COLLERAN, PLA
DESIGNED BY	LEE TOMKINS
DRAWN BY	OLIVIA WESTMORELAND
PLOT DATE	April 20, 2023

JOB NUMBER: 21-073

FIGURE: EC

Apr 20, 2023 - 2:21pm - User awestmoreland
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DEVELOPED CONDITIONS

The project will create 7 single-family lots with residential landscaping, a detention vault, and associated utilities. The site will provide an open space tract and a private utility/access tract. The project will dedicate 0.05 acres along the eastern property boundary as right-of-way. Refer to the Developed Conditions Exhibit included on the following page. Refer to the Downstream Drainage Exhibit included in Section 3 of this report.

The majority of runoff from the developed basin will be routed to an onsite detention vault via a network of catch basins/pipes and outfall to the existing storm conveyance system within the intersection of 53rd Ave W and 92nd St SW. The site is subject to one threshold discharge area as the proposed downstream drainage paths combine within a quarter-mile. Refer to the Downstream Drainage Exhibit included in Section 3 of this report.

Flow control will be achieved by an onsite detention facility located in Tract 998. Treatment for Enhanced Water quality is proposed through Contech Modular Wetland System (MWS).

The developed drainage basin consists of the parcel, post dedication (2.38 acres), minus approximately 0.19 acres of undisturbed/protected area, plus an additional 0.12 acres of frontage area, for a total basin of 2.31 acres. Approximately 0.12 acres of targeted area cannot physically be routed to the proposed detention system and will therefore be considered bypass. The maximum impervious coverage for each lot has been restricted to 23%, therefore the detention facility has been designed to accommodate a maximum impervious hard surface coverage of 32% for each lot. Private Utility and Access Tract (Tract 998) is assumed to be 95% impervious and Open Space Tract (Tract 999) is assumed to contain 0.02-acres of impervious. A maximum impervious coverage per zoning, percentage of 55%, is assumed for the upstream area within 00611600015902.

All landscaped and open areas will have compost amended soils per BMP T5.13. Areas meeting BMP T5.13 design guidelines may be entered into WWHM as "Pasture" rather than "Lawn" per Volume V, BMP T5.13 of the DOE Manual.

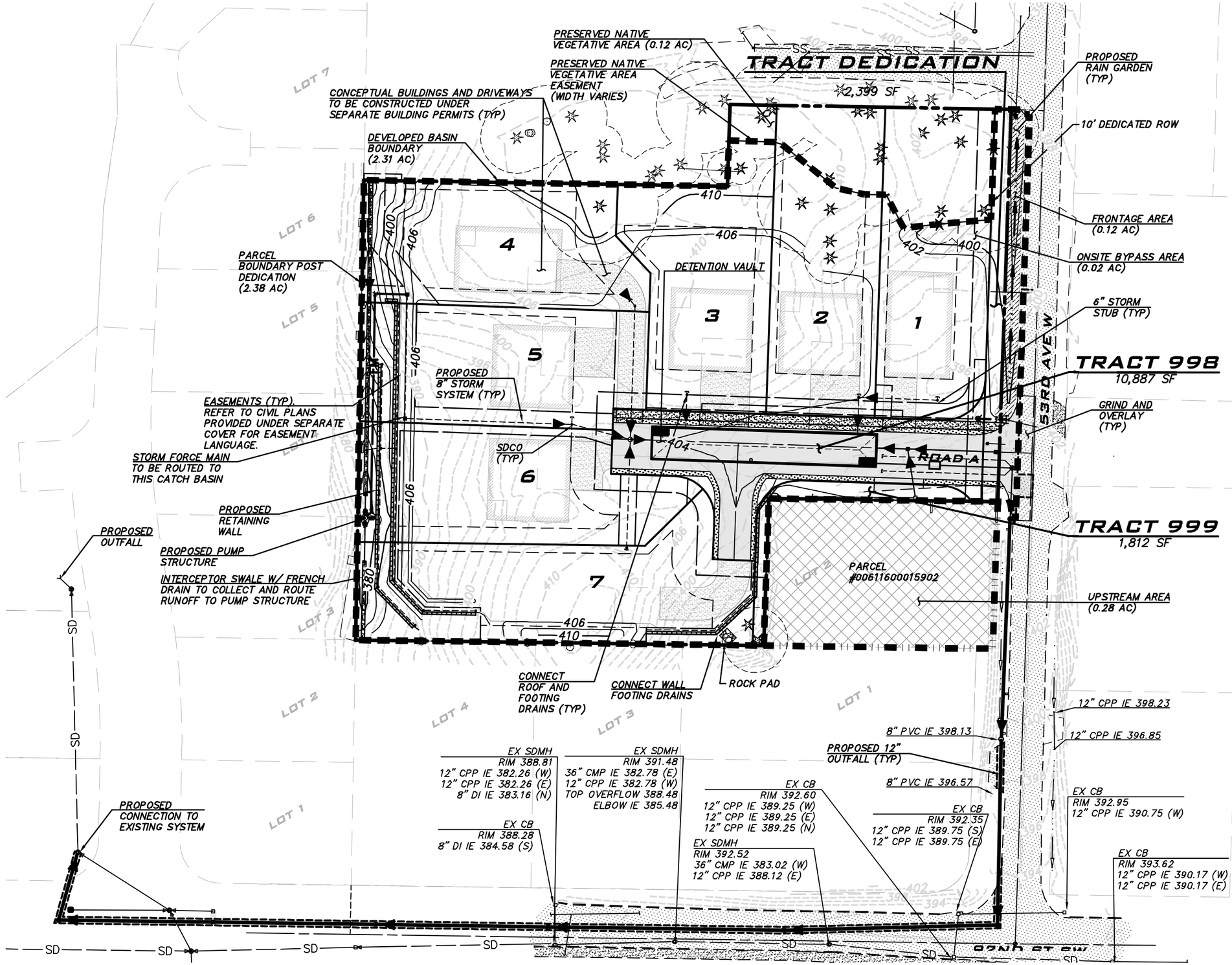
Refer to the developed conditions areas, WWHM Flood printouts, and the *Developed Conditions Exhibit* included on the following pages and Appendix A.

DEVELOPED CONDITIONS

Detention Vault Tributary		
Impervious		
Lot 1-7	0.67	ac
Private Access Tract (Tract 998)	0.24	ac
Tract To Be Deeded to Neighbor (Tract 999)	0.02	ac
Frontage / Dedicated Right-of-Way	0.03	ac
Frontage / Dedicated Right-of-Way	(0.01)	ac
Upstream	0.15	ac
Total Impervious	**1.10**	**ac**
Pasture		
Lot 1-7	1.42	ac
Lot Bypass	(0.02)	ac
Undisturbed/Protected Lot Area*	(0.19)	ac
Private Access Tract (Tract 998)	0.01	ac
Tract To Be Deeded to Neighbor (Tract 999)	0.02	ac
Frontage / Dedicated Right-of-Way	0.09	ac
Frontage / Dedicated Right-of-Way Bypass	(0.09)	ac
Total Pasture (Till - Soil Group C)	**1.24**	**ac**
Lawn		
Upstream	0.13	ac
Total Lawn (Till - Soil Group C)	**0.13**	**ac**
TOTAL DETENTION VAULT TRIBUTARY	**2.47**	**ac**
Frontage/ROW Bypass		
Impervious		
Frontage Bypass	0.01	ac
Total Impervious	**0.01**	**ac**
Pasture		
Parcel	0.02	ac
Frontage / Dedicated Right-of-Way	0.09	ac
Total Pasture (Till - Soil Group C)	0.11	**ac**
TOTAL BYPASS BASIN	**0.12**	**ac**
TOTAL DEVELOPED CONDITIONS	**2.59**	**ac**

*Unconverted areas are excluded from drainage analysis per Volume I, Chapter 2 of the DOE Manual. Minimum requirements only apply to new and replaced hard surfaces and land disturbed.

DEVELOPED CONDITIONS EXHIBIT



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SCALE: 1" = 60'

0 15 30 60

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DEVELOPED CONDITIONS EXHIBIT
HARBOR GROVE
STORM DRAINAGE REPORT

SCALE	1" = 50'
PROJECT MANAGER	TC COLLERAN, PLA
DESIGNED BY	LEE TOMKINS
DRAWN BY	OLIVIA WESTMORELAND
PLOT DATE	April 21, 2023

JOB NUMBER: 21-073

FIGURE: DC

Apr 21, 2023 - 11:32am - User owestmoreland
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4.3 VAULT PERFORMANCE

Per the WWHM printout provided on the following page, the live volume required at the maximum stage of 7' is 17,500 cubic feet. The provided vault volume will exceed the minimum required. The proposed vault will provide a single 136'L x 19'W x 7' Deep cell for a total of 18,088 cubic feet. The proposed vault is adequately sized to accommodate for the required flow control requirements, per COM Development Standards and the DOE Manual. Refer to the full WWHM pdf report included in the Appendix of the report.

Live Storage Volume
Required = 17,500 CF
Provided = 18,088 CF (3.36% Factor of Safety)

4.4 DETENTION VAULT CONTROL STRUCTURE OVERFLOW

The riser was sized using the 100-year developed undetained WWHM 15-minute peak flow (0.8530 cfs). Riser overflow was designed using the Weir Equation.

Weir Equation: $Q_{weir} = 9.739\ DH^{3/2}$; $H = (Q_{weir} / 9.739D)^{2/3}$

Where: Q = 100-year developed undetained flow (0.8530 cfs)
D = riser diameter (1.0 feet)
H = head above riser

$H = (0.8530\ cfs / 9.739(1.0\ feet))^{2/3} = 0.20\ feet$

A 12-inch riser conveying the 100-year 15-minute WWHM storm event of 0.8530 cfs requires a minimum freeboard of 0.20 feet. The minimum required freeboard required per DOE Manual is 0.5 feet is provided.

The overflow system has been analyzed using 15-minute time series for the developed site conditions less bypass areas. A summary output from WWHM 15-minute flows is as follows:

WWHM (15-Minute Time Steps) Developed Area Flows (not including bypass areas)

Flow Frequency Return Periods for Developed. Basin POC #1	
Return Period	**Flow(cfs)**
2 year	0.3300
5 year	0.4480
10 year	0.5346
25 year	0.6538
50 year	0.7501
100 year	0.8530

4.5 WATER QUALITY ANALYSIS AND DESIGN

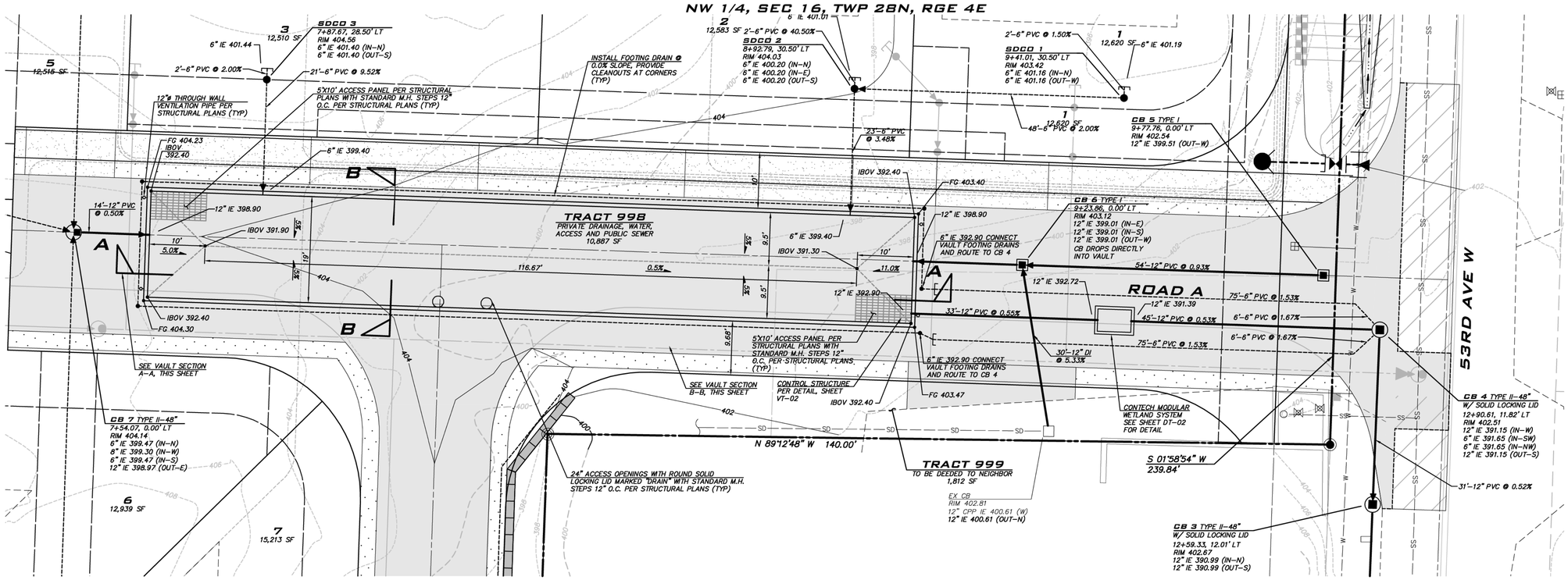
The project will provide Enhanced Water Quality Treatment Requirements as defined by Section 2.5.6 of the DOE Manual. The project will provide treatment for the majority of the parcel, post dedication, via a Contech Modular Wetland System (MWS). The MWS is located downstream of the detention vault and has been sized to accommodate runoff from the total detention vault tributary (2.47 ac).

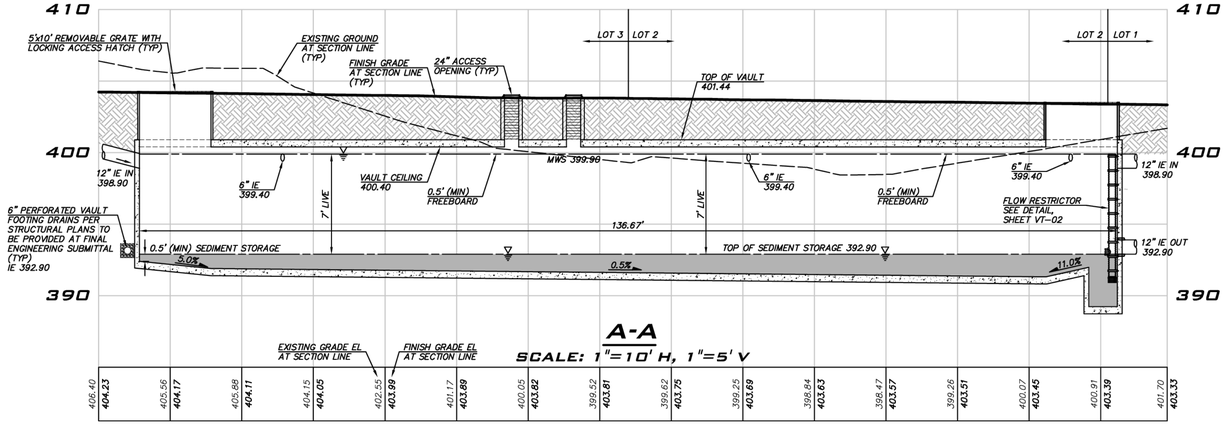
Refer to the tributary areas and WWHM output below.

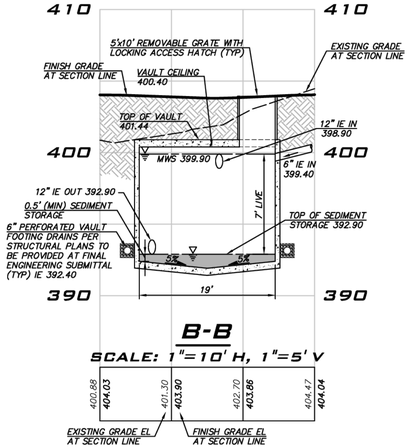
WWHM (15-minute Time Steps) Developed Area Flows (not including bypass areas)

Flow Frequency Return Periods for Developed. Onsite Basin POC #1	
Return Period	**Flow(cfs)**
2 year	0.0305
5 year	0.0421
10 year	0.0513
25 year	0.0647
50 year	0.0761
100 year	0.0888

Per WWHM, the 2-year (WQ flow) is 0.0305 cfs, and the 100-year (peak flow) is 0.8530 cfs. The MWS has been designed to adequately accommodate these flow rates and therefore meets the Enhanced Water Quality Treatment requirement. Please see correspondence with Contech on the following pages for additional information.







VAULT INFO

FG OVER VAULT:	403.40 (MIN) 404.30 (MAX)
MAX WATER SURFACE:	399.90
BOTTOM OF LIVE:	392.90
BOTTOM OF DEAD:	388.90

VAULT VOLUMES

	REQ'D	PROVIDED	ASBUILT
LIVE	17,080	18,088	XX,XXX
DEAD	3,946	4,256	X,XXX

GROUNDWATER ELEVATION NOTE

ACCORDING TO THE GROUNDWATER ELEVATION EVALUATION BY COBALT GEOSCIENCES, LLC DATED MARCH 14, 2022, THE GROUNDWATER ELEVATION IN THE SITE VICINITY APPEARS TO BE AT 375 FEET. A COPY OF THE EVALUATION IS PROVIDED UNDER SEPARATE COVER.

EXISTING UTILITY NOTE

EXISTING UTILITIES ARE SHOWN IN THE APPROXIMATE LOCATION. THERE IS NO GUARANTEE THAT ALL UTILITY LINES ARE SHOWN, OR THAT THE LOCATION, SIZE AND MATERIAL IS ACCURATE. THE CONTRACTOR SHALL UNCOVER ALL INDICATED PIPING WHERE CROSSING, INTERFERENCES, OR CONNECTIONS OCCUR PRIOR TO TRENCHING OR EXCAVATION FOR ANY PIPE OR STRUCTURES, TO DETERMINE ACTUAL LOCATIONS, SIZE AND MATERIAL. THE CONTRACTOR SHALL MAKE THE APPROPRIATE PROVISION FOR PROTECTION OF SAID FACILITIES. THE CONTRACTOR SHALL NOTIFY ONE CALL AT 8-1-1 (WASHINGTON811.COM) AND ARRANGE FOR FIELD LOCATION OF EXISTING FACILITIES BEFORE CONSTRUCTION.

CITY OF MUKILTEO FILE NUMBERS
SD-2021-001/ENG-2021-019/SEPA-2021-010

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WWW.THEBLUELINEGROUP.COM

SCALE: AS NOTED
PROJECT MANAGER: T.C. COLLERAN, PLA, AICP
PROJECT ENGINEER: LUCAS ZIROTTI
DESIGNER: LEE M. TOMKINS
ISSUE DATE: 7/26/21

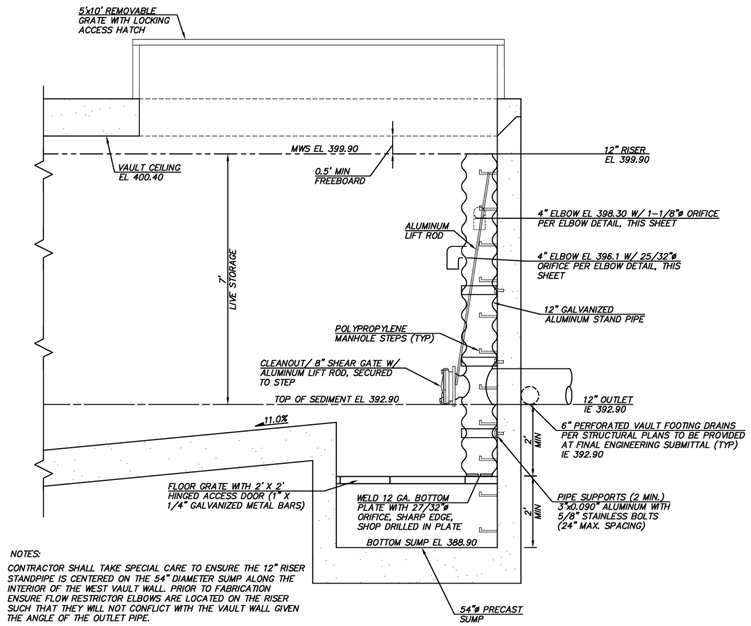
REVISIONS

NO	DATE	BY	
1	8/9/22	LCZ	REVISIONS PER CITY 1ST ROUND COMMENTS
2	4/12/23	LMT	REVISIONS PER CITY 2ND ROUND COMMENTS

VAULT PLANS & SECTIONS
HARBOR GROVE
CIVIL PLANS
9110 53RD AVE W
SNOHOMISH COUNTY WASHINGTON

KRISTAL A. KEATING
STATE OF WASHINGTON
20920
REGISTERED
PROFESSIONAL ENGINEER
4/12/23

JOB NUMBER: 21-073
SHEET NAME: VT-01
SHT 13 OF 22



NOTES:

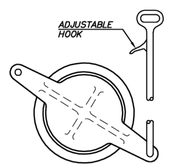
CONTRACTOR SHALL TAKE SPECIAL CARE TO ENSURE THE 12" RISER STANDPIPE IS CENTERED ON THE 54" DIAMETER SUMP ALONG THE INTERIOR OF THE WEST VAULT WALL. PRIOR TO FABRICATION ENSURE FLOW RESTRICTOR ELBOWS ARE LOCATED ON THE RISER SUCH THAT THEY WILL NOT CONFLICT WITH THE VAULT WALL GIVEN THE ANGLE OF THE OUTLET PIPE.

CONTROL STRUCTURE

SCALE: 1" = 2'

VAULT NOTES

1. DIMENSIONS DEPICTING OVERALL SIZE OF VAULT ARE FOR REFERENCE ONLY. SEE STRUCTURAL PLANS FOR TOTAL LENGTH, WIDTH, HEIGHT AND WALL THICKNESS DESIGN, AS WELL AS LOCATIONS FOR ALL MAINTENANCE ACCESS POINTS AND PROPOSED PENETRATIONS
2. JOINTS AND PENETRATIONS IN VAULT AND LID TO BE WATER TIGHT. PROVIDE WATERSTOPS IN CAST IN PLACE JOINTS
3. ALL WATERSTOPS TO BE INSTALLED PER PLAN AND SPECIFICATION AND TO BE INSPECTED BY CITY
4. PIPES SEALED WITH GROUT
5. VENTILATION PIPES (MIN 12 INCH DIAMETER) PROVIDED AT CORNERS. VENT PIPE SHALL BE SCHEDULE 40 PVC OR BETTER AND SHALL HAVE LOCKING DUCTILE IRON RINGS AND LIDS.
6. WALL DRAINS TO BE CONSTRUCTED OF A MINIMUM 6-INCH PERFORATED PVC PIPE SURROUNDED BY 6" MIN THICK WASHED ROCK (ALL SIDES) UNLESS OTHERWISE NOTED BY STRUCTURAL ENGINEER. DRAIN TO BE LOCATED AT THE WALL BASE, SHALL INCLUDE CLEANOUT AT ALL CORNERS, AND SHALL GRAVITY FLOW TO DISCHARGE POINT. NO ONE-WAY VALVES ALLOWED. DRAINS TO BE INSTALLED AT ELEVATION SHOWN. CONNECT PERFORATED DRAIN TO A 6" SOLID WALL PVC AT 2% MIN. SLOPE DIRECTED TO DOWNSTREAM CATCH BASIN. INSTALL CLEANOUT AT BENDS TOTALING 90° AND AT 100' MAX O.C.
7. ACCESS OPENINGS TO HAVE OSHA CONFINED SPACE WARNING
8. PIPE SIZES AND SLOPES: PER PLANS.
9. FINISHED GRADE OVER VAULT TO BE PER PLAN
10. VAULT EXCAVATION TO BE FENCED AND SECURED BY CONTRACTOR. SAFETY FENCING, SHORING, EXCAVATION SAFETY, AND OTHER SAFETY ITEMS ARE THE RESPONSIBILITY OF THE CONTRACTOR. ALL ACCESS TO HAVE SECURE COVERING DURING CONSTRUCTION.
11. ALL STORMWATER FACILITIES, CATCH BASINS, AND CONVEYANCE SHALL BE CLEANED FOR CITY INSPECTION PRIOR TO FINAL PLAT AND ALSO FOR CITY INSPECTION PRIOR TO PERFORMANCE AND MAINTENANCE BOND RELEASE
12. THE CONTRACTOR AND HIS SUBCONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING ALL DIMENSION AND ELEVATIONS SHOWN ON THESE DRAWINGS WITH THE CURRENT PERMITTED SET OF STRUCTURAL DRAWINGS, AND SHALL NOTIFY BOTH THE STRUCTURAL & CIVIL ENGINEERS IN WRITING OF ALL DISCREPANCIES BETWEEN THE CIVIL DRAWINGS AND THESE DRAWINGS TO CONSTRUCTION.
13. CONCRETE FINISH TO BE SMOOTH WITH NO FINS, VOIDS, ROCK POCKETS, OR OTHER IRREGULARITIES.
14. CONE SNAP TIES ARE REQUIRED FOR FORMWORK AND EPOXY GROUT SEALED AT ALL INTERIOR AND EXTERIOR WALL SURFACES. NO FLAT TIES ALLOWED.
15. PER THE 2014 SWMMWW, ALL VAULTS SHALL BE DESIGNED FOR H 20 LOADING.
16. MINIMUM AND MAXIMUM GRADES OVER VAULT AS SHOWN. FOOTING DRAIN ELEVATIONS ARE PROVIDED FOR REFERENCE.

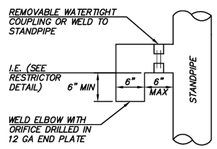


NOTES:

1. SHEAR GATE SHALL BE:
   A. CAST IRON BODY AND GATE, OLYMPIC FDY, STD., OR EQUAL.
   B. ALUMINUM, DRAINAGE SPECIALTIES (SAVANNA, GA) STD., OR EQUAL.
2. GATE SHALL BE 8" DIAMETER UNLESS OTHERWISE SPECIFIED.
3. GATE SHALL BE JOINED TO TEE SECTION BY BOLTING (THROUGH FLANGE), WELDING, OR OTHER SECURE MEANS.
4. LIFT ROD: AS SPECIFIED BY MANUFACTURER WITH HANDLE EXTENDED TO WITHIN ONE FOOT OF COVER AND ADJUSTABLE HOOK LOCK FASTENED TO FRAME OR UPPER HANDHOLD.

SHEAR GATE

NOT TO SCALE



ELBOW DETAIL

NOT TO SCALE

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CITY OF MUKILTEO FILE NUMBERS
SD-2021-001/ENG-2021-019/SEPA-2021-010

BLUELINE
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P: 425.216.4051 F: 425.216.4052
WWW.THEBLUELINEGROUP.COM

SCALE: AS NOTED
PROJECT MANAGER: T.C. COLLERAN, PLA, AICP
PROJECT ENGINEER: LUCAS ZIROTTI
DESIGNER: LEE M. TOMKINS
ISSUE DATE: 7/28/21

REVISIONS

NO	DATE	BY	
1	8/9/22	LCZ	REVISIONS PER CITY 1ST ROUND COMMENTS
2	4/12/23	LMT	REVISIONS PER CITY 2ND ROUND COMMENTS

VAULT DETAILS & NOTES

HARBOR GROVE
CIVIL PLANS
9110 53RD AVE W
SNOHOMISH COUNTY WASHINGTON

KRISTAL A. KEATING
STATE OF WASHINGTON
20939
REGISTERED
PROFESSIONAL ENGINEER

4/12/23

JOB NUMBER: 21-073
SHEET NAME: VT-02
SHT 14 OF 22

24x36
Apr 19, 2023 - 10:36am - Ulan Ishchi
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4.6 LID FEASIBILITY ANALYSIS

The City of Mukilteo adopted the Department of Ecology's 2012 Stormwater Management Manual for Western Washington as amended in 2014. The project requires LID to be evaluated per Figure I-2.5.1: Flow Chart for Determining LID MR #5 Requirements found in the DOE Manual. A copy of the flow chart is provided on the following pages. Development on any parcel inside the UGA must meet the Low Impact Development Performance Standard and BMP T5.13 or List #2.

See below for a feasibility evaluation of each BMP from List #2.

LAWN AND LANDSCAPED AREAS:

1. Post-Construction Soil Quality and Depth in accordance with BMP T5.13 in Chapter 5 of Volume V of the DOE Manual.

Post-Construction Soil Quality and Depth in accordance with BMP T5.13 is feasible and will be used for all disturbed lawn and landscaped areas. See soil amendment note and detail within Civil Plans, provided under separate cover.

ROOFS:

1. Full Dispersion in accordance with BMP T5.30 in Chapter 5 of Volume V of the DOE Manual, or Downspout Full Infiltration Systems in accordance with BMP T5.10A in Section 3.1.1 of Volume III of the DOE Manual.

The site is bound to the north, west, and south by single-family residences, and to the east by 53rd Ave W, so there are no viable 100-ft flow paths through native vegetation to disperse all impervious areas. Therefore, full dispersion in accordance with BMP T5.3 is not feasible. Downspout full infiltration systems are infeasible as site soils are considered unsuitable for infiltration per the Geotechnical Report provided by Earth Solutions NW, LLC., dated July 28, 2022. See Section 6 for the full geotechnical report.

2. Bioretention (See Chapter 7 of Volume V of the DOE Manual) facilities that have a minimum horizontally projected surface area below the overflow which is at least 5% of the of the total surface area draining to it.

Bioretention is infeasible as the till soils encountered onsite are not conducive to infiltration per the Geotechnical Report provided by Earth Solutions NW, LLC., dated July 28, 2022. See Section 6 for the full geotechnical report. As such, implementation of bioretention will not be provided.

3. Downspout Dispersion Systems in accordance with BMP T5.10B in Section 3.1.2 of Volume III of the DOE Manual.

Basin dispersion will be evaluated at building permit to accurately assess the vegetated flow paths as lot structures are conceptual and subject to change.

4. Perforated Stub-out Connections in accordance with BMP T5.10C in Section 3.1.3 of Volume III of the DOE Manual.

The till soils encountered onsite are not conducive to infiltration. BMP T5.10C is infeasible due to an insufficient infiltration rate.

OTHER HARD SURFACES:

1. Full Dispersion in accordance with BMP T5.30 in Chapter 5 of Volume V of the DOE Manual.

Remaining hard surfaces are unable to utilize full dispersion as the project is bound to the north, west, and south by single-family residences, and to the east by 53rd Ave W, so there are no viable 100-ft flow paths through native vegetation to disperse impervious areas. Refer to Section 4.4 of this report for full dispersion thresholds and subsequent discussion.

2. Permeable pavement in accordance with BMP T5.15 in Chapter 5 of Volume V of the DOE Manual.

Permeable pavement will not be implemented onsite as site soils not considered suitable for stormwater infiltration per the Geotechnical Report provided by Earth Solutions NW, LLC., dated July 28, 2022. See Section 6 for the full geotechnical report.

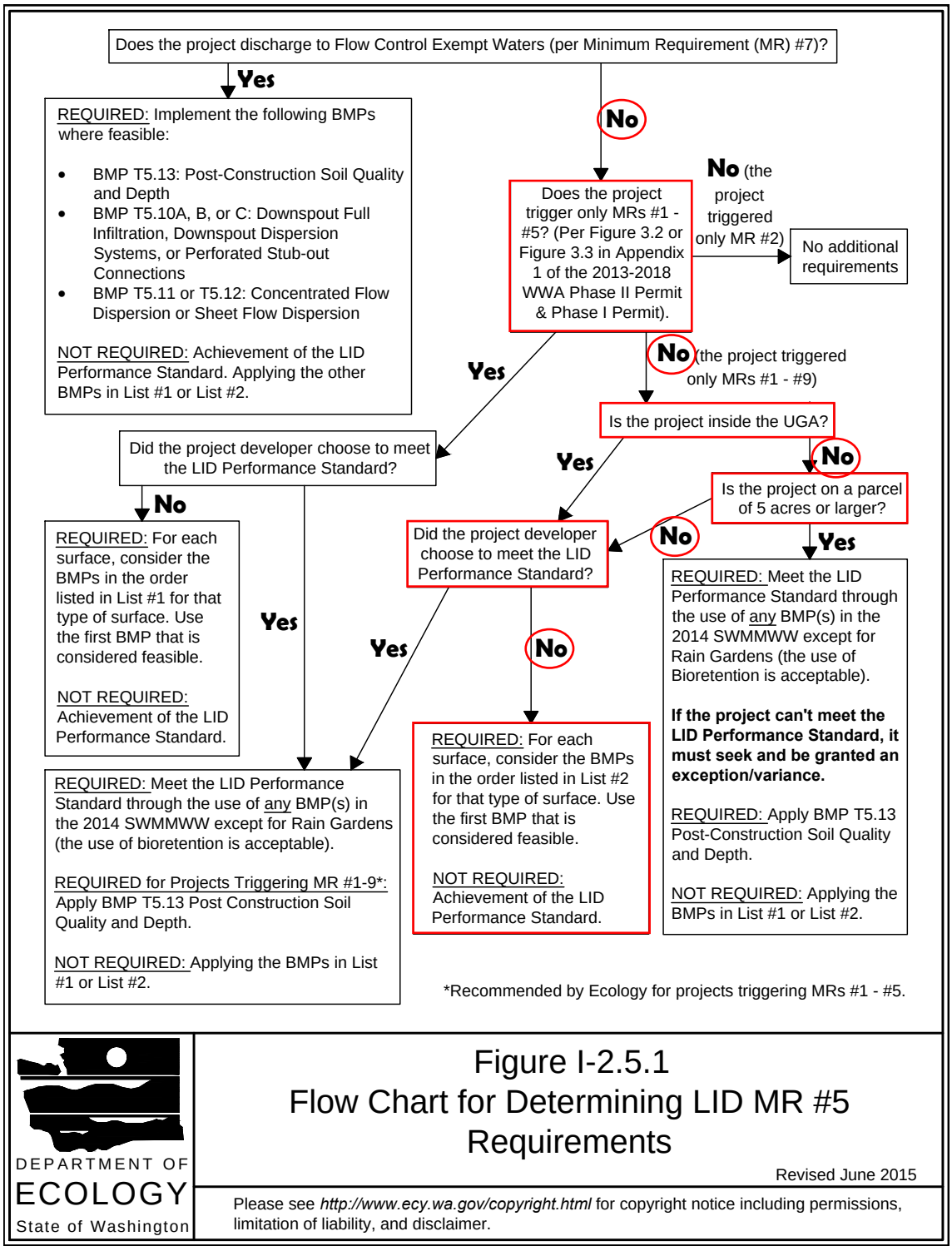
3. Bioretention (See Chapter 7, Volume V of the DOE Manual) facilities that have a minimum horizontally projected surface area below the overflow which is at least 5% of the total surface area draining to it.

Bioretention is infeasible as the till soils encountered onsite are not conducive to infiltration per the Geotechnical Report provided by Earth Solutions NW, LLC., dated July 28, 2022. See Section 6 for the full geotechnical report. As such, implementation of bioretention will not be provided.

4. Sheet Flow Dispersion in accordance with BMP T5.12, or Concentrated Flow Dispersion in accordance with BMP T5.11 in Chapter 5 of Volume V of the DOE Manual.

Due to onsite proposed grading, proposed sidewalk and access improvements are unable to utilize dispersion BMPs with a lack of viable flow path. Therefore, sheet flow and concentrated flow dispersion will not be utilized.

Figure I-2.5.1 Flow Chart for Determining LID MR #5 Requirements



4.7 PUMP DESIGN

This section will provide storm water pump and force main design calculations for the western slope of this development. Refer to the end of this section for pump system schematics.

There is a proposed catch basin and storm drainage system located within the western portion of Lot 6. In the existing condition the site slopes from east to west from a ridgeline near the middle of the site. In the developed condition a portion of runoff slopes west towards the western property line. To route surface stormwater in the developed condition from the western slopes to the gravity storm drain system, a pump system is proposed.

To address runoff from the western sloped area (approximately 10,500 sf, 0.24 acres), stormwater will be collected via the onsite interceptor swale w/ french drain and conveyed to a Type II-54" diameter catch basin with an alternating pump system. Drainage will then be pumped through approximately 160' of 2" force main to a Type 1 catch basin and then gravity flow through the site's proposed gravity storm drain system to the detention vault.

PUMP SIZING:

A dual pump alternating system (Zoeller Model 153) will be located in a 54" diameter Type II catch basin on the western side of Lot 6. The pump is sized to convey runoff from the proposed western slope into a Type 1 catch basin and then gravity flow into to the rest of the site's proposed storm drainage system.

The pumps were designed with the most limiting constraints so that it would be adequately sized using a single calculation. Peak runoff rates for the pump tributary area (0.24 acres) were estimated in the developed condition with C type soils, steep and pasture ground cover using WWHM2012 with 15-minute time steps. A portion of the output is included below.

WWHM2012 Summary Output: 15-Minute Time Steps – Developed Condition

Return Period	Flow(cfs)
2 year	0.006037
5 year	0.009203
10 year	0.011527
25 year	0.014706
50 year	0.017246
100 year	0.01993

*25-year Runoff Rate = 0.014706 cfs * 448.83 gpm/cfs = 6.60 gpm*
*100-year Runoff Rate = 0.01993 cfs * 448.83 gpm/cfs = 8.95 gpm*

The pump will discharge via a 2-inch, approximately 160-ft long, force line to a Type 1 catch basin in the rear of Lot 6. Fittings include a check valve, (3)-90° bends, one per pump, and (3)-45° bends. Float switches will allow the system to operate in two stages. Each pump must operate at a minimum of 6.60 gpm (the 25-year runoff rate) which was determined to produce a total dynamic head loss of 34.11'.

A Zoeller Model 153 pump was chosen for this project for its ability to pump approximately 24.0 gpm against 34.11' of head. A combined flow rate of two Zoeller 153 pumps operating simultaneously (24.0 gpm x 2 = 48.0 gpm) exceeds the 100-year peak runoff rate of 8.95 gpm.

The first float switch is anticipated to maintain approximately 5.9 station starts per hour during the 25-year storm event (about 3 starts per pump per hour in a dual-pump alternating system). This is below the maximum range 6 to 10 starts per pump per hour recommended by the manufacturer. The 25-year cycle time is calculated below.

When the water level reaches the first float switch ("Pump 1/Pump 2 On"), a single pump is activated. When the water level recedes to the original "Pump Off" level, the active pump deactivates. The pumps alternate as this process repeats so that each pump is only active once in every two cycles.

An emergency float switch at a higher level ("Emergency Pump On") activates the second pump during large storms so that both pumps operate simultaneously. The pump system has the capacity to convey both the 25-year and 100-year storm events. Backup power for the pump will be a natural gas powered generator. Refer to the end of this section for pump system schematics.

25-year Cycle Time Calculation:

"Pump Off" stage = Elev 370.00

"Pump 1 On" stage = Elev 371.50

Volume during stage 1 between "pump off" and "pump on"

$V1 = (\pi)(r)^2 * (\Delta h) = (\pi)(2.25)^2 * (371.50 – 370.00)$

V1 = 23.86 cf

Pump Rate = 24.0 gpm / 448.83 cfs/gpm= 0.0536 cfs (Zoeller Model 153)

Cycle Time = Time to pump out stage volume + Time to fill stage volume

Cycle Time = (V1 / (pump rate-Q25)) + (V1 / Q25)

Cycle Time = (23.86 / (0.0536-0.0147)) + (23.86 / 0.0147) = 615.4 seconds = **10.26 minutes**

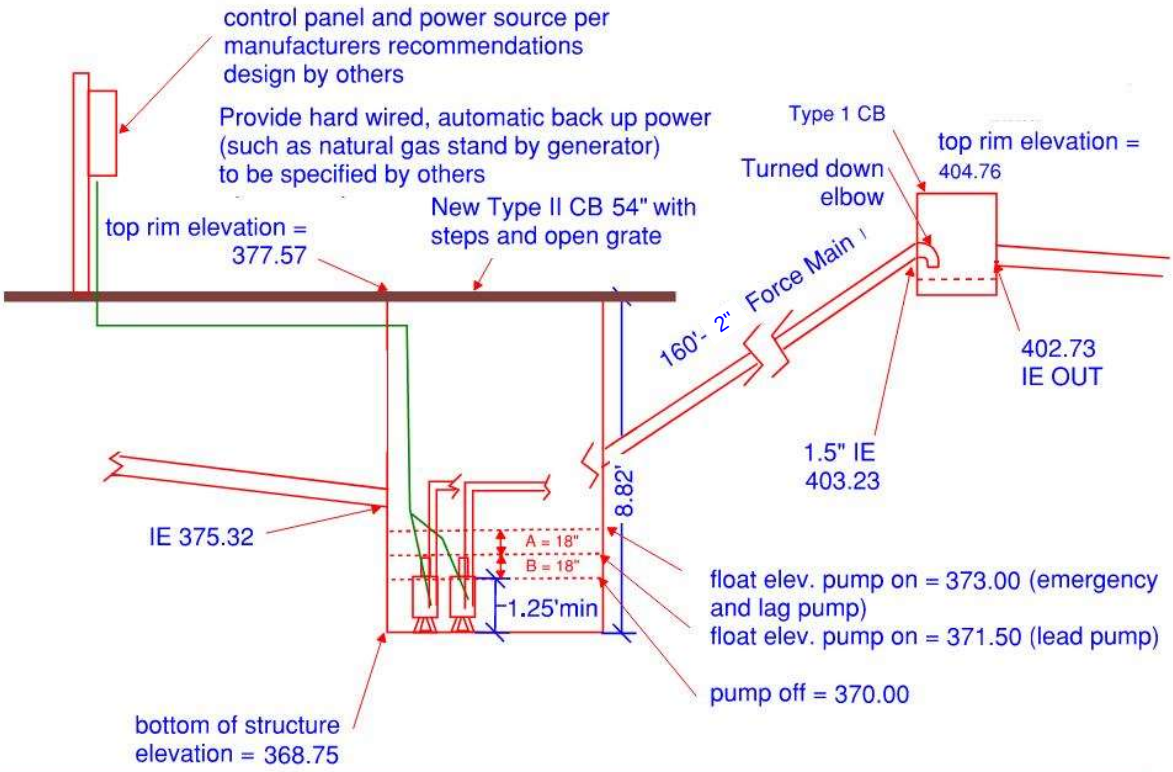
Station Cycle Calculation:

1 pump

Station Starts per Hour = (1 hour / Cycle Time)

Station Starts per Hour = (60 min / 10.26 min) = **5.9 Starts per Hour**

HARBOR GROVE - PUMP SCHEMATICS

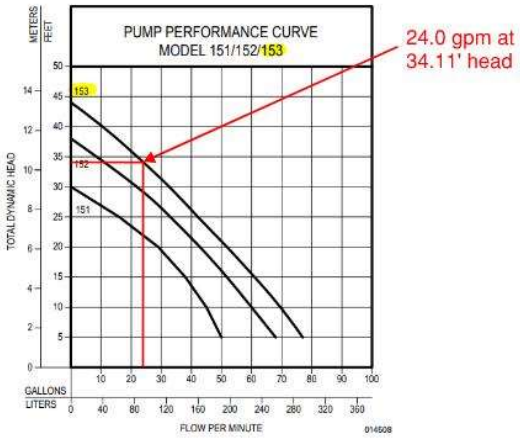


Static Head = 403.23 - 371.50 = 31.73'
Dynamic Head = 2.38' (determined by: 160.0 LF of 2" force main, one check valve, three-90° Bends, and three-45° Bends)
Total Head = 31.73'+2.38' = 34.11'

Total Head = 34.11'
Note: Two pumps selection @ 24.0 gpm will exceed 100 year flow rate of 8.95 gpm

TOTAL DYNAMIC HEAD FLOW PER MINUTE

MODEL		151		152		153	
Feet	Meters	Gal.	Liters	Gal.	Liters	Gal.	Liters
5	1.5	50	189	69	261	77	291
10	3.0	45	170	61	231	70	265
15	4.6	38	144	53	201	61	231
20	6.1	29	110	44	167	52	197
25	7.6	16	61	34	129	42	159
30	9.1	--	--	23	87	33	125
35	10.7	--	--	--	--	22	85
40	12.2	--	--	--	--	11	42
Shut-off Head:		30 ft. (9.1m)		38 ft. (11.6m)		44 ft. (13.4m)	



4.8 FRONTAGE BASIN – PEAK FLOW ANALYSIS

Drainage complaints were noted along the frontage basin downstream drainage path. A description of the frontage basin downstream drainage path can be found in Section 3, Task 3 of this report. Due to capacity concerns along this downstream path the project is proposing to reroute majority of stormwater to the existing system within 92nd St SW. A small portion of the developed site is still tributary to the frontage basin downstream drainage path. The proposed 100-year peak flow tributary to the frontage basin downstream drainage path will be less than the existing 100-year peak flow. The frontage basin flow analysis was modeled using the Western Washington Hydrology Model software program (WWHM2012), which is recognized as an approved model in the COM Development Standards.

EXISTING CONDITIONS

The existing frontage basin totals 0.24 acres. Flows within the basin generally sheet flow east and northeast towards 53rd Ave W. Flows are collected by a roadside swale, and routes runoff north along the west side of 53rd Ave W. The frontage basin contains approximately 0.19-acres of forested area with understory vegetation that has moderate to steep slopes. The existing swale/landscaping along the west side of 53rd Ave W is approximately 0.04 acres and is modeled as lawn and approximately 0.01-acres of gravel driveway is modeled as impervious area.

The areas used to compute the drainage calculations associated with the existing basin conditions, as well as the corresponding WWHM output, are summarized on the following page and included in the Appendix of this report.

EXISTING CONDITIONS - TRIBUTARY TO FRONTAGE BASIN

Impervious		
Access	0.01	ac
Total Impervious	**0.01**	**ac**
Lawn		
Swale/Landscaping	0.04	ac
Total Lawn (Soil Group C - Till)	**0.04**	**ac**
Forest		
Forested Area	0.19	ac
Total Forest (Soil Group C - Till)	**0.19**	**ac**
TOTAL EXISTING CONDITIONS	**0.24**	**ac**

Flow Frequency Return Periods for Predeveloped. Basin POC #1	
Return Period	**Flow(cfs)**
2 year	0.0073
5 year	0.0115
10 year	0.0148
25 year	0.0197
50 year	0.0239
100 year	0.0286

DEVELOPED CONDITIONS

The developed frontage basin totals 0.30-acres. Approximately 0.19-acres of undisturbed area will be modeled as forested area, 0.10-acres of onsite pervious area will be modeled as pasture, and 0.01-acres of access improvements will be modeled as impervious. All landscaped areas will have compost amended soils per BMP T5.13. Area's meeting BMP T5.13 design guidelines may be entered into WWHM as "Pasture" rather than "Lawn" per Volume V, BMP T5.13 of the DOE Manual.

Refer to the developed conditions areas, WWHM Flood printouts, and the *Developed Conditions Exhibit* included on the following pages and Appendix A.

DEVELOPED CONDITIONS - TRIBUTARY TO FRONTAGE BASIN

Impervious		
Frontage	0.01	ac
Total Impervious	**0.01**	**ac**
Pasture		
Parcel	0.01	ac
Frontage / Dedicated ROW	0.08	ac
Total Pasture (Till - Soil Group C)	**0.10**	**ac**
Forest		
Parcel	0.19	ac
Total Forest (Soil Group C - Till)	**0.19**	**ac**
TOTAL DEVELOPED CONDITIONS	**0.30**	**ac**

Flow Frequency Return Periods for Developed. Basin POC #1	
Return Period	**Flow(cfs)**
2 year	0.0070
5 year	0.0103
10 year	0.0128
25 year	0.0163
50 year	0.0191
100 year	0.0222

The frontage basin 100-year peak flow for the proposed development when modeled using WWHM software and a 15-minute time-step creates a decrease over the existing predeveloped condition. The development will not cause or aggravate the existing drainage concerns along the frontage basin downstream drainage path.

4.9 PROPOSED CONVEYANCE SYSTEM ANALYSIS

6" AND 8" CONVEYANCE SYSTEM CALCULATIONS

Stormwater runoff from Lots 1-4, 7 will be conveyed to the detention vault via a 6-inch stormwater conveyance system. Runoff from Lots 5-6 will be routed to the detention vault via an 8-inch system.

The 6-inch and 8-inch conveyance system was sized using Rational Method and Manning's Equation. For the rational method equation, the peak flow rate was calculated using the characteristic of the areas tributary to the conveyance system. It is conservatively assumed that the entire lot is tributary to each respective system. Lot impervious coverages are restricted to 32%. The site's precipitation factor for the 100-yr 24-hour storm per Figure III-A.3 of the DOE Manual is 3.0 inches. The largest flow tributary to the 6-inch system is the combined flow from Lots 1 and 2, resulting in a peak flow of 0.78-cfs for the 100-year storm event. The largest flow tributary to the 8-inch system is the combined flow from Lots 5 and 6, which results in a flow of 0.50 cfs. The pump system will provide an additional 0.11 cfs to this system, for a total flow of 0.61 cfs. The capacity for the 6-inch and 8-inch conveyance system was calculated using Manning's Equation. Using Manning's equation, a 6-inch pipe at 2.0% minimum slope has capacity to convey 0.93-cfs. An 8-inch pipe at 1.0% minimum slope has capacity to convey 1.41-cfs. The conveyance systems have adequate capacity to convey the 100-year storm. Please see calculations for the conveyance system below and on the following page.

Area Tributary to 6-inch System:

Type of Land Cover	C-Value	Area
Pavements and Roofs	0.90	0.19
Pasture	0.20	0.39
Total	**0.429**	**0.58**

I_R - Peak Rainfall Intensity

Storm Event	P_R Total Precipitation	A_R Coefficient	B_R Coefficient	T_C Time of Concentration	I_R
100-year	**3.0**	2.92	0.56	6.30	**3.125**

Rational Method

Storm Event	C	I_R	A	Q_R
100-year	0.429	3.125	0.58	**0.78**

Manning's Equation: 6" Pipe at 2.0% Minimum Slope

$Q = 1.486/n * A * R^{2/3} * S^{1/2}$

n = roughness coefficient = **0.011**

A = cross sectional area of pipe = $\pi (D/2)^2 = \pi ((6/12)\text{ ft}/2)^2$ = **0.196**

R = wetted perimeter of pipe

$R^{2/3} = (D/4)^{2/3} = ((6/12)\text{ ft}/4)^{2/3}$ = **0.25**

S = slope

$S^{1/2} = (0.02\text{ ft/ft})^{1/2}$ = **0.141**

$Q = (1.486/0.011) * 0.196 * 0.25 * 0.141$ = **0.93 cfs > 0.78 cfs**

Area Tributary to 8-inch System:

Type of Land Cover	C-Value	Area
Pavements and Roofs	0.90	0.19
Total	**0.90**	**0.19**

I_R - Peak Rainfall Intensity

Storm Event	P_R Total Precipitation	A_R Coefficient	B_R Coefficient	T_C Time of Concentration	I_R
100-year	**3.0**	2.92	0.56	6.30	**3.125**

Rational Method

Storm Event	C	I_R	A	Q_R
100-year	0.429	3.125	0.19	**0.50**

Q_{100} Pump Station: 0.11 cfs
Q_{100} Total: 0.61 cfs

Manning's Equation: 8" Pipe at 1.0% Minimum Slope

$Q = 1.486/n * A * R^{2/3} * S^{1/2}$

n = roughness coefficient = **0.011**

A = cross sectional area of pipe = $\pi (D/2)^2 = \pi ((8/12)\ ft/2)^2$ = **0.342**

R = wetted perimeter of pipe

$R^{2/3} = (D/4)^{2/3} = ((8/12)\ ft/4)^{2/3}$ = **0.306**

S = slope

$S^{1/2} = (0.01\ ft/ft)^{1/2}$ = **0.100**

$Q = (1.486/0.011) * 0.342 * 0.306 * 0.100$ = **1.41 cfs > 0.61 cfs**

12” CONVEYANCE SYSTEM – VAULT OUTFALL

The proposed vault outfall will be routed to the existing public stormwater system via a 12-inch system.

The 12-inch conveyance system was designed to convey the 100-year developed undetained flow without overtopping, in accordance with the 2014 DOE Manual. The conveyance system was sized so that the headwater elevations remain below rim elevations for the 100-year, 24-hour storm event.

The conveyance sheets were generated using the rational method to calculate flows for the area collected by the proposed storm system. The site’s precipitation factor for the 100-year, 24-hour storm per Figure III-A.3 of the 2014 DOE Manual is 3.0 inches.

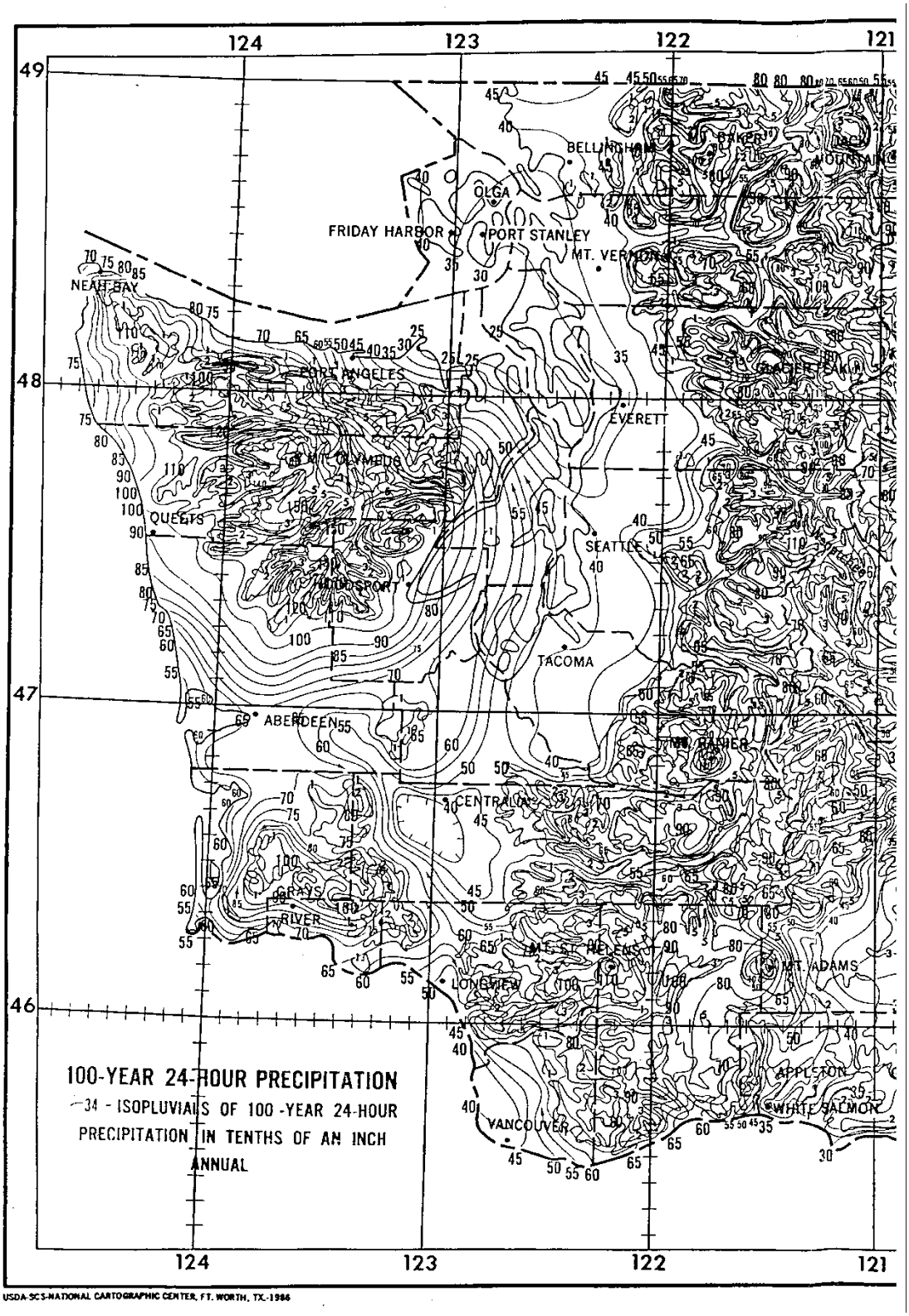
The average C value for the site is based on the total area collected by the proposed conveyance system. The proposed conveyance system collects 1.10 acres of impervious and 1.37 acres of pervious area, for a total of 2.47 acres. The average C value is [(0.25*1.37) + (0.90*1.10)]/2.47 = 0.539.

The WWHM2012 15-minute timestep output for the detained 100-year vault outflow is 0.094 cfs. The tailwater elevation is set as the outlet elevation at outfall (IE=350.90) plus the pipe diameter (18”), or 351.40.

As shown on the spreadsheet on the following page, all headwater elevations remain below the rims during the 100-year storm. Therefore, the system meets the requirements of the 2014 DOE Manual and is adequately designed.

The proposed development will connect to the existing system at CB 4 as shown in the *Developed Conditions Exhibit* included in Section 4.2 of this report. Per the *Rational Method Conveyance Spreadsheet* and the *King County Backwater Analysis Spreadsheet* included on the following pages, the additional 0.094 cfs of flow from the 100-year storm will not cause the pipes downstream of the proposed connection to fail, nor to be in a backwater condition. Therefore, the proposed development is not creating any backwater or capacity issues within the existing system downstream of the proposed connection. Please see the *Capacity Analysis Memo* included in the Appendix of this report for additional information.

Western Washington Isopluvial 100-year, 24 hour



RATIONAL METHOD CONVEYANCE SYSTEM DESIGN

PROJECT NAME:	**Harbor Grove**				**PROJECT NUMBER:**	**21-073**			**PREPARED BY:**	**Olivia Westmoreland**				**DESIGN STORM:**	**100**	**YEAR**		
LOCATION		**SUBBASIN AREA**			**SUM OF**	**Tc**	**I_R**	**Q_R**	**MANNING'S**	**PIPE SIZE**	**PIPE SLOPE**	**PIPE LENGTH**	**ACTUAL VELOCITY (V_R)**	**TRAVEL TIME**	**PIPE CAPACITY SUMMARY**		
FROM	**TO**	**(AC)**	**"C"**	**(A * C)**	**(A * C)**	**(MIN)**	**(IN/HR)**	**(CFS)**	**"n"**	**(IN)**	**(%)**	**(FT)**	**(FT/SEC)**	**(MIN)**	**Q(FULL) (CFS)**	**V(FULL) (FT/SEC)**	**Q_R/Q(FULL) (%)**
Vault	MWS	0.000	0.54	0.000	0.000	6.30	3.13	0.094	0.012	12	0.550	33	1.57	0.35	2.862	3.64	3.3%
MWS	CB 4	0.000	0.54	0.000	0.000	6.65	3.03	0.094	0.012	12	0.530	45	1.54	0.49	2.810	3.58	3.3%
CB 4	CB 3	0.000	0.54	0.000	0.000	7.14	2.91	0.094	0.012	12	0.520	31	1.52	0.34	2.783	3.54	3.4%
CB 3	CB 2	0.000	0.54	0.000	0.000	7.48	2.84	0.094	0.012	12	0.550	135	1.57	1.44	2.862	3.64	3.3%
CB 2	CB 1	0.040	0.54	0.022	0.022	8.91	2.57	0.150	0.012	12	2.770	114	3.11	0.61	6.424	8.18	2.3%
CB 1	CB 1A	0.000	0.54	0.000	0.022	9.52	2.48	0.148	0.012	12	0.550	131	1.84	1.19	2.862	3.64	5.2%
CB 1A	CB 1B	0.000	0.54	0.000	0.022	10.71	2.32	0.144	0.012	12	2.810	144	3.13	0.77	6.470	8.24	2.2%
CB 1B	CB 1C	0.000	0.54	0.000	0.022	11.48	2.23	0.142	0.012	12	6.500	106	3.82	0.46	9.840	12.53	1.4%
CB 1C	CB 1D	0.000	0.54	0.000	0.022	11.94	2.18	0.141	0.012	12	7.950	100	4.23	0.39	10.883	13.86	1.3%
CB 1D	CB 1E	0.000	0.54	0.000	0.022	12.33	2.15	0.140	0.012	12	5.710	94	3.58	0.44	9.223	11.74	1.5%
CB 1E	EX CB 4	0.000	0.54	0.000	0.022	12.77	2.10	0.139	0.012	12	2.230	43	2.79	0.26	5.764	7.34	2.4%
EX CB 4	EX CB 5	12.300	0.54	6.642	6.664	13.03	2.08	13.957	0.012	18	6.210	166	15.89	0.17	28.358	16.05	49.2%
EX CB 5	Outfall	0.000	0.54	0.000	6.664	13.20	2.07	13.855	0.012	18	6.000	27	15.62	0.03	27.874	15.77	49.7%

BACKWATER CALCULATIONS

PROJECT NAME: Harbor Grove **PREPARED BY:** OCW

PROJECT NUMBER: 21-073 **DESIGN STORM:** 100 YEAR

PIPE SEGMENT																							
FROM CB	TO CB	Q (CFS)	PIPE LENGTH (FT)	PIPE SIZE (IN)	MANNING'S "n" VALUE	OUTLET ELEVATION (FT)	INLET ELEVATION (FT)	PIPE AREA (SQ FT)	FULL VELOCITY (FT/SEC)	VELOCITY HEAD (FT)	TAILWATER ELEVATION (FT)	FRICTION LOSS (FT)	ENTRANCE HGL ELEVATION (FT)	ENTRANCE HEAD LOSS (FT)	EXIT HEAD LOSS (FT)	OUTLET CONTROL ELEVATION (FT)	INLET CONTROL ELEVATION (FT)	APPROACH VELOCITY HEAD (FT)	BEND HEAD LOSS (FT)	JUNCTION HEAD LOSS (FT)	HEADWATER ELEVATION (FT)	RIM ELEVATION (FT)	FREEBOARD (FT)
OUTFALL	EX CB 5	15.97	27	18	0.012	349.40	350.98	1.77	9.03	1.27	350.90	0.53	352.48	0.63	1.27	354.38	355.19	1.29	0.48	0.00	354.39	357.59	3.20
EX CB 5	EX CB 4	16.08	166	18	0.012	351.09	361.08	1.77	9.10	1.29	354.39	3.29	362.58	0.64	1.29	364.51	365.33	0.06	0.70	0.00	365.97	368.90	2.93
EX CB 4	CB 1E	1.60	42	12	0.012	361.16	362.12	0.79	2.04	0.06	365.97	0.07	366.04	0.03	0.06	366.13	363.12	0.07	0.00	0.00	366.07	367.75	1.68
CB 1E	CB 1D	1.61	83	12	0.012	362.12	367.50	0.79	2.05	0.07	366.07	0.14	368.50	0.03	0.07	368.60	368.50	0.00	0.09	0.08	368.77	370.48	1.71
CB 1C	CB 1B	0.25	7	12	0.012	367.50	367.53	0.79	0.32	0.00	368.77	0.00	368.77	0.00	0.00	368.77	368.53	0.00	0.00	0.00	368.77	370.99	2.22
CB 1A	CB 1	1.96	100	12	0.012	367.50	375.44	0.79	2.50	0.10	368.77	0.26	376.44	0.05	0.10	376.59	376.44	0.10	0.00	0.00	376.49	379.78	3.29
CB 1	CB 2	1.99	110	12	0.012	375.44	382.33	0.79	2.54	0.10	376.49	0.29	383.33	0.05	0.10	383.48	383.33	0.00	0.13	0.00	383.62	388.54	4.92
CB 3	CB 4	1.90	14	8	0.012	383.79	384.58	0.35	5.45	0.46	383.62	0.29	385.25	0.23	0.46	385.94	386.19	0.00	0.01	0.00	386.20	388.28	2.08
#REF!	#REF!	0.09	140	12	0.012	382.33	386.37	0.79	0.12	0.00	383.62	0.00	387.37	0.00	0.00	387.37	387.37	0.00	0.00	0.00	387.37	392.07	4.70
#REF!	#REF!	0.09	131	12	0.012	386.37	388.42	0.79	0.12	0.00	387.37	0.00	389.42	0.00	0.00	389.42	389.42	0.00	0.00	0.00	389.42	392.81	3.39

Section 5 Stormwater Pollution Prevention Plan

Design of the SWPPP has been completed in accordance with the COM Development Standards and the DOE Manual. See SWPPP under separate cover and see Civil Plans under separate cover for location of BMPs.

The temporary erosion and sedimentation control plan has been designed to reduce discharge of sediment-laden runoff from the site. The plan will be comprised of temporary measures as well as permanent measures. A TESC plan has been submitted with the Final Engineering Submittal.

The following BMPs will be applied to prevent erosion and trap sediments within the project site:

- Element 1: Preserve Vegetation / Mark Clearing Limits – To protect adjacent properties and to reduce the area of soil exposed to construction, the limits of construction will be clearly marked before land-disturbing activities begin.

- Element 2: Establish Construction Access - Construction access or activities occurring on unpaved areas shall be minimized, where necessary, access points shall be stabilized to minimize the tracking of sediment onto public roads. Wheel washing, street sweeping, and street cleaning may be necessary if the stabilized construction access is not effective. All wash wastewater shall be controlled on site and cannot be discharged into waters of the State. If sediment is tracked off site, roads shall be cleaned thoroughly at the end of each day, or more frequently during wet weather. Sediment shall be removed from roads by shoveling or pickup sweeping and shall be transported to a controlled sediment disposal area.

- Element 3: Control Flow Rates – In order to protect the properties and waterways downstream of the project site, stormwater discharges from the site will be controlled. In general, discharge rates of stormwater from the site will be controlled where increases in impervious area or soil compaction during construction could lead to downstream erosion, or where necessary to meet local agency stormwater discharge requirements. Perimeter control is not required on the upgradient border of the site.

- Element 4: Install Sediment Controls - All stormwater runoff from disturbed areas shall pass through appropriate sediment removal BMPs before leaving the construction site. BMPs will be constructed as one of the first steps of grading and will be functional before other land disturbing activities take place. Additionally, sediment will be removed from paved areas in and adjacent to construction work areas manually or using mechanical sweepers to minimize tracking of sediments on vehicle tires away from the site and to minimize wash off sediments from adjacent streets in runoff. When permanent stormwater BMPs will be used to control sediment discharge during construction, the structure is to be protected from excessive sedimentation with adequate erosion and sediment control BMPs. Any accumulated sediment shall be removed after construction is complete and the permanent stormwater BMP is to be re-stabilized with vegetation per applicable design requirements once the site has been stabilized.

- Element 5: Stabilize Soils –Exposed and unworked soils shall be stabilized with the application of effective BMPs to prevent erosion throughout the life of the project. In general, cut and fill

slopes will be stabilized as soon as possible, and soil stockpiles will be temporarily covered with plastic sheeting. All stockpiled soils shall be stabilized from erosion, protected with sediment trapping measures, and where possible, be located away from storm drain inlets, waterways, and drainage channels.

- Element 6: Protect Slopes – Cut and fill slopes within the site will be designed, constructed, and protected in a manner that minimizes erosion.

- Element 7: Protect Drain Inlets – All storm drain inlets and culverts operable during construction shall be protected to prevent unfiltered or untreated water from entering the drainage conveyance system. The priority, however, shall be to keep all access roads clean of sediment and keep street wash water from entering storm drains until treatment can be provided. Inlet protection shall be implemented for all drainage inlets and culverts that could potentially be impacted by sediment-laden runoff on and near the project site.

- Element 8: Stabilize Channels and Outlets – Where site runoff is to be conveyed in channels or discharged to a stream or some other natural drainage point, efforts will be taken to prevent downstream erosion.

- Element 9: Control Pollutants – All pollutants, including waste materials and demolition debris, that occur onsite shall be handled and disposed of in a manner that does not cause contamination of stormwater. Good housekeeping and preventative measures will be taken to ensure that the site will be kept clean, well-organized, and free of debris.

- Element 10: Control Dewatering - All dewatering water from open cut excavation, tunneling, foundation work, trench, or underground vaults shall be discharged into a controlled conveyance system prior to discharge to a sediment trap or sediment pond. Channels will be stabilized, per Element #8. Clean, non-turbid dewatering water will not be routed through stormwater sediment ponds and will not be discharged to systems tributary to the receiving waters of the State in a manner that does no cause erosion, flooding, or a violation of State water quality standards in the receiving water. Highly turbid dewatering water from soils known or suspected to be contaminated, or from use of construction equipment, will require additional monitoring and treatment as required for the specific pollutants based on the receiving waters into which the discharge is occurring. Such monitoring is the responsibility of the contractor.

- Element 11: Maintain BMPs - All temporary and permanent Erosion and Sediment Control (ESC) BMPs shall be maintained and repaired as needed to ensure continued performance of their intended function. Maintenance and repair shall be conducted in accordance with each particular BMP specification (see *Volume II of the SWMMWW*).

- Element 12: Manage the Project – Projects will be phased to the maximum extent practicable and seasonal work limitations will be taken into account. Inspection, maintenance and repair of all BMPs will occur as needed to ensure performance of their intended function. The SWPPP will be updated, maintained, and implemented in accordance with Special Conditions S3, S4, and S9 of the CSWGP.

- Element 13: Project Low Impact Development (LID) BMPs – Protect the proposed rain garden area from compaction during all phases of construction.

Section 6 Special Reports and Studies

Additional reports and studies within this section include the following:

- Critical Area Reconnaissance Report provided by Wetland Resources, dated May 6th, 2021.
- Groundwater Elevation Evaluation provided by Cobalt Geosciences, LLC., dated March 14th, 2022.
- Geotechnical Engineering Study provided by Earth Solutions NW, LLC., dated July 28th, 2022.
- Hydrologic Impacts Assessment provided by Kindred Hydro, Inc., dated April 19th, 2023.

These reports are included on the following pages.

May 6, 2021

Sea Pac Homes
Attn: Glen Belew
120 SW Everett Mall Way, Suite 100
Everett, WA 98204

RE: Critical Area Reconnaissance Report for 9018 53rd Avenue West; Parcel 00611600015900

SITE DESCRIPTION

Wetland Resources, Inc. (WRI) performed a site reconnaissance on March 29, 2021, to evaluate wetland and stream conditions on and near the subject property. The site is composed of one 1.33-acre parcel, located at 9018 53rd Avenue West, within the city limits of Mukilteo, Washington. The Public Land Survey System (PLSS) locator for the property is Section 16, Township 28N, Range 4E, W.M. It is located within the Puget Sound Drainage of the Snohomish Watershed, Water Resources Inventory Area (WRIA) 8.

Figure 1 - Aerial photograph of the subject property and data site locations.

The parcel is located in a residential setting, situated between 53rd Ave W and Hargreaves Place, north of Big Gulch Park. A single-family home lies in the northern portion property. Vegetation is generally forested, with an upland species assemblage.

Topography has a gentle northern aspect. The forested vegetation that remains on the site is dominated by Douglas-fir, Western red cedar, Himalayan blackberry, salmonberry, Oso-berry, trailing blackberry, and swordfern. Observed soil pits generally display very dark grayish brown (10YR 3/2) loam from the surface to eight inches below. Between eight and sixteen inches below the surface, soils are dark yellowish brown (10YR 3/4 to 10YR 4/4). Soils were dry at the time of our March 2021 inspection, during a period of normal precipitation.

PUBLIC INFORMATION

Prior to conducting the site reconnaissance, publicly available information was reviewed to gather background information on the subject property and the surrounding area regarding wetlands, streams, and other critical areas. These sources include the following:

- United States Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI)
  No wetlands are mapped on or near the subject property by this source. A forested/scrub-shrub wetland is mapped approximately 250 feet off-site to the east, across 53rd Ave W. A riverine feature is mapped approximately 400 feet off-site to the west.

- USDA/Natural Resources Conservation Service (NRCS) Web Soil Survey
  The NRCS Web Soil Survey indicates that the site is underlain by Alderwood-Urban land complex, 2 to 15 percent slopes. This unit is not listed as a hydric soil. A small area of Mukilteo muck is mapped near 53rd Ave W, however, the mapping appears to be incorrect as no muck soils are present in this area.

- WDFW Priority Habitat and Species (PHS) Interactive Map
  There are no priority habitats or species mapped on or near the site. The same forested/scrub-shrub wetland mapped by NWI is displayed approximately 250 feet off-site to the east. Big Gulch Creek is mapped approximately 0.4 miles off-site to the south and is listed as a habitat for Coho Salmon and Resident Coastal Cutthroat Trout.

  Washington Department of Fish and Wildlife (WDFW) SalmonScape Mapping System
  No streams are mapped by this source on or near the site. The closest fish-bearing features are Big Gulch Creek, approximately 0.4 miles off-site to the south, and another unnamed waterway approximately 0.4 miles off-site to the west. Both streams are documented as Coho habitat and Big Gulch Creek is listed as habitat for Resident Coastal Cutthroat Trout.

  Washington Department of Natural Resources (DNR) Forest Practices Application Mapping Tool (FPAMT)
  No wetlands or streams are mapped on site by DNR. A wetland is mapped approximately 250 feet off-site to the east of the subject property, mapped as non-fish habitat. The two off-site streams mapped by WDFW are the closest streams to the site. DNR depicts a water type break for the unnamed stream 0.4 miles west of the site where it becomes a Type F stream.

- Snohomish County PDS Map Portal
  No wetlands or streams are mapped on or near the site by Snohomish County. The closest mapped stream is a non-fish seasonal stream located approximately 250 feet south of the property. A wetland is mapped approximately 250 feet off-site to the east, east of 53rd Ave W. A remote sensing-based potential wetland is mapped approximately 200 feet off-site to the west, west of Hargreaves Place.
- City of Mukilteo Online Critical Areas Map
  No wetlands or streams are mapped on site by this source. Smuggler's Gulch Creek is mapped off-site to the east and north. According to Mukilteo Municipal Code (MMC) 17.52C.080, this stream is classified as a Type 4. As a low mass wasting channel, a 50 foot buffer is required by MMC 17.52C.090.A.1 The buffer does not reach the subject property. The same off-site wetlands mapped by Snohomish County are shown by this source.

METHODOLOGY

The presence of wetlands was determined using the routine determination approach described in the Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region (Version 2.0) (U.S. Army Corps of Engineers 2010). Under the routine methodology, the process for making a wetland determination is based on three steps:

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

The ordinary high-water marks (OHWM) of streams and waterbodies were identified using the methodology described in *Determining the Ordinary High-Water Mark for Shoreline Management Act Compliance in Washington State* (Anderson et al. 2016). Streams and lakes were classified according to the water typing system provided in Mukilteo Municipal Code (MMC) 17B.52C.080.

FINDINGS

No wetlands, streams or buffers are located on the subject property. No areas on or near the site exhibit the combined positive indicators of hydrophytic vegetation, hydric soils, and wetland hydrology. A depressional area in the eastern portion of the property, adjacent to 53rd Ave W, contains a non-hydrophytic vegetation community and bright, non-hydric soils. Buffers from off-site critical areas do not reach the site.

USE OF THIS REPORT

This Critical Area Reconnaissance Report is supplied to Sea Pac Homes as a means of determining the presence of on-site and nearby critical areas. This report is based largely on readily observable conditions and, to a lesser extent, on readily ascertainable conditions. No attempt has been made to determine hidden or concealed conditions.

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

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

Wetland Resources, Inc.

John Laufenberg
Principal Ecologist
Professional Wetland Scientist

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

Project/Site: Sea Pac Homes - 53rd Ave W City/County: Mukilteo Sampling Date: 3/29/21

Applicant/Owner: Sea Pac Homes State: WA Sampling Point: S1

Investigator(s): JL Section, Township, Range: SEC 16, TWP 28N, RGE 4E

Landform (hillslope, terrace, etc.): _____ Local relief (concave, convex, none): _____ Slope (%): _____

Subregion (LRR): LRR-A Lat: 47.916617 Long: -122.306578 Datum: WSP1984

Soil Map Unit Name: Alderwood NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ☑ No ☐ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ☑ No ☐

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

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

Hydrophytic Vegetation Present? Yes ☐ No ☑ Hydric Soil Present? Yes ☐ No ☑ Wetland Hydrology Present? Yes ☐ No ☑	**Is the Sampled Area within a Wetland?** Yes ☐ No ☑

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10m x 10m)	Absolute % Cover	Dominant Species?	Indicator Status
1. Pseudotsuga menziesii	90	Y	FACU
2.			
3.			
4.			
	90	= Total Cover	
Sapling/Shrub Stratum (Plot size: 5m x 5m)			
1. Rubus spectabilis	30	Y	FAC
2. Rubus armeniacus	20	Y	FAC
3.			
4.			
5.			
	50	= Total Cover	
Herb Stratum (Plot size: 1m x 1m)			
1. Rubus ursinus	20	Y	FACU
2. Polystichum munitum	10	N	FACU
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	30	= Total Cover	
Woody Vine Stratum (Plot size: 1m x 1m)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 70

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species		x 1 =	0
FACW species		x 2 =	0
FAC species	50	x 3 =	150
FACU species	120	x 4 =	480
UPL species		x 5 =	0
Column Totals:	170 (A)		630 (B)

Prevalence Index = B/A = 3.7

Hydrophytic Vegetation Indicators:

- ☐ Rapid Test for Hydrophytic Vegetation
- ☐ Dominance Test is >50%
- ☐ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Wetland Non-Vascular Plants[1]
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ☐ No ☑

Remarks:

SOIL

Sampling Point: S1

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

Depth (inches)	Matrix Color (moist)	%	Redox Features Color (moist)	%	Type[1]	Loc[2]	Texture	Remarks
0-8	10YR 3/2	100						
8-16	10 YR 4/4	100						

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

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

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ 2 cm Muck (A10)
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

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

Restrictive Layer (if present):

Type:_____

Depth (inches):_____

Hydric Soil Present? Yes ☐ No ☑

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
- ☐ Algal Mat or Crust (B4)
- ☐ Iron Deposits (B5)
- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
- ☐ Salt Crust (B11)
- ☐ Aquatic Invertebrates (B13)
- ☐ Hydrogen Sulfide Odor (C1)
- ☐ Oxidized Rhizospheres along Living Roots (C3)
- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Stunted or Stressed Plants (D1) (**LRR A**)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Raised Ant Mounds (D6) (**LRR A**)
- ☐ Frost-Heave Hummocks (D7)

Field Observations:

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

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

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

Wetland Hydrology Present? Yes ☐ No ☑

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

Remarks:

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

Project/Site: Sea Pac Homes - 53rd Ave W City/County: Mukilteo Sampling Date: 3/29/21

Applicant/Owner: Sea Pac Homes State: WA Sampling Point: S2

Investigator(s): JL Section, Township, Range: SEC 16, TWP 28N, RGE 4E

Landform (hillslope, terrace, etc.): _____ Local relief (concave, convex, none): _____ Slope (%): _____

Subregion (LRR): LRR-A Lat: 47.916617° Long: -122.306578° Datum: WGS84

Soil Map Unit Name: Alderwood NWI classification: none

Are climatic / hydrologic conditions on the site typical for this time of year? Yes ☑ No ☐ (If no, explain in Remarks.)

Are Vegetation ☐, Soil ☐, or Hydrology ☐ significantly disturbed? Are "Normal Circumstances" present? Yes ☑ No ☐

Are Vegetation ☐, Soil ☐, or Hydrology ☐ naturally problematic? (If needed, explain any answers in Remarks.)

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

Hydrophytic Vegetation Present? Yes ☐ No ☑ Hydric Soil Present? Yes ☐ No ☑ Wetland Hydrology Present? Yes ☐ No ☑	**Is the Sampled Area within a Wetland?** Yes ☐ No ☑

Remarks:

VEGETATION – Use scientific names of plants.

Tree Stratum (Plot size: 10)	Absolute % Cover	Dominant Species?	Indicator Status
1. Pseudotsuga menziesii	70	Y	FACU
2. Thuja plicata	20	Y	FAC
3.			
4.			
	90	= Total Cover	
Sapling/Shrub Stratum (Plot size: 5)			
1. Rubus armeniacus	20	Y	FAC
2.			
3.			
4.			
5.			
	20	= Total Cover	
Herb Stratum (Plot size: 1)			
1. Polystichum munitum	10	Y	FACU
2.			
3.			
4.			
5.			
6.			
7.			
8.			
9.			
10.			
11.			
	10	= Total Cover	
Woody Vine Stratum (Plot size: 1)			
1.			
2.			
	0	= Total Cover	

% Bare Ground in Herb Stratum 90

Dominance Test worksheet:

Number of Dominant Species That Are OBL, FACW, or FAC: 2 (A)

Total Number of Dominant Species Across All Strata: 4 (B)

Percent of Dominant Species That Are OBL, FACW, or FAC: 50 (A/B)

Prevalence Index worksheet:

Total % Cover of:		Multiply by:	
OBL species	0	x 1 =	0
FACW species	0	x 2 =	0
FAC species	40	x 3 =	120
FACU species	80	x 4 =	320
UPL species	0	x 5 =	0
Column Totals:	120 (A)		440 (B)

Prevalence Index = B/A = 3.7

Hydrophytic Vegetation Indicators:

- ☐ Rapid Test for Hydrophytic Vegetation
- ☐ Dominance Test is >50%
- ☐ Prevalence Index is ≤3.0[1]
- ☐ Morphological Adaptations[1] (Provide supporting data in Remarks or on a separate sheet)
- ☐ Wetland Non-Vascular Plants[1]
- ☐ Problematic Hydrophytic Vegetation[1] (Explain)

[1]Indicators of hydric soil and wetland hydrology must be present, unless disturbed or problematic.

Hydrophytic Vegetation Present? Yes ☐ No ☑

Remarks:

SOIL

Sampling Point: S2

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

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

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

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

- ☐ Histosol (A1)
- ☐ Histic Epipedon (A2)
- ☐ Black Histic (A3)
- ☐ Hydrogen Sulfide (A4)
- ☐ Depleted Below Dark Surface (A11)
- ☐ Thick Dark Surface (A12)
- ☐ Sandy Mucky Mineral (S1)
- ☐ Sandy Gleyed Matrix (S4)
- ☐ Sandy Redox (S5)
- ☐ Stripped Matrix (S6)
- ☐ Loamy Mucky Mineral (F1) (**except MLRA 1**)
- ☐ Loamy Gleyed Matrix (F2)
- ☐ Depleted Matrix (F3)
- ☐ Redox Dark Surface (F6)
- ☐ Depleted Dark Surface (F7)
- ☐ Redox Depressions (F8)

Indicators for Problematic Hydric Soils[3]:

- ☐ 2 cm Muck (A10)
- ☐ Red Parent Material (TF2)
- ☐ Very Shallow Dark Surface (TF12)
- ☐ Other (Explain in Remarks)

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

Restrictive Layer (if present):

Type:_____

Depth (inches):_____

Hydric Soil Present? Yes ☐ No ☑

Remarks:

HYDROLOGY

Wetland Hydrology Indicators:

Primary Indicators (minimum of one required; check all that apply)

- ☐ Surface Water (A1)
- ☐ High Water Table (A2)
- ☐ Saturation (A3)
- ☐ Water Marks (B1)
- ☐ Sediment Deposits (B2)
- ☐ Drift Deposits (B3)
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- ☐ Surface Soil Cracks (B6)
- ☐ Inundation Visible on Aerial Imagery (B7)
- ☐ Sparsely Vegetated Concave Surface (B8)
- ☐ Water-Stained Leaves (B9) (**except MLRA 1, 2, 4A, and 4B**)
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- ☐ Presence of Reduced Iron (C4)
- ☐ Recent Iron Reduction in Tilled Soils (C6)
- ☐ Stunted or Stressed Plants (D1) (**LRR A**)
- ☐ Other (Explain in Remarks)

Secondary Indicators (2 or more required)

- ☐ Water-Stained Leaves (B9) (**MLRA 1, 2, 4A, and 4B**)
- ☐ Drainage Patterns (B10)
- ☐ Dry-Season Water Table (C2)
- ☐ Saturation Visible on Aerial Imagery (C9)
- ☐ Geomorphic Position (D2)
- ☐ Shallow Aquitard (D3)
- ☐ FAC-Neutral Test (D5)
- ☐ Raised Ant Mounds (D6) (**LRR A**)
- ☐ Frost-Heave Hummocks (D7)

Field Observations:

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

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

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

Wetland Hydrology Present? Yes ☐ No ☑

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

Remarks:

Cobalt Geosciences, LLC
P.O. Box 82243
Kenmore, Washington 98028

March 14, 2022

Matthew Strittmatter
mstrittmatter@thebluelinegroup.com

RE: Groundwater Elevation Evaluation
Proposed Development
9110 53rd Avenue West
Mukilteo, Washington

In accordance with your authorization, Cobalt Geosciences, LLC has prepared this letter to discuss the results of our groundwater elevation evaluation at the site. In preparation of this letter, we have reviewed the provided civil plans dated March 30, 2021 by Blueline Group and the previous geotechnical report for the project dated July 30, 2021 by Earth Solutions Northwest (ESNW).

The plans indicate that the development will include seven new residential lots, an access roadway, retaining walls, and a detention vault. The detention vault will be located in the eastern portion of the site below the new access roadway. The vault will extend about 16 feet below existing grade in that area.

We anticipate that stormwater runoff from new driveways, roadways, and roof areas will be collected and routed to the detention vault with overflow to City infrastructure. We are not aware of the use of infiltration systems at the site. The plans show retaining walls will be located near the west property line and near the southeast corner of the property, supporting new structural fills.

We understand that the City of Mukilteo requested seasonal high groundwater elevations at the site and a discussion of "how surface and groundwater will move through the site to the proposed wall footing drains."

The site is located near the top of a low ridge that slopes downward to the east and west at variable magnitudes. There are steeper slopes near the west property line above existing residential developments. The City notes that there have been drainage issues within downslope developments, including surface water runoff, local groundwater at shallow depths, and ponding.

The site elevations range from about 410 to 380 feet above sea level with the lower elevations located near the west property line within a moderately steep slope area. There is a possible wetland area located several hundred feet east of the property at or near an elevation of 393 feet above sea level. Figure 1 shows the area topography relative to the site. Figure 2 is a light detection and ranging (LiDAR) map showing the surface features in this area.

There are local ravine/gully features north and west of the site, sloping downward to the west would presumably be an area where groundwater and surface waters are most easily conveyed/flow (path of least resistance).

Soil & Groundwater Conditions

As part of our evaluation, we excavated two test pits at the site where accessible to supplement the work previously performed by ESNW; specifically, to determine if groundwater is present at the site at shallow depths below the site. This work was conducted in early March 2022, during the typical wet season. The previous test pits by ESNW were conducted in June 2021 and did not encounter groundwater to the depths explored.

The soils encountered were logged in the field and are described in accordance with the Unified Soil Classification System (USCS).

A Cobalt Geosciences field representative conducted the explorations, collected disturbed soil samples, classified the encountered soils, kept a detailed log of the explorations, and observed and recorded pertinent site features.

Our test pits encountered approximately 12 inches of vegetation and topsoil underlain by approximately 5 to 7 feet of loose to medium dense, silty-fine to medium grained sand with gravel (Weathered Glacial Till or Drift). These materials were underlain by dense to very dense, silty-fine to medium grained sand with gravel (Glacial Till or Drift), which continued to the termination depths of the explorations.

Groundwater was not encountered in the test pits during our excavation work. Based on the soil conditions and topography, it appears that groundwater is at an elevation of 375 feet above sea level or lower within the property.

This part of Mukilteo is mapped as being underlain by Vashon Glacial Till which is typically dense and impermeable. We encountered soils generally consistent with a coarser glacial till (ablation till). Vashon Advance Outwash is mapped within the ravine features west and downslope of the site.

Based on the presence of an apparent wetland east of the site (surface expression of likely groundwater) and large upslope areas that contribute to surface and shallow groundwater, it is our opinion that there are areas where surface waters become ponded on fine grained till. This surface water slowly infiltrates and migrates along the denser till, likely downward to the west until the groundwater either emanates from slopes as spring activity, is intercepted by drainage features (utility trenches, subsurface collection drains), or flows into the outwash sands that underlie the till.

Water table elevations often fluctuate over time. The groundwater level will depend on a variety of factors that may include seasonal precipitation, irrigation, land use, climatic conditions and soil permeability. Water levels at the time of the field investigation may be different from those encountered during the construction phase of the project.

Conclusions and Recommendations

The site is underlain by coarser glacial till which becomes denser with depth. We did not observe groundwater in our recent test pits or any signs that groundwater becomes perched within the till. It appears that groundwater in this area is well below the site elevations, likely perched on finer grained dense glacial till likely slowing migrating to the west.

The proposed development includes collection of all runoff from new impervious surfaces with routing into a detention vault. The overflow for the vault is anticipated to be connected to City infrastructure. This should result in a net decrease in the volume of precipitation that currently falls onto the property and presumably either infiltrates down to the groundwater table or

migrates laterally over the ground or at shallow depths and onto adjacent properties. The project civil engineer's runoff calculations should confirm the anticipated change in runoff for pre- and post-development conditions.

The retaining wall drain systems will collect any built-up surface water (from precipitation primarily) and direct it from behind the walls. This is necessary since most retaining walls are designed under drained conditions and would fail if the backfill soils become saturated. We do not expect these drains to collect much stormwater based on the soil conditions observed.

Closure

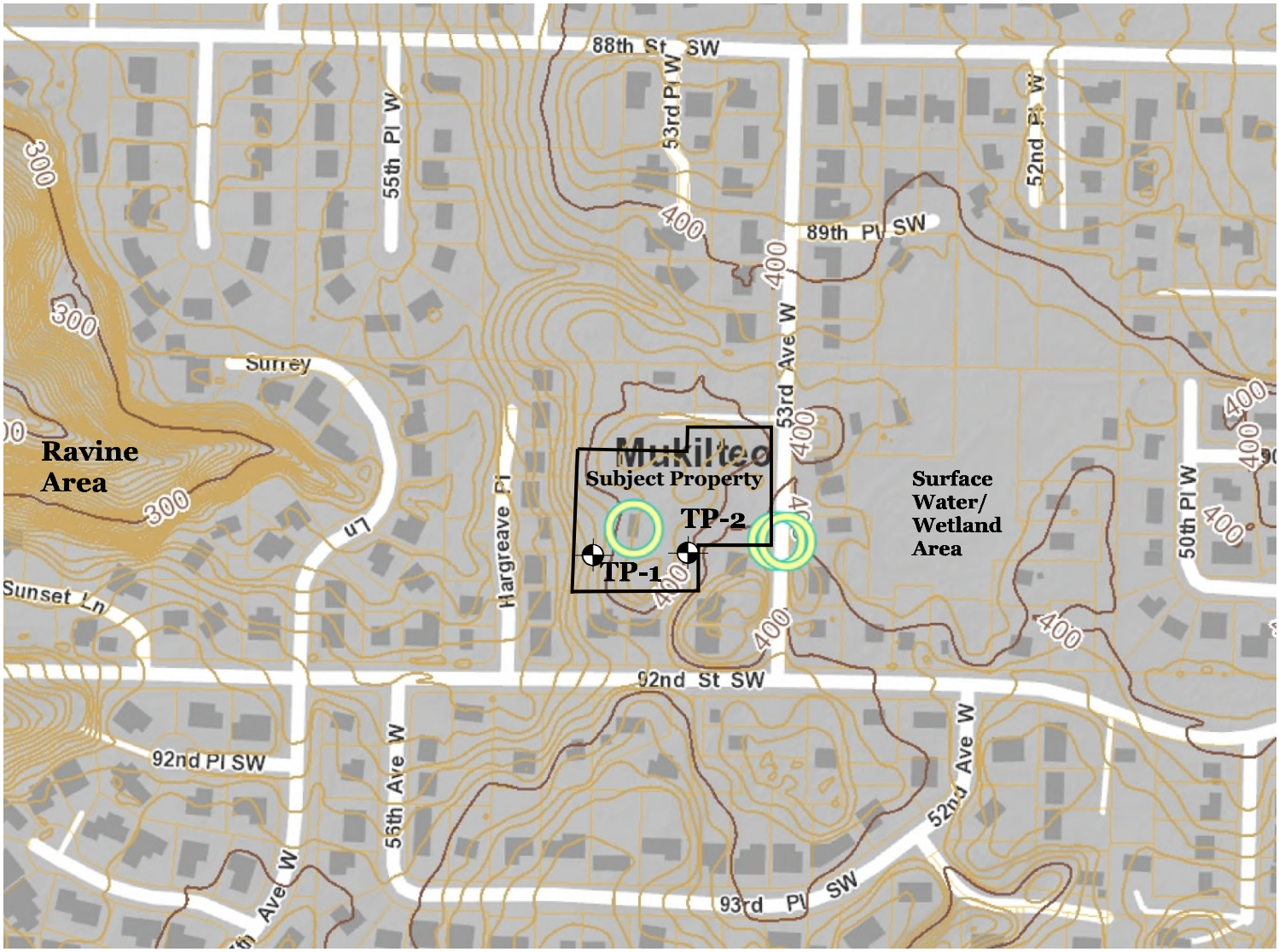
The recommendations contained in this report are based on assumed continuity of soils with those of our test holes and planned grading/drainage systems. Cobalt Geosciences should be provided with final civil drawings when they become available in order that we may review our design recommendations and advise of any revisions, if necessary.

Sincerely,

Cobalt Geosciences, LLC

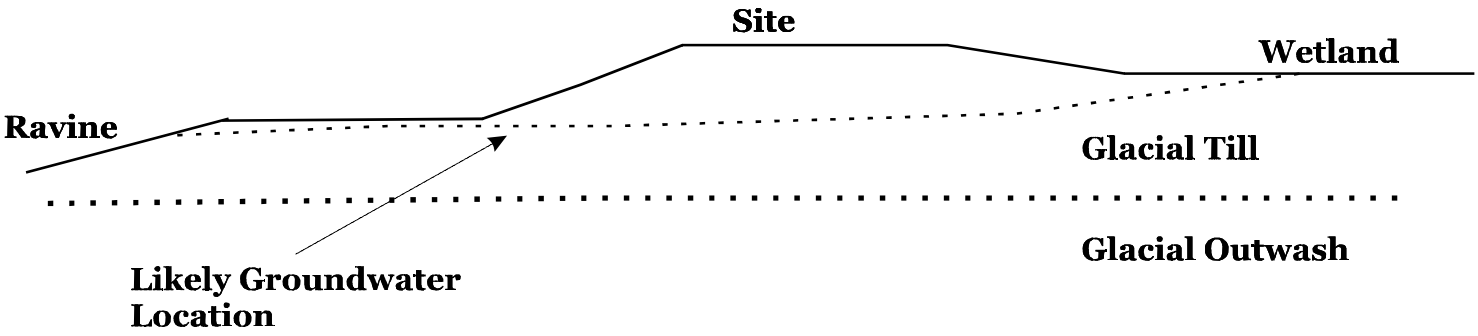
3/14/2022

Phil Haberman, PE, LG, LEG
Principal



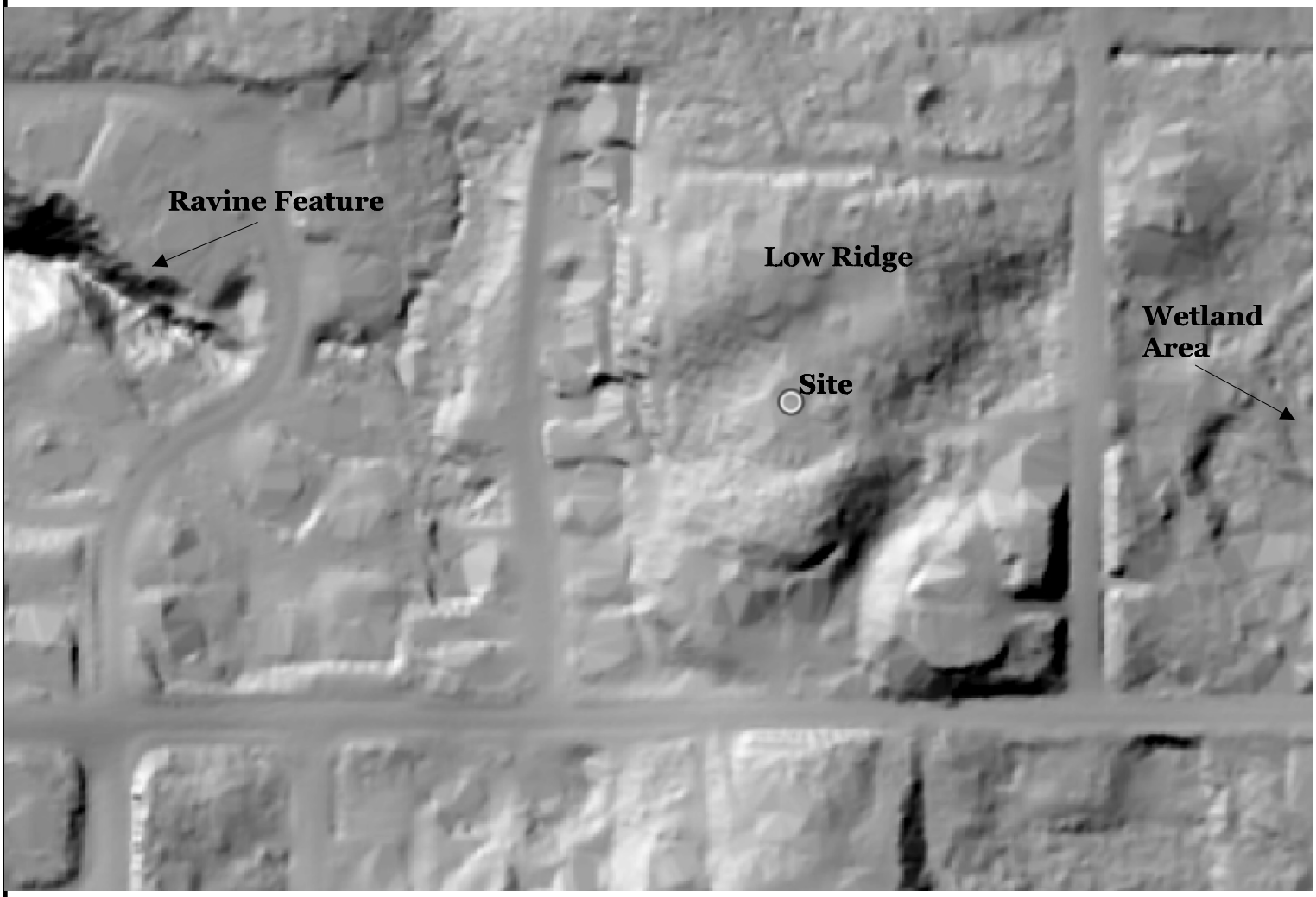
TP-1 **Approximate Test Pit Location**

N



Generalized Section

COBALT GEOSCIENCES	Proposed Development 9110 53rd Avenue West Mukilteo, Washington	**SITE MAP** **FIGURE 1**	Cobalt Geosciences, LLC P.O. Box 82243 Kenmore, WA 98028 (206) 331-1097 www.cobaltgeo.com cobaltgeo@gmail.com



COBALT GEOSCIENCES

Proposed Development
9110 53rd Avenue West
Mukilteo, Washington

LIDAR IMAGE FIGURE 2

Cobalt Geosciences, LLC
P.O. Box 82243
Kenmore, WA 98028
(206) 331-1097
www.cobaltgeo.com
cobaltgeo@gmail.com

Unified Soil Classification System (USCS)

MAJOR DIVISIONS			SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS (more than 50% retained on No. 200 sieve)	Gravels (more than 50% of coarse fraction retained on No. 4 sieve)	Clean Gravels (less than 5% fines)	GW	Well-graded gravels, gravels, gravel-sand mixtures, little or no fines
			GP	Poorly graded gravels, gravel-sand mixtures, little or no fines
		Gravels with Fines (more than 12% fines)	GM	Silty gravels, gravel-sand-silt mixtures
			GC	Clayey gravels, gravel-sand-clay mixtures
	Sands (50% or more of coarse fraction passes the No. 4 sieve)	Clean Sands (less than 5% fines)	SW	Well-graded sands, gravelly sands, little or no fines
			SP	Poorly graded sand, gravelly sands, little or no fines
		Sands with Fines (more than 12% fines)	SM	Silty sands, sand-silt mixtures
			SC	Clayey sands, sand-clay mixtures
FINE GRAINED SOILS (50% or more passes the No. 200 sieve)	Silts and Clays (liquid limit less than 50)	Inorganic	ML	Inorganic silts of low to medium plasticity, sandy silts, gravelly silts, or clayey silts with slight plasticity
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays silty clays, lean clays
		Organic	OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays (liquid limit 50 or more)	Inorganic	MH	Inorganic silts, micaceous or diatomaceous fine sands or silty soils, elastic silt
			CH	Inorganic clays of medium to high plasticity, sandy fat clay, or gravelly fat clay
		Organic	OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor		PT	Peat, humus, swamp soils with high organic content (ASTM D4427)

Classification of Soil Constituents

MAJOR constituents compose more than 50 percent, by weight, of the soil. Major constituents are capitalized (i.e., SAND).

Minor constituents compose 12 to 50 percent of the soil and precede the major constituents (i.e., silty SAND). Minor constituents preceded by "slightly" compose 5 to 12 percent of the soil (i.e., slightly silty SAND).

Trace constituents compose 0 to 5 percent of the soil (i.e., slightly silty SAND, trace gravel).

Grain Size Definitions

Description	Sieve Number and/or Size
Fines	<#200 (0.08 mm)
Sand	
-Fine	#200 to #40 (0.08 to 0.4 mm)
-Medium	#40 to #10 (0.4 to 2 mm)
-Coarse	#10 to #4 (2 to 5 mm)
Gravel	
-Fine	#4 to 3/4 inch (5 to 19 mm)
-Coarse	3/4 to 3 inches (19 to 76 mm)
Cobbles	3 to 12 inches (75 to 305 mm)
Boulders	>12 inches (305 mm)

Relative Density (Coarse Grained Soils)

N, SPT, Blows/FT	Relative Density
0 - 4	Very loose
4 - 10	Loose
10 - 30	Medium dense
30 - 50	Dense
Over 50	Very dense

Consistency (Fine Grained Soils)

N, SPT, Blows/FT	Relative Consistency
Under 2	Very soft
2 - 4	Soft
4 - 8	Medium stiff
8 - 15	Stiff
15 - 30	Very stiff
Over 30	Hard

Moisture Content Definitions

Dry	Absence of moisture, dusty, dry to the touch
Moist	Damp but no visible water
Wet	Visible free water, from below water table

COBALT GEOSCIENCES
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Soil Classification Chart

Figure C1

Test Pit TP-1

Date: March 2022	Depth: 14'	Groundwater: None
Contractor: Jim	Elevation:	Logged By: PH Checked By: SC

Depth (Feet)	Interval	Graphic Log	USCS Symbol	Material Description
				Topsoil/Vegetation
			SM	Loose to medium dense, silty-fine to medium grained sand with gravel, reddish brown to yellowish brown, moist to wet. (Weathered Glacial Till) Locally gradational with SP-SM
8			SM	Dense to very dense, silty-fine to medium grained sand with gravel, grayish brown, moist. (Glacial Till)
14				End of Test Pit 14'

Groundwater

Moisture Content (%)
Plastic Limit — Liquid Limit

DCP Equivalent N-Value
0 10 20 30 40 50

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Test Pit TP-2

Date: March 2022	Depth: 14'	Groundwater: None
Contractor: Jim	Elevation:	Logged By: PH Checked By: SC

Depth (Feet)	Interval	Graphic Log	USCS Symbol	Material Description	Groundwater
				Topsoil/Vegetation	
4			SM	Loose to medium dense, silty-fine to medium grained sand with gravel, reddish brown to yellowish brown, moist to wet. (Weathered Glacial Till) Locally gradational with SP-SM	
8			SM	Dense to very dense, silty-fine to medium grained sand with gravel, grayish brown, moist. (Glacial Till)	
14				End of Test Pit 14'	
16					
18					
20					

Moisture Content (%)
Plastic Limit — Liquid Limit

DCP Equivalent N-Value
0 10 20 30 40 50

COBALT GEOSCIENCES

Proposed Development
9110 53rd Avenue West
Mukilteo, Washington

Test Pit Logs

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Earth Solutions NW LLC

Geotechnical Engineering
Construction Observation/Testing
Environmental Services

GEOTECHNICAL ENGINEERING STUDY
DAFFRON PROPERTY
9110 – 53RD AVENUE WEST
MUKILTEO, WASHINGTON

ES-7975

15365 N.E. 90th Street, Suite 100 Redmond, WA 98052
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PREPARED FOR

SEA PAC HOMES

July 30, 2021
Updated July 28, 2022

Brian C. Snow, G.I.T.
Senior Staff Geologist

07/28/2022

Henry T. Wright, P.E.
Associate Principal Engineer

GEOTECHNICAL ENGINEERING STUDY
DAFFRON PROPERTY
9110 – 53RD AVENUE WEST
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Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of 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.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept*

responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GEOPROFESSIONAL BUSINESS ASSOCIATION

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Earth Solutions NW LLC
Geotechnical Engineering, Construction
Observation/Testing and Environmental Services

July 30, 2021
Updated July 28, 2022
ES-7975

Sea Pac Homes
120 Southwest Everett Mall Way, Suite 100
Everett, Washington 98204

Attention: Mr. Glen Belew

Dear Mr. Belew:

Earth Solutions NW, LLC (ESNW), is pleased to present this report titled "Geotechnical Engineering Study, Daffron Property, 9110 – 53rd Avenue West, Mukilteo, Washington"; this report was updated to correctly state the area of the subject site. Our field observations indicate the site is underlain primarily by medium dense to very dense silty sand glacial till deposits. Based on the results of our investigation, construction of the proposed residential short plat is feasible from a geotechnical standpoint.

The site will be mass graded to create access drives and building pads. New structural fill should be placed on competent native soil. If earthwork activities occur during wet weather, additional drainage measures, cement treatment of native soil, and the use of select fill material may be necessary. After completing earthwork activities in accordance with recommendations in this report, the proposed structures can be supported on conventional spread and continuous foundations bearing on undisturbed, competent native soil, recompacted native soil, or new structural fill. If structural building pads are disturbed during wet weather, remediation measures such as cement treatment or overexcavation and replacement with rock may be necessary in some areas.

This report provides geotechnical analyses and recommendations for the proposed residential short plat. The opportunity to be of service to you is appreciated. If you have any questions regarding the content of this geotechnical engineering study, please call.

Sincerely,

EARTH SOLUTIONS NW, LLC

Brian C. Snow, G.I.T.
Senior Staff Geologist

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GEOTECHNICAL ENGINEERING STUDY
DAFFRON PROPERTY
9110 – 53RD AVENUE WEST
MUKILTEO, WASHINGTON

ES-7975

INTRODUCTION

General

This geotechnical engineering study (study) was prepared for the proposed short plat to be constructed on the west side of 53rd Avenue West, approximately 250 to 500 feet north of the intersection with 92nd Street Southwest in Mukilteo, Washington; this study was updated to correctly state the area of the subject site. To complete our scope of services, we performed the following:

- Subsurface exploration to characterize the soil and groundwater conditions;
- Laboratory testing of representative soil sample collected on site;
- Review of on-site geologically hazardous areas;
- Engineering analyses and recommendations for the proposed residential short plat, and;
- Preparation of this report.

The following documents and resources were reviewed as part of our report preparation:

- Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington, Minard, J.P., 1982;
- Web Soil Survey (WSS) online resource, maintained by the Natural Resources Conservation Service (NRCS) under the United States Department of Agriculture (USDA);
- Soil Survey of Snohomish County Area, Washington, compiled by the USDA Soil Conservation Service, issued July 1983;
- Snohomish County Geologic Hazards Seismic Hazard Areas Map, dated February 1, 2016;
- Snohomish County Geologic Hazards Mine Hazard Areas Map, dated February 1, 2016;
- Liquefaction Susceptibility Map of Snohomish County, Washington, by Palmer, S.P. et al., dated September 2004;
- Geologic Information Portal online resource, maintained by the Washington Department of Natural Resources, and;
- Mukilteo Municipal Code.

Project Description

The subject site is located at 9110 – 53rd Avenue West in Mukilteo, Washington, as illustrated on Plate 1 (Vicinity Map). The site consists of one tax parcel (Snohomish County Parcel No. 00611600015901) totaling approximately 2.43 acres of land area.

We understand site development plans include construction of seven new residential lots, an access road, a stormwater vault, and associated improvements; the existing structure and site improvements will be demolished. We anticipate grade cuts and fills on the order of five to ten feet will be necessary to establish level building pads in some areas of the site.

At the time of report submission, specific building load values were not available for review; however, we anticipate the proposed residential structures will consist of relatively lightly loaded wood framing supported on conventional foundations. Based on our experience with similar developments, we estimate wall loads of about 1 to 2 kips per linear foot and slab-on-grade loading of 150 pounds per square foot (psf) will be incorporated into the final design.

If the above design assumptions are incorrect or change, ESNW should be contacted to review the recommendations provided in this report. ESNW should review the final design to confirm that our geotechnical recommendations have been incorporated into the final plans.

SITE CONDITIONS

Surface

The site is currently developed with an existing single-family residence, detached garage, and associated site improvements. The existing topography consists of a localized high area within the central portion of the site, which gently descends to the west, south, and east, with approximately 30 feet of vertical relief across the parcel. Vegetation consists primarily of forested areas with mature trees, underbrush, landscaping, and yard areas.

Subsurface

A representative of ESNW observed, logged, and sampled eight test pits at accessible locations within the property boundaries, on June 21, 2021. The test pits were completed using a machine and operator retained by our firm, to assess and classify the site soils, and to characterize the groundwater conditions within areas proposed for new development. The maximum exploration depth was approximately 13 feet below the existing ground surface (bgs).

The approximate locations of the test pits are depicted on Plate 2 (Test Pit Location Plan). Please refer to the test pit logs provided in Appendix A for a more detailed description of subsurface conditions. Representative soil samples collected at the exploration locations were analyzed in general accordance with Unified Soil Classification System (USCS) and USDA methods and procedures.

Topsoil and Fill

Topsoil was generally encountered within the upper 8 to 12 inches of existing grades at the test pit locations. Deeper pockets of topsoil up to 24 inches may be encountered locally across the site, as observed at test location TP-2; shallower sections of topsoil may also be present. The topsoil was characterized by its dark brown color, the presence of fine organic material, and small root intrusions.

Isolated fill was encountered at test location TP-2, characterized as topsoil intermixed with imported crushed rock gravel, extending to a maximum observed depth of 24 inches below existing grades. Additional fill will likely be encountered surrounding the existing foundations, utility lines, and other existing site improvements. Where encountered, fill intended for reuse as structural fill should be evaluated by ESNW at the time of construction and should be primarily free of organics and other deleterious material.

Native Soil

Underlying the topsoil and fill, native soils consisting primarily of medium dense to very dense silty sand (USCS: SM) glacial till deposits were observed. The glacial till soil was observed to be in a lightly to moderately weathered, medium dense condition near surface, becoming very dense and unweathered (hardpan) between about one to four feet bgs. Unweathered glacial till deposits were observed extending to the termination depth of each test pit, except for test location TP-6.

The native soils at test location TP-6 were characterized as poorly to well-graded gravel with silt and sand (USCS: GP-GM, GW-GM), with fines contents ranging between about 7 and 10 percent by weight. The gravelly soil deposits were overlain by approximately three feet of silty sand with gravel deposits (USCS: SM) and topsoil, and were generally in a medium dense to dense and damp condition at the time of exploration.

Geologic Setting

Geologic mapping of the area identifies Vashon glacial till (Qvt) as the primary geologic unit underlying the site. As reported on the geologic map resource, glacial till is a non-sorted mixture of clay, silt, sand, and gravel in variable amounts (commonly referred to as “hardpan”), deposited directly beneath the glacier as it advanced over bedrock and older Quaternary deposits

The online WSS resource identifies Alderwood-Urban land complex (Map Unit Symbols: 5 and 6) as the primary soil unit underlying the site. Alderwood soils formed over glacial till; designation as urban land indicates the potential for man-made modifications to the native soil stratigraphy, including artificial grade cuts and fill. Alderwood-Urban land soils are characterized in the referenced USDA soil survey with slow surface water runoff and slight hazard of water erosion.

In our opinion, the soils observed during our subsurface exploration are generally representative of glacial till deposits, consistent with the geologic and soils mapping resources outlined in this section.

Groundwater

Groundwater seepage was not observed during our June 2021 subsurface exploration. However, discrete zones of groundwater seepage are typical within glacial deposits, particularly during the wet season. In our opinion, zones of perched groundwater should be expected within site excavations. Groundwater seepage rates and elevations may fluctuate depending on many factors, including precipitation duration and intensity, the time of year, and soil conditions. In general, groundwater flow rates are higher during the winter, spring, and early summer months.

Geologically Sensitive Areas Evaluation

As part of this study, we reviewed Chapter 17.52A.020 – Designation of Geologic Sensitive Areas of the Mukilteo Municipal Code (MMC) to evaluate the presence of geologic hazards at the subject site. We also reviewed the City of Mukilteo Critical Areas online interactive map and the referenced hazard mapping resources. Geologically hazardous areas in the City of Mukilteo include areas susceptible to erosion, landslide, earthquake, or other geological events and conditions.

Based on our review of the geologic sensitive areas designation criteria outlined in MMC 17.52A.020, the site does not contain geologically sensitive areas. Additional justification for this conclusion is provided below.

Landslide Hazard Areas

Criterion H. of MMC 17.52A.020 designates “areas of steep slopes; slopes that have forty percent or steeper gradients and having a vertical relief greater than ten feet”. Our review of the readily available online hazard mapping resources indicates an area of steep slope is present within the southwestern site corner; however, the vertical relief across the identified area of steep slope appears to be less than ten feet. In our opinion, the area of steep slope identified by the referenced online mapping resource does not meet the City’s designation criteria for geologically sensitive areas.

Seismic Hazard Areas

We reviewed the referenced seismic hazards maps to assess the presence of seismic hazards on the subject site. The mapping resources indicate an inferred Class B fault trace (Structure “G”), in association with the Southern Whidbey Island Fault Zone, is located within about 500 to 1,000 feet north of the property, trending in a northwest-southeast orientation.

Class B faults are defined as faults for which Quaternary-age (within the past 2,588,000 years) deformation is suspected but insufficient evidence has been gathered to support the determination. The locations and activity of Class B faults are inferred based on the best available data but have not been confirmed.

During our fieldwork, we did not observe any evidence of faulting, deformation, or other disturbances within the native stratigraphy or surficial geomorphology. We also reviewed available LIDAR mapping resources for evidence of fault scarps or associated linear features on site and in the surrounding area. No evidence of surficial deformation was observed during our LIDAR review. Based on the results of our analysis, no active fault was identified, and the seismic hazard at the subject site is no greater than the surrounding area.

DISCUSSION AND RECOMMENDATIONS

General

In our opinion, construction of the proposed short plat is feasible from a geotechnical standpoint. The primary geotechnical considerations associated with the proposed project include earthwork, foundations and soil bearing capacity, utility support and trench backfill, and stormwater control and drainage.

The site will be mass graded to create access drives and building pads. New structural fill should be placed on competent native soil. If earthwork activities occur during wet weather, additional drainage measures, cement treatment of native soil, and the use of select fill material may be necessary. After completing earthwork activities in accordance with recommendations in this report, the proposed structures can be supported on conventional spread and continuous foundations bearing on undisturbed, competent native soil, recompacted native soil, or new structural fill. If structural building pads are disturbed during wet weather, remediation measures such as cement treatment or overexcavation and replacement with rock may be necessary in some areas.

This study has been prepared for the exclusive use of Sea Pac Homes and its representatives. A warranty is neither expressed nor implied. This study has been prepared in a manner consistent with the level of care and skill ordinarily exercised by other members of the profession currently practicing under similar conditions in this area.

Site Preparation and Earthwork

Site preparation activities should consist of installing temporary erosion control measures and performing site stripping within the designated clearing limits. Subsequent earthwork activities may involve additional mass grading and infrastructure and utility installations.

Temporary Erosion Control

The following temporary erosion control measures should be considered:

- Temporary construction entrances and drive lanes, consisting of at least six inches of quarry spalls, should be considered to both minimize off-site soil tracking and provide stable surfaces at site entrances. Placing geotextile fabric underneath the quarry spalls will provide greater stability if needed.

- Silt fencing should be placed around the appropriate portions of the site perimeter.

- When not in use, soil stockpiles should be covered or otherwise protected to reduce the potential for soil erosion, especially during periods of wet weather.

- Temporary measures for controlling surface water runoff, such as interceptor trenches, sumps, or interceptor swales, should be installed prior to beginning earthwork activities.

- Dry soils disturbed during construction should be wetted to minimize dust and airborne soil erosion.

- When appropriate, permanent planting or hydroseeding will help to stabilize site soils.

Additional Best Management Practices, as specified by the project civil engineer and indicated on the plans, should be incorporated into construction activities. Temporary erosion control measures may be modified during construction as site conditions require, as approved by the site erosion control lead.

Stripping

Topsoil was generally encountered within the upper 8 to 12 inches, locally extending as deep as 24 inches bgs. Root intrusions generally extended below the topsoil into the upper weathered soil. The organic-rich topsoil should be stripped and segregated into a stockpile for later use on site or to haul off site. The material remaining immediately below the topsoil may have some root zones and will likely be variable in composition, density, and/or moisture content. The material exposed after initial topsoil stripping will likely not be suitable for direct structural support as is and will likely need to either be compacted in place or stripped and stockpiled for reuse as fill; depending on the time of year stripping occurs, the soil exposed below the topsoil may be too wet to compact and will likely need to be aerated or treated. ESNW should observe initial stripping activities to provide recommendations regarding stripping depths and material suitability.

Excavations and Slopes

Excavation activities are likely to expose loose to medium dense native soils within the upper four feet of existing grades, becoming dense to very dense with depth. Based on the soil conditions observed at the subsurface exploration locations, the following maximum allowable temporary slope inclinations may be used.

The applicable Federal Occupation Safety and Health Administration and Washington Industrial Safety and Health Act soil classifications are also provided:

- Areas exposing groundwater seepage — 1.5H:1V (Type C)
- Loose soil — 1.5H:1V (Type C)
- Medium dense soil — 1H:1V (Type B)
- Dense to very dense “hardpan” native soil — 0.75H:1V (Type A)

Permanent slopes should be planted with vegetation to both enhance stability and minimize erosion and should maintain a gradient of 2H:1V or flatter. The presence of perched groundwater may cause localized sloughing of temporary slopes; groundwater seepage should be expected within site excavations, particularly if excavations take place during the wet season. An ESNW representative should observe temporary and permanent slopes to confirm the slope inclinations are suitable for the exposed soil conditions and to provide additional excavation and slope recommendations, as necessary. If the recommended temporary slope inclinations cannot be achieved, temporary shoring may be necessary to support excavations.

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, roadway, permanent slope, retaining wall, and utility trench backfill areas. Structural fill placed and compacted during site grading activities should meet the following specifications and guidelines:

- Structural fill material — Granular soil*
- Moisture Content — At or slightly above optimum**
- Relative compaction (minimum) — 95 percent (Modified Proctor)***
- Loose lift thickness (maximum) — 12 inches

* *Existing soil may not be suitable for use as structural fill unless at (or slightly above) the optimum moisture content at the time of placement of and compaction.*

** *Soil shall not be placed dry of optimum and should be evaluated by ESNW during construction.*

*** *Minimum relative compaction of 90% may be feasible for mass grading activities and should be evaluated by ESNW during construction.*

With respect to underground utility installations and backfill, local jurisdictions may dictate the soil type(s) and compaction requirements. Unsuitable material or debris must be removed from structural areas if encountered.

In-situ and Imported Soil

The in-situ soils encountered at the subject site have a moderate to high sensitivity to moisture and were generally in a damp to moist condition at the time of exploration. Soils anticipated to be exposed on site will degrade if exposed to wet weather and construction traffic. Compaction of the soils to the levels necessary for use as structural fill may be difficult or infeasible during wet weather conditions. Soils encountered during site excavations that are excessively over the optimum moisture content will likely require aeration or treatment prior to placement and compaction. Conversely, soils that are substantially below the optimum moisture content will require moisture conditioning through the addition of water prior to use as structural fill. An ESNW representative should determine the suitability of in-situ soils for use as structural fill at the time of construction.

Imported soil intended for use as structural fill should be evaluated by ESNW during construction. The imported soil must be workable to the optimum moisture content, as determined by the Modified Proctor Method (ASTM D1557), at the time of placement and compaction. During wet weather conditions, imported soil intended for use as structural fill should consist of a well-graded, granular soil with a fines content of 5 percent or less (where the fines content is defined as the percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction).

Wet-Season Grading

Earthwork activities that occur during the wet season may require additional measures to protect both structural subgrades and soil intended for use as structural fill. Site specific recommendations can be provided at the time of construction and may include leaving cut areas several inches above design subgrade elevations, covering working surfaces with crushed rock, protecting structural fill soil from adverse moisture conditions, and additional TESC recommendations. ESNW can assist in obtaining a wet-season grading permit if required by the governing jurisdiction.

Void Space Restoration

The process of removing the existing structures may produce voids where old foundations are removed and where crawl space areas may have been present. Complete restoration of voids from old foundation areas must be executed as part of the subgrade preparation activities. The following guidelines for preparing structural subgrade areas should be incorporated into the final design:

- Where voids and related demolition disturbances extend below planned subgrade elevations, restoration of these areas should be completed. Structural fill should be used to restore voids or unstable areas resulting from the removal of existing structural elements.

- Recompact, or overexcavate and replace, areas of existing fill exposed at structural subgrade elevations. Overexcavations should extend into competent native soils and structural fill should be utilized to restore subgrade elevations as necessary.

- ESNW should confirm subgrade conditions, as well as the required level of recompaction and/or overexcavation and replacement, during site preparation activities. ESNW should also evaluate the overall suitability of prepared subgrade areas following site preparation activities.

Foundations

The proposed residential structures can be supported on conventional spread and continuous footings bearing on undisturbed, competent native soil, recompacted native soil, or new structural fill. Provided site earthwork activities are completed in accordance with our recommendations, suitable soil conditions should be exposed in building pad structural subgrade areas.

Due to the high moisture sensitivity of the site soils, foundation subgrade areas should be protected from wet weather or areas of remediation should be anticipated; a layer of crushed rock can be considered to protect foundation subgrade areas. If structural building pads are disturbed during wet weather, remediation measures such as cement treatment or overexcavation and replacement with rock may be necessary in some areas. Provided the structures will be supported as described above, the following parameters may be used for design of the new foundations:

- Allowable soil bearing capacity 2,500 psf
- Passive earth pressure 300 pcf
- Coefficient of friction 0.40

A one-third increase in the allowable soil bearing capacity can be assumed for short-term wind and seismic loading conditions. The passive earth pressure and coefficient of friction values include a safety factor of 1.5. With structural loading as expected, total settlement in the range of one inch is anticipated, with differential settlement of about one-half inch. The majority of the settlement should occur during construction as dead loads are applied.

Retaining Walls

Retaining walls must be designed to resist earth pressures and applicable surcharge loads. The following parameters may be used for retaining wall design:

- Active earth pressure (unrestrained condition) 35 pcf
- At-rest earth pressure (restrained condition) 55 pcf
- Traffic surcharge (passenger vehicles) 70 psf (rectangular distribution)
- Passive earth pressure 300 pcf
- Coefficient of friction 0.40
- Seismic surcharge 8H psf*

* *Where H equals the retained height (in feet).*

The passive earth pressure and coefficient of friction values include a safety factor of 1.5. Additional surcharge loading from adjacent foundations, sloped backfill, or other loads should be included in the retaining wall design.

Retaining walls should be backfilled with free-draining material that extends along the height of the wall and a distance of at least 18 inches behind the wall. The upper 12 inches of the wall backfill may consist of a less permeable soil, if desired.

Drainage should be provided behind retaining walls such that hydrostatic pressures do not develop. If drainage is not provided, hydrostatic pressures should be included in the wall design. A perforated drainpipe should be placed along the base of the wall and connected to an approved discharge location. A typical retaining wall drainage detail is provided on Plate 3.

Slab-on-Grade Floors

Slab-on-grade floors should be supported on a firm and unyielding subgrade consisting of competent native soil or at least 12 inches of new structural fill. Unstable or yielding areas of the subgrade should be recompacted or overexcavated and replaced with suitable structural fill prior to slab construction.

A capillary break consisting of a minimum of four inches of free-draining crushed rock or gravel should be placed below the slab. The free-draining material should have a fines content of 5 percent or less defined as the percent passing the number 200 sieve, based on the minus three-quarters-inch fraction. In areas where slab moisture is undesirable, installation of a vapor barrier below the slab should be considered. If used, the vapor barrier should consist of a material specifically designed to function as a vapor barrier and should be installed in accordance with the manufacturer's specifications.

Utility Support and Trench Backfill

The soils observed at the subsurface exploration locations are generally suitable for support of utilities. The presence of perched groundwater seepage should be anticipated within utility excavations at depth. Use of the native soil as structural backfill in the utility trench excavations will depend on the in-situ moisture content at the time of placement and compaction. If native soil is placed below the optimum moisture content, settlement will likely occur once wet weather impacts the trenches. Native soil will be difficult or impossible to use as utility trench backfill during wet weather conditions. Moisture conditioning or treatment of the soils may be necessary at some locations prior to use as structural fill. Utility trench backfill should be placed and compacted to the specifications of structural fill provided in this report or to the applicable requirements of the presiding jurisdiction.

Preliminary Pavement Sections

The performance of site pavements is largely related to the condition of the underlying subgrade. To ensure adequate pavement performance, the subgrade should be in a firm and unyielding condition when subjected to proof rolling with a loaded dump truck. Structural fill in pavement areas should be compacted to the specifications previously detailed in this report. Soft, wet, or otherwise unsuitable or yielding subgrade conditions will require remedial measures, such as overexcavation and/or placement of thick crushed rock or structural fill sections, prior to pavement.

We anticipate new pavement sections will be subjected primarily to passenger vehicle traffic. For lightly loaded pavement areas subjected primarily to passenger vehicles, the following preliminary pavement sections may be considered:

- A minimum of two inches of hot-mix asphalt (HMA) placed over four inches of crushed rock base (CRB), or;

- A minimum of two inches of HMA placed over three inches of asphalt-treated base (ATB).

Heavier traffic areas generally require thicker pavement sections depending on site usage, pavement life expectancy, and site traffic. For preliminary design purposes, the following pavement sections for occasional truck traffic and access roadways may be considered:

- Three inches of HMA placed over six inches of CRB, or;

- Three inches of HMA placed over four and one-half inches of ATB.

A representative of ESNW should be requested to observe subgrade conditions prior to placement of CRB or ATB. As necessary, supplemental recommendations for achieving subgrade stability and drainage can be provided. If on-site roads will be constructed with an inverted crown, additional drainage measures may be recommended to assist in maintaining road subgrade and pavement stability.

Final pavement design recommendations, including recommendations for heavy traffic areas, access roads, and frontage improvement areas, can be provided once final traffic loading has been determined. Road standards utilized by the governing jurisdiction may supersede the recommendations provided in this report. The HMA, ATB, and CRB materials should conform to WSDOT specifications. All soil base material should be compacted to a relative compaction of 95 percent, based on the laboratory maximum dry density as determined by ASTM D1557.

Drainage

Groundwater seepage will likely be encountered within site excavations depending on the time of year grading operations take place. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches, interceptor swales, and sumps. ESNW should be consulted during preliminary grading to identify areas of seepage and provide recommendations to reduce the potential for seepage-related instability.

Finish grades must be designed to direct surface drain water away from structures and slopes. Water must not be allowed to pond adjacent to structures or slopes. In our opinion, a foundation drain should be installed along building perimeter footings. A typical foundation drain detail is provided on Plate 4.

Infiltration Evaluation

The dense, cemented, and unweathered glacial till soils (hardpan) observed at depths beginning at about one to four feet bgs across the site generally exhibit very poor soil infiltration characteristics. In our opinion, the unweathered glacial soils should be considered impermeable for design purposes, and the use of infiltration systems at the subject site is not recommended.

Stormwater Vault Design

We anticipate site stormwater will be managed using a stormwater vault. Vault foundations should be supported on competent native soil or crushed rock placed on competent native soil. Final storm vault designs must incorporate adequate buffer space from the property boundaries such that temporary excavations to construct the vault structure can be successfully completed. Perimeter drains should be installed around the vault and conveyed to an approved discharge point. The presence of perched groundwater seepage should be anticipated during excavation activities for the vault, particularly during the wet season, which may dictate temporary slope inclinations required for the vault excavation (as described in the *Excavations and Slopes* section of this report).

The following parameters can be used for stormwater vault design:

- Allowable soil bearing capacity (dense native soil) 5,000 psf
- Active earth pressure (unrestrained) 35 pcf
- Active earth pressure (unrestrained, hydrostatic) 80 pcf
- At-rest earth pressure (restrained) 55 pcf
- At-rest earth pressure (restrained, hydrostatic) 100 pcf
- Coefficient of friction 0.40
- Passive earth pressure 300 pcf
- Seismic surcharge 8H*

* *Where H equals the retained height.*

The passive earth pressure and coefficient of friction values include a safety factor of 1.5. The vault walls should be backfilled with free-draining material or suitable common earth if a sheet drain material is used. The upper one foot of the vault backfill can consist of a less permeable soil, if desired. A perforated drain pipe should be placed along the base of the vault walls and connected to an approved discharge location. If the elevation of the vault bottom is such that gravity flow to an outlet is not possible, the portion of the vault below the drain should be designed to include hydrostatic pressure. Design values accounting for hydrostatic pressure are included above.

ESNW should observe grading operations for the vault and the subgrade conditions prior to concrete forming and pouring to confirm conditions are as anticipated, and to provide supplemental recommendations as necessary. Additionally, ESNW should be contacted to review final vault designs to confirm that appropriate geotechnical parameters have been incorporated.

We anticipate native soil will be used as vault backfill. We recommend placing the native soil at or slightly above optimum moisture. Native soil placed substantially above optimum moisture will require additional time or remediation prior to supporting a structure.

Seismic Design

The 2018 International Building Code (2018 IBC) recognizes the most recent edition of the Minimum Design Loads for Buildings and Other Structures manual (ASCE 7-16) for seismic design, specifically with respect to earthquake loads. Based on the soil conditions encountered at the boring locations, the parameters and values provided below are recommended for seismic design per the 2018 IBC.

Parameter	**Value**
Site Class	C*
Mapped short period spectral response acceleration, S_S (*g*)	1.401
Mapped 1-second period spectral response acceleration, S_1 (*g*)	0.500
Short period site coefficient, F_a	1.200
Long period site coefficient, F_v	1.500
Adjusted short period spectral response acceleration, S_{MS} (*g*)	1.682
Adjusted 1-second period spectral response acceleration, S_{M1} (*g*)	0.750
Design short period spectral response acceleration, S_{DS} (*g*)	1.121
Design 1-second period spectral response acceleration, S_{D1} (*g*)	0.500

* *Assumes very dense soil conditions, encountered to a maximum depth of 13 feet bgs during the June 2021 field exploration, remain very dense to at least 100 feet bgs. Based on our experience with the project geologic setting (glacial till) across the Puget Sound region, soil conditions are likely consistent with this assumption.*

Further discussion between the project structural engineer, the project owner (or their representative), and ESNW may be prudent to determine the possible impacts to the structural design due to increased earthquake load requirements under the 2018 IBC. ESNW can provide additional consulting services to aid with design efforts, including supplementary geotechnical and geophysical investigation, upon request.

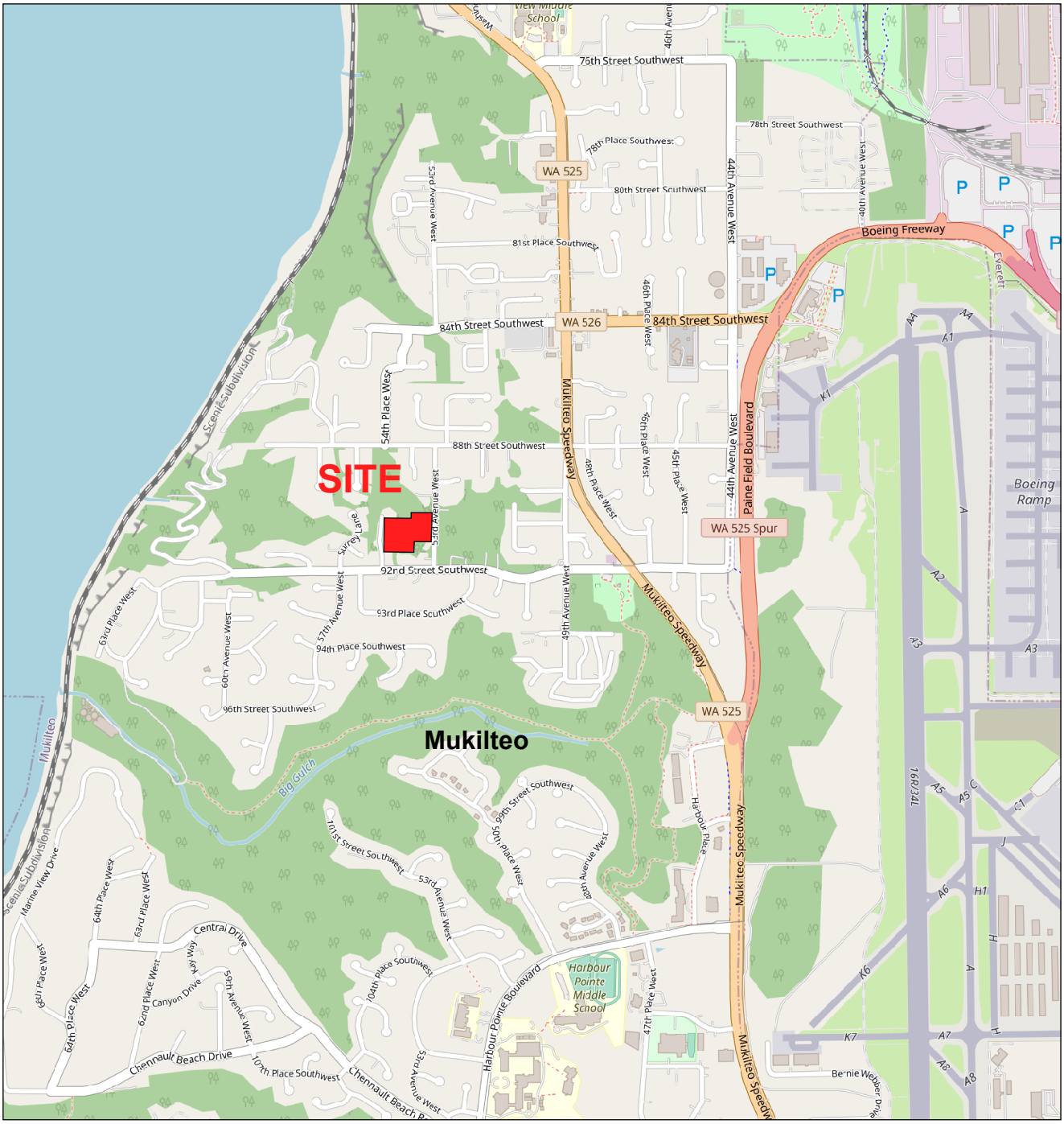
Liquefaction is a phenomenon where saturated or loose soil suddenly loses internal strength and behaves as a fluid. This behavior is in response to increased pore water pressures resulting from an earthquake or another intense ground shaking. In our opinion, site susceptibility to liquefaction may be considered negligible. The absence of a shallow groundwater table and the relatively dense characteristics of the native soil were the primary bases for this opinion.

LIMITATIONS

The recommendations and conclusions provided in this study are professional opinions consistent with the level of care and skill that is typical of other members in the profession currently practicing under similar conditions in this area. A warranty is neither expressed nor implied. Variations in the soil and groundwater conditions observed at the exploration locations may exist and may not become evident until construction. ESNW should reevaluate the conclusions provided in this study if variations are encountered.

Additional Services

ESNW should have an opportunity to review final project plans with respect to the geotechnical recommendations provided in this report. ESNW should also be retained to provide testing and consultation services as needed during design and construction phases of the project.



Reference:
Snohomish County, Washington
OpenStreetMap.org

NORTH

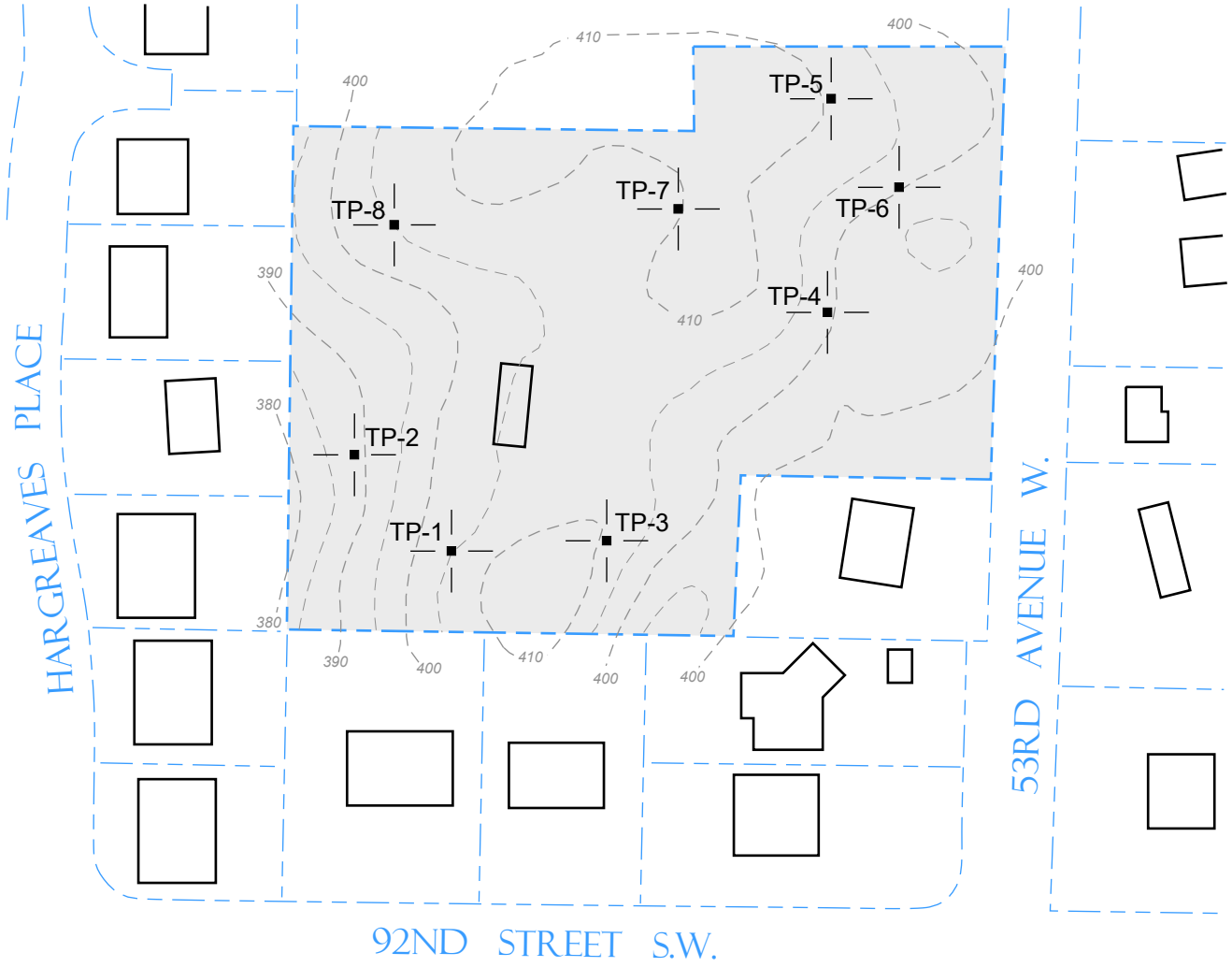
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Vicinity Map
Daffron Property
Mukilteo, Washington

Drwn. MRS	Date 07/15/2021	Proj. No. 7975
Checked BCS	Date July 2021	Plate 1



NORTH

1"=100'

0 50 100 200

Scale in Feet

LEGEND

TP-1 — Approximate Location of ESNW Test Pit, Proj. No. ES-7975, June 2021

Subject Site

Existing Building

NOTE: The graphics shown on this plate are not intended for design purposes or precise scale measurements, but only to illustrate the approximate test locations relative to the approximate locations of existing and / or proposed site features. The information illustrated is largely based on data provided by the client at the time of our study. ESNW cannot be responsible for subsequent design changes or interpretation of the data by others.

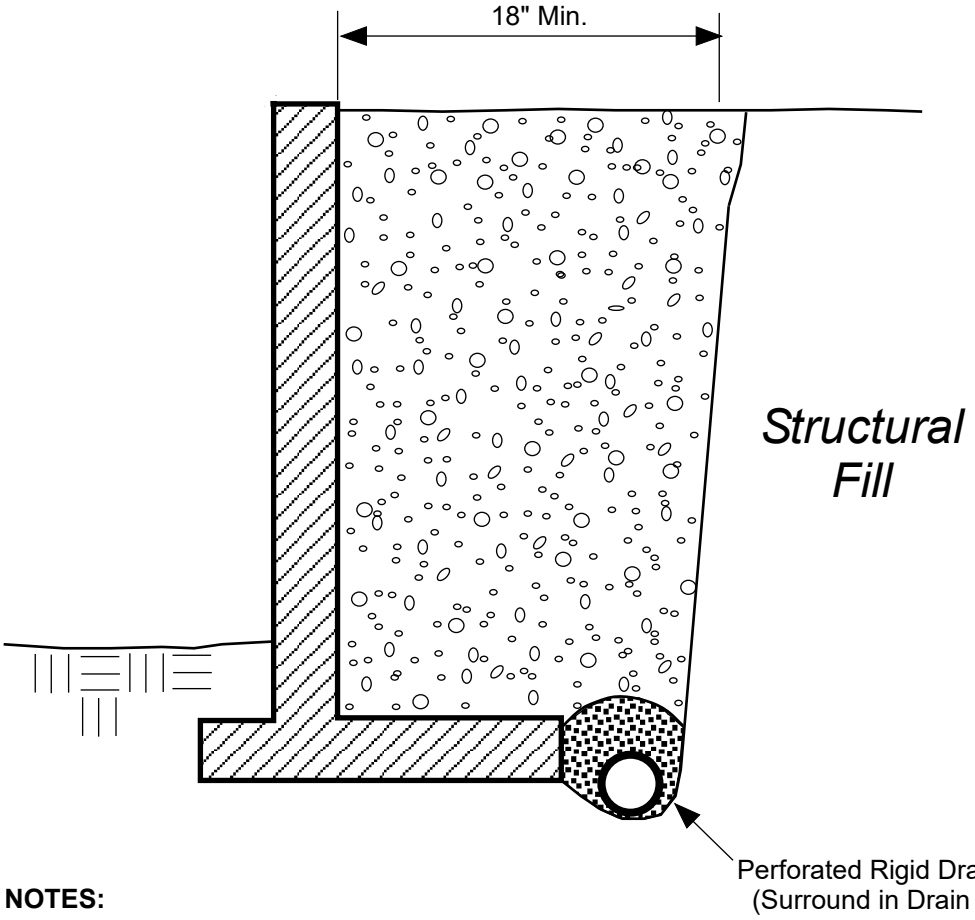
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Test Pit Location Plan
Daffron Property
Mukilteo, Washington

Drwn. MRS	Date 07/14/2021	Proj. No. 7975
Checked BCS	Date July 2021	Plate 2



NOTES:

- Free-draining Backfill should consist of soil having less than 5 percent fines. Percent passing No. 4 sieve should be 25 to 75 percent.
- Sheet Drain may be feasible in lieu of Free-draining Backfill, per ESNW recommendations.
- Drain Pipe should consist of perforated, rigid PVC Pipe surrounded with 1-inch Drain Rock.

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:

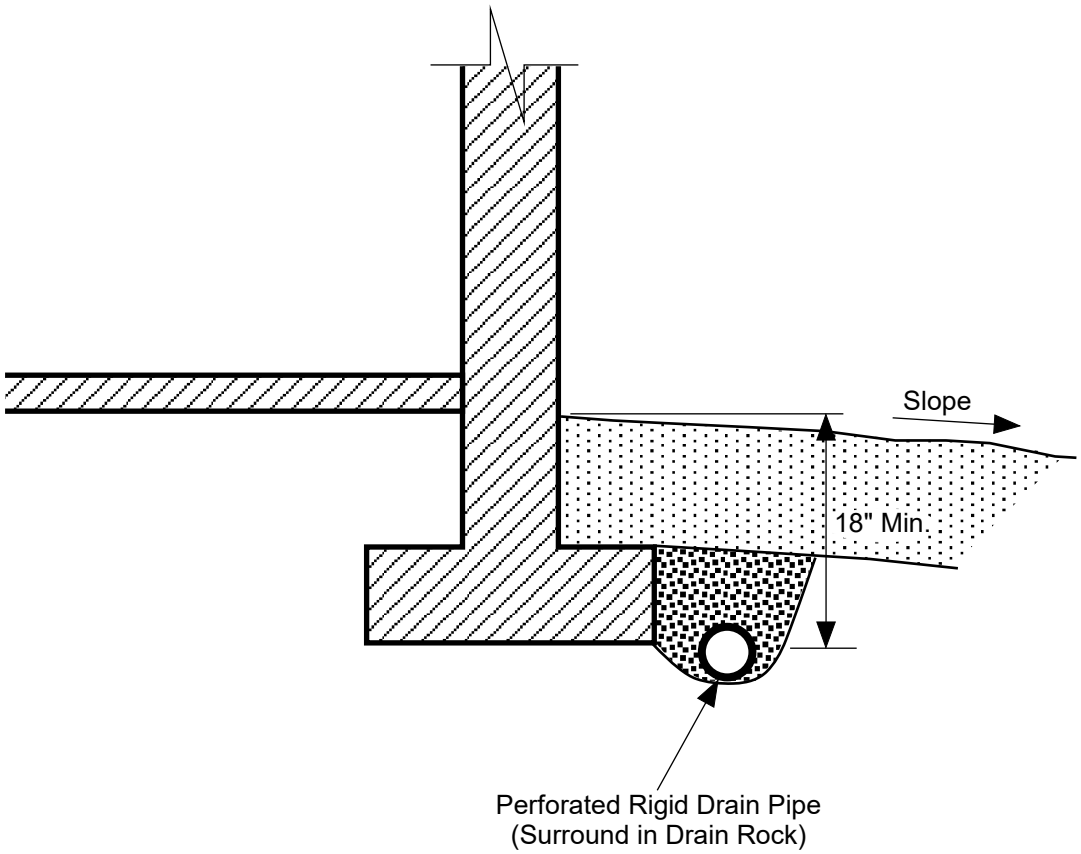
Free-draining Structural Backfill

1-inch Drain Rock

Earth Solutions NW LLC
Geotechnical Engineering Construction Observation/Testing and Environmental Services

Retaining Wall Drainage Detail
Daffron Property
Mukilteo, Washington

Drwn. MRS	Date 07/15/2021	Proj. No. 7975
Checked BCS	Date July 2021	Plate 3



NOTES:

- Do NOT tie roof downspouts to Footing Drain.
- Surface Seal to consist of 12" of less permeable, suitable soil. Slope away from building.

LEGEND:

Surface Seal: native soil or other low-permeability material.

1-inch Drain Rock

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

Earth Solutions NW LLC
Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Footing Drain Detail
Daffron Property
Mukilteo, Washington

Drwn. MRS	Date 07/15/2021	Proj. No. 7975
Checked BCS	Date July 2021	Plate 4

Appendix A

Subsurface Exploration
Test Pit Logs

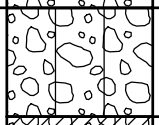
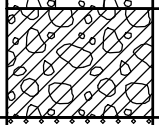
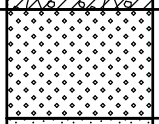
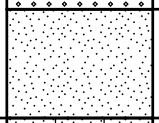
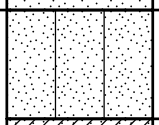
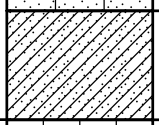
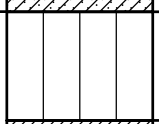
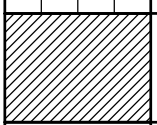
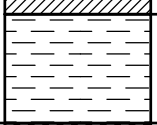
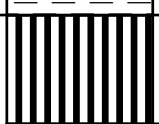
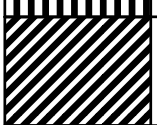
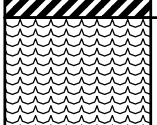
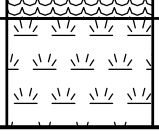
ES-7975

Subsurface conditions on site were explored on June 21, 2021 by excavating eight test pits using a machine and operator retained by our firm. The approximate locations of the test pits are illustrated on Plate 2 of this study. The subsurface exploration logs are provided in this Appendix. The test pits were advanced to a maximum depth of about 13 feet bgs.

The final logs represent the interpretations of the field logs and the results of laboratory analyses. The stratification lines on the logs represent the approximate boundaries between soil types. In actuality, the transitions may be more gradual.

Earth Solutions NW LLC

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			SYMBOLS		TYPICAL DESCRIPTIONS
			GRAPH	LETTER	
COARSE GRAINED SOILS MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE	GRAVEL AND GRAVELLY SOILS MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	CLEAN GRAVELS (LITTLE OR NO FINES)		GW	WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)		GM	SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES
	SAND AND SANDY SOILS MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE	CLEAN SANDS (LITTLE OR NO FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES
		SANDS WITH FINES (APPRECIABLE AMOUNT OF FINES)		SM	SILTY SANDS, SAND - SILT MIXTURES
				SC	CLAYEY SANDS, SAND - CLAY MIXTURES
FINE GRAINED SOILS MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS
				OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY
	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

DUAL SYMBOLS are used to indicate borderline soil classifications.

The discussion in the text of this report is necessary for a proper understanding of the nature of the material presented in the attached logs.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-1

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property

DATE STARTED 6/21/21 **COMPLETED** 6/21/21 **GROUND ELEVATION**

EXCAVATION CONTRACTOR NW Excavating **LATITUDE** 47.9157 **LONGITUDE** -122.30695

EXCAVATION METHOD **GROUND WATER LEVEL:**

LOGGED BY BCS **CHECKED BY** HTW ▽ **AT TIME OF EXCAVATION**

NOTES Depth of Topsoil & Sod 6": brush

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, minor root intrusions
0.5					Brown silty SAND, dense, damp to moist
					-becomes gray, weakly cemented
		MC = 7.0%	SM		
					-becomes very dense, light iron oxide staining
4.0		MC = 11.8%			-sparse gravel
					Test pit terminated at 4.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

Earth Solutions NW, LLC
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Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-2

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property
DATE STARTED 6/21/21 **COMPLETED** 6/21/21 **GROUND ELEVATION**
EXCAVATION CONTRACTOR NW Excavating **LATITUDE** 47.91585 **LONGITUDE** -122.30717
EXCAVATION METHOD **GROUND WATER LEVEL:**
LOGGED BY BCS **CHECKED BY** HTW ▽ **AT TIME OF EXCAVATION**
NOTES Depth of Topsoil & Sod 24": brush

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					
			TPSL		Dark brown TOPSOIL intermixed with 5/8" crushed rock (Fill)
		MC = 14.1%			2.0
					Brown silty SAND, loose to medium dense, moist
		MC = 9.8%			-light iron oxide staining
					-becomes gray, dense
5					-sparse gravel
			SM		
					-becomes very dense, weakly cemented
		MC = 12.5%			-decreasing fines content
					-increasing gravel content
		MC = 8.7%			9.0
					Test pit terminated at 9.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

Earth Solutions NW, LLC
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Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-3

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property

DATE STARTED 6/21/21 **COMPLETED** 6/21/21 **GROUND ELEVATION**

EXCAVATION CONTRACTOR NW Excavating **LATITUDE** 47.91573 **LONGITUDE** -122.30661

EXCAVATION METHOD **GROUND WATER LEVEL:**

LOGGED BY BCS **CHECKED BY** HTW ▽ **AT TIME OF EXCAVATION**

NOTES Surface Conditions: brush/ferns

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, minor root intrusions
				1.0	
			SM		Brown silty SAND, medium dense to dense, damp
		MC = 3.2%			
					-becomes gray, dense
		MC = 8.7%			
5					-becomes very dense, moist (unweathered till), weakly cemented
					-light iron oxide staining
		MC = 9.2%		6.0	

Test pit terminated at 6.0 feet below existing grade due to refusal in very dense till. No groundwater encountered during excavation. No caving observed.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-4

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property

DATE STARTED 6/21/21 **COMPLETED** 6/21/21 **GROUND ELEVATION**

EXCAVATION CONTRACTOR NW Excavating **LATITUDE** 47.91615 **LONGITUDE** -122.30609

EXCAVATION METHOD **GROUND WATER LEVEL:**

LOGGED BY BCS **CHECKED BY** HTW ▽ **AT TIME OF EXCAVATION**

NOTES Depth of Topsoil & Sod 8": ferns/forest floor

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, minor root intrusions
				0.6	Brown silty SAND, loose to medium dense, damp to moist
		MC = 10.3%			
					-becomes gray, medium dense to dense
					-weakly cemented
		MC = 9.1%			
					-becomes very dense
5			SM		
					-trace iron oxide staining
		MC = 7.3%		9.0	
					Test pit terminated at 9.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-5

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property

DATE STARTED 6/21/21 **COMPLETED** 6/21/21 **GROUND ELEVATION**

EXCAVATION CONTRACTOR NW Excavating **LATITUDE** 47.91639 **LONGITUDE** -122.30612

EXCAVATION METHOD **GROUND WATER LEVEL:**

LOGGED BY BCS **CHECKED BY** HTW ▽ **AT TIME OF EXCAVATION**

NOTES Depth of Topsoil & Sod 8": brush

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, minor root intrusions
				0.6	Brown silty SAND, loose, damp
		MC = 5.7%			
					-becomes gray, dense, moist
		MC = 8.8% Fines = 27.6%			-weakly cemented, light iron oxide staining [USDA Classification: slightly gravelly sandy LOAM]
			SM		-trace gravel
5					-becomes very dense
		MC = 5.8%			-increasing gravel content, decreasing fines content
		MC = 7.6% Fines = 19.9%		8.0	[USDA Classification: gravelly sandy LOAM]
					Test pit terminated at 8.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-6

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property

DATE STARTED 6/21/21 **COMPLETED** 6/21/21 **GROUND ELEVATION**

EXCAVATION CONTRACTOR NW Excavating **LATITUDE** 47.9162 **LONGITUDE** -122.30598

EXCAVATION METHOD **GROUND WATER LEVEL:**

LOGGED BY BCS **CHECKED BY** HTW ▽ **AT TIME OF EXCAVATION**

NOTES Depth of Topsoil & Sod 10": brush

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, minor root intrusions to 3.5'
				0.8	
			SM		Tan silty SAND with gravel, loose to medium dense, damp
		MC = 5.7%		3.0	Tan well-graded gravel with silt and sand, dense, damp
5					
		MC = 2.6% Fines = 7.3%	GW-GM		[USDA Classification: extremely gravelly sandy LOAM]
10		MC = 8.8% Fines = 9.2%		10.0	Tan poorly graded GRAVEL with silt and sand, medium dense, damp [USDA Classification: very gravelly sandy LOAM] -light iron oxide staining
			GP-GM		
		MC = 17.9%		13.0	-increasing moisture, silt lenses
					Test pit terminated at 13.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-7

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property

DATE STARTED 6/21/21 **COMPLETED** 6/21/21 **GROUND ELEVATION**

EXCAVATION CONTRACTOR NW Excavating **LATITUDE** 47.91619 **LONGITUDE** -122.30649

EXCAVATION METHOD **GROUND WATER LEVEL:**

LOGGED BY BCS **CHECKED BY** HTW ▽ **AT TIME OF EXCAVATION**

NOTES Depth of Topsoil & 10": grass

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, minor root intrusions
				0.8	Brown silty SAND, medium dense, damp
					-becomes gray
					-light iron oxide staining
		MC = 9.6%			-becomes dense, moist
			SM		-becomes very dense, weakly cemented
5		MC = 11.6%			
		MC = 9.7%		7.5	
					Test pit terminated at 7.5 feet below existing grade. No groundwater encountered during excavation. No caving observed.

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-8

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property

DATE STARTED 6/21/21 **COMPLETED** 6/21/21 **GROUND ELEVATION**

EXCAVATION CONTRACTOR NW Excavating **LATITUDE** 47.9162 **LONGITUDE** -122.3071

EXCAVATION METHOD **GROUND WATER LEVEL:**

LOGGED BY BCS **CHECKED BY** HTW ▽ **AT TIME OF EXCAVATION**

NOTES Depth of Topsoil & 10": brush/ferns

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, minor root intrusions
				0.8	Gray silty SAND, loose to medium dense, damp
		MC = 6.5%			-light iron oxide staining
					-becomes dense
					-becomes very dense, weakly cemented
			SM		
5		MC = 7.6%			
					-heavy oxide staining
		MC = 10.7%		7.0	-becomes moist
					Test pit terminated at 7.0 feet below existing grade. No groundwater encountered during excavation. No caving observed.

Appendix B

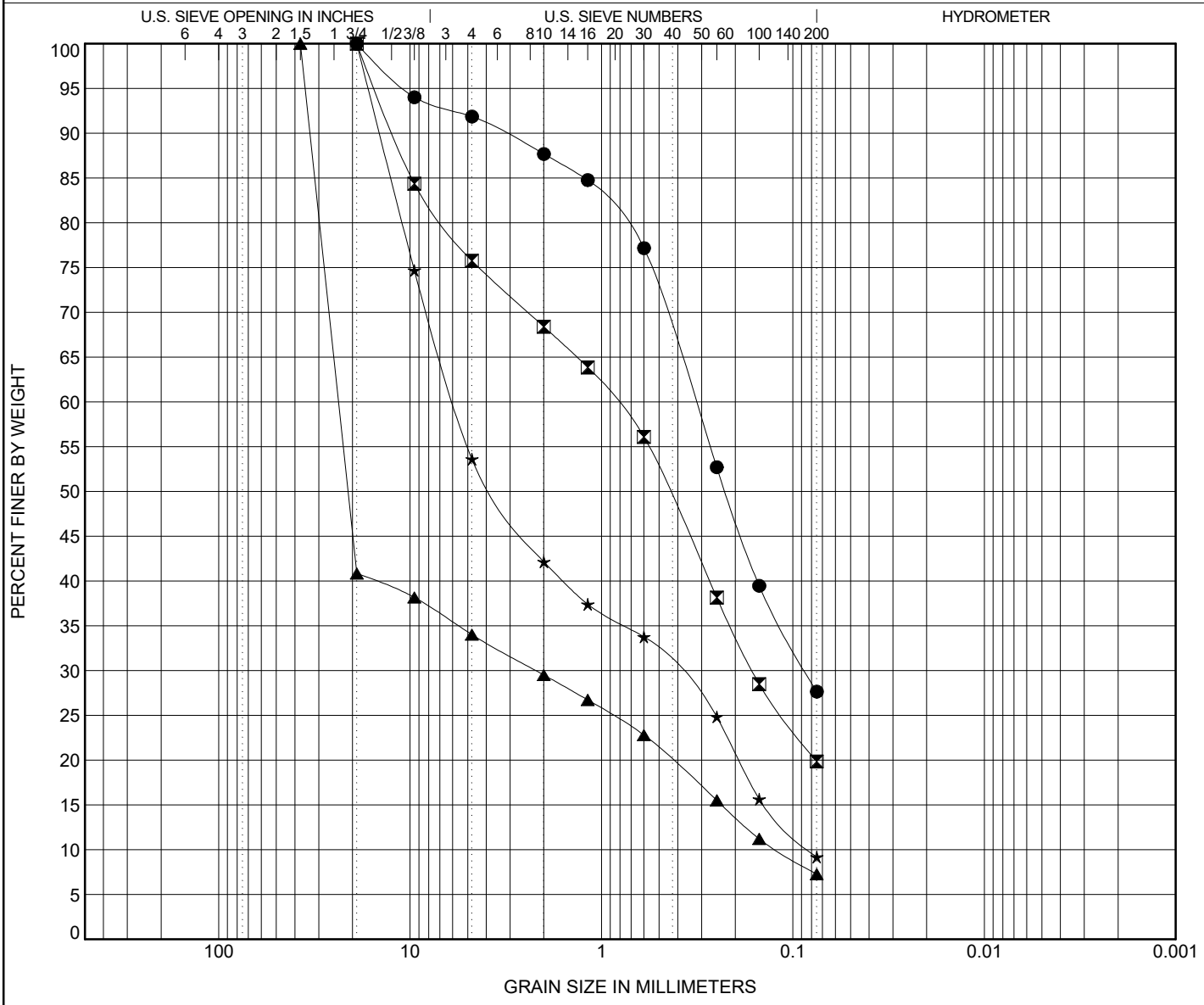
Laboratory Test Results

ES-7975

Earth Solutions NW, LLC
15365 N.E. 90th Street, Suite 100
Redmond, Washington 98052
Telephone: 425-449-4704
Fax: 425-449-4711

GRAIN SIZE DISTRIBUTION

PROJECT NUMBER ES-7975 **PROJECT NAME** Daffron Property



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		Classification	Cc	Cu
●	TP-05	3.50ft.	USDA: Gray Slightly Gravelly Sandy Loam. USCS: SM.		
⊠	TP-05	8.00ft.	USDA: Gray Gravelly Sandy Loam. USCS: SM with Gravel.		
▲	TP-06	6.00ft.	USDA: Tan Extremely Gravelly Sandy Loam. USCS: GW-GM with Sand.	1.68	195.19
★	TP-06	10.00ft.	USDA: Tan Very Gravelly Sandy Loam. USCS: GP-GM with Sand.	0.36	71.58

	Specimen Identification		D100	D60	D30	D10	LL	PL	PI	%Silt	%Clay
●	TP-05	3.5ft.	19	0.324	0.086					27.6	
⊠	TP-05	8.0ft.	19	0.843	0.163					19.9	
▲	TP-06	6.0ft.	37.5	23.681	2.199	0.121				7.3	
★	TP-06	10.0ft.	19	5.861	0.415	0.082				9.2	

GRAIN SIZE USDA ES-7975 DAFFRON PROPERTY.GPJ GINT US LAB.GDT 7/6/21

Report Distribution

ES-7975

EMAIL ONLY

Sea Pac Homes
120 Southwest Everett Mall Way, Suite 100
Everett, Washington 98204

Attention: Mr. Glen Belew

EMAIL ONLY

Perkl Properties, LLC
P.O. Pox 558
Lake Stevens, Washington 98258

Attention: Mr. Nate Perkl

Project: Harbor Grove Development Hydrologic Impacts Assessment
Location: 9110 53rd Ave West, Mukilteo, WA
Job#: SEA-23-1

Sea Pac Homes
120 SW Everett Mall Way Suite #100
Everett, WA 98204
Attn: Glen Belew

Dear Mr. Belew:

I am pleased to submit this letter report providing the results of my hydrologic impacts assessment for the Harbor Grove Development (the Site) at 9110 53rd Ave West in Mukilteo, WA. This project will result in a 7-lot single-family lots on 2.43 acres. The City of Mukilteo has requested this assessment to comply with Section 15.16(C.2.b.i.[b]) of the Mukilteo Municipal Code and "shall include an adequate description of the hydrology of the site, conclusions and recommendations regarding the effect of hydrologic conditions on the proposed development and options and recommendations covering the carrying capabilities of the sites to be developed." The City is primarily concerned with the potential for the development to increase water flow into residential lots west of the Site. Slope stability is not a concern for this site, particularly given the plans to build a retaining structure on the west side of the property.

Background

Existing site conditions are shown on the survey in Figure 1. The Site has a total area of 2.43 acres. There is an abandoned house and garage on the property. There is no formal drainage system on the property, although there is a ditch along the eastern side of the property along 53rd Avenue West.

The proposed development plan is provided in Figure 2. The proposed development plan includes seven single-family residential lots, roads, stormwater drainage, and a detention vault. The site would be graded relatively flat and a retaining wall would be constructed on the west side of the property. A portion of the site (0.19 acres) in the northeast corner of the site would be left unchanged and preserved as native growth.

All of the captured stormwater runoff will be directed to a detention vault beneath the road and equipped with flow control to meet the stormwater detention requirements before leaving the site. Flow from the detention vault will be piped south and west to the existing stormwater system at the intersection of 92nd Street Southwest and Hargreaves place and eventually discharges to Smuggler's Gulch Creek west of the site. The west side of the site at the base of the retaining wall will not gravity drain to the detention vault. Therefore, any drainage from the base of the wall will be captured and pumped to a structure at the top of the wall where it can gravity drain to the detention vault. Public comments have expressed concern regarding maintenance and operation of the pump.

A wetlands survey conducted by Wetland Resources (May 6, 2021) did not identify any wetlands.

Topography, Geology, and Hydrogeology

Regional topography near the site is shown in Figure 3. As shown on this figure, the site is located on a topographic high with Smuggler's Gulch Creek ravine located north and west of the site. Based on City of Mukilteo mapping, the northern ravine drains into the western ravine. The more refined site topography provided on Figure 1 indicates that elevations across the site range from ranging from 410 ft above mean sea level (AMSL) in the center of the site to 378 ft AMSL in the southwest corner of the property. Figure 1 shows the location of the topographic divide that runs north-south through the property. The western portion of the property slopes to the west and the eastern portion of the property generally slopes to the southeast. There is a closed basin (i.e., a bowl where standing water could collect) near the eastern boundary of the site. Although there is no evidence of surface runoff, any surface runoff from the west basin would flow to the west and any surface runoff from the east basin would flow to the southeast. Groundwater flow may not follow the land contours, and it is likely that groundwater flows towards Smuggler's Gulch Creek located north and west of the site.

Earth Solutions NW, LLC conducted a geotechnical study for the Site dated July 30, 2021. This study included eight test pits to depths of 4 to 13 ft and determined that the site was underlain by dense glacial till. The upper 1-4 feet was a combination of topsoil, fill, and weathered glacial till that is generally relatively permeable and well drained. The underlying unweathered glacial till is usually relatively impermeable and perched water often occurs above and within unweathered glacial till. No perched groundwater was detected during excavation of the test pits in June of 2021.

Cobalt Geosciences, LLC conducted a groundwater evaluation dated March 14, 2022. This study included two test pits excavated in early March 2022 to a depth of 14 feet. These explorations encountered 4 to 8 feet of weathered glacial till over unweathered glacial till. No perched groundwater was encountered in either test pit, even though the explorations were conducted at the end of the wet season. Based on these observations, they concluded that saturated groundwater is unlikely to occur above an elevation of 375 feet AMSL. The footing drains for the proposed retaining wall on the west side of the property, with an elevation of 376 feet AMSL and less than 2 ft below existing grade, are unlikely to intercept significant groundwater. In a letter dated August 4, 2022, Earth Solutions NW, LLC estimated that less than 0.5 gpm would be collected in the retaining wall drain during the peak wet season.

Site Visit

I conducted a site visit on March 8, 2022, to observe conditions at and near the Site. The Site surrounded by single-family homes on the north, west, and south sides, and by 53rd Avenue West on the east side. Currently, the Site is lightly forested along with a variety of shrubbery, ferns, and other low vegetation. Portions of the site were disturbed in places, likely due to traversing the site with a trackhoe during the geotechnical investigations. There is no evidence of ponding, surface runoff, or erosion on the site. The ditch along 53rd Avenue West was vegetated with no evidence of erosion.

Surface Water Changes Associated with Development

Hydrologic conditions at a site are determined by a variety of factors, including precipitation, topography, vegetation, soils, and groundwater flux beneath the site. Precipitation that falls on a site is distributed into four boxes: evapotranspiration back into the atmosphere, surface runoff, horizontal interflow within near-surface soils (when perching conditions are present), and deep infiltration to groundwater. Development of a site changes how precipitation is partitioned into these boxes and mitigation is generally required to mitigate hydrologic changes that may increase flooding and erosion or adversely impact streams, wetlands, and associated fish and wildlife habitat.

As documented in the Storm Drainage Plan dated April 19, 2023 and shown on Figure 2, Blueline had developed a stormwater management plan that will convey almost all the surface water from the site into a detention vault that will include flow control measures to restrict peak flows from the site. The Storm Drainage Plan includes WWHM hydrologic modeling to demonstrate that these measures will achieve stormwater permit requirements. In compliance with the stormwater permit, Blueline compared surface runoff from a completely forested pre-developed site (plus the neighboring lot) and the developed site with the detention vault and the flow control. These results are summarized in Table 1 and illustrate that the mitigated surface flows from the site are less than the forested flows from the site. Therefore, in terms of impacts to Smuggler's Gulch Creek (the receiving water body) development of the site will reduce peak flows and erosion.

Although consistent with permit requirements, the Blueline modeling does not directly address the potential hydrologic impacts to properties downhill of the Site. As shown on Figure 1, the eastern portion of the site drains east and into the ditch that flows north along 53rd Avenue West. Water from the east basin does not flow into the properties west of the site on Hargreaves Place. The western portion of the site does drain towards the west and any surface water runoff would flow into the properties along Hargreaves Place (shown on Figure 3). Furthermore, consistent with permit requirements, Blueline modeled 100% forested pre-development conditions, while the site has been developed with a single-family home and is not 100% forested with open areas and low-lying vegetation more similar to pasture. Runoff from pasture is generally higher than runoff from forests.

In order to support this hydrologic assessment, additional hydrologic modeling was conducted to estimate surface water flows towards the Hargreaves properties under existing conditions. The modeling was conducted using the WWHM model and assumed 1.24 acres of either pasture or forest on glacial till soil (type C). As shown on Figure 1,

the west basin includes a small area of impervious surface (the house and a portion of the garage). However, the runoff from these structure discharges to the ground and these surfaces were treated as pervious surface for simplicity. As provided in Table 1, surface discharge from the west basin towards the Hargreaves properties ranged from 0.024 cfs to 0.1 cfs depending on the return period and the vegetation cover (forest or pasture). WWHM results are provided in Attachment A.

As shown on Figure 2, most of the developed site will gravity drain to the detention vault and then to the piped stormwater drainage system that discharges directly to Smuggler's Gulch Creek. However, the area associated with the retaining wall on the west side of the property will be captured at the base of the wall and pumped up to the gravity drainage system at the top of the wall. As long as the pump is functioning, any surface water runoff in this area will not flow towards the Hargreaves properties. However, in the unlikely event that the pump was to fail, it is useful to estimate the surface water runoff from this area. As shown on Figure 2, the retaining wall area is 0.24 acres. WWHM hydrologic modeling was conducted for this area assuming grass vegetation and glacial till soils. (runoff from grass is higher than pasture which is higher than forested). The WWHM output file is provided in Attachment B and the results are summarized in Table 1. As shown in the table, surface discharge from the retaining wall area would range from 0.009 cfs to 0.056 cfs. These flows are significantly less (between 20 percent and 70 percent than existing surface flows towards the Hargreaves properties from the west basin. Therefore, development of the site will reduce surface flow towards the Hargreaves properties with or without the pump at the base of the retaining wall.

Table 1: Surface Discharge Estimates (in cubic feet/second) based on Hydrologic Modeling

Return Period	Entire Site 100% Forested[a]	Entire Site Developed with Flow Control[a]	Existing West Basin (Forest/Pasture)	Retaining Wall area w/o pump
2 year	0.07	0.032	0.024/0.031	0.009
5 year	0.10	0.044	0.037/0.048	0.016
10 year	0.12	0.054	0.045/0.060	0.022
25 year	0.16	0.068	0.055/0.076	0.034
50 year	0.19	0.080	0.063/0.089	0.044
100 year	0.22	0.094	0.070/0.10	0.056

[a] Based on WWHM modeling provided in the Storm Drainage Report dated April 11, 2023.

Groundwater Changes Associated with Site Development

Public comments have expressed concern that site development will increase groundwater recharge and increase the potential for groundwater seepage downhill of the site. The WWHM hydrologic model is designed to predict surface water flows and does not provide estimates of groundwater recharge. Bidlake and Payne (2001)[1] provide an excellent analysis of hydrologic processes in the Puget Sound basin and equations to estimate groundwater recharge based on soil, vegetation, and site development. The equations relevant to this analysis are provided in Table 2. As shown in Table 2, assuming an annual rainfall of 40 inches, development of a glacial till site reduces the groundwater recharge from an estimate of 11.2 inches to 5.6 inches per year. Therefore, site development is likely to reduce the potential for groundwater seepage down gradient of the site.

Table 2: Estimates of Groundwater Recharge (based on Bidlake and Payne (2001)

Soil and land-cover group	**Equation (R = Recharge and P = Precipitation)**	**Recharge (in.) when P = 40 in.**
Forest and non-forest vegetation on soils formed on glacial till	R = 0.388P -4.27	11.2
Developed or urban land with any soil type	R = 0.l94P- 2.13	5.6

[1] Bidlake, W.R. and Payne, K.L., 2001, Estimating Recharge to Ground Water from Precipitation at Naval Submarine Base Bangor and Vicinity, Kitsap County, Washington, U.S. Geologic Survey, Water-Resources Investigation Report 01-4110.

Conclusions

The proposed development plan includes seven single-family residential lots, roads, stormwater drainage, and a detention vault. The site would be graded relatively flat and a retaining wall would be constructed on the west side of the property. A portion of the site (0.19 acres) in the northeast corner of the site would be left unchanged and preserved as native growth. The City of Mukilteo has requested a hydrologic assessment to comply with Section 15.16.0S0(C.2.b.i.[b]) of the Mukilteo Municipal Code. The City is primarily concerned with the potential for the development to increase water flow into residential lots west of the Site.

After development, all of the captured stormwater runoff will be directed to a detention vault beneath the road and equipped with flow control to meet the stormwater detention requirements before leaving the site. Flow from the detention vault will be piped south and west to the existing stormwater system at the intersection of 92nd Street Southwest and Hargreaves place and eventually discharges to Smuggler's Gulch Creek west of the site. The west side of the site at the base of the retaining wall will not gravity drain to the detention vault. Therefore, any drainage from the base of the wall will be captured and pumped to a structure at the top of the wall where it can gravity drain to the detention vault.

The site is located on a topographic high with Smuggler's Gulch Creek ravine located north and west of the site. The western portion of the property slopes to the west and the eastern portion of the property generally slopes to the southeast. Although there is no evidence of surface runoff, any surface runoff from the west basin would flow to the west and any surface runoff from the east basin would flow to the southeast.

Geotechnical explorations have identified that that site is underlain by glacial till and no groundwater was observed in any of the explorations, including two deep test pits conducted in March of 2022. Based on these observations, footing drains for the proposed retaining wall on the west side of the property are unlikely to intercept groundwater. However, groundwater conditions can vary depending on precipitation and soil conditions and it is possible that the footing drains will capture groundwater during periods of high precipitation.

Based on hydrologic modeling presented in the Storm Drainage Report, the stormwater controls proposed for the site will reduce peak flows in Smuggler's Gulch Creek. Hydrologic modeling presented in this report indicates that development of the site will reduce surface discharge towards the Hargreaves properties by 20-70 percent, even without the pump at the base of the retaining wall. Based on methods developed by Bidlake and Payne (2001) development of the site will also reduce groundwater recharge at the site by approximately 50 percent. These analyses indicate that development of the site should reduce the water flow into and beneath the Hargrove properties west of the site.

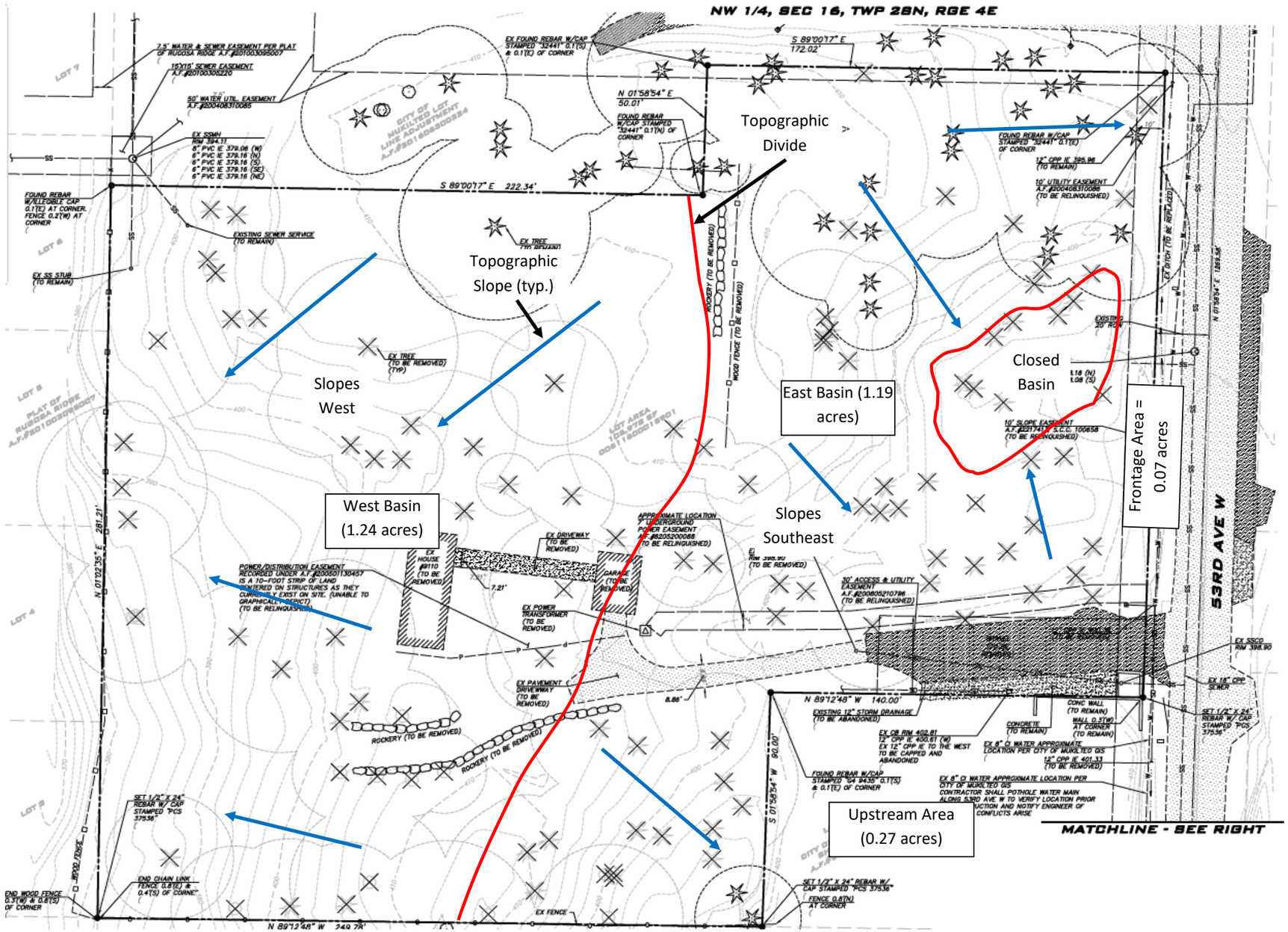
Limitations and Closure

Work for this project was performed and this report prepared in accordance with generally accepted professional practices for the nature and conditions of work completed in the same or similar localities at the time the work was performed. It is intended for the exclusive use of Sea Pac Homes for specific application to the referenced matter. No other warranty, expressed or implied, is made.

I am pleased to provide this letter report. If you have any questions or concerns, please contact the undersigned.

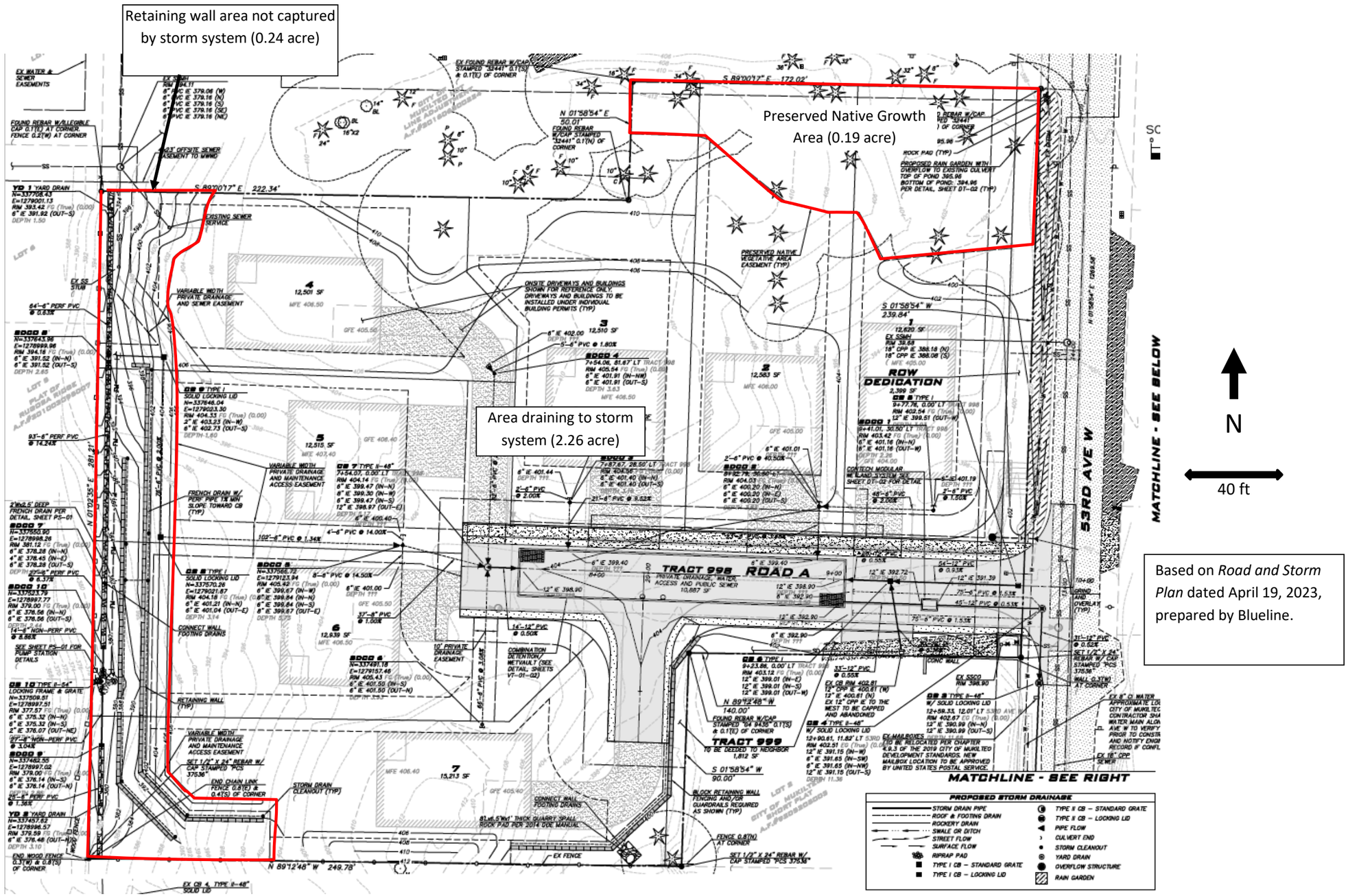
Sincerely,

J. Scott Kindred, PE, LHG
President
Kindred Hydro, Inc.
Date: April 19, 2023



Based on *Existing Conditions & Demo Plan* dated April 19, 2023, prepared by Blueline.

Figure 1: Existing Conditions



Based on *Road and Storm Plan* dated April 19, 2023, prepared by Blueline.

Figure 2: Site Plan Showing Grading and Stormwater Plan

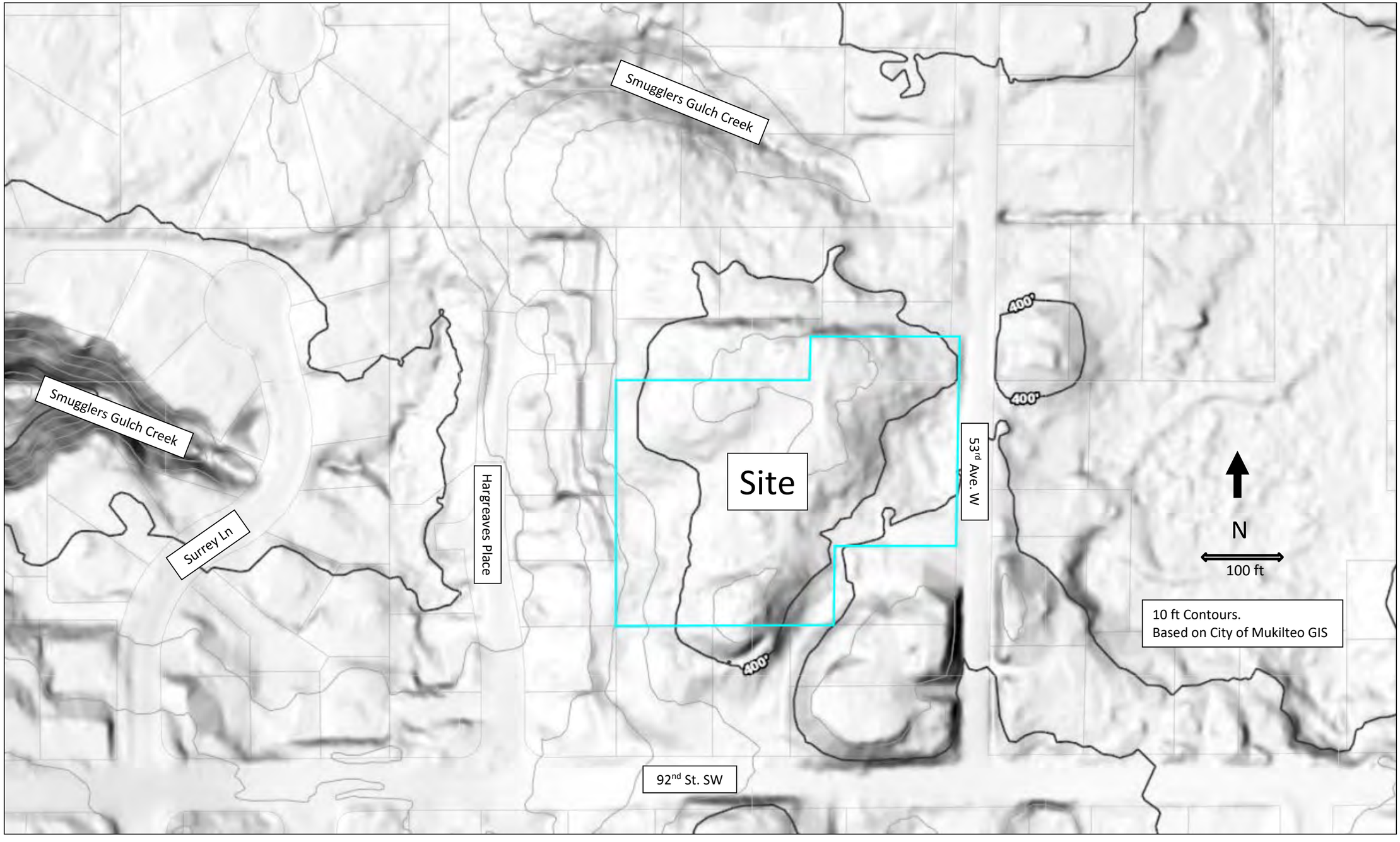


Figure 3: Regional Topography

Kindred Hydro

Attachment A: WWHM Hydrologic Modeling of West Basin

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Harbor Grove West Basin
Site Name:	Harbor Grove
Site Address:	9018 53rd Ave W
City:	Mukilteo
Report Date:	3/10/2023
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	0.800
Version Date:	2019/09/13
Version:	4.2.17

POC Thresholds

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

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Steep	1.24
Pervious Total	1.24
Impervious Land Use	acre
Impervious Total	0
Basin Total	1.24

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

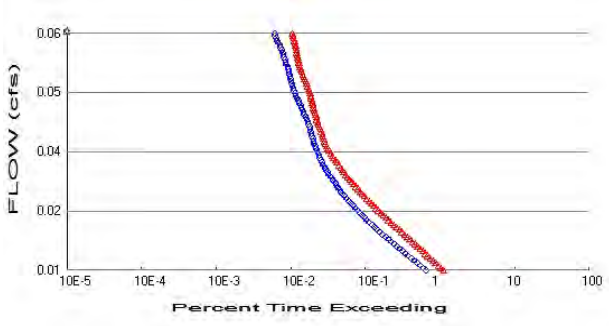
Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Pasture, Steep	1.24
Pervious Total	1.24
Impervious Land Use	acre
Impervious Total	0
Basin Total	1.24

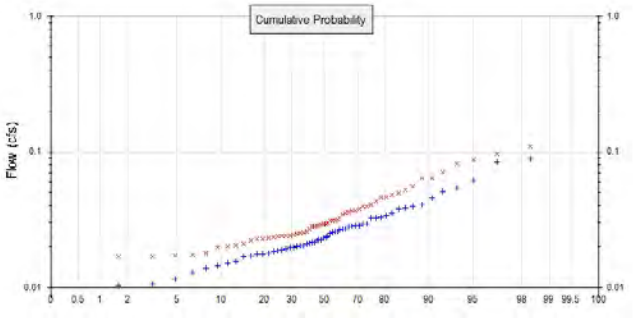
Element Flows To:

Surface	Interflow	Groundwater

Analysis Results

POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 1.24
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 1.24
Total Impervious Area: 0

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.024468
5 year	0.036908
10 year	0.045117
25 year	0.055318
50 year	0.062752
100 year	0.070031

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.031193
5 year	0.047551
10 year	0.059554
25 year	0.075981
50 year	0.089104
100 year	0.102971

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.010	0.020
1950	0.032	0.036
1951	0.021	0.028
1952	0.020	0.024
1953	0.017	0.020
1954	0.045	0.088
1955	0.040	0.046
1956	0.033	0.038
1957	0.038	0.043
1958	0.029	0.036

1959	0.028	0.034
1960	0.026	0.031
1961	0.026	0.031
1962	0.019	0.024
1963	0.026	0.037
1964	0.025	0.031
1965	0.021	0.027
1966	0.013	0.017
1967	0.035	0.039
1968	0.039	0.046
1969	0.018	0.070
1970	0.018	0.023
1971	0.028	0.037
1972	0.028	0.033
1973	0.017	0.023
1974	0.028	0.050
1975	0.018	0.023
1976	0.020	0.022
1977	0.011	0.018
1978	0.019	0.025
1979	0.033	0.052
1980	0.024	0.029
1981	0.020	0.024
1982	0.027	0.030
1983	0.027	0.048
1984	0.022	0.028
1985	0.034	0.040
1986	0.083	0.097
1987	0.029	0.039
1988	0.020	0.024
1989	0.018	0.023
1990	0.023	0.028
1991	0.025	0.029
1992	0.020	0.025
1993	0.014	0.017
1994	0.010	0.017
1995	0.023	0.029
1996	0.054	0.064
1997	0.089	0.110
1998	0.014	0.021
1999	0.022	0.026
2000	0.015	0.017
2001	0.003	0.006
2002	0.022	0.028
2003	0.015	0.020
2004	0.021	0.032
2005	0.021	0.025
2006	0.051	0.064
2007	0.040	0.055
2008	0.061	0.081
2009	0.019	0.024

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.0892	0.1101
2	0.0832	0.0965
3	0.0611	0.0879

4	0.0536	0.0814
5	0.0509	0.0703
6	0.0454	0.0644
7	0.0405	0.0639
8	0.0398	0.0555
9	0.0386	0.0521
10	0.0376	0.0497
11	0.0351	0.0479
12	0.0336	0.0464
13	0.0329	0.0462
14	0.0326	0.0430
15	0.0324	0.0404
16	0.0294	0.0395
17	0.0291	0.0394
18	0.0285	0.0379
19	0.0284	0.0369
20	0.0283	0.0367
21	0.0282	0.0360
22	0.0271	0.0355
23	0.0269	0.0342
24	0.0264	0.0326
25	0.0259	0.0316
26	0.0257	0.0309
27	0.0253	0.0308
28	0.0250	0.0308
29	0.0237	0.0295
30	0.0234	0.0294
31	0.0230	0.0292
32	0.0223	0.0289
33	0.0223	0.0284
34	0.0220	0.0283
35	0.0215	0.0281
36	0.0214	0.0280
37	0.0212	0.0270
38	0.0207	0.0259
39	0.0204	0.0253
40	0.0202	0.0249
41	0.0200	0.0247
42	0.0198	0.0244
43	0.0197	0.0242
44	0.0192	0.0242
45	0.0190	0.0239
46	0.0187	0.0236
47	0.0183	0.0233
48	0.0178	0.0231
49	0.0177	0.0228
50	0.0175	0.0228
51	0.0170	0.0222
52	0.0169	0.0210
53	0.0154	0.0202
54	0.0150	0.0201
55	0.0144	0.0196
56	0.0139	0.0179
57	0.0129	0.0173
58	0.0115	0.0172
59	0.0105	0.0168
60	0.0103	0.0168
61	0.0033	0.0059

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0122	13881	23891	172	Fail
0.0127	12690	21966	173	Fail
0.0133	11586	20146	173	Fail
0.0138	10587	18572	175	Fail
0.0143	9625	17182	178	Fail
0.0148	8787	15862	180	Fail
0.0153	8029	14649	182	Fail
0.0158	7360	13560	184	Fail
0.0163	6731	12545	186	Fail
0.0168	6171	11559	187	Fail
0.0173	5668	10675	188	Fail
0.0178	5191	9862	189	Fail
0.0184	4763	9095	190	Fail
0.0189	4365	8376	191	Fail
0.0194	3991	7747	194	Fail
0.0199	3640	7146	196	Fail
0.0204	3315	6583	198	Fail
0.0209	3050	6072	199	Fail
0.0214	2821	5591	198	Fail
0.0219	2633	5144	195	Fail
0.0224	2413	4735	196	Fail
0.0229	2224	4363	196	Fail
0.0235	2079	4013	193	Fail
0.0240	1942	3717	191	Fail
0.0245	1825	3459	189	Fail
0.0250	1705	3191	187	Fail
0.0255	1581	2969	187	Fail
0.0260	1478	2766	187	Fail
0.0265	1372	2577	187	Fail
0.0270	1268	2391	188	Fail
0.0275	1191	2224	186	Fail
0.0281	1112	2072	186	Fail
0.0286	1038	1932	186	Fail
0.0291	985	1819	184	Fail
0.0296	944	1694	179	Fail
0.0301	901	1594	176	Fail
0.0306	860	1487	172	Fail
0.0311	816	1391	170	Fail
0.0316	773	1320	170	Fail
0.0321	741	1232	166	Fail
0.0326	695	1163	167	Fail
0.0332	663	1097	165	Fail
0.0337	632	1043	165	Fail
0.0342	608	999	164	Fail
0.0347	581	945	162	Fail
0.0352	560	892	159	Fail
0.0357	543	849	156	Fail
0.0362	525	798	152	Fail
0.0367	511	766	149	Fail
0.0372	497	732	147	Fail
0.0377	481	699	145	Fail
0.0383	464	670	144	Fail
0.0388	455	646	141	Fail
0.0393	443	624	140	Fail

0.0398	430	603	140	Fail
0.0403	420	590	140	Fail
0.0408	412	577	140	Fail
0.0413	401	564	140	Fail
0.0418	395	547	138	Fail
0.0423	387	535	138	Fail
0.0429	380	519	136	Fail
0.0434	371	502	135	Fail
0.0439	364	491	134	Fail
0.0444	350	479	136	Fail
0.0449	338	471	139	Fail
0.0454	325	460	141	Fail
0.0459	316	450	142	Fail
0.0464	305	442	144	Fail
0.0469	295	434	147	Fail
0.0474	289	427	147	Fail
0.0480	275	419	152	Fail
0.0485	269	411	152	Fail
0.0490	262	403	153	Fail
0.0495	249	398	159	Fail
0.0500	244	387	158	Fail
0.0505	237	379	159	Fail
0.0510	232	372	160	Fail
0.0515	224	358	159	Fail
0.0520	220	351	159	Fail
0.0525	217	341	157	Fail
0.0531	211	327	154	Fail
0.0536	208	320	153	Fail
0.0541	204	308	150	Fail
0.0546	202	297	147	Fail
0.0551	197	291	147	Fail
0.0556	194	285	146	Fail
0.0561	187	280	149	Fail
0.0566	183	277	151	Fail
0.0571	177	268	151	Fail
0.0576	173	265	153	Fail
0.0582	169	260	153	Fail
0.0587	167	256	153	Fail
0.0592	163	254	155	Fail
0.0597	155	250	161	Fail
0.0602	153	249	162	Fail
0.0607	145	243	167	Fail
0.0612	139	240	172	Fail
0.0617	136	235	172	Fail
0.0622	132	229	173	Fail
0.0628	131	225	171	Fail

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.
The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

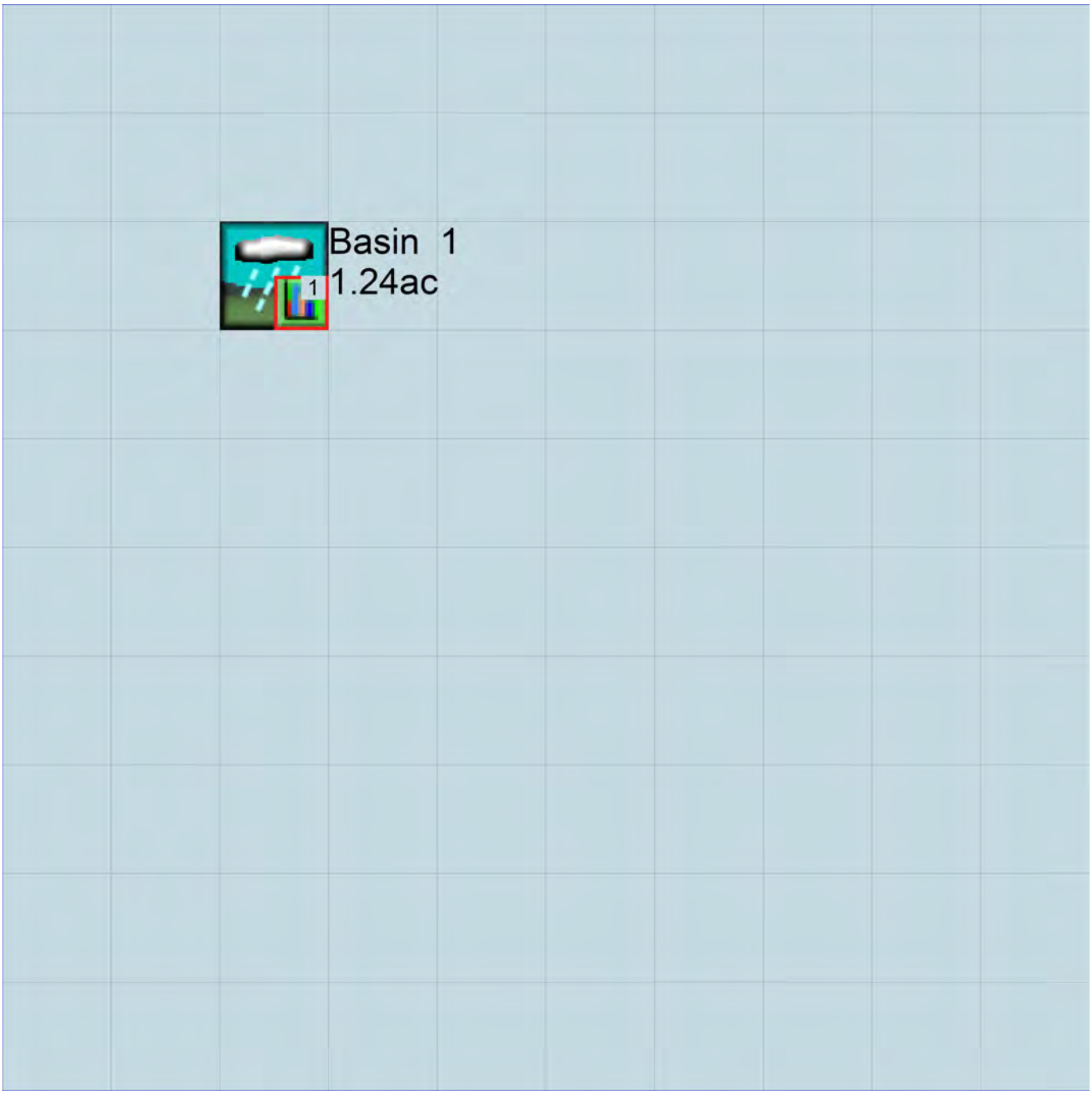
PERLND Changes

No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic

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Kindred Hydro

Attachment B: WWHM Hydrologic Modeling of Retaining Wall Area

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	Harbor Grove Model Retaining Area
Site Name:	Harbor Grove
Site Address:	9018 53rd Ave W
City:	Mukilteo
Report Date:	3/10/2023
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	0.800
Version Date:	2019/09/13
Version:	4.2.17

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
A B, Lawn, Flat	0.24
Pervious Total	0.24

Impervious Land Use	acre
Impervious Total	0
Basin Total	0.24

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

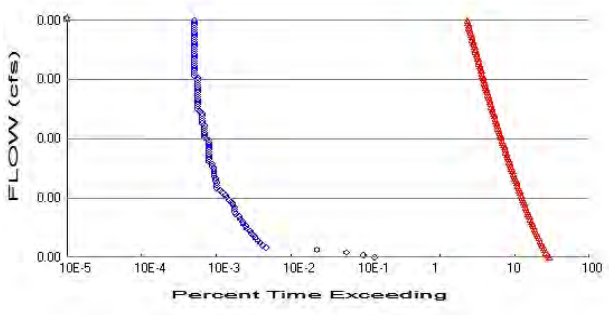
Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.24
Pervious Total	0.24
Impervious Land Use	acre
Impervious Total	0
Basin Total	0.24

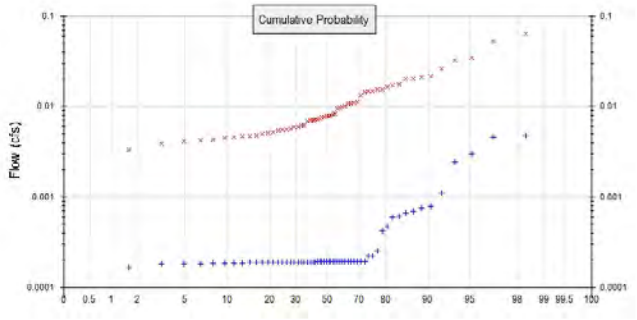
Element Flows To:

Surface	Interflow	Groundwater

Analysis Results

POC 1





\+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0.24
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.24
Total Impervious Area: 0

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.000248
5 year	0.000526
10 year	0.000831
25 year	0.001425
50 year	0.00208
100 year	0.002982

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.008595
5 year	0.015925
10 year	0.022587
25 year	0.033485
50 year	0.043692
100 year	0.05595

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.000	0.011
1950	0.000	0.013
1951	0.000	0.008
1952	0.000	0.008
1953	0.000	0.007
1954	0.001	0.034
1955	0.001	0.016
1956	0.000	0.008
1957	0.000	0.017
1958	0.000	0.021

1959	0.000	0.007
1960	0.000	0.007
1961	0.001	0.064
1962	0.000	0.008
1963	0.000	0.022
1964	0.001	0.011
1965	0.000	0.005
1966	0.000	0.003
1967	0.000	0.008
1968	0.000	0.009
1969	0.000	0.053
1970	0.000	0.006
1971	0.001	0.011
1972	0.000	0.016
1973	0.000	0.008
1974	0.000	0.018
1975	0.000	0.011
1976	0.000	0.006
1977	0.000	0.004
1978	0.000	0.005
1979	0.000	0.026
1980	0.000	0.010
1981	0.000	0.005
1982	0.000	0.007
1983	0.000	0.015
1984	0.000	0.006
1985	0.001	0.010
1986	0.002	0.020
1987	0.001	0.008
1988	0.000	0.005
1989	0.000	0.010
1990	0.000	0.006
1991	0.000	0.005
1992	0.000	0.007
1993	0.000	0.004
1994	0.000	0.005
1995	0.000	0.006
1996	0.003	0.015
1997	0.005	0.032
1998	0.000	0.004
1999	0.000	0.005
2000	0.000	0.006
2001	0.000	0.001
2002	0.000	0.006
2003	0.000	0.004
2004	0.000	0.007
2005	0.000	0.005
2006	0.005	0.020
2007	0.000	0.015
2008	0.000	0.015
2009	0.000	0.005

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.0048	0.0643
2	0.0046	0.0534
3	0.0030	0.0344

4	0.0024	0.0324
5	0.0011	0.0264
6	0.0008	0.0218
7	0.0008	0.0214
8	0.0007	0.0205
9	0.0007	0.0203
10	0.0006	0.0177
11	0.0006	0.0171
12	0.0005	0.0164
13	0.0004	0.0155
14	0.0003	0.0154
15	0.0002	0.0147
16	0.0002	0.0147
17	0.0002	0.0146
18	0.0002	0.0133
19	0.0002	0.0112
20	0.0002	0.0109
21	0.0002	0.0108
22	0.0002	0.0108
23	0.0002	0.0101
24	0.0002	0.0099
25	0.0002	0.0096
26	0.0002	0.0094
27	0.0002	0.0083
28	0.0002	0.0082
29	0.0002	0.0080
30	0.0002	0.0078
31	0.0002	0.0077
32	0.0002	0.0077
33	0.0002	0.0077
34	0.0002	0.0073
35	0.0002	0.0073
36	0.0002	0.0072
37	0.0002	0.0070
38	0.0002	0.0070
39	0.0002	0.0069
40	0.0002	0.0062
41	0.0002	0.0062
42	0.0002	0.0060
43	0.0002	0.0059
44	0.0002	0.0057
45	0.0002	0.0055
46	0.0002	0.0055
47	0.0002	0.0054
48	0.0002	0.0052
49	0.0002	0.0052
50	0.0002	0.0050
51	0.0002	0.0048
52	0.0002	0.0047
53	0.0002	0.0047
54	0.0002	0.0046
55	0.0002	0.0045
56	0.0002	0.0043
57	0.0002	0.0042
58	0.0002	0.0041
59	0.0002	0.0039
60	0.0002	0.0033
61	0.0002	0.0015

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0001	2868	626906	21858	Fail
0.0001	2002	597603	29850	Fail
0.0002	1202	570225	47439	Fail
0.0002	478	545628	114148	Fail
0.0002	100	523384	523384	Fail
0.0002	90	503920	559911	Fail
0.0002	83	484670	583939	Fail
0.0003	78	466918	598612	Fail
0.0003	72	450448	625622	Fail
0.0003	68	435690	640720	Fail
0.0003	64	420932	657706	Fail
0.0003	61	407243	667611	Fail
0.0004	55	394409	717107	Fail
0.0004	53	382432	721569	Fail
0.0004	49	370454	756028	Fail
0.0004	48	359118	748162	Fail
0.0004	45	348424	774275	Fail
0.0005	43	338585	787406	Fail
0.0005	39	328532	842389	Fail
0.0005	38	319121	839792	Fail
0.0005	38	309924	815589	Fail
0.0005	38	301582	793636	Fail
0.0006	36	293027	813963	Fail
0.0006	34	284899	837938	Fail
0.0006	32	276771	864909	Fail
0.0006	30	269713	899043	Fail
0.0006	29	262227	904231	Fail
0.0007	26	255168	981415	Fail
0.0007	24	248110	1033791	Fail
0.0007	22	241693	1098604	Fail
0.0007	22	235277	1069440	Fail
0.0007	22	229074	1041245	Fail
0.0008	21	222871	1061290	Fail
0.0008	21	217096	1033790	Fail
0.0008	20	211664	1058320	Fail
0.0008	20	206188	1030940	Fail
0.0008	20	200862	1004309	Fail
0.0009	20	195729	978645	Fail
0.0009	19	191023	1005384	Fail
0.0009	19	186168	979831	Fail
0.0009	17	181463	1067429	Fail
0.0009	17	176885	1040500	Fail
0.0010	17	172650	1015588	Fail
0.0010	17	168373	990429	Fail
0.0010	17	164159	965641	Fail
0.0010	17	160074	941611	Fail
0.0010	17	156352	919717	Fail
0.0011	17	152524	897200	Fail
0.0011	17	148823	875429	Fail
0.0011	17	145209	854170	Fail
0.0011	15	141872	945813	Fail
0.0011	15	138450	923000	Fail
0.0012	15	135156	901040	Fail
0.0012	15	131883	879220	Fail

0.0012	15	128868	859120	Fail
0.0012	15	125809	838726	Fail
0.0012	14	122857	877550	Fail
0.0013	14	119991	857078	Fail
0.0013	14	117382	838442	Fail
0.0013	14	114751	819650	Fail
0.0013	14	112141	801007	Fail
0.0013	13	109618	843215	Fail
0.0013	12	107372	894766	Fail
0.0014	12	105019	875158	Fail
0.0014	12	102730	856083	Fail
0.0014	12	100527	837725	Fail
0.0014	12	98367	819725	Fail
0.0014	12	96357	802975	Fail
0.0015	12	94303	785858	Fail
0.0015	12	92271	768925	Fail
0.0015	12	90346	752883	Fail
0.0015	12	88464	737200	Fail
0.0015	12	86603	721691	Fail
0.0016	12	84742	706183	Fail
0.0016	12	83010	691750	Fail
0.0016	12	81384	678200	Fail
0.0016	11	79695	724500	Fail
0.0016	11	78048	709527	Fail
0.0017	11	76444	694945	Fail
0.0017	11	75011	681918	Fail
0.0017	11	73513	668300	Fail
0.0017	11	71995	654500	Fail
0.0017	11	70519	641081	Fail
0.0018	11	69150	628636	Fail
0.0018	11	67760	616000	Fail
0.0018	11	66305	602772	Fail
0.0018	11	64936	590327	Fail
0.0018	11	63653	578663	Fail
0.0019	11	62327	566609	Fail
0.0019	11	61022	554745	Fail
0.0019	11	59739	543081	Fail
0.0019	11	58541	532190	Fail
0.0019	11	57322	521109	Fail
0.0020	11	56124	510218	Fail
0.0020	11	54926	499327	Fail
0.0020	11	53857	489609	Fail
0.0020	11	52745	479500	Fail
0.0020	11	51675	469772	Fail
0.0021	11	50649	460445	Fail
0.0021	11	49643	451300	Fail

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.
The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

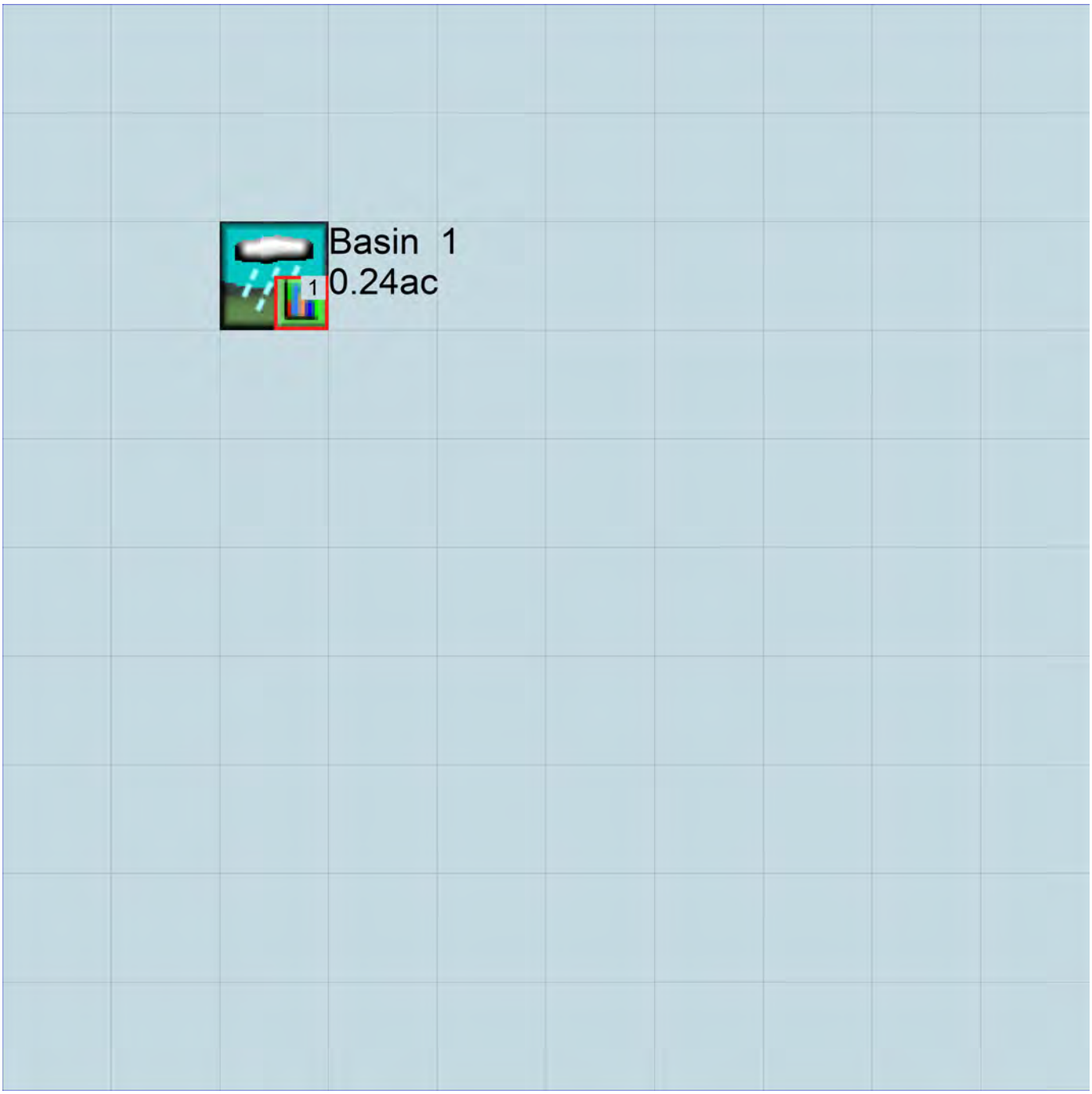
PERLND Changes

No PERLND changes have been made.

IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic

Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                    UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM         26   Harbor Grove Model Retaining Area.wdm
MESSU       25   PreHarbor Grove Model Retaining Area.MES
            27   PreHarbor Grove Model Retaining Area.L61
            28   PreHarbor Grove Model Retaining Area.L62
            30   POCHarbor Grove Model Retaining Area1.dat
END FILES

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

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

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

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

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

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

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

END PERLND

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

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

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

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

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

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

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

```
END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND   7                        0.24     COPY   501     12
PERLND   7                        0.24     COPY   501     13

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

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



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

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

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

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

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

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

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    0.8            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    0.8            IMPLND   1 999 EXTNL  PREC
```

```
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    501 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

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


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                    UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM         26   Harbor Grove Model Retaining Area.wdm
MESSU       25   MitHarbor Grove Model Retaining Area.MES
            27   MitHarbor Grove Model Retaining Area.L61
            28   MitHarbor Grove Model Retaining Area.L62
            30   POCHarbor Grove Model Retaining Area1.dat
END FILES

OPN SEQUENCE
    INGRP               INDELT 00:15
      PERLND      16
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title---------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                   MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                       in  out           ***
   16     C, Lawn, Flat           1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************ Active Sections ******************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   16         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   16         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO
```

```
  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   16         0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   16             0       4.5      0.03       400      0.05       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   16             0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                              ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   16           0.1      0.25      0.25         6       0.5      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
             ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS       IFWS       LZS       AGWS       GWVS
   16             0         0         0          0       2.5          1          0
  END PWAT-STATE1

END PERLND

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

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

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

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

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

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

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

```
END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  16                        0.24     COPY   501     12
PERLND  16                        0.24     COPY   501     13

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

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



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

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

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

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

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

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

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    0.8            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    0.8            IMPLND   1 999 EXTNL  PREC
```

```
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>             <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

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


END MASS-LINK

END RUN
```

Disclaimer

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Section 7 Other Permits

No other permits are required at this time.

Section 8 Operations and Maintenance

See Operations and Maintenance (O&M) information on the following pages. The operation and maintenance manual was prepared in accordance with the City of Mukilteo Development Standards and the DOE Manual.

Individual lot owners will be responsible for tightlined roof and footing drains, drainage facilities, and private service drain systems located within their property limits. Symptoms of failure of this system are yard drains or clean-outs overtopping. If this happens, the homeowners should remove the yard drain lid or clean-out lid and remove visible debris. If problems still persist, the homeowner should have the service drain line cleaned.

Detention, water quality treatment facilities, and majority of the onsite stormwater conveyance are within the right-of-way or dedicated public easements/tracts. Operation and maintenance of these facilities and of all storm drain collection and conveyance systems within the public right-of-way will be the responsibility of the City of Mukilteo.

Operation and Maintenance information from the DOE Manual standards, Rain Garden Handbook for Western Washington, and the Contech Modular Wetland System is included on the following pages for each of the facilities listed below:

- No. 3 - Closed Detention (Tanks/Vaults)
- No. 4 - Control Structure/Flow Restrictor
- No. 5 - Catch Basins
- No. 18 - Catch Basin Inserts
- Rain Garden
- Contech Modular Wetland System
- Zoeller Model 153

No. 3 – Closed Detention Systems (Tanks/Vaults)

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
Storage Area	Plugged Air Vents	One-half of the cross section of a vent is blocked at any point or the vent is damaged.	Vents open and functioning.
	Debris and Sediment	Accumulated sediment depth exceeds 10% of the diameter of the storage area for 1/2 length of storage vault or any point depth exceeds 15% of diameter. (Example: 72-inch storage tank would require cleaning when sediment reaches depth of 7 inches for more than 1/2 length of tank.)	All sediment and debris removed from storage area.
	Joints Between Tank/Pipe Section	Any openings or voids allowing material to be transported into facility. (Will require engineering analysis to determine structural stability).	All joint between tank/pipe sections are sealed.
	Tank Pipe Bent Out of Shape	Any part of tank/pipe is bent out of shape more than 10% of its design shape. (Review required by engineer to determine structural stability).	Tank/pipe repaired or replaced to design.
	Vault Structure Includes Cracks in Wall, Bottom, Damage to Frame and/or Top Slab	Cracks wider than 1/2-inch and any evidence of soil particles entering the structure through the cracks, or maintenance/inspection personnel determines that the vault is not structurally sound. Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or any evidence of soil particles entering the vault through the walls.	Vault replaced or repaired to design specifications and is structurally sound. No cracks more than 1/4-inch wide at the joint of the inlet/outlet pipe.
Manhole	Cover Not in Place	Cover is missing or only partially in place. Any open manhole requires maintenance.	Manhole is closed.
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread (may not apply to self-locking lids).	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. Intent is to keep cover from sealing off access to maintenance.	Cover can be removed and reinstalled by one maintenance person.
	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, misalignment, not securely attached to structure wall, rust, or cracks.	Ladder meets design standards. Allows maintenance person safe access.
Catch Basins	See “Catch Basins” (No. 5)	See “Catch Basins” (No. 5).	See “Catch Basins” (No. 5).

No. 4 – Control Structure/Flow Restrictor

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash and Debris (Includes Sediment)	Material exceeds 25% of sump depth or 1 foot below orifice plate.	Control structure orifice is not blocked. All trash and debris removed.
	Structural Damage	Structure is not securely attached to manhole wall.	Structure securely attached to wall and outlet pipe.
		Structure is not in upright position (allow up to 10% from plumb).	Structure in correct position.
		Connections to outlet pipe are not watertight and show signs of rust.	Connections to outlet pipe are water tight; structure repaired or replaced and works as designed.
		Any holes--other than designed holes--in the structure.	Structure has no holes other than designed holes.
Cleanout Gate	Damaged or Missing	Cleanout gate is not watertight or is missing.	Gate is watertight and works as designed.
		Gate cannot be moved up and down by one maintenance person.	Gate moves up and down easily and is watertight.
		Chain/rod leading to gate is missing or damaged.	Chain is in place and works as designed.
		Gate is rusted over 50% of its surface area.	Gate is repaired or replaced to meet design standards.
Orifice Plate	Damaged or Missing	Control device is not working properly due to missing, out of place, or bent orifice plate.	Plate is in place and works as designed.
	Obstructions	Any trash, debris, sediment, or vegetation blocking the plate.	Plate is free of all obstructions and works as designed.
Overflow Pipe	Obstructions	Any trash or debris blocking (or having the potential of blocking) the overflow pipe.	Pipe is free of all obstructions and works as designed.
Manhole	See “Closed Detention Systems” (No. 3).	See “Closed Detention Systems” (No. 3).	See “Closed Detention Systems” (No. 3).
Catch Basin	See “Catch Basins” (No. 5).	See “Catch Basins” (No. 5).	See “Catch Basins” (No. 5).

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
General	Trash & Debris	Trash or debris which is located immediately in front of the catch basin opening or is blocking inletting capacity of the basin by more than 10%.	No Trash or debris located immediately in front of catch basin or on grate opening.
		Trash or debris (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of six inches clearance from the debris surface to the invert of the lowest pipe.	No trash or debris in the catch basin.
		Trash or debris in any inlet or outlet pipe blocking more than 1/3 of its height.	Inlet and outlet pipes free of trash or debris.
		Dead animals or vegetation that could generate odors that could cause complaints or dangerous gases (e.g., methane).	No dead animals or vegetation present within the catch basin.
	Sediment	Sediment (in the basin) that exceeds 60 percent of the sump depth as measured from the bottom of basin to invert of the lowest pipe into or out of the basin, but in no case less than a minimum of 6 inches clearance from the sediment surface to the invert of the lowest pipe.	No sediment in the catch basin
	Structure Damage to Frame and/or Top Slab	Top slab has holes larger than 2 square inches or cracks wider than 1/4 inch (Intent is to make sure no material is running into basin).	Top slab is free of holes and cracks.
		Frame not sitting flush on top slab, i.e., separation of more than 3/4 inch of the frame from the top slab. Frame not securely attached	Frame is sitting flush on the riser rings or top slab and firmly attached.
	Fractures or Cracks in Basin Walls/ Bottom	Maintenance person judges that structure is unsound.	Basin replaced or repaired to design standards.
		Grout fillet has separated or cracked wider than 1/2 inch and longer than 1 foot at the joint of any inlet/outlet pipe or any evidence of soil particles entering catch basin through cracks.	Pipe is regrouted and secure at basin wall.
	Settlement/ Misalignment	If failure of basin has created a safety, function, or design problem.	Basin replaced or repaired to design standards.
	Vegetation	Vegetation growing across and blocking more than 10% of the basin opening.	No vegetation blocking opening to basin.
		Vegetation growing in inlet/outlet pipe joints that is more than six inches tall and less than six inches apart.	No vegetation or root growth present.
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

No. 6 – Debris Barriers (e.g., Trash Racks)

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

No. 12 – Wetvaults

Maintenance Component	Defect	Condition When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Trash/Debris Accumulation	Trash and debris accumulated in vault, pipe or inlet/outlet (includes floatables and non-floatables).	Remove trash and debris from vault.
	Sediment Accumulation in Vault	Sediment accumulation in vault bottom exceeds the depth of the sediment zone plus 6-inches.	Remove sediment from vault.
	Damaged Pipes	Inlet/outlet piping damaged or broken and in need of repair.	Pipe repaired and/or replaced.
	Access Cover Damaged/Not Working	Cover cannot be opened or removed, especially by one person.	Pipe repaired or replaced to proper working specifications.
	Ventilation	Ventilation area blocked or plugged.	Blocking material removed or cleared from ventilation area. A specified % of the vault surface area must provide ventilation to the vault interior (see design specifications).
	Vault Structure Damage - Includes Cracks in Walls Bottom, Damage to Frame and/or Top Slab	Maintenance/inspection personnel determine that the vault is not structurally sound.	Vault replaced or repairs made so that vault meets design specifications and is structurally sound.
		Cracks wider than 1/2-inch at the joint of any inlet/outlet pipe or evidence of soil particles entering through the cracks.	Vault repaired so that no cracks exist wider than 1/4-inch at the joint of the inlet/outlet pipe.
	Baffles	Baffles corroding, cracking, warping and/or showing signs of failure as determined by maintenance/inspection staff.	Baffles repaired or replaced to specifications.
	Access Ladder Damage	Ladder is corroded or deteriorated, not functioning properly, not attached to structure wall, missing rungs, has cracks and/or misaligned. Confined space warning sign missing.	Ladder replaced or repaired to specifications, and is safe to use as determined by inspection personnel. Replace sign warning of confined space entry requirements. Ladder and entry notification complies with OSHA standards.

No. 18 – Catchbasin Inserts

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is Performed
General	Sediment Accumulation	When sediment forms a cap over the insert media of the insert and/or unit.	No sediment cap on the insert media and its unit.
	Trash and Debris Accumulation	Trash and debris accumulates on insert unit creating a blockage/restriction.	Trash and debris removed from insert unit. Runoff freely flows into catch basin.
	Media Insert Not Removing Oil	Effluent water from media insert has a visible sheen.	Effluent water from media insert is free of oils and has no visible sheen.
	Media Insert Water Saturated	Catch basin insert is saturated with water and no longer has the capacity to absorb.	Remove and replace media insert
	Media Insert-Oil Saturated	Media oil saturated due to petroleum spill that drains into catch basin.	Remove and replace media insert.
	Media Insert Use Beyond Normal Product Life	Media has been used beyond the typical average life of media insert product.	Remove and replace media at regular intervals, depending on insert product.

Maintenance Checklist

RAIN GARDEN LOCATION	CONDITION	MAINTENANCE ACTIVITY
Side Slopes	Persistent soil erosion on slopes	See "Minimize Exposed Soil and Erosion."
Rain Garden Bottom Area	Visible sediment in the rain garden that reduces drainage rate	• Remove sediment accumulation. • If sediment is deposited from water entering the rain garden, determine the source and stabilize the area. See "Minimize Exposed Soil and Erosion."
	Matted accumulation of leaves reducing drainage rate	Remove leaves.
Ponded Water	Ponded water remains in the basin more than 3 days after the end of a storm	Confirm leaf, debris or sediment buildup is not reducing drainage rate. If necessary, remove leaf litter, debris or sediment. If this does not solve the problem, consult a professional with rain garden expertise to evaluate the following: • Check for other water inputs (e.g., groundwater). • Verify that the rain garden is sized appropriately for the contributing area. Confirm that the contributing area has not increased. • Determine if the soil is clogged by sediment or if the soil is compacted.
Pipe Inlet/Outlet	Water is backing up in pipe	Clear pipes of sediment and debris with snake and/or flush with water.
	Damaged or cracked drain pipes	Repair or seal cracks, or replace if repair is insufficient.
Water Inlet	Rock or cobble is removed or missing and flow is eroding soil.	Maintain a cover of rock or cobbles to protect the ground where water flows into the rain garden from a pipe or swale.
Weeds	Problem weeds are present.	• Remove weeds by hand, especially in spring when the soil is moist and the weeds are small. • Dig or pull weeds out by the roots before they go to seed. • Apply mulch after weeding (see "Mulch").

RAIN GARDEN LOCATION	CONDITION	MAINTENANCE ACTIVITY
Vegetation	Dying, dead, or unhealthy plants	• Maintain a healthy cover of plants. • Remove any diseased plants or plant parts and dispose to avoid risk of spreading the disease to other plants. • Disinfect gardening tools after pruning to prevent the spread of disease. • Re-stake trees if they need more support, but plan to remove stakes and ties after the first year.
	Vegetation reduces sight distances and sidewalks.	Keep sidewalks and sight distances on roadways clear. Choose low-growing species where sight lines are required.
	Vegetation is crowding inlets and outlets.	Keep water inlets and outlets in the rain garden clear of vegetation. Move vegetation if problem persists.
	Yellowing, poor growth, poor flowering, spotting or curled leaves, weak roots or stems	• Test soil to identify specific nutrient deficiencies. • Consult with a professional knowledgeable in natural amendments or refer to natural lawn and garden care resources. • Do not use synthetic fertilizers. • Consider selecting different plants for soil conditions.
Mulch	Bare spots (without mulch cover) are present or mulch depth less than 2 inches.	• Supplement mulch with hand tools to a depth of 2 to 3 inches. • Keep all mulch away from woody stems.

Notice to installing contractor: Instructions must remain with installation.

Trusted. Tested. Tough.®

FM2676
0419
Supersedes
0117

Product information presented here reflects conditions at time of publication. Consult factory regarding discrepancies or inconsistencies.

Register your Zoeller Pump Company Product on our website: http://reg.zoellerpumps.com/

ZOELLER® PUMP COMPANY

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SHIP TO: 3649 Cane Run Road • Louisville, KY 40211-1961
TEL: (502) 778-2731 • 1 (800) 928-PUMP • **FAX**: (502) 774-3624

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FAMILY OWNED AMERICAN PROUD

INSTALLATION INSTRUCTIONS

RECOMMENDED MODELS

DATE INSTALLED:
MODEL NUMBER:

EFFLUENT*/SUMP/DEWATERING	SEWAGE
53® / 57 Series, 98 Series	264 Series
137 Series, 151 / 152 / 153 Series	266 / 267 Series

NOTICE: VENT HOLE FOR CHECK VALVE SEE #3 IN CAUTION SECTION BELOW AND #4 ON PAGE 3

P/N 151797

* Effluent systems should specify that pumps should not handle solids exceeding 3/4" (19.1 mm) in order to prevent large solids from entering leeching fields, mound systems, etc. (Model 49 Series has 3/8" [9.5 mm] solids capability. 50, 90, and 151 Series have 1/2" [12.7 mm], 130 Series has 5/8" [15.9 mm], 152 and 153 models have 3/4" [19.1 mm].) Where code permits, sewage pumps can be used for effluent systems. Nonautomatic pumps with external-level controls are recommended for septic tank effluent applications.

PREINSTALLATION CHECKLIST - ALL INSTALLATIONS

1. Inspect your pump. Occasionally, products are damaged during shipment. If the unit is damaged, contact your dealer before using. DO NOT remove the test plugs in the cover nor the motor housing.
2. Carefully read the literature provided to familiarize yourself with specific details regarding installation and use. These materials should be retained for future reference.

⚠ WARNING

SEE BELOW FOR LIST OF WARNINGS

1. Make certain that the receptacle is within the reach of the pump's power supply cord. DO NOT USE AN EXTENSION CORD. Extension cords that are too long or too light do not deliver sufficient voltage to the pump motor, and they could present a safety hazard if the insulation were to become damaged or the connection end were to fall into a wet or damp area.
2. **Make sure the pump electrical supply circuit is equipped with fuses or circuit breakers of proper capacity.** A separate branch circuit is recommended, sized according to the "National Electrical Code" for the current shown on the pump nameplate.
3. **Testing for ground.** As a safety measure, each electrical outlet should be checked for ground using an Underwriters Laboratory Listed circuit analyzer which will indicate if the power, neutral and ground wires are correctly connected to your outlet. If they are not, call a qualified, licensed electrician.
4. **For Added Safety.** Pumping and other equipment with a 3-prong grounded plug must be connected to a 3-prong grounded receptacle. For added safety the receptacle may be protected with a ground-fault circuit interrupter. When a pump needs to be connected in a watertight junction box, the plug can be removed and spliced to the supply cable with proper grounding. For added safety this circuit may be protected by a ground-fault circuit interrupter. The complete installation must comply with the National Electrical Code and all applicable local codes and ordinances.
5. **FOR YOUR PROTECTION, ALWAYS DISCONNECT PUMP FROM ITS POWER SOURCE BEFORE HANDLING.** Single phase pumps are supplied with a 3-prong grounded plug to help protect you against the possibility of electrical shock. **DO NOT, UNDER ANY CIRCUMSTANCES, REMOVE THE GROUND PIN.** The 3-prong plug must be inserted into a mating 3-prong grounded receptacle. If the installation does not have such a receptacle, it must be changed to the proper type, wired and grounded in accordance with the National Electrical Code and all applicable local codes and ordinances. Three phase pumps require motor starting devices with motor overload protection. See FM0486 for duplex installations.
6. The tank is to be vented in accordance with local plumbing code. Pumps **must** be installed in accordance with the National Electrical Code and all applicable local codes and ordinances. Pumps are not to be installed in locations classified as hazardous in accordance with National Electrical Code, ANSI/NFPA 70.
7. **Risk of electrical shock.** Do not remove power supply cord and strain relief or connect conduit directly to the pump.
8. Installation and servicing of electrical circuits and hardware should be performed by a qualified licensed electrician.
9. Pump installation and servicing should be performed by a qualified person.
10. Risk of electrical shock - These pumps have not been investigated for use in swimming pool and marine areas.
11. Prop65 Warning for California residents: Cancer and Reproductive Harm- www.P65Warnings.ca.gov.

⚠ CAUTION

SEE BELOW FOR LIST OF CAUTIONS

1. Check to be sure your power source is capable of handling the voltage requirements of the motor, as indicated on the pump name plate.
2. The installation of automatic pumps with variable level float switches or nonautomatic pumps using auxiliary variable level float switches is the responsibility of the installing party and care should be taken that the tethered float switch will not hang up on the pump apparatus or pit peculiarities and is secured so that the pump will shut off. It is recommended to use rigid piping and fittings and the pit be 18" (46 cm) or larger in diameter.
3. **Information - vent hole purpose.** It is necessary that all submersible sump, effluent, and sewage pumps capable of handling various sizes of solid waste be of the bottom intake design to reduce clogging and seal failures. If a check valve is incorporated in the installation, a vent hole (approx. 3/16" [5 mm]) must be drilled in the discharge pipe below the check valve and pit cover to purge the unit of trapped air. Trapped air is caused by agitation and/or a dry basin. Vent hole should be checked periodically for clogging. The 53® / 57, and 98 Series pumps have a vent located in the pump housing opposite the float, adjacent to a housing lug, but an additional vent hole is recommended. The vent hole on a High Head application may cause too much turbulence. You may not want to drill one. If you choose not to drill a vent hole, be sure the pump case and impeller is covered with liquid before connecting the pipe to the check valve and no inlet carries air to the pump intake. NOTE: THE HOLE MUST ALSO BE BELOW THE BASIN COVER AND CLEANED PERIODICALLY. Water stream will be visible from this hole during pump run periods.
4. Pump should be checked frequently for debris and/or buildup which may interfere with the float "on" or "off" position. Repair and service should be performed by Zoeller Pump Company Authorized Service and Warranty Center.
5. Dewatering and effluent sump pumps are not designed for use in pits handling raw sewage.
6. Maximum operating temperature for standard model pumps must not exceed 130 °F (54 °C).
7. Pump models 266, 267, and 137 must be operated in an upright position. Do not attempt to start pump when tilted or laying on its side.
8. Do not operate a pump in an application where the Total Dynamic Head is less than the minimum Total Dynamic Head listed on the Pump Performance Curves.

NOTE: Pumps with the "UL" mark and pumps with the "US" mark are tested to UL Standard UL778. CSA Certified pumps are certified to CSA Standard C22.2 No. 108.

REFER TO WARRANTY ON PAGE 2.

Limited Warranty

Manufacturer warrants, to the purchaser and subsequent owner during the warranty period, every new product to be free from defects in material and workmanship under normal use and service, when properly used and maintained, for a period of three years from the date of purchase. Proof of purchase is required. Parts that fail within the warranty period, that inspections determine to be defective in material or workmanship, will be repaired, replaced or remanufactured at Manufacturer's option, provided however, that by so doing we will not be obligated to replace an entire assembly, the entire mechanism or the complete unit. No allowance will be made for shipping charges, damages, labor or other charges that may occur due to product failure, repair or replacement.

This warranty does not apply to and there shall be no warranty for any material or product that has been disassembled without prior approval of Manufacturer, subjected to misuse, misapplication, neglect, alteration, accident or act of nature; that has not been installed, operated or maintained in accordance with Manufacturer's installation instructions; that has been exposed to outside substances including but not limited to the following: sand, gravel, cement, mud, tar, hydrocarbons, hydrocarbon derivatives (oil, gasoline, solvents, etc.), or other abrasive or corrosive substances, wash towels or feminine sanitary products, etc. in all pumping applications. The warranty set out in the paragraph above is in lieu of all other warranties expressed or implied; and we do not authorize any representative or other person to assume for us any other liability in connection with our products.

Contact Manufacturer at, 3649 Cane Run Road, Louisville, Kentucky 40211, Attention: Customer Service Department to obtain any needed repair or replacement of part(s) or additional information pertaining to our warranty.

MANUFACTURER EXPRESSLY DISCLAIMS LIABILITY FOR SPECIAL, CONSEQUENTIAL OR INCIDENTAL DAMAGES OR BREACH OF EXPRESSED OR IMPLIED WARRANTY; AND ANY IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE AND OF MERCHANTABILITY SHALL BE LIMITED TO THE DURATION OF THE EXPRESSED WARRANTY.

Some states do not allow limitations on the duration of an implied warranty, so the above limitation may not apply to you. Some states do not allow the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights and you may also have other rights which vary from state to state.

In instances where property damages are incurred as a result of an alleged product failure, the property owner must retain possession of the product for investigation purpose.

EASY DO'S & DON'T'S FOR INSTALLING A SUMP PUMP

1. **DO** read thoroughly all installation material provided with the pump.
2. **DO** inspect pump for any visible damage caused by shipping. Contact dealer if pump appears to be damaged.
3. **DO** clean all debris from the sump. Be sure that the pump will have a hard, flat surface beneath it. DO NOT install on sand, gravel or dirt.
4. **DO** be sure that the sump is large enough to allow proper clearance for the level control switch(es) to operate properly.
5. **DO Always Disconnect Pump From Power Source Before Handling.**
   DO always connect to a separately protected and properly grounded circuit.
   DO NOT ever cut, splice, or damage power cord (Only splice in a watertight junction box).
   DO NOT carry or lift pump by its power cord.
   DO NOT use an extension cord with a sump pump.
6. **DO** install a check valve and a union in the discharge line.
   DO NOT use a discharge pipe smaller than the pump discharge.
7. **DO NOT** use a sump pump as a trench or excavation pump, or for pumping sewage, gasoline, or other hazardous liquids.
8. **DO** test pump immediately after installation to be sure that the system is working properly.
9. **DO** cover sump with an adequate sump cover.
10. **DO** review all applicable local and national codes and verify that the installation conforms to each of them.
11. **DO** consult manufacturer for clarifications or questions.
12. **DO** consider a two pump system with an alarm where an installation may become overloaded or primary pump failure would result in property damages.
13. **DO** consider a D.C. Backup System where a sump or dewatering pump is necessary for the prevention of property damages from flooding due to A.C. power disruptions, mechanical or electrical problems or system overloading.
14. **DO** inspect and test system for proper operations at least every three months.

SERVICE CHECKLIST

⚠ WARNING **ELECTRICAL PRECAUTIONS**- Before servicing a pump, always shut off the main power breaker and then unplug the pump - making sure you are wearing insulated protective sole shoes and not standing in water. Under flooded conditions, contact your local electric company or a qualified licensed electrician for disconnecting electrical service prior to pump removal.

⚠ WARNING Submersible pumps contain oils which becomes pressurized and hot under operating conditions. **Allow 2-1/2 hours after disconnecting before attempting service.**

CONDITION	COMMON CAUSES
A. Pump will not start or run.	Check fuse, low voltage, overload open, open or incorrect wiring, open switch, impeller or seal bound mechanically, defective capacitor or relay when used, motor or wiring shorted. Float assembly held down. Switch defective, damaged, or out of adjustment.
B. Motor overheats and trips overload or blows fuse.	Incorrect voltage, negative head (discharge open lower than normal) impeller or seal bound mechanically, defective capacitor or relay, motor shorted.
C. Pump starts and stops too often.	Float tight on rod, check valve stuck or none installed in long distance line, overload open, level switch(s) defective, sump pit too small.
D. Pump will not shut off.	Debris under float assembly, float or float rod bound by pit sides or other, switch defective, damaged or out of adjustment.
E. Pump operates but delivers little or no water.	Check strainer housing, discharge pipe, or if check valve is used vent hole must be clear. Discharge head exceeds pump capacity. Low or incorrect voltage. Incorrect motor rotation. Capacitor defective. Incoming water containing air or causing air to enter pumping chamber.
F. Drop in head and/or capacity after a period of use.	Increased pipe friction, clogged line or check valve. Abrasive material and adverse chemicals could possibly deteriorate impeller and pump housing. Check line. Remove base and inspect.

If the above checklist does not uncover the problem, consult the factory. Do not attempt to service or otherwise disassemble pump. Service must be performed by Zoeller Authorized Service and Warranty Centers. Go to www.zoellerpumps.com to find the Authorized Service Center in your area.

Section 9 Bond Quantities

A bond quantity worksheet will be completed for the proposed improvements before permit issuance.

Appendix

A.1 FULL WWHM OUTPUT – DETENTION VAULT

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	21073 Vault Remodel
Site Name:	
Site Address:	
City:	
Report Date:	8/5/2022
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	0.800
Version Date:	2021/08/18
Version:	4.2.18

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
C, Forest, Mod	2.31
C, Lawn, Mod	0.13
Pervious Total	2.44

Impervious Land Use	acre
ROADS MOD	0.08
ROOF TOPS FLAT	0.07
Impervious Total	0.15
Basin Total	2.59

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
C, Pasture, Mod	1.24
C, Lawn, Mod	0.13
Pervious Total	1.37

Impervious Land Use	acre
ROADS MOD	0.36
ROOF TOPS FLAT	0.74
Impervious Total	1.1
Basin Total	2.47

Element Flows To:

Surface	Interflow	Groundwater
Vault 1	Vault 1	

Basin 2

Bypass:	Yes
GroundWater:	No

Pervious Land Use	acre
C, Pasture, Mod	0.11
Pervious Total	0.11

Impervious Land Use	acre
ROADS FLAT	0.01
Impervious Total	0.01
Basin Total	0.12

Element Flows To:

Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Vault 1

Width: 20 ft.
Length: 125 ft.
Depth: 7.5 ft.
Discharge Structure
Riser Height: 7 ft.
Riser Diameter: 12 in.
Orifice 1 Diameter: 0.84375 in Elevation:0 ft.
Orifice 2 Diameter: 0.78125 in Elevation:3.2 ft.
Orifice 3 Diameter: 1.125 in. Elevation:5.4 ft.
Element Flows To:
Outlet 1 Outlet 2

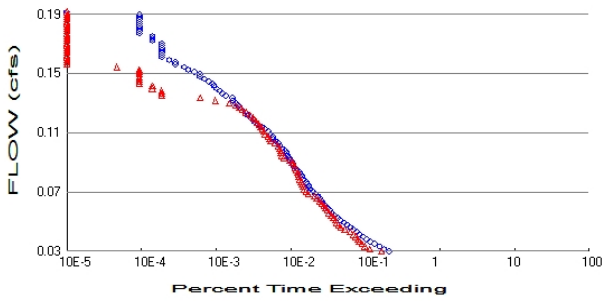
Vault Hydraulic Table

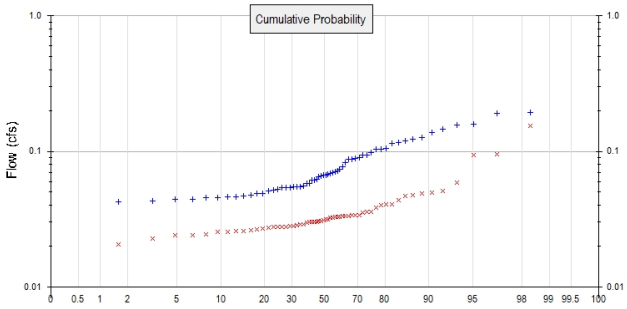
Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.057	0.000	0.000	0.000
0.0833	0.057	0.004	0.005	0.000
0.1667	0.057	0.009	0.007	0.000
0.2500	0.057	0.014	0.009	0.000
0.3333	0.057	0.019	0.011	0.000
0.4167	0.057	0.023	0.012	0.000
0.5000	0.057	0.028	0.013	0.000
0.5833	0.057	0.033	0.014	0.000
0.6667	0.057	0.038	0.015	0.000
0.7500	0.057	0.043	0.016	0.000
0.8333	0.057	0.047	0.017	0.000
0.9167	0.057	0.052	0.018	0.000
1.0000	0.057	0.057	0.019	0.000
1.0833	0.057	0.062	0.020	0.000
1.1667	0.057	0.067	0.020	0.000
1.2500	0.057	0.071	0.021	0.000
1.3333	0.057	0.076	0.022	0.000
1.4167	0.057	0.081	0.023	0.000
1.5000	0.057	0.086	0.023	0.000
1.5833	0.057	0.090	0.024	0.000
1.6667	0.057	0.095	0.024	0.000
1.7500	0.057	0.100	0.025	0.000
1.8333	0.057	0.105	0.026	0.000
1.9167	0.057	0.110	0.026	0.000
2.0000	0.057	0.114	0.027	0.000
2.0833	0.057	0.119	0.027	0.000
2.1667	0.057	0.124	0.028	0.000
2.2500	0.057	0.129	0.029	0.000
2.3333	0.057	0.133	0.029	0.000
2.4167	0.057	0.138	0.030	0.000
2.5000	0.057	0.143	0.030	0.000
2.5833	0.057	0.148	0.031	0.000
2.6667	0.057	0.153	0.031	0.000
2.7500	0.057	0.157	0.032	0.000
2.8333	0.057	0.162	0.032	0.000
2.9167	0.057	0.167	0.033	0.000
3.0000	0.057	0.172	0.033	0.000
3.0833	0.057	0.177	0.033	0.000

3.1667	0.057	0.181	0.034	0.000
3.2500	0.057	0.186	0.038	0.000
3.3333	0.057	0.191	0.041	0.000
3.4167	0.057	0.196	0.043	0.000
3.5000	0.057	0.200	0.045	0.000
3.5833	0.057	0.205	0.046	0.000
3.6667	0.057	0.210	0.048	0.000
3.7500	0.057	0.215	0.049	0.000
3.8333	0.057	0.220	0.051	0.000
3.9167	0.057	0.224	0.052	0.000
4.0000	0.057	0.229	0.053	0.000
4.0833	0.057	0.234	0.054	0.000
4.1667	0.057	0.239	0.055	0.000
4.2500	0.057	0.243	0.056	0.000
4.3333	0.057	0.248	0.057	0.000
4.4167	0.057	0.253	0.058	0.000
4.5000	0.057	0.258	0.059	0.000
4.5833	0.057	0.263	0.060	0.000
4.6667	0.057	0.267	0.061	0.000
4.7500	0.057	0.272	0.062	0.000
4.8333	0.057	0.277	0.063	0.000
4.9167	0.057	0.282	0.064	0.000
5.0000	0.057	0.287	0.065	0.000
5.0833	0.057	0.291	0.066	0.000
5.1667	0.057	0.296	0.067	0.000
5.2500	0.057	0.301	0.068	0.000
5.3333	0.057	0.306	0.068	0.000
5.4167	0.057	0.310	0.074	0.000
5.5000	0.057	0.315	0.081	0.000
5.5833	0.057	0.320	0.085	0.000
5.6667	0.057	0.325	0.089	0.000
5.7500	0.057	0.330	0.093	0.000
5.8333	0.057	0.334	0.096	0.000
5.9167	0.057	0.339	0.099	0.000
6.0000	0.057	0.344	0.101	0.000
6.0833	0.057	0.349	0.104	0.000
6.1667	0.057	0.353	0.106	0.000
6.2500	0.057	0.358	0.108	0.000
6.3333	0.057	0.363	0.111	0.000
6.4167	0.057	0.368	0.113	0.000
6.5000	0.057	0.373	0.115	0.000
6.5833	0.057	0.377	0.117	0.000
6.6667	0.057	0.382	0.119	0.000
6.7500	0.057	0.387	0.121	0.000
6.8333	0.057	0.392	0.123	0.000
6.9167	0.057	0.397	0.125	0.000
7.0000	0.057	0.401	0.126	0.000
7.0833	0.057	0.406	0.382	0.000
7.1667	0.057	0.411	0.833	0.000
7.2500	0.057	0.416	1.349	0.000
7.3333	0.057	0.420	1.817	0.000
7.4167	0.057	0.425	2.148	0.000
7.5000	0.057	0.430	2.340	0.000
7.5833	0.057	0.435	2.544	0.000
7.6667	0.000	0.000	2.711	0.000

Analysis Results

POC 1





\+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 2.44
Total Impervious Area: 0.15

Mitigated Landuse Totals for POC #1
Total Pervious Area: 1.48
Total Impervious Area: 1.11

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.069517
5 year	0.100436
10 year	0.124218
25 year	0.158287
50 year	0.186754
100 year	0.218011

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.032094
5 year	0.044348
10 year	0.054026
25 year	0.068196
50 year	0.080278
100 year	0.093771

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.061	0.028
1950	0.089	0.032
1951	0.065	0.028
1952	0.066	0.024
1953	0.066	0.023
1954	0.156	0.033
1955	0.090	0.038
1956	0.067	0.048
1957	0.094	0.044
1958	0.138	0.031

1959	0.058	0.034
1960	0.058	0.032
1961	0.194	0.033
1962	0.062	0.029
1963	0.098	0.027
1964	0.055	0.027
1965	0.044	0.033
1966	0.046	0.024
1967	0.105	0.030
1968	0.071	0.041
1969	0.146	0.028
1970	0.048	0.028
1971	0.087	0.040
1972	0.087	0.030
1973	0.068	0.030
1974	0.104	0.031
1975	0.069	0.027
1976	0.046	0.029
1977	0.044	0.026
1978	0.054	0.026
1979	0.123	0.031
1980	0.056	0.026
1981	0.055	0.026
1982	0.051	0.035
1983	0.077	0.028
1984	0.052	0.041
1985	0.082	0.036
1986	0.159	0.096
1987	0.068	0.059
1988	0.054	0.031
1989	0.074	0.021
1990	0.054	0.036
1991	0.055	0.034
1992	0.062	0.033
1993	0.043	0.024
1994	0.042	0.030
1995	0.049	0.047
1996	0.119	0.049
1997	0.191	0.154
1998	0.071	0.026
1999	0.052	0.030
2000	0.115	0.033
2001	0.037	0.020
2002	0.045	0.034
2003	0.049	0.028
2004	0.103	0.049
2005	0.045	0.031
2006	0.127	0.051
2007	0.114	0.034
2008	0.094	0.094
2009	0.047	0.028

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.1936	0.1542
2	0.1906	0.0958
3	0.1588	0.0945

4	0.1564	0.0587
5	0.1457	0.0510
6	0.1382	0.0494
7	0.1266	0.0487
8	0.1227	0.0478
9	0.1190	0.0467
10	0.1154	0.0436
11	0.1142	0.0407
12	0.1053	0.0406
13	0.1043	0.0398
14	0.1033	0.0384
15	0.0977	0.0360
16	0.0943	0.0358
17	0.0940	0.0353
18	0.0902	0.0338
19	0.0889	0.0336
20	0.0874	0.0336
21	0.0868	0.0335
22	0.0823	0.0333
23	0.0768	0.0333
24	0.0736	0.0327
25	0.0713	0.0327
26	0.0711	0.0326
27	0.0693	0.0324
28	0.0684	0.0323
29	0.0680	0.0315
30	0.0671	0.0314
31	0.0664	0.0312
32	0.0656	0.0307
33	0.0652	0.0305
34	0.0619	0.0301
35	0.0616	0.0300
36	0.0613	0.0300
37	0.0583	0.0300
38	0.0580	0.0297
39	0.0556	0.0291
40	0.0550	0.0290
41	0.0549	0.0283
42	0.0548	0.0282
43	0.0543	0.0279
44	0.0542	0.0278
45	0.0540	0.0278
46	0.0523	0.0278
47	0.0516	0.0276
48	0.0506	0.0272
49	0.0489	0.0270
50	0.0488	0.0267
51	0.0476	0.0261
52	0.0468	0.0258
53	0.0461	0.0257
54	0.0459	0.0256
55	0.0455	0.0255
56	0.0453	0.0245
57	0.0442	0.0242
58	0.0440	0.0241
59	0.0432	0.0228
60	0.0422	0.0207
61	0.0371	0.0200

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0348	4440	3501	78	Pass
0.0363	3814	2453	64	Pass
0.0378	3298	2119	64	Pass
0.0394	2864	1939	67	Pass
0.0409	2494	1788	71	Pass
0.0424	2218	1707	76	Pass
0.0440	1990	1590	79	Pass
0.0455	1787	1482	82	Pass
0.0470	1624	1340	82	Pass
0.0486	1479	1129	76	Pass
0.0501	1347	1004	74	Pass
0.0516	1214	930	76	Pass
0.0532	1108	889	80	Pass
0.0547	983	848	86	Pass
0.0563	898	803	89	Pass
0.0578	824	753	91	Pass
0.0593	763	699	91	Pass
0.0609	705	664	94	Pass
0.0624	662	631	95	Pass
0.0639	627	595	94	Pass
0.0655	585	559	95	Pass
0.0670	556	522	93	Pass
0.0685	521	481	92	Pass
0.0701	496	441	88	Pass
0.0716	454	369	81	Pass
0.0731	426	344	80	Pass
0.0747	399	327	81	Pass
0.0762	374	312	83	Pass
0.0777	353	304	86	Pass
0.0793	341	295	86	Pass
0.0808	317	282	88	Pass
0.0824	306	275	89	Pass
0.0839	292	270	92	Pass
0.0854	280	264	94	Pass
0.0870	263	257	97	Pass
0.0885	244	249	102	Pass
0.0900	232	237	102	Pass
0.0916	223	225	100	Pass
0.0931	213	208	97	Pass
0.0946	204	173	84	Pass
0.0962	195	162	83	Pass
0.0977	189	159	84	Pass
0.0992	177	157	88	Pass
0.1008	165	152	92	Pass
0.1023	154	144	93	Pass
0.1038	144	131	90	Pass
0.1054	134	115	85	Pass
0.1069	125	111	88	Pass
0.1085	121	106	87	Pass
0.1100	115	97	84	Pass
0.1115	107	93	86	Pass
0.1131	96	89	92	Pass
0.1146	88	85	96	Pass

0.1161	77	80	103	Pass
0.1177	71	75	105	Pass
0.1192	67	70	104	Pass
0.1207	61	66	108	Pass
0.1223	56	61	108	Pass
0.1238	53	54	101	Pass
0.1253	47	48	102	Pass
0.1269	44	44	100	Pass
0.1284	42	39	92	Pass
0.1299	39	32	82	Pass
0.1315	36	21	58	Pass
0.1330	35	13	37	Pass
0.1346	29	4	13	Pass
0.1361	26	4	15	Pass
0.1376	24	4	16	Pass
0.1392	22	3	13	Pass
0.1407	20	3	15	Pass
0.1422	19	2	10	Pass
0.1438	17	2	11	Pass
0.1453	15	2	13	Pass
0.1468	13	2	15	Pass
0.1484	13	2	15	Pass
0.1499	11	2	18	Pass
0.1514	9	2	22	Pass
0.1530	8	1	12	Pass
0.1545	6	0	0	Pass
0.1560	6	0	0	Pass
0.1576	5	0	0	Pass
0.1591	4	0	0	Pass
0.1607	4	0	0	Pass
0.1622	4	0	0	Pass
0.1637	4	0	0	Pass
0.1653	4	0	0	Pass
0.1668	4	0	0	Pass
0.1683	4	0	0	Pass
0.1699	3	0	0	Pass
0.1714	3	0	0	Pass
0.1729	3	0	0	Pass
0.1745	2	0	0	Pass
0.1760	2	0	0	Pass
0.1775	2	0	0	Pass
0.1791	2	0	0	Pass
0.1806	2	0	0	Pass
0.1821	2	0	0	Pass
0.1837	2	0	0	Pass
0.1852	2	0	0	Pass
0.1868	2	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Vault 1 POC	☐	152.29			☐	0.00			
Total Volume Infiltrated		152.29	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

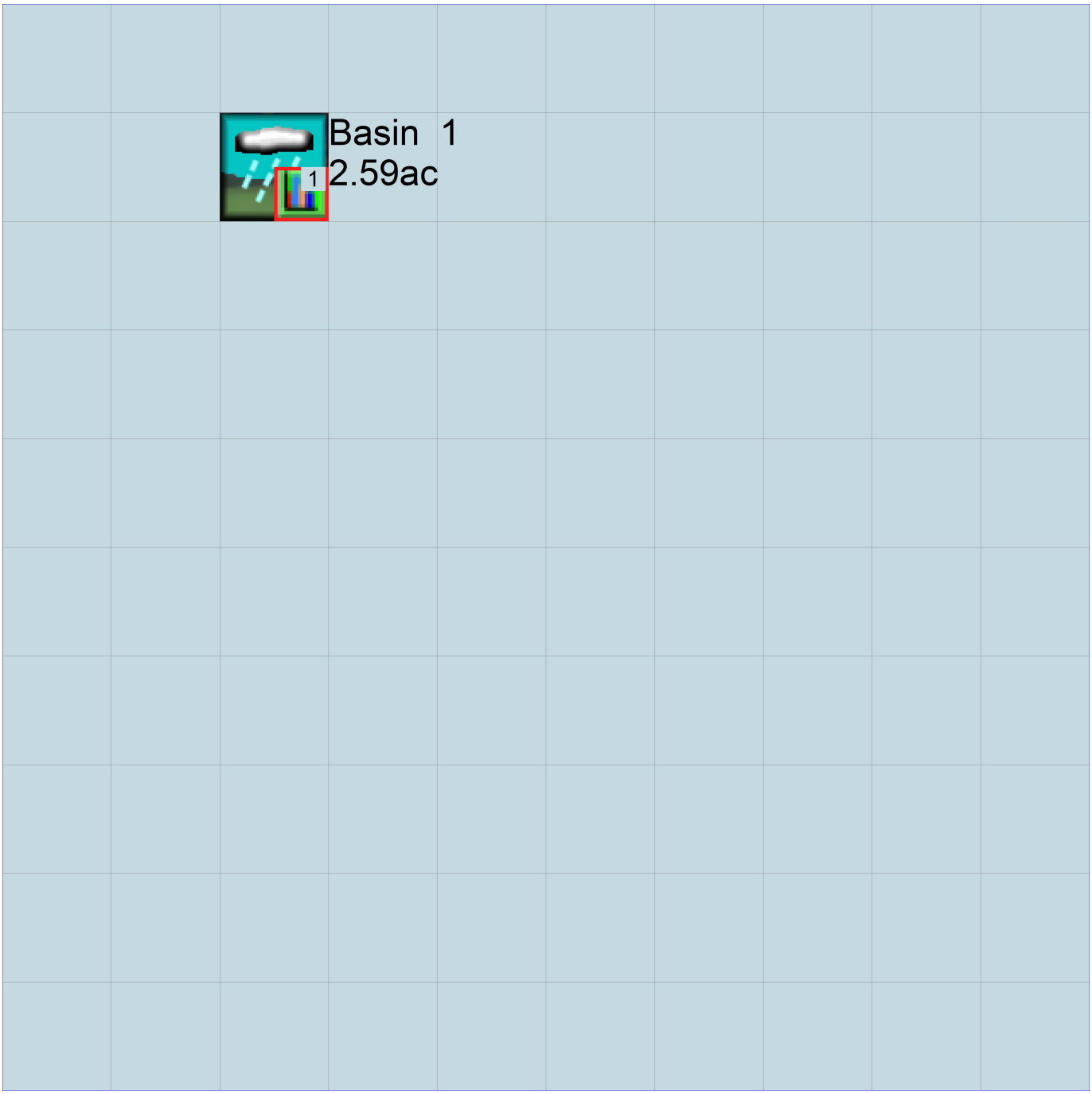
PERLND Changes

No PERLND changes have been made.

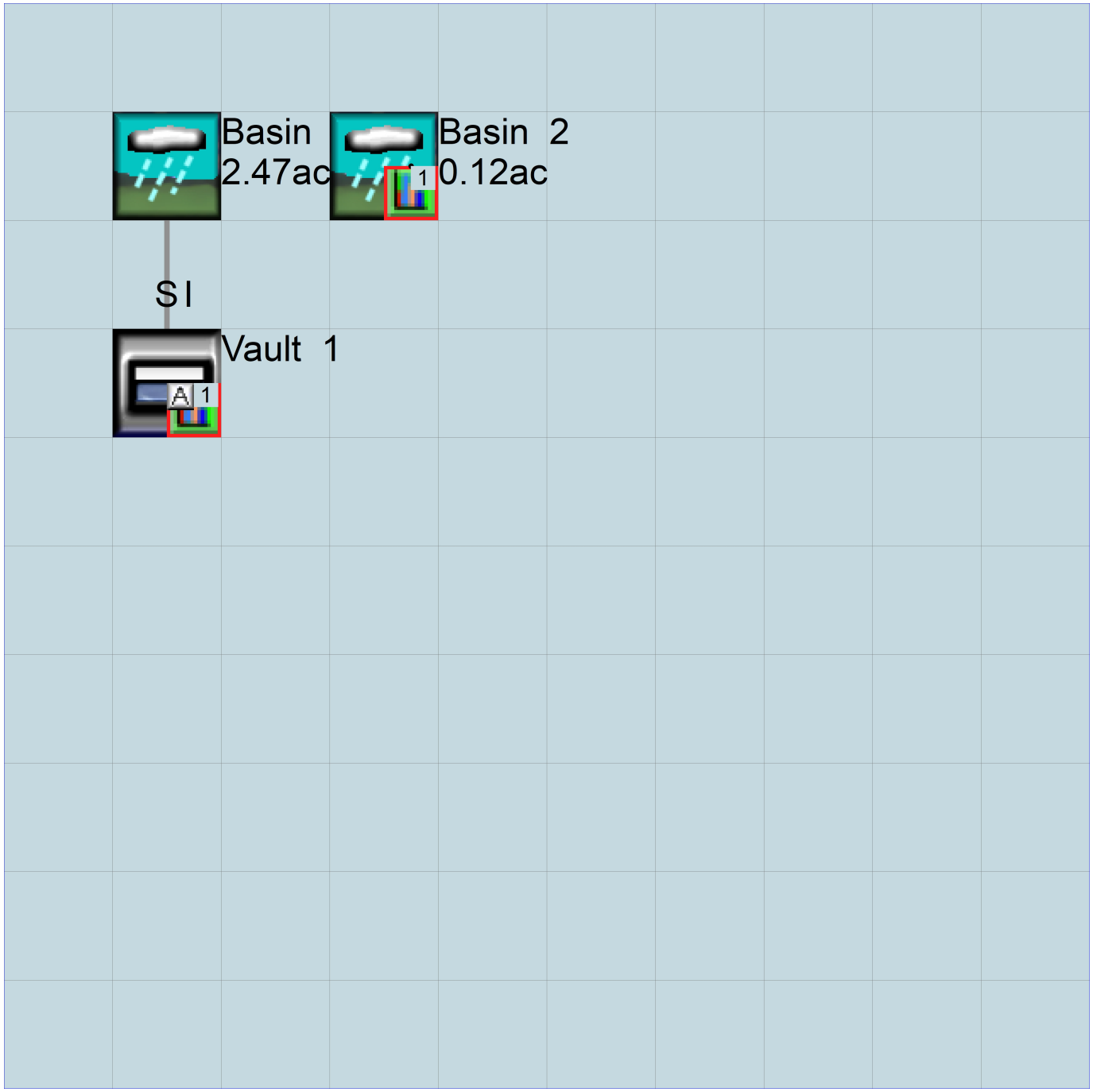
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                    UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM         26   21073 Vault Remodel.wdm
MESSU       25   Mit21073 Vault Remodel.MES
            27   Mit21073 Vault Remodel.L61
            28   Mit21073 Vault Remodel.L62
            30   POC21073 Vault Remodel1.dat
END FILES

OPN SEQUENCE
    INGRP               INDELT 00:15
      PERLND      14
      PERLND      17
      IMPLND       2
      IMPLND       4
      IMPLND       1
      RCHRES       1
      COPY         1
      COPY       501
      COPY       601
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Vault  1                   MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  601         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out           ***
   14     C, Pasture, Mod         1    1    1    1   27    0
   17     C, Lawn, Mod            1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

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

```
   14         0    0    1    0    0    0    0    0    0    0    0    0
   17         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   14         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   17         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   14         0    0    0    0    0    0    0    0    0    0    0
   17         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   14              0       4.5      0.06       400       0.1       0.5     0.996
   17              0       4.5      0.03       400       0.1       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   14              0         0         2         2         0         0         0
   17              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                              ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   14           0.15       0.4       0.3         6       0.5       0.4
   17            0.1      0.25      0.25         6       0.5      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
               ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS       AGWS      GWVS
   14              0         0         0         0       2.5          1         0
   17              0         0         0         0       2.5          1         0
  END PWAT-STATE1

END PERLND

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

  ACTIVITY
    <PLS > ************* Active Sections ******************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    2         0    0    1    0    0    0
    4         0    0    1    0    0    0
    1         0    0    1    0    0    0
  END ACTIVITY

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

```
    2         0    0    4    0    0    0    1    9
    4         0    0    4    0    0    0    1    9
    1         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    2         0    0    0    0    0
    4         0    0    0    0    0
    1         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    2           400      0.05       0.1      0.08
    4           400      0.01       0.1       0.1
    1           400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    2             0         0
    4             0         0
    1             0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    2             0         0
    4             0         0
    1             0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                 <--Area-->     <-Target->   MBLK   ***
<Name>   #                 <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  14                       1.24     RCHRES   1      2
PERLND  14                       1.24     RCHRES   1      3
PERLND  17                       0.13     RCHRES   1      2
PERLND  17                       0.13     RCHRES   1      3
IMPLND   2                       0.36     RCHRES   1      5
IMPLND   4                       0.74     RCHRES   1      5
Basin  2***
PERLND  14                       0.11     COPY   501     12
PERLND  14                       0.11     COPY   601     12
PERLND  14                       0.11     COPY   501     13
PERLND  14                       0.11     COPY   601     13
IMPLND   1                       0.01     COPY   501     15
IMPLND   1                       0.01     COPY   601     15

******Routing******
PERLND  14                       1.24     COPY     1     12
PERLND  17                       0.13     COPY     1     12
IMPLND   2                       0.36     COPY     1     15
IMPLND   4                       0.74     COPY     1     15
PERLND  14                       1.24     COPY     1     13
PERLND  17                       0.13     COPY     1     13
RCHRES   1                          1     COPY   501     16
END SCHEMATIC

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

```
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1


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

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

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

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

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

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1              1      0.02       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                       ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
           *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1           0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
   92    4
     Depth      Area    Volume  Outflow1 Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.057392  0.000000  0.000000
  0.083333  0.057392  0.004783  0.005577
  0.166667  0.057392  0.009565  0.007887
  0.250000  0.057392  0.014348  0.009660
  0.333333  0.057392  0.019131  0.011154
  0.416667  0.057392  0.023913  0.012470
  0.500000  0.057392  0.028696  0.013661
  0.583333  0.057392  0.033479  0.014755
  0.666667  0.057392  0.038261  0.015774
  0.750000  0.057392  0.043044  0.016731
  0.833333  0.057392  0.047827  0.017636
  0.916667  0.057392  0.052609  0.018497
```

1.000000	0.057392	0.057392	0.019319
1.083333	0.057392	0.062175	0.020108
1.166667	0.057392	0.066957	0.020867
1.250000	0.057392	0.071740	0.021599
1.333333	0.057392	0.076523	0.022308
1.416667	0.057392	0.081305	0.022994
1.500000	0.057392	0.086088	0.023661
1.583333	0.057392	0.090871	0.024309
1.666667	0.057392	0.095654	0.024941
1.750000	0.057392	0.100436	0.025557
1.833333	0.057392	0.105219	0.026158
1.916667	0.057392	0.110002	0.026746
2.000000	0.057392	0.114784	0.027321
2.083333	0.057392	0.119567	0.027885
2.166667	0.057392	0.124350	0.028437
2.250000	0.057392	0.129132	0.028979
2.333333	0.057392	0.133915	0.029510
2.416667	0.057392	0.138698	0.030033
2.500000	0.057392	0.143480	0.030546
2.583333	0.057392	0.148263	0.031051
2.666667	0.057392	0.153046	0.031548
2.750000	0.057392	0.157828	0.032037
2.833333	0.057392	0.162611	0.032519
2.916667	0.057392	0.167394	0.032994
3.000000	0.057392	0.172176	0.033462
3.083333	0.057392	0.176959	0.033923
3.166667	0.057392	0.181742	0.034379
3.250000	0.057392	0.186524	0.038532
3.333333	0.057392	0.191307	0.041320
3.416667	0.057392	0.196090	0.043419
3.500000	0.057392	0.200872	0.045215
3.583333	0.057392	0.205655	0.046825
3.666667	0.057392	0.210438	0.048308
3.750000	0.057392	0.215220	0.049695
3.833333	0.057392	0.220003	0.051006
3.916667	0.057392	0.224786	0.052255
4.000000	0.057392	0.229568	0.053453
4.083333	0.057392	0.234351	0.054605
4.166667	0.057392	0.239134	0.055719
4.250000	0.057392	0.243916	0.056799
4.333333	0.057392	0.248699	0.057849
4.416667	0.057392	0.253482	0.058870
4.500000	0.057392	0.258264	0.059867
4.583333	0.057392	0.263047	0.060840
4.666667	0.057392	0.267830	0.061793
4.750000	0.057392	0.272612	0.062726
4.833333	0.057392	0.277395	0.063641
4.916667	0.057392	0.282178	0.064538
5.000000	0.057392	0.286961	0.065420
5.083333	0.057392	0.291743	0.066287
5.166667	0.057392	0.296526	0.067140
5.250000	0.057392	0.301309	0.067980
5.333333	0.057392	0.306091	0.068807
5.416667	0.057392	0.310874	0.074056
5.500000	0.057392	0.315657	0.081287
5.583333	0.057392	0.320439	0.085925
5.666667	0.057392	0.325222	0.089737
5.750000	0.057392	0.330005	0.093093
5.833333	0.057392	0.334787	0.096146
5.916667	0.057392	0.339570	0.098979
6.000000	0.057392	0.344353	0.101641
6.083333	0.057392	0.349135	0.104165
6.166667	0.057392	0.353918	0.106575
6.250000	0.057392	0.358701	0.108888
6.333333	0.057392	0.363483	0.111118
6.416667	0.057392	0.368266	0.113273
6.500000	0.057392	0.373049	0.115364
6.583333	0.057392	0.377831	0.117395
6.666667	0.057392	0.382614	0.119374
6.750000	0.057392	0.387397	0.121305

```
  6.833333  0.057392  0.392179  0.123191
  6.916667  0.057392  0.396962  0.125036
  7.000000  0.057392  0.401745  0.126844
  7.083333  0.057392  0.406527  0.382908
  7.166667  0.057392  0.411310  0.833788
  7.250000  0.057392  0.416093  1.349620
  7.333333  0.057392  0.420875  1.817213
  7.416667  0.057392  0.425658  2.148481
  7.500000  0.057392  0.430441  2.340359
  7.583333  0.057392  0.435223  2.544196
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    0.8            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    0.8            IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
COPY   601 OUTPUT MEAN   1 1     48.4      WDM    901 FLOW     ENGL      REPL
RCHRES   1 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1001 STAG     ENGL      REPL
END EXT TARGETS

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

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

  MASS-LINK        5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5

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

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

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

  MASS-LINK       16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
  END MASS-LINK   16


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

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A.2 FULL WWHM OUTPUT – FRONTAGE BASIN – PEAK FLOW ANALYSIS

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	21073 Frontage Basin Flow Comparison
Site Name:	
Site Address:	
City:	
Report Date:	8/8/2022
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	0.000 (adjusted)
Version Date:	2021/08/18
Version:	4.2.18

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
C, Forest, Mod	0.15
C, Forest, Steep	0.04
C, Lawn, Steep	0.04
Pervious Total	0.23

Impervious Land Use	acre
ROADS MOD	0.01
Impervious Total	0.01
Basin Total	0.24

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
C, Pasture, Mod	0.02
C, Pasture, Steep	0.08
C, Forest, Mod	0.15
C, Forest, Steep	0.04
Pervious Total	0.29

Impervious Land Use	acre
ROADS MOD	0.01
Impervious Total	0.01
Basin Total	0.3

Element Flows To:

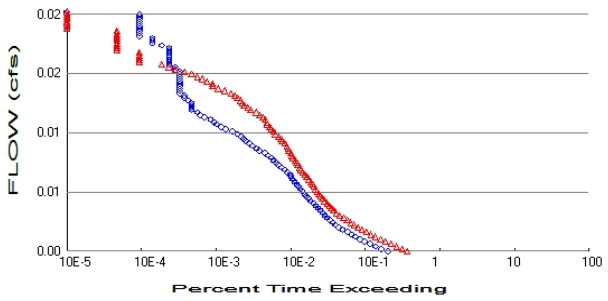
Surface	Interflow	Groundwater

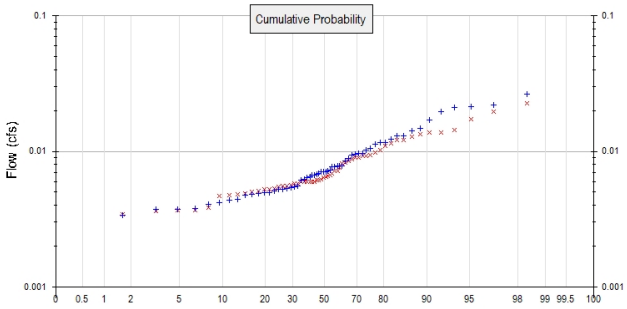
Routing Elements
Predeveloped Routing

Mitigated Routing

Analysis Results

POC 1





\+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0.23
Total Impervious Area: 0.01

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.29
Total Impervious Area: 0.01

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.007302
5 year	0.011452
10 year	0.014779
25 year	0.019698
50 year	0.023919
100 year	0.028649

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.00698
5 year	0.010304
10 year	0.012794
25 year	0.016277
50 year	0.019121
100 year	0.022185

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.007	0.005
1950	0.009	0.009
1951	0.007	0.007
1952	0.007	0.006
1953	0.006	0.006
1954	0.020	0.017
1955	0.009	0.010
1956	0.007	0.008
1957	0.010	0.010
1958	0.022	0.011

1959	0.006	0.007
1960	0.007	0.006
1961	0.027	0.012
1962	0.006	0.006
1963	0.012	0.009
1964	0.007	0.006
1965	0.004	0.005
1966	0.004	0.004
1967	0.008	0.008
1968	0.008	0.009
1969	0.021	0.013
1970	0.005	0.005
1971	0.010	0.009
1972	0.009	0.007
1973	0.006	0.005
1974	0.012	0.011
1975	0.008	0.006
1976	0.005	0.005
1977	0.004	0.004
1978	0.005	0.006
1979	0.014	0.012
1980	0.007	0.006
1981	0.005	0.006
1982	0.005	0.006
1983	0.010	0.009
1984	0.005	0.006
1985	0.008	0.009
1986	0.017	0.020
1987	0.007	0.008
1988	0.005	0.005
1989	0.008	0.007
1990	0.005	0.006
1991	0.006	0.006
1992	0.007	0.006
1993	0.004	0.004
1994	0.003	0.003
1995	0.005	0.006
1996	0.013	0.014
1997	0.021	0.022
1998	0.008	0.005
1999	0.005	0.005
2000	0.012	0.009
2001	0.003	0.003
2002	0.005	0.006
2003	0.004	0.004
2004	0.010	0.007
2005	0.004	0.005
2006	0.015	0.014
2007	0.013	0.013
2008	0.011	0.014
2009	0.004	0.005

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.0266	0.0225
2	0.0221	0.0197
3	0.0214	0.0173

4	0.0211	0.0144
5	0.0196	0.0139
6	0.0171	0.0138
7	0.0148	0.0133
8	0.0142	0.0128
9	0.0130	0.0121
10	0.0130	0.0121
11	0.0123	0.0114
12	0.0117	0.0109
13	0.0116	0.0102
14	0.0112	0.0098
15	0.0104	0.0094
16	0.0103	0.0093
17	0.0097	0.0093
18	0.0097	0.0091
19	0.0095	0.0090
20	0.0094	0.0088
21	0.0089	0.0085
22	0.0085	0.0083
23	0.0079	0.0082
24	0.0078	0.0076
25	0.0078	0.0072
26	0.0077	0.0072
27	0.0077	0.0068
28	0.0072	0.0067
29	0.0071	0.0066
30	0.0071	0.0065
31	0.0070	0.0064
32	0.0070	0.0062
33	0.0068	0.0061
34	0.0067	0.0061
35	0.0067	0.0060
36	0.0067	0.0060
37	0.0065	0.0060
38	0.0064	0.0060
39	0.0063	0.0059
40	0.0061	0.0059
41	0.0055	0.0058
42	0.0055	0.0058
43	0.0054	0.0057
44	0.0053	0.0056
45	0.0053	0.0055
46	0.0052	0.0055
47	0.0051	0.0053
48	0.0049	0.0053
49	0.0049	0.0052
50	0.0049	0.0051
51	0.0048	0.0051
52	0.0048	0.0049
53	0.0044	0.0048
54	0.0044	0.0047
55	0.0042	0.0047
56	0.0041	0.0038
57	0.0038	0.0037
58	0.0037	0.0037
59	0.0037	0.0036
60	0.0034	0.0034
61	0.0028	0.0026

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0037	4261	7790	182	Fail
0.0039	3512	6650	189	Fail
0.0041	2950	5600	189	Fail
0.0043	2479	4712	190	Fail
0.0045	2098	3989	190	Fail
0.0047	1815	3414	188	Fail
0.0049	1591	2917	183	Fail
0.0051	1401	2552	182	Fail
0.0053	1232	2207	179	Fail
0.0055	1061	1928	181	Fail
0.0057	945	1700	179	Fail
0.0059	853	1509	176	Fail
0.0061	784	1361	173	Fail
0.0063	719	1221	169	Fail
0.0065	657	1094	166	Fail
0.0067	611	968	158	Fail
0.0069	573	876	152	Fail
0.0071	533	803	150	Fail
0.0073	493	748	151	Fail
0.0075	465	706	151	Fail
0.0077	430	659	153	Fail
0.0080	394	612	155	Fail
0.0082	367	572	155	Fail
0.0084	345	538	155	Fail
0.0086	327	509	155	Fail
0.0088	304	484	159	Fail
0.0090	287	462	160	Fail
0.0092	271	436	160	Fail
0.0094	256	419	163	Fail
0.0096	240	398	165	Fail
0.0098	229	376	164	Fail
0.0100	217	349	160	Fail
0.0102	208	330	158	Fail
0.0104	190	309	162	Fail
0.0106	177	295	166	Fail
0.0108	161	282	175	Fail
0.0110	145	267	184	Fail
0.0112	135	256	189	Fail
0.0114	125	246	196	Fail
0.0116	119	232	194	Fail
0.0118	106	220	207	Fail
0.0120	96	214	222	Fail
0.0122	81	202	249	Fail
0.0125	74	197	266	Fail
0.0127	65	191	293	Fail
0.0129	59	178	301	Fail
0.0131	53	163	307	Fail
0.0133	50	158	316	Fail
0.0135	46	146	317	Fail
0.0137	41	133	324	Fail
0.0139	35	126	360	Fail
0.0141	29	118	406	Fail
0.0143	25	112	448	Fail
0.0145	22	105	477	Fail

0.0147	20	102	510	Fail
0.0149	18	97	538	Fail
0.0151	15	90	600	Fail
0.0153	13	81	623	Fail
0.0155	12	74	616	Fail
0.0157	10	62	620	Fail
0.0159	10	57	570	Fail
0.0161	10	51	510	Fail
0.0163	10	48	480	Fail
0.0165	9	45	500	Fail
0.0168	8	41	512	Fail
0.0170	8	38	475	Fail
0.0172	7	34	485	Fail
0.0174	7	28	400	Fail
0.0176	7	23	328	Fail
0.0178	7	19	271	Fail
0.0180	7	19	271	Fail
0.0182	7	16	228	Fail
0.0184	7	14	200	Fail
0.0186	7	12	171	Fail
0.0188	7	10	142	Fail
0.0190	7	8	114	Fail
0.0192	6	6	100	Pass
0.0194	6	5	83	Pass
0.0196	5	4	80	Pass
0.0198	5	2	40	Pass
0.0200	5	2	40	Pass
0.0202	5	2	40	Pass
0.0204	5	2	40	Pass
0.0206	5	2	40	Pass
0.0208	5	1	20	Pass
0.0211	5	1	20	Pass
0.0213	4	1	25	Pass
0.0215	3	1	33	Pass
0.0217	3	1	33	Pass
0.0219	3	1	33	Pass
0.0221	2	1	50	Pass
0.0223	2	1	50	Pass
0.0225	2	1	50	Pass
0.0227	2	0	0	Pass
0.0229	2	0	0	Pass
0.0231	2	0	0	Pass
0.0233	2	0	0	Pass
0.0235	2	0	0	Pass
0.0237	2	0	0	Pass
0.0239	2	0	0	Pass

The development has an increase in flow durations from 1/2 Predeveloped 2 year flow to the 2 year flow or more than a 10% increase from the 2 year to the 50 year flow.
The development has an increase in flow durations for more than 50% of the flows for the range of the duration analysis.

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Total Volume Infiltrated		0.00	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

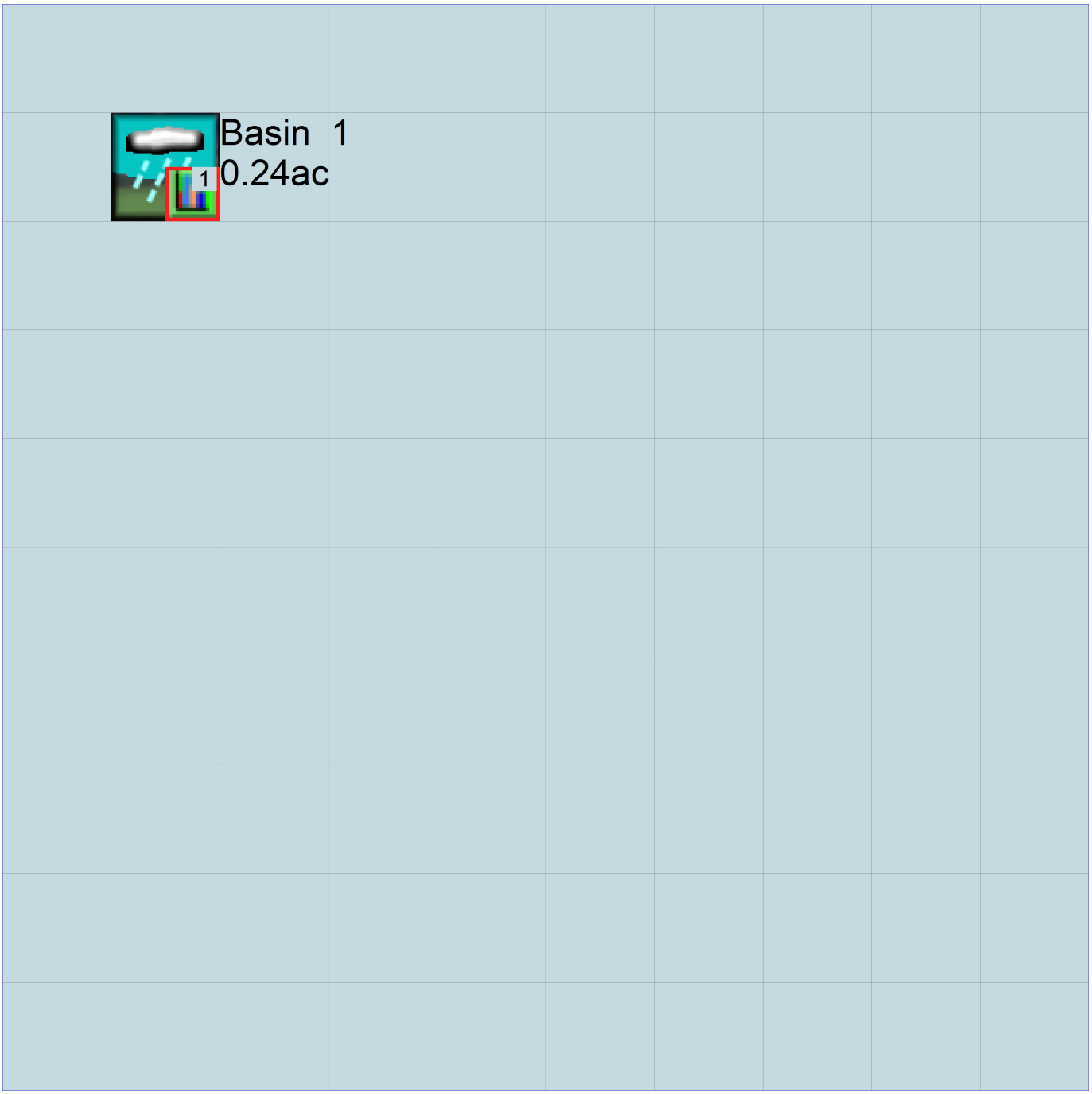
PERLND Changes

No PERLND changes have been made.

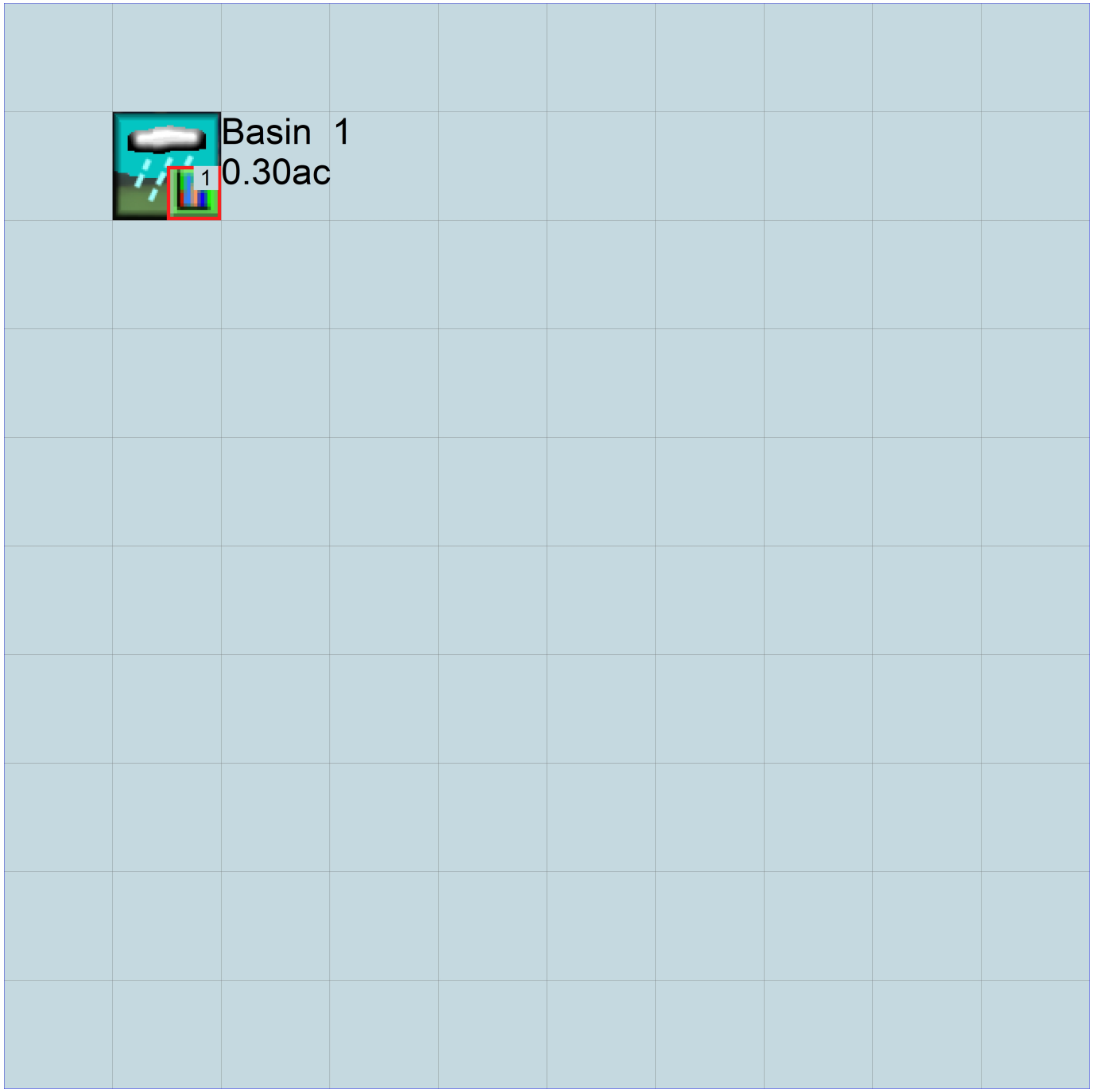
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                   UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM         26   21073 Frontage Basin Flow Comparison.wdm
MESSU       25   Pre21073 Frontage Basin Flow Comparison.MES
            27   Pre21073 Frontage Basin Flow Comparison.L61
            28   Pre21073 Frontage Basin Flow Comparison.L62
            30   POC21073 Frontage Basin Flow Comparison1.dat
END FILES

OPN SEQUENCE
    INGRP               INDELT 00:15
      PERLND      11
      PERLND      12
      PERLND      18
      IMPLND       2
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title---------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                   MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                      in  out           ***
   11     C, Forest, Mod          1    1    1    1   27    0
   12     C, Forest, Steep        1    1    1    1   27    0
   18     C, Lawn, Steep          1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************ Active Sections ******************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   11         0    0    1    0    0    0    0    0    0    0    0    0
   12         0    0    1    0    0    0    0    0    0    0    0    0
   18         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY
```

```
  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   11         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   12         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   18         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   11         0    0    0    0    0    0    0    0    0    0    0
   12         0    0    0    0    0    0    0    0    0    0    0
   18         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2          ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   11              0       4.5      0.08       400       0.1       0.5     0.996
   12              0       4.5      0.08       400      0.15       0.5     0.996
   18              0       4.5      0.03       400      0.15       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3          ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   11              0         0         2         2         0         0         0
   12              0         0         2         2         0         0         0
   18              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                              ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   11            0.2       0.5      0.35         6       0.5       0.7
   12            0.2       0.3      0.35         6       0.3       0.7
   18            0.1      0.15      0.25         6       0.3      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
               ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS       IFWS       LZS       AGWS      GWVS
   11              0         0         0         0       2.5          1         0
   12              0         0         0         0       2.5          1         0
   18              0         0         0         0       2.5          1         0
  END PWAT-STATE1

END PERLND

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

  ACTIVITY
    <PLS > ************* Active Sections ******************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    2         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    2         0    0    4    0    0    0    1    9
```

```
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    2         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    2            400      0.05       0.1      0.08
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    2              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    2              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                 <--Area-->     <-Target->   MBLK   ***
<Name>   #                 <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  11                       0.15     COPY   501     12
PERLND  11                       0.15     COPY   501     13
PERLND  12                       0.04     COPY   501     12
PERLND  12                       0.04     COPY   501     13
PERLND  18                       0.04     COPY   501     12
PERLND  18                       0.04     COPY   501     13
IMPLND   2                       0.01     COPY   501     15

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

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



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

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

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

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

```
  END PRINT-INFO

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

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

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    0.8            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    0.8            IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    501 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

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

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


END MASS-LINK

END RUN
```

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                    UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM         26   21073 Frontage Basin Flow Comparison.wdm
MESSU       25   Mit21073 Frontage Basin Flow Comparison.MES
            27   Mit21073 Frontage Basin Flow Comparison.L61
            28   Mit21073 Frontage Basin Flow Comparison.L62
            30   POC21073 Frontage Basin Flow Comparison1.dat
END FILES

OPN SEQUENCE
    INGRP              INDELT 00:15
      PERLND      14
      PERLND      15
      PERLND      11
      PERLND      12
      IMPLND       2
      COPY       501
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Basin  1                   MAX                    1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out            ***
   14     C, Pasture, Mod         1    1    1    1   27    0
   15     C, Pasture, Steep       1    1    1    1   27    0
   11     C, Forest, Mod          1    1    1    1   27    0
   12     C, Forest, Steep        1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

  ACTIVITY
    <PLS > ************ Active Sections ******************************
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC ***
   14         0    0    1    0    0    0    0    0    0    0    0    0
   15         0    0    1    0    0    0    0    0    0    0    0    0
```

```
   11         0    0    1    0    0    0    0    0    0    0    0    0
   12         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags **************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   14         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   15         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   11         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   12         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   14         0    0    0    0    0    0    0    0    0    0    0
   15         0    0    0    0    0    0    0    0    0    0    0
   11         0    0    0    0    0    0    0    0    0    0    0
   12         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2          ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR      KVARY      AGWRC
   14              0       4.5      0.06       400       0.1        0.5      0.996
   15              0       4.5      0.06       400      0.15        0.5      0.996
   11              0       4.5      0.08       400       0.1        0.5      0.996
   12              0       4.5      0.08       400      0.15        0.5      0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3          ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   14              0         0         2         2         0         0         0
   15              0         0         2         2         0         0         0
   11              0         0         2         2         0         0         0
   12              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                              ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   14          0.15       0.4       0.3         6       0.5       0.4
   15          0.15      0.25       0.3         6       0.3       0.4
   11           0.2       0.5      0.35         6       0.5       0.7
   12           0.2       0.3      0.35         6       0.3       0.7
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
               ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS       AGWS      GWVS
   14              0         0         0         0       2.5          1         0
   15              0         0         0         0       2.5          1         0
   11              0         0         0         0       2.5          1         0
   12              0         0         0         0       2.5          1         0
  END PWAT-STATE1

END PERLND

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

  ACTIVITY
```

```
    <PLS > ************* Active Sections ****************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    2         0    0    1    0    0    0
  END ACTIVITY

  PRINT-INFO
    <ILS > ******** Print-flags ******** PIVL  PYR
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL    *********
    2         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    2         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    2            400      0.05       0.1      0.08
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    2              0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    2              0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                  <--Area-->     <-Target->   MBLK   ***
<Name>   #                  <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  14                        0.02     COPY   501     12
PERLND  14                        0.02     COPY   501     13
PERLND  15                        0.08     COPY   501     12
PERLND  15                        0.08     COPY   501     13
PERLND  11                        0.15     COPY   501     12
PERLND  11                        0.15     COPY   501     13
PERLND  12                        0.04     COPY   501     12
PERLND  12                        0.04     COPY   501     13
IMPLND   2                        0.01     COPY   501     15

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

NETWORK
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   #        <Name> # #<-factor->strg <Name>   #   #        <Name> # #  ***
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1



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

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

```
  END GEN-INFO
  *** Section RCHRES***

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

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

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

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

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    0.8            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    0.8            IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
END EXT TARGETS

MASS-LINK
<Volume>   <-Grp> <-Member-><--Mult-->     <Target>       <-Grp> <-Member->***
<Name>            <Name> # #<-factor->     <Name>                <Name> # #***
  MASS-LINK       12
PERLND     PWATER SURO       0.083333      COPY           INPUT  MEAN
  END MASS-LINK   12

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

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

```
END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

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A.2 FULL WWHM OUTPUT – CONVEYANCE MEMO

BLUELINE

MEMORANDUM

DATE: **April 20, 2023**

TO: **Perteet on Behalf of City of Mukilteo**

FROM: **Blueline**

RE: **Harbor Grove - Permit SD-2021-001/ENG-2021-019/SEPA-2021-010 - Quantitative Analysis of Existing Storm System**

Introduction

This memo is provided in response to a second review comment by Perteet on Behalf of City of Mukilteo made regarding the Project Harbor Grove, Permit SD-2021-00/ENG-2021-019/SEPA-2021-010. The subject comment is provided below.

"It is acknowledged that the applicant has bypassed the existing detention vault on 92nd. However, the existing conveyance system that you are connecting to does not currently see these flows from the project site. Therefore, this system will see an increase in runoff flows and the applicant will need to provide a quantitative analysis of the existing system up to its discharge point on the west side of Hargreaves PI to make sure the system has capacity to handle the increase in flows."

The purpose of this memo is to demonstrate that the proposed development will not create capacity issues within the existing system after the proposed outfall up to its discharge point on the west side of Hargreaves Pl.

Conveyance – Existing Condition

As required by Section 3.6 of the City of Mukilteo's 2019 Development Standards, Rational Method was used for all stormwater flow calculations. A conservative estimate of the local tributary parcels was made per available GIS data. Please see the *Capacity Analysis Exhibit* included at the end of this memo for additional information.

The existing conveyance system was modeled per the 100-year, 24-hour storm event. Flows within each existing pipe were determined using the Rational Method. The total area assumed to be tributary to the existing system is 13.55 acres, as shown on the *Capacity Analysis Exhibit* included at the end of this memo. The areas used to compute the conveyance calculations are summarized on the following page.

In the existing condition, impervious and pervious areas within tributary lots were delineated per available GIS data, as shown on the *Capacity Analysis Exhibit* included at the end of this memo. Right-of-Way area was assumed to be 66% impervious on average based on available GIS data.

EXISTING CONDITIONS		
Impervious		
Lots	5.18	ac
Right-of-Way	2.22	ac
Total Impervious	**7.40**	**ac**
Pervious - Lawn		
Lots	5.01	ac
Right-of-Way	1.14	ac
Total Lawn - Soil Group C (Till)	**6.15**	**ac**
TOTAL EXISTING CONDITIONS	**13.55**	**ac**

A weighted C-value was determined for the site based on the existing condition areas tributary to the existing storm system. An assigned value of 0.90 was used for impervious areas and a value of 0.25 was used for pervious areas. Please see the *Rational Method Conveyance Spreadsheet* and the *Capacity Analysis Exhibit* included at the end of this memo for additional information.

The hydraulic grade line is calculated using the *King County Backwater Analysis Spreadsheet*, included at the end of this memo. The spreadsheet performs a standard step backwater analysis on the network based on flows to each pipe, accounting for friction losses, bend losses, and velocity head losses. The steady state energy (Bernoulli) equation is used to calculate the hydraulic grade line at each existing catch basin from downstream to upstream, beginning with the tailwater elevation in the existing storm main. The spreadsheet identifies the total hydraulic headwater elevation at each basin for the 100-year storm event.

According to the analysis, the existing conveyance system downstream of the proposed connection at CB 4, has adequate capacity to convey the 100-year storm event up to its discharge point on the west side of Hargreaves PI.

Please note that in the existing condition analysis, it is conservatively assumed that none of the stormwater tributary to the existing system is being detained.

Conveyance – Developed Condition

The vault outfall for the proposed development will be routed to the existing public stormwater system via a 12-inch system, which will travel south along 53rd Ave W before travelling west along 92nd St SW and will eventually connect to the existing system at CB 4, within Hargreaves Pl.

Post-development, approximately 1.10 acres of additional impervious and 1.37 acres of additional pervious area will be tributary to the existing storm system. Please see the area breakdown below. In the developed condition, the additional 2.47 acres of area will be detained in accordance with the flow control requirements for the site, per COM Development Standards and the DOE Manual.

DEVELOPED CONDITIONS		
Impervious		
Lots	5.18	ac
Right-of-Way	2.22	ac
Project Area*	1.10	ac
Total Impervious	**8.50**	**ac**
Pervious - Lawn		
Lots	5.01	ac
Right-of-Way	1.14	ac
Project Area*	1.37	ac
Total Lawn - Soil Group C (Till)	**7.52**	**ac**
TOTAL DEVELOPED CONDITIONS	**16.02**	**ac**

*Project area to be detained onsite and outfall to the subject existing system

Per WWHM2012, using the 15-minute timestep, the additional 2.47 acres tributary to the onsite detention facility will add 0.0938 cfs to the existing system in the 100-year developed detained condition. Please see the WWHM printout at the end of this memo for additional information.

According to the *Rational Method Conveyance Spreadsheet* and the *King County Backwater Analysis Spreadsheet*, all headwater elevations remain below the rims during the 100-year storm. Therefore, the subject existing system, post development of the Harbor Grove property, will have adequate capacity.

BLUELINE

Thank you for your time in reviewing this memorandum. If you have any questions or need any additional information, please contact me at (425) 250-7275.

Sincerely,

BLUELINE

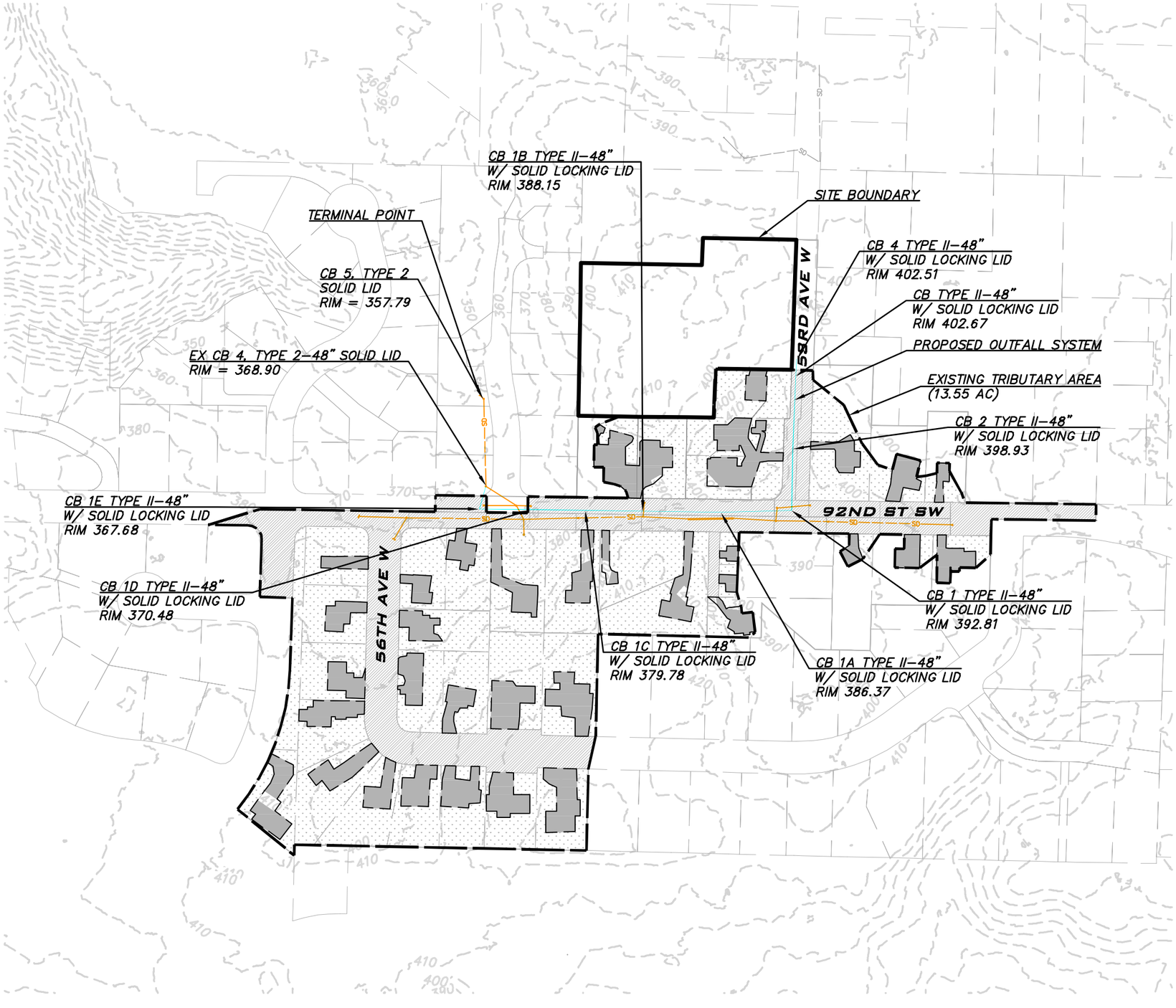
Kristal Keating, PE
Project Manager

CC:

Attachments:

a. Capacity Analysis Exhibit
b. Rational Method Conveyance Spreadsheet
c. King County Backwater Analysis Spreadsheet
d. WWHM Printout – Detention Vault Outflow

CAPACITY ANALYSIS EXHIBIT



N

SCALE: 1" = 200'

0 50 100 200

PERVIOUS LOT AREA

IMPERVIOUS LOT AREA

RIGHT–OF–WAY

BLUELINE

25 CENTRAL WAY, SUITE 410
KIRKLAND, WA 98033
P: 425.216.4052 F: 425.216.4052
WWW.THEBLUELINEGROUP.COM

CAPACITY ANALYSIS EXHIBIT
HARBOR GROVE
STORM DRAINAGE REPORT

SCALE	AS NOTED
PROJECT MANAGER	TC COLLERAN, PLA
DESIGNED BY	MATTHEW STRITTMATTER, EIT
DRAWN BY	MATTHEW STRITTMATTER, EIT
PLOT DATE	April 20, 2023

JOB NUMBER:
21–073

FIGURE:
CA

RATIONAL METHOD CONVEYANCE SYSTEM DESIGN

PROJECT NAME:	**Harbor Grove**				**PROJECT NUMBER:**	**21-073**			**PREPARED BY:**	**Olivia Westmoreland**				**DESIGN STORM:**	**100**	**YEAR**		
LOCATION		**SUBBASIN AREA**			**SUM OF**	**Tc**	**I_R**	**Q_R**	**MANNING'S**	**PIPE SIZE**	**PIPE SLOPE**	**PIPE LENGTH**	**ACTUAL VELOCITY (V_R)**	**TRAVEL TIME**	**PIPE CAPACITY SUMMARY**		
FROM	**TO**	**(AC)**	**"C"**	**(A * C)**	**(A * C)**	**(MIN)**	**(IN/HR)**	**(CFS)**	**"n"**	**(IN)**	**(%)**	**(FT)**	**(FT/SEC)**	**(MIN)**	**Q(FULL) (CFS)**	**V(FULL) (FT/SEC)**	**Q_R/Q(FULL) (%)**
Vault	MWS	0.000	0.54	0.000	0.000	6.30	3.13	0.094	0.012	12	0.550	33	1.57	0.35	2.862	3.64	3.3%
MWS	CB 4	0.000	0.54	0.000	0.000	6.65	3.03	0.094	0.012	12	0.530	45	1.54	0.49	2.810	3.58	3.3%
CB 4	CB 3	0.000	0.54	0.000	0.000	7.14	2.91	0.094	0.012	12	0.520	31	1.52	0.34	2.783	3.54	3.4%
CB 3	CB 2	0.000	0.54	0.000	0.000	7.48	2.84	0.094	0.012	12	0.550	135	1.57	1.44	2.862	3.64	3.3%
CB 2	CB 1	0.040	0.54	0.022	0.022	8.91	2.57	0.150	0.012	12	2.770	114	3.11	0.61	6.424	8.18	2.3%
CB 1	CB 1A	0.000	0.54	0.000	0.022	9.52	2.48	0.148	0.012	12	0.550	131	1.84	1.19	2.862	3.64	5.2%
CB 1A	CB 1B	0.000	0.54	0.000	0.022	10.71	2.32	0.144	0.012	12	2.810	144	3.13	0.77	6.470	8.24	2.2%
CB 1B	CB 1C	0.000	0.54	0.000	0.022	11.48	2.23	0.142	0.012	12	6.500	106	3.82	0.46	9.840	12.53	1.4%
CB 1C	CB 1D	0.000	0.54	0.000	0.022	11.94	2.18	0.141	0.012	12	7.950	100	4.23	0.39	10.883	13.86	1.3%
CB 1D	CB 1E	0.000	0.54	0.000	0.022	12.33	2.15	0.140	0.012	12	5.710	94	3.58	0.44	9.223	11.74	1.5%
CB 1E	EX CB 4	0.000	0.54	0.000	0.022	12.77	2.10	0.139	0.012	12	2.230	43	2.79	0.26	5.764	7.34	2.4%
EX CB 4	EX CB 5	12.300	0.54	6.642	6.664	13.03	2.08	13.957	0.012	18	6.210	166	15.89	0.17	28.358	16.05	49.2%
EX CB 5	Outfall	0.000	0.54	0.000	6.664	13.20	2.07	13.855	0.012	18	6.000	27	15.62	0.03	27.874	15.77	49.7%

BACKWATER CALCULATIONS

PROJECT NAME: Harbor Grove **PREPARED BY:** Olivia Westmoreland

PROJECT NUMBER: 21-073 **DESIGN STORM:** 100 YEAR

PIPE SEGMENT																							
FROM CB	TO CB	Q (CFS)	PIPE LENGTH (FT)	PIPE SIZE (IN)	MANNING'S "n" VALUE	OUTLET ELEVATION (FT)	INLET ELEVATION (FT)	PIPE AREA (SQ FT)	FULL VELOCITY (FT/SEC)	VELOCITY HEAD (FT)	TAILWATER ELEVATION (FT)	FRICTION LOSS (FT)	ENTRANCE HGL ELEVATION (FT)	ENTRANCE HEAD LOSS (FT)	EXIT HEAD LOSS (FT)	OUTLET CONTROL ELEVATION (FT)	INLET CONTROL ELEVATION (FT)	APPROACH VELOCITY HEAD (FT)	BEND HEAD LOSS (FT)	JUNCTION HEAD LOSS (FT)	HEADWATER ELEVATION (FT)	RIM ELEVATION (FT)	FREEBOARD (FT)
OUTFAL	EX CB 5	13.86	27	18	0.012	349.40	350.98	1.77	7.84	0.96	351.40	0.40	352.48	0.48	0.96	353.91	354.39	0.97	0.36	0.00	353.78	357.59	3.81
EX CB 5	EX CB 4	13.96	166	18	0.012	351.09	361.08	1.77	7.90	0.97	353.78	2.48	362.58	0.48	0.97	364.03	364.52	0.00	0.52	0.00	365.05	368.90	3.85
EX CB 4	CB 1E	0.14	43	12	0.012	361.16	362.12	0.79	0.18	0.00	365.05	0.00	365.05	0.00	0.00	365.05	363.12	0.00	0.00	0.00	365.05	367.68	2.63
CB 1E	CB 1D	0.14	94	12	0.012	362.12	367.49	0.79	0.18	0.00	365.05	0.00	368.49	0.00	0.00	368.49	368.49	0.00	0.00	0.00	368.49	370.48	1.99
CB 1D	CB 1C	0.14	100	12	0.012	367.49	375.44	0.79	0.18	0.00	368.49	0.00	376.44	0.00	0.00	376.44	376.44	0.00	0.00	0.00	376.44	379.78	3.34
CB 1C	CB 1B	0.14	106	12	0.012	375.44	382.33	0.79	0.18	0.00	376.44	0.00	383.33	0.00	0.00	383.33	383.33	0.00	0.00	0.00	383.33	388.15	4.82
CB 1B	CB 1A	0.14	144	12	0.012	382.33	386.37	0.79	0.18	0.00	383.33	0.00	387.37	0.00	0.00	387.37	387.37	0.00	0.00	0.00	387.37	392.07	4.70
CB 1A	CB 1	0.15	131	12	0.012	386.37	387.09	0.79	0.19	0.00	387.37	0.00	388.09	0.00	0.00	388.09	388.09	0.00	0.00	0.00	388.09	392.81	4.72
CB 1	CB 2	0.15	114	12	0.012	387.09	390.25	0.79	0.19	0.00	388.09	0.00	391.25	0.00	0.00	391.25	391.25	0.00	0.00	0.00	391.25	398.93	7.68
CB 2	CB 3	0.09	135	12	0.012	390.25	390.99	0.79	0.12	0.00	391.25	0.00	391.99	0.00	0.00	391.99	391.99	0.00	0.00	0.00	391.99	402.67	10.68
CB 3	CB 4	0.09	31	12	0.012	390.99	391.15	0.79	0.12	0.00	391.99	0.00	392.15	0.00	0.00	392.15	392.15	0.00	0.00	0.00	392.15	402.51	10.36
CB 4	MWS	0.09	45	12	0.012	391.15	391.39	0.79	0.12	0.00	392.15	0.00	392.39	0.00	0.00	392.39	392.39	0.00	0.00	0.00	392.39	403.20	10.81
MWS	Vault	0.09	33	12	0.012	392.72	392.90	0.79	0.12	0.00	392.39	0.00	393.90	0.00	0.00	393.90	393.90	0.00	0.00	0.00	393.90	399.90	6.00

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	21073 Vault Remodel
Site Name:	
Site Address:	
City:	
Report Date:	8/5/2022
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	0.800
Version Date:	2021/08/18
Version:	4.2.18

POC Thresholds

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

Landuse Basin Data

Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
C, Forest, Mod	2.31
C, Lawn, Mod	0.13
Pervious Total	2.44

Impervious Land Use	acre
ROADS MOD	0.08
ROOF TOPS FLAT	0.07
Impervious Total	0.15
Basin Total	2.59

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No

Pervious Land Use	acre
C, Pasture, Mod	1.24
C, Lawn, Mod	0.13
Pervious Total	1.37

Impervious Land Use	acre
ROADS MOD	0.36
ROOF TOPS FLAT	0.74
Impervious Total	1.1
Basin Total	2.47

Element Flows To:

Surface	Interflow	Groundwater
Vault 1	Vault 1	

Basin 2

Bypass:	Yes
GroundWater:	No

Pervious Land Use	acre
C, Pasture, Mod	0.11
Pervious Total	0.11

Impervious Land Use	acre
ROADS FLAT	0.01
Impervious Total	0.01
Basin Total	0.12

Element Flows To:

Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Vault 1

Width: 20 ft.
Length: 125 ft.
Depth: 7.5 ft.
Discharge Structure
Riser Height: 7 ft.
Riser Diameter: 12 in.
Orifice 1 Diameter: 0.84375 in Elevation:0 ft.
Orifice 2 Diameter: 0.78125 in Elevation:3.2 ft.
Orifice 3 Diameter: 1.125 in. Elevation:5.4 ft.
Element Flows To:
Outlet 1 Outlet 2

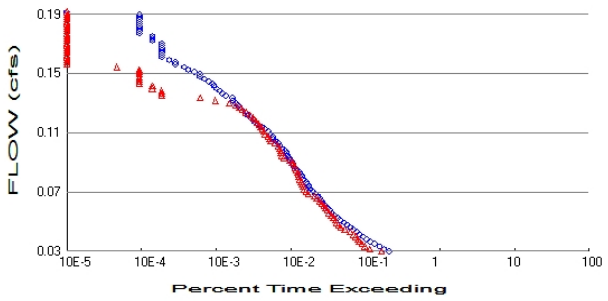
Vault Hydraulic Table

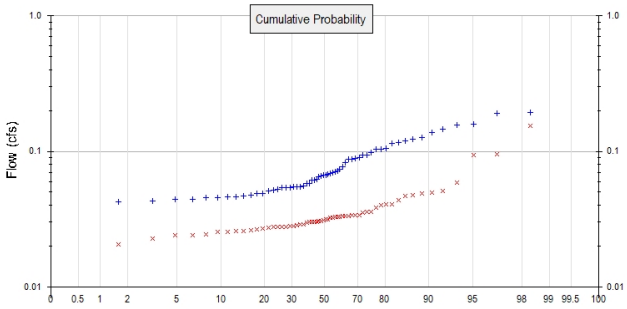
Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.057	0.000	0.000	0.000
0.0833	0.057	0.004	0.005	0.000
0.1667	0.057	0.009	0.007	0.000
0.2500	0.057	0.014	0.009	0.000
0.3333	0.057	0.019	0.011	0.000
0.4167	0.057	0.023	0.012	0.000
0.5000	0.057	0.028	0.013	0.000
0.5833	0.057	0.033	0.014	0.000
0.6667	0.057	0.038	0.015	0.000
0.7500	0.057	0.043	0.016	0.000
0.8333	0.057	0.047	0.017	0.000
0.9167	0.057	0.052	0.018	0.000
1.0000	0.057	0.057	0.019	0.000
1.0833	0.057	0.062	0.020	0.000
1.1667	0.057	0.067	0.020	0.000
1.2500	0.057	0.071	0.021	0.000
1.3333	0.057	0.076	0.022	0.000
1.4167	0.057	0.081	0.023	0.000
1.5000	0.057	0.086	0.023	0.000
1.5833	0.057	0.090	0.024	0.000
1.6667	0.057	0.095	0.024	0.000
1.7500	0.057	0.100	0.025	0.000
1.8333	0.057	0.105	0.026	0.000
1.9167	0.057	0.110	0.026	0.000
2.0000	0.057	0.114	0.027	0.000
2.0833	0.057	0.119	0.027	0.000
2.1667	0.057	0.124	0.028	0.000
2.2500	0.057	0.129	0.029	0.000
2.3333	0.057	0.133	0.029	0.000
2.4167	0.057	0.138	0.030	0.000
2.5000	0.057	0.143	0.030	0.000
2.5833	0.057	0.148	0.031	0.000
2.6667	0.057	0.153	0.031	0.000
2.7500	0.057	0.157	0.032	0.000
2.8333	0.057	0.162	0.032	0.000
2.9167	0.057	0.167	0.033	0.000
3.0000	0.057	0.172	0.033	0.000
3.0833	0.057	0.177	0.033	0.000

3.1667	0.057	0.181	0.034	0.000
3.2500	0.057	0.186	0.038	0.000
3.3333	0.057	0.191	0.041	0.000
3.4167	0.057	0.196	0.043	0.000
3.5000	0.057	0.200	0.045	0.000
3.5833	0.057	0.205	0.046	0.000
3.6667	0.057	0.210	0.048	0.000
3.7500	0.057	0.215	0.049	0.000
3.8333	0.057	0.220	0.051	0.000
3.9167	0.057	0.224	0.052	0.000
4.0000	0.057	0.229	0.053	0.000
4.0833	0.057	0.234	0.054	0.000
4.1667	0.057	0.239	0.055	0.000
4.2500	0.057	0.243	0.056	0.000
4.3333	0.057	0.248	0.057	0.000
4.4167	0.057	0.253	0.058	0.000
4.5000	0.057	0.258	0.059	0.000
4.5833	0.057	0.263	0.060	0.000
4.6667	0.057	0.267	0.061	0.000
4.7500	0.057	0.272	0.062	0.000
4.8333	0.057	0.277	0.063	0.000
4.9167	0.057	0.282	0.064	0.000
5.0000	0.057	0.287	0.065	0.000
5.0833	0.057	0.291	0.066	0.000
5.1667	0.057	0.296	0.067	0.000
5.2500	0.057	0.301	0.068	0.000
5.3333	0.057	0.306	0.068	0.000
5.4167	0.057	0.310	0.074	0.000
5.5000	0.057	0.315	0.081	0.000
5.5833	0.057	0.320	0.085	0.000
5.6667	0.057	0.325	0.089	0.000
5.7500	0.057	0.330	0.093	0.000
5.8333	0.057	0.334	0.096	0.000
5.9167	0.057	0.339	0.099	0.000
6.0000	0.057	0.344	0.101	0.000
6.0833	0.057	0.349	0.104	0.000
6.1667	0.057	0.353	0.106	0.000
6.2500	0.057	0.358	0.108	0.000
6.3333	0.057	0.363	0.111	0.000
6.4167	0.057	0.368	0.113	0.000
6.5000	0.057	0.373	0.115	0.000
6.5833	0.057	0.377	0.117	0.000
6.6667	0.057	0.382	0.119	0.000
6.7500	0.057	0.387	0.121	0.000
6.8333	0.057	0.392	0.123	0.000
6.9167	0.057	0.397	0.125	0.000
7.0000	0.057	0.401	0.126	0.000
7.0833	0.057	0.406	0.382	0.000
7.1667	0.057	0.411	0.833	0.000
7.2500	0.057	0.416	1.349	0.000
7.3333	0.057	0.420	1.817	0.000
7.4167	0.057	0.425	2.148	0.000
7.5000	0.057	0.430	2.340	0.000
7.5833	0.057	0.435	2.544	0.000
7.6667	0.000	0.000	2.711	0.000

Analysis Results

POC 1





\+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 2.44
Total Impervious Area: 0.15

Mitigated Landuse Totals for POC #1
Total Pervious Area: 1.48
Total Impervious Area: 1.11

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.069517
5 year	0.100436
10 year	0.124218
25 year	0.158287
50 year	0.186754
100 year	0.218011

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.032094
5 year	0.044348
10 year	0.054026
25 year	0.068196
50 year	0.080278
100 year	0.093771

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.061	0.028
1950	0.089	0.032
1951	0.065	0.028
1952	0.066	0.024
1953	0.066	0.023
1954	0.156	0.033
1955	0.090	0.038
1956	0.067	0.048
1957	0.094	0.044
1958	0.138	0.031

1959	0.058	0.034
1960	0.058	0.032
1961	0.194	0.033
1962	0.062	0.029
1963	0.098	0.027
1964	0.055	0.027
1965	0.044	0.033
1966	0.046	0.024
1967	0.105	0.030
1968	0.071	0.041
1969	0.146	0.028
1970	0.048	0.028
1971	0.087	0.040
1972	0.087	0.030
1973	0.068	0.030
1974	0.104	0.031
1975	0.069	0.027
1976	0.046	0.029
1977	0.044	0.026
1978	0.054	0.026
1979	0.123	0.031
1980	0.056	0.026
1981	0.055	0.026
1982	0.051	0.035
1983	0.077	0.028
1984	0.052	0.041
1985	0.082	0.036
1986	0.159	0.096
1987	0.068	0.059
1988	0.054	0.031
1989	0.074	0.021
1990	0.054	0.036
1991	0.055	0.034
1992	0.062	0.033
1993	0.043	0.024
1994	0.042	0.030
1995	0.049	0.047
1996	0.119	0.049
1997	0.191	0.154
1998	0.071	0.026
1999	0.052	0.030
2000	0.115	0.033
2001	0.037	0.020
2002	0.045	0.034
2003	0.049	0.028
2004	0.103	0.049
2005	0.045	0.031
2006	0.127	0.051
2007	0.114	0.034
2008	0.094	0.094
2009	0.047	0.028

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.1936	0.1542
2	0.1906	0.0958
3	0.1588	0.0945

4	0.1564	0.0587
5	0.1457	0.0510
6	0.1382	0.0494
7	0.1266	0.0487
8	0.1227	0.0478
9	0.1190	0.0467
10	0.1154	0.0436
11	0.1142	0.0407
12	0.1053	0.0406
13	0.1043	0.0398
14	0.1033	0.0384
15	0.0977	0.0360
16	0.0943	0.0358
17	0.0940	0.0353
18	0.0902	0.0338
19	0.0889	0.0336
20	0.0874	0.0336
21	0.0868	0.0335
22	0.0823	0.0333
23	0.0768	0.0333
24	0.0736	0.0327
25	0.0713	0.0327
26	0.0711	0.0326
27	0.0693	0.0324
28	0.0684	0.0323
29	0.0680	0.0315
30	0.0671	0.0314
31	0.0664	0.0312
32	0.0656	0.0307
33	0.0652	0.0305
34	0.0619	0.0301
35	0.0616	0.0300
36	0.0613	0.0300
37	0.0583	0.0300
38	0.0580	0.0297
39	0.0556	0.0291
40	0.0550	0.0290
41	0.0549	0.0283
42	0.0548	0.0282
43	0.0543	0.0279
44	0.0542	0.0278
45	0.0540	0.0278
46	0.0523	0.0278
47	0.0516	0.0276
48	0.0506	0.0272
49	0.0489	0.0270
50	0.0488	0.0267
51	0.0476	0.0261
52	0.0468	0.0258
53	0.0461	0.0257
54	0.0459	0.0256
55	0.0455	0.0255
56	0.0453	0.0245
57	0.0442	0.0242
58	0.0440	0.0241
59	0.0432	0.0228
60	0.0422	0.0207
61	0.0371	0.0200

Duration Flows

The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0348	4440	3501	78	Pass
0.0363	3814	2453	64	Pass
0.0378	3298	2119	64	Pass
0.0394	2864	1939	67	Pass
0.0409	2494	1788	71	Pass
0.0424	2218	1707	76	Pass
0.0440	1990	1590	79	Pass
0.0455	1787	1482	82	Pass
0.0470	1624	1340	82	Pass
0.0486	1479	1129	76	Pass
0.0501	1347	1004	74	Pass
0.0516	1214	930	76	Pass
0.0532	1108	889	80	Pass
0.0547	983	848	86	Pass
0.0563	898	803	89	Pass
0.0578	824	753	91	Pass
0.0593	763	699	91	Pass
0.0609	705	664	94	Pass
0.0624	662	631	95	Pass
0.0639	627	595	94	Pass
0.0655	585	559	95	Pass
0.0670	556	522	93	Pass
0.0685	521	481	92	Pass
0.0701	496	441	88	Pass
0.0716	454	369	81	Pass
0.0731	426	344	80	Pass
0.0747	399	327	81	Pass
0.0762	374	312	83	Pass
0.0777	353	304	86	Pass
0.0793	341	295	86	Pass
0.0808	317	282	88	Pass
0.0824	306	275	89	Pass
0.0839	292	270	92	Pass
0.0854	280	264	94	Pass
0.0870	263	257	97	Pass
0.0885	244	249	102	Pass
0.0900	232	237	102	Pass
0.0916	223	225	100	Pass
0.0931	213	208	97	Pass
0.0946	204	173	84	Pass
0.0962	195	162	83	Pass
0.0977	189	159	84	Pass
0.0992	177	157	88	Pass
0.1008	165	152	92	Pass
0.1023	154	144	93	Pass
0.1038	144	131	90	Pass
0.1054	134	115	85	Pass
0.1069	125	111	88	Pass
0.1085	121	106	87	Pass
0.1100	115	97	84	Pass
0.1115	107	93	86	Pass
0.1131	96	89	92	Pass
0.1146	88	85	96	Pass

0.1161	77	80	103	Pass
0.1177	71	75	105	Pass
0.1192	67	70	104	Pass
0.1207	61	66	108	Pass
0.1223	56	61	108	Pass
0.1238	53	54	101	Pass
0.1253	47	48	102	Pass
0.1269	44	44	100	Pass
0.1284	42	39	92	Pass
0.1299	39	32	82	Pass
0.1315	36	21	58	Pass
0.1330	35	13	37	Pass
0.1346	29	4	13	Pass
0.1361	26	4	15	Pass
0.1376	24	4	16	Pass
0.1392	22	3	13	Pass
0.1407	20	3	15	Pass
0.1422	19	2	10	Pass
0.1438	17	2	11	Pass
0.1453	15	2	13	Pass
0.1468	13	2	15	Pass
0.1484	13	2	15	Pass
0.1499	11	2	18	Pass
0.1514	9	2	22	Pass
0.1530	8	1	12	Pass
0.1545	6	0	0	Pass
0.1560	6	0	0	Pass
0.1576	5	0	0	Pass
0.1591	4	0	0	Pass
0.1607	4	0	0	Pass
0.1622	4	0	0	Pass
0.1637	4	0	0	Pass
0.1653	4	0	0	Pass
0.1668	4	0	0	Pass
0.1683	4	0	0	Pass
0.1699	3	0	0	Pass
0.1714	3	0	0	Pass
0.1729	3	0	0	Pass
0.1745	2	0	0	Pass
0.1760	2	0	0	Pass
0.1775	2	0	0	Pass
0.1791	2	0	0	Pass
0.1806	2	0	0	Pass
0.1821	2	0	0	Pass
0.1837	2	0	0	Pass
0.1852	2	0	0	Pass
0.1868	2	0	0	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0 acre-feet
On-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.
Off-line facility target flow:	0 cfs.
Adjusted for 15 min:	0 cfs.

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Vault 1 POC	☐	152.29			☐	0.00			
Total Volume Infiltrated		152.29	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

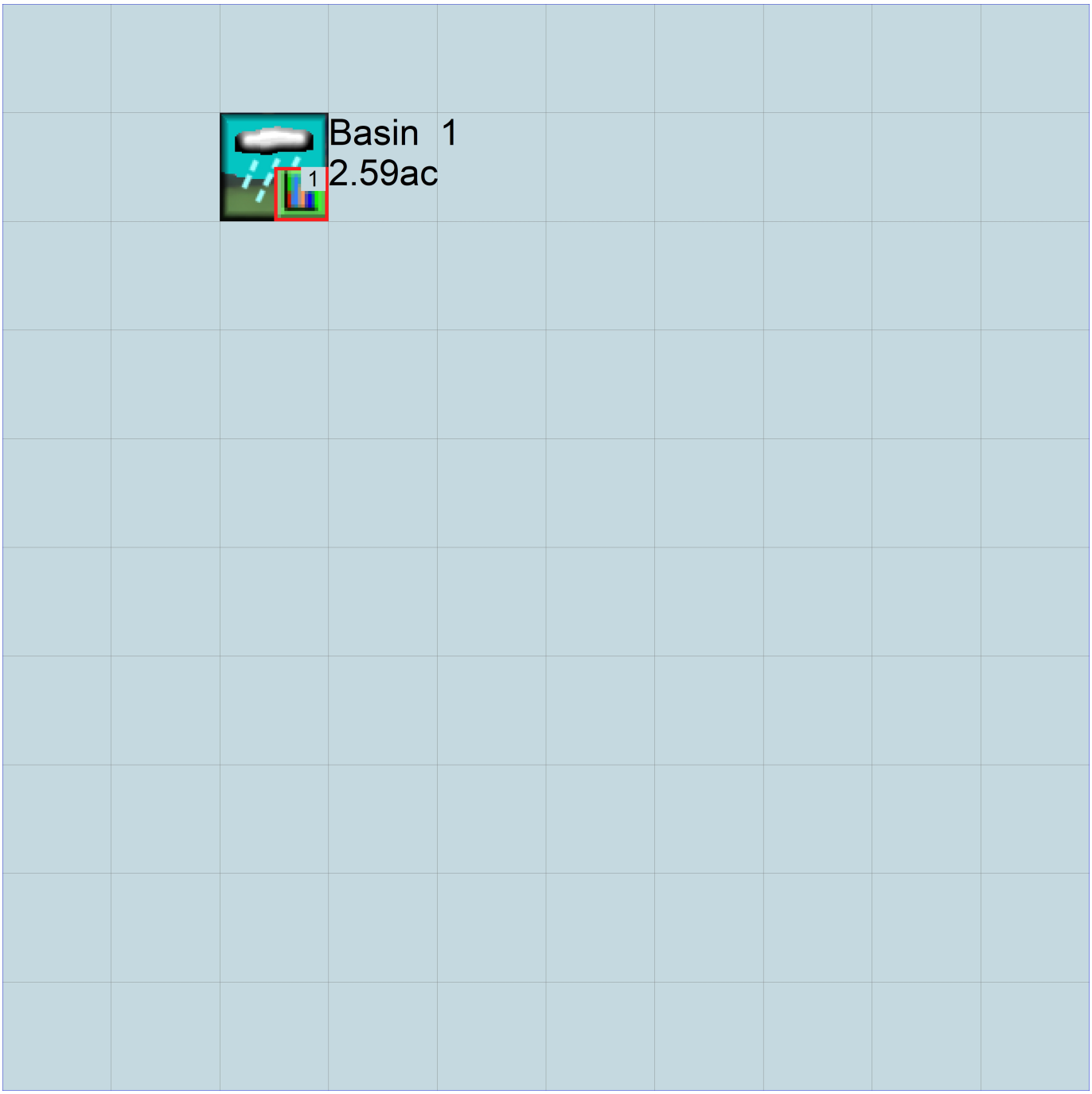
PERLND Changes

No PERLND changes have been made.

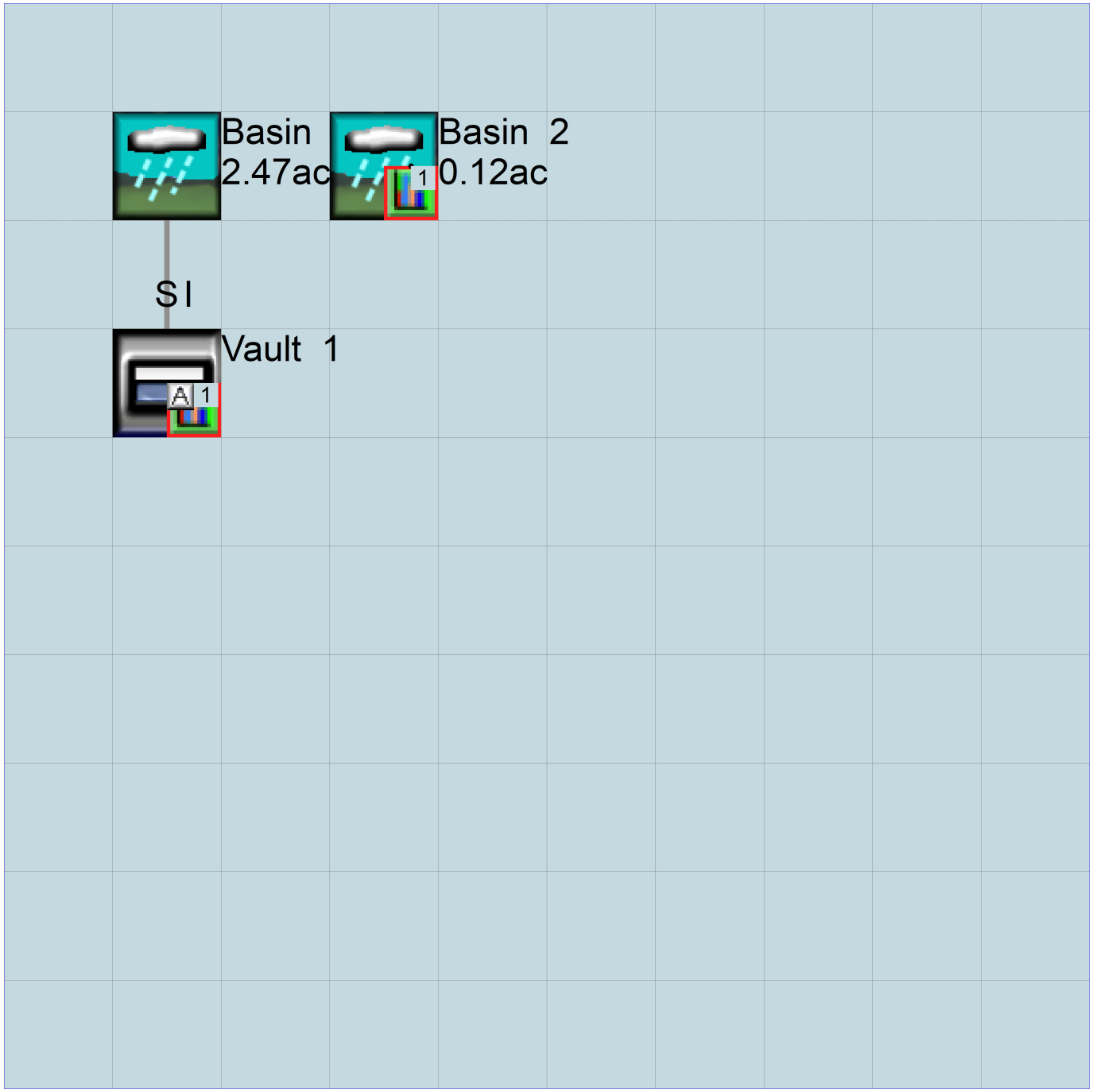
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



Predeveloped UCI File

Mitigated UCI File

```
RUN

GLOBAL
  WWHM4 model simulation
  START       1948 10 01        END    2009 09 30
  RUN INTERP OUTPUT LEVEL    3    0
  RESUME     0 RUN     1                    UNIT SYSTEM     1
END GLOBAL

FILES
<File>  <Un#>   <-----------File Name------------------------------>***
<-ID->                                                              ***
WDM         26   21073 Vault Remodel.wdm
MESSU       25   Mit21073 Vault Remodel.MES
            27   Mit21073 Vault Remodel.L61
            28   Mit21073 Vault Remodel.L62
            30   POC21073 Vault Remodel1.dat
END FILES

OPN SEQUENCE
    INGRP               INDELT 00:15
      PERLND      14
      PERLND      17
      IMPLND       2
      IMPLND       4
      IMPLND       1
      RCHRES       1
      COPY         1
      COPY       501
      COPY       601
      DISPLY       1
    END INGRP
END OPN SEQUENCE
DISPLY
  DISPLY-INFO1
    # -  #<----------Title----------->***TRAN PIVL DIG1 FIL1  PYR DIG2 FIL2 YRND
    1        Vault  1                   MAX                     1    2   30    9
  END DISPLY-INFO1
END DISPLY
COPY
  TIMESERIES
    # -  #  NPT  NMN ***
    1         1    1
  501         1    1
  601         1    1
  END TIMESERIES
END COPY
GENER
  OPCODE
    #    # OPCD ***
  END OPCODE
  PARM
    #    #         K ***
  END PARM
END GENER
PERLND
  GEN-INFO
    <PLS ><-------Name------->NBLKS   Unit-systems   Printer ***
    # -  #                          User  t-series Engl Metr ***
                                          in  out           ***
   14     C, Pasture, Mod         1    1    1    1   27    0
   17     C, Lawn, Mod            1    1    1    1   27    0
  END GEN-INFO
  *** Section PWATER***

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

```
   14         0    0    1    0    0    0    0    0    0    0    0    0
   17         0    0    1    0    0    0    0    0    0    0    0    0
  END ACTIVITY

  PRINT-INFO
    <PLS > ***************** Print-flags ***************************** PIVL  PYR
    # -  # ATMP SNOW PWAT  SED  PST  PWG PQAL MSTL PEST NITR PHOS TRAC  *********
   14         0    0    4    0    0    0    0    0    0    0    0    0    1    9
   17         0    0    4    0    0    0    0    0    0    0    0    0    1    9
  END PRINT-INFO

  PWAT-PARM1
    <PLS >  PWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP UZFG  VCS  VUZ  VNN VIFW VIRC  VLE INFC  HWT ***
   14         0    0    0    0    0    0    0    0    0    0    0
   17         0    0    0    0    0    0    0    0    0    0    0
  END PWAT-PARM1

  PWAT-PARM2
    <PLS >      PWATER input info: Part 2         ***
    # -  # ***FOREST      LZSN    INFILT      LSUR     SLSUR     KVARY     AGWRC
   14              0       4.5      0.06       400       0.1       0.5     0.996
   17              0       4.5      0.03       400       0.1       0.5     0.996
  END PWAT-PARM2

  PWAT-PARM3
    <PLS >      PWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN    INFEXP    INFILD    DEEPFR    BASETP    AGWETP
   14              0         0         2         2         0         0         0
   17              0         0         2         2         0         0         0
  END PWAT-PARM3
  PWAT-PARM4
    <PLS >     PWATER input info: Part 4                              ***
    # -  #     CEPSC      UZSN      NSUR     INTFW       IRC     LZETP ***
   14           0.15       0.4       0.3         6       0.5       0.4
   17            0.1      0.25      0.25         6       0.5      0.25
  END PWAT-PARM4

  PWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
               ran from 1990 to end of 1992 (pat 1-11-95) RUN 21 ***
    # -  # ***  CEPS      SURS       UZS      IFWS       LZS       AGWS      GWVS
   14              0         0         0         0       2.5          1         0
   17              0         0         0         0       2.5          1         0
  END PWAT-STATE1

END PERLND

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

  ACTIVITY
    <PLS > ************* Active Sections ******************************
    # -  # ATMP SNOW IWAT  SLD  IWG IQAL   ***
    2         0    0    1    0    0    0
    4         0    0    1    0    0    0
    1         0    0    1    0    0    0
  END ACTIVITY

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

```
    2         0    0    4    0    0    0    1    9
    4         0    0    4    0    0    0    1    9
    1         0    0    4    0    0    0    1    9
  END PRINT-INFO

  IWAT-PARM1
    <PLS >  IWATER variable monthly parameter value flags  ***
    # -  # CSNO RTOP  VRS  VNN RTLI     ***
    2         0    0    0    0    0
    4         0    0    0    0    0
    1         0    0    0    0    0
  END IWAT-PARM1

  IWAT-PARM2
    <PLS >      IWATER input info: Part 2         ***
    # -  # ***  LSUR     SLSUR      NSUR     RETSC
    2           400      0.05       0.1      0.08
    4           400      0.01       0.1       0.1
    1           400      0.01       0.1       0.1
  END IWAT-PARM2

  IWAT-PARM3
    <PLS >      IWATER input info: Part 3         ***
    # -  # ***PETMAX    PETMIN
    2             0         0
    4             0         0
    1             0         0
  END IWAT-PARM3

  IWAT-STATE1
    <PLS > *** Initial conditions at start of simulation
    # -  # ***  RETS      SURS
    2             0         0
    4             0         0
    1             0         0
  END IWAT-STATE1

END IMPLND

SCHEMATIC
<-Source->                 <--Area-->     <-Target->   MBLK   ***
<Name>   #                 <-factor->     <Name>   #   Tbl#   ***
Basin  1***
PERLND  14                       1.24     RCHRES   1      2
PERLND  14                       1.24     RCHRES   1      3
PERLND  17                       0.13     RCHRES   1      2
PERLND  17                       0.13     RCHRES   1      3
IMPLND   2                       0.36     RCHRES   1      5
IMPLND   4                       0.74     RCHRES   1      5
Basin  2***
PERLND  14                       0.11     COPY   501     12
PERLND  14                       0.11     COPY   601     12
PERLND  14                       0.11     COPY   501     13
PERLND  14                       0.11     COPY   601     13
IMPLND   1                       0.01     COPY   501     15
IMPLND   1                       0.01     COPY   601     15

******Routing******
PERLND  14                       1.24     COPY     1     12
PERLND  17                       0.13     COPY     1     12
IMPLND   2                       0.36     COPY     1     15
IMPLND   4                       0.74     COPY     1     15
PERLND  14                       1.24     COPY     1     13
PERLND  17                       0.13     COPY     1     13
RCHRES   1                          1     COPY   501     16
END SCHEMATIC

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

```
COPY   501 OUTPUT MEAN   1 1   48.4        DISPLY   1     INPUT  TIMSER 1


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

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

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

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

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

  HYDR-PARM2
    # -  #    FTABNO       LEN     DELTH     STCOR        KS      DB50       ***
  <------><--------><--------><--------><--------><--------><-------->       ***
    1              1      0.02       0.0       0.0       0.5       0.0
  END HYDR-PARM2
  HYDR-INIT
    RCHRES  Initial conditions for each HYDR section                       ***
    # -  # ***   VOL     Initial  value  of COLIND     Initial  value  of OUTDGT
           *** ac-ft     for each possible exit        for each possible exit
  <------><-------->     <---><---><---><---><---> *** <---><---><---><---><--->
    1           0         4.0  0.0  0.0  0.0  0.0       0.0  0.0  0.0  0.0  0.0
  END HYDR-INIT
END RCHRES

SPEC-ACTIONS
END SPEC-ACTIONS
FTABLES
  FTABLE      1
   92    4
     Depth      Area    Volume  Outflow1 Velocity  Travel Time***
      (ft)   (acres) (acre-ft)   (cfs)   (ft/sec)    (Minutes)***
  0.000000  0.057392  0.000000  0.000000
  0.083333  0.057392  0.004783  0.005577
  0.166667  0.057392  0.009565  0.007887
  0.250000  0.057392  0.014348  0.009660
  0.333333  0.057392  0.019131  0.011154
  0.416667  0.057392  0.023913  0.012470
  0.500000  0.057392  0.028696  0.013661
  0.583333  0.057392  0.033479  0.014755
  0.666667  0.057392  0.038261  0.015774
  0.750000  0.057392  0.043044  0.016731
  0.833333  0.057392  0.047827  0.017636
  0.916667  0.057392  0.052609  0.018497
```

1.000000	0.057392	0.057392	0.019319
1.083333	0.057392	0.062175	0.020108
1.166667	0.057392	0.066957	0.020867
1.250000	0.057392	0.071740	0.021599
1.333333	0.057392	0.076523	0.022308
1.416667	0.057392	0.081305	0.022994
1.500000	0.057392	0.086088	0.023661
1.583333	0.057392	0.090871	0.024309
1.666667	0.057392	0.095654	0.024941
1.750000	0.057392	0.100436	0.025557
1.833333	0.057392	0.105219	0.026158
1.916667	0.057392	0.110002	0.026746
2.000000	0.057392	0.114784	0.027321
2.083333	0.057392	0.119567	0.027885
2.166667	0.057392	0.124350	0.028437
2.250000	0.057392	0.129132	0.028979
2.333333	0.057392	0.133915	0.029510
2.416667	0.057392	0.138698	0.030033
2.500000	0.057392	0.143480	0.030546
2.583333	0.057392	0.148263	0.031051
2.666667	0.057392	0.153046	0.031548
2.750000	0.057392	0.157828	0.032037
2.833333	0.057392	0.162611	0.032519
2.916667	0.057392	0.167394	0.032994
3.000000	0.057392	0.172176	0.033462
3.083333	0.057392	0.176959	0.033923
3.166667	0.057392	0.181742	0.034379
3.250000	0.057392	0.186524	0.038532
3.333333	0.057392	0.191307	0.041320
3.416667	0.057392	0.196090	0.043419
3.500000	0.057392	0.200872	0.045215
3.583333	0.057392	0.205655	0.046825
3.666667	0.057392	0.210438	0.048308
3.750000	0.057392	0.215220	0.049695
3.833333	0.057392	0.220003	0.051006
3.916667	0.057392	0.224786	0.052255
4.000000	0.057392	0.229568	0.053453
4.083333	0.057392	0.234351	0.054605
4.166667	0.057392	0.239134	0.055719
4.250000	0.057392	0.243916	0.056799
4.333333	0.057392	0.248699	0.057849
4.416667	0.057392	0.253482	0.058870
4.500000	0.057392	0.258264	0.059867
4.583333	0.057392	0.263047	0.060840
4.666667	0.057392	0.267830	0.061793
4.750000	0.057392	0.272612	0.062726
4.833333	0.057392	0.277395	0.063641
4.916667	0.057392	0.282178	0.064538
5.000000	0.057392	0.286961	0.065420
5.083333	0.057392	0.291743	0.066287
5.166667	0.057392	0.296526	0.067140
5.250000	0.057392	0.301309	0.067980
5.333333	0.057392	0.306091	0.068807
5.416667	0.057392	0.310874	0.074056
5.500000	0.057392	0.315657	0.081287
5.583333	0.057392	0.320439	0.085925
5.666667	0.057392	0.325222	0.089737
5.750000	0.057392	0.330005	0.093093
5.833333	0.057392	0.334787	0.096146
5.916667	0.057392	0.339570	0.098979
6.000000	0.057392	0.344353	0.101641
6.083333	0.057392	0.349135	0.104165
6.166667	0.057392	0.353918	0.106575
6.250000	0.057392	0.358701	0.108888
6.333333	0.057392	0.363483	0.111118
6.416667	0.057392	0.368266	0.113273
6.500000	0.057392	0.373049	0.115364
6.583333	0.057392	0.377831	0.117395
6.666667	0.057392	0.382614	0.119374
6.750000	0.057392	0.387397	0.121305

```
  6.833333  0.057392  0.392179  0.123191
  6.916667  0.057392  0.396962  0.125036
  7.000000  0.057392  0.401745  0.126844
  7.083333  0.057392  0.406527  0.382908
  7.166667  0.057392  0.411310  0.833788
  7.250000  0.057392  0.416093  1.349620
  7.333333  0.057392  0.420875  1.817213
  7.416667  0.057392  0.425658  2.148481
  7.500000  0.057392  0.430441  2.340359
  7.583333  0.057392  0.435223  2.544196
  END FTABLE  1
END FTABLES

EXT SOURCES
<-Volume-> <Member> SsysSgap<--Mult-->Tran <-Target vols> <-Grp> <-Member->  ***
<Name>   # <Name> # tem strg<-factor->strg <Name>   #   #        <Name> # #  ***
WDM      2 PREC     ENGL    0.8            PERLND   1 999 EXTNL  PREC
WDM      2 PREC     ENGL    0.8            IMPLND   1 999 EXTNL  PREC
WDM      1 EVAP     ENGL    0.76           PERLND   1 999 EXTNL  PETINP
WDM      1 EVAP     ENGL    0.76           IMPLND   1 999 EXTNL  PETINP

END EXT SOURCES

EXT TARGETS
<-Volume-> <-Grp> <-Member-><--Mult-->Tran <-Volume-> <Member> Tsys Tgap Amd ***
<Name>   #        <Name> # #<-factor->strg <Name>   # <Name>    tem strg strg***
COPY     1 OUTPUT MEAN   1 1     48.4      WDM    701 FLOW     ENGL      REPL
COPY   501 OUTPUT MEAN   1 1     48.4      WDM    801 FLOW     ENGL      REPL
COPY   601 OUTPUT MEAN   1 1     48.4      WDM    901 FLOW     ENGL      REPL
RCHRES   1 HYDR   RO     1 1        1      WDM   1000 FLOW     ENGL      REPL
RCHRES   1 HYDR   STAGE  1 1        1      WDM   1001 STAG     ENGL      REPL
END EXT TARGETS

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

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

  MASS-LINK        5
IMPLND     IWATER SURO       0.083333      RCHRES         INFLOW IVOL
  END MASS-LINK    5

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

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

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

  MASS-LINK       16
RCHRES     ROFLOW                          COPY           INPUT  MEAN
  END MASS-LINK   16


END MASS-LINK

END RUN
```

Predeveloped HSPF Message File

Mitigated HSPF Message File

Disclaimer

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