LAND TECHNOLOGIES, INC.
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MAKING A "WAY" OUT OF "NO WAY"

927 Alder LLC

927 Alder Ave, Marysville, WA 98270

PN -

1st Submittal: March 2024

2nd Submittal: September 2024

# Stormwater Site Plan Report for 927 Alder Ave Townhomes


09/03/2024

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## Acronyms

The following acronyms and abbreviations may or may not be called out within the body of this report.

- ASTM - American Society for Testing and Materials
- BMPs - Best Management Practices
- CB - Catch Basin
- CAO - Critical Areas Ordinance
- CESCL - Certified Erosion and Sediment Control Lead
- DOE - Department of Ecology
- EDDS - Engineering Design & Development Standards
- FEMA - Federal Emergency Management Agency
- HSPF - Hydrological Simulation Program—Fortran
- LiDAR - Light Detecting And Ranging
- LDA - Land disturbing activity
- LID - Low Impact Development
- LID Manual - DOE 2005 LID Technical Guidance Manual for Puget Sound
- MRs - Minimum Requirements (for Stormwater Management)
- MS4 - Municipal Separate Storm Sewer System
- MSL - Mean Sea Level
- NAVD88 - North American Vertical Datum of 1888
- NGVD29 - National Geodetic Vertical Datum of 1929
- NPDES - National Pollutant Discharge Elimination System
- NRCS - Natural Resources Conservation Service
- NPGIS - Non-Pollutant Generating Impervious Surface
- O&M - Operations and Maintenance
- PGIS - Pollutant Generating Impervious Surface
- PGPS - Pollutant Generating Pervious Surface
- PLSS - Public Land Survey System
- POC - Point of Compliance
- RCW - Revised Code of Washington
- ROW - Right-of-Way
- SCDM-2010 - Snohomish County 2010 Drainage Manual
- SMMWW - DOE 2005 Stormwater Management Manual for Western Washington
- SWPPP - Stormwater Pollution Prevention Plan
- TDA - Threshold Discharge Area
- TESC - Temporary Erosion and Sediment Controls
- USDA - United States Department of Agriculture
- US EPA - United States Environmental Protection Agency
- WSDOT - Washington State Department of Transportation
- WWHM - Western Washington Hydrology Model

# Section 1 – Report Summary

## 1.1 Project Description

927 Alder LLC is proposing the development of 0.45-*acres* of land in Southwest Marysville, WA off of Alder Ave. The parcel contains an existing single family home. The existing house will remain. No known critical areas are known to exist onsite or directly offsite. The development of the parcel will result in 6 townhomes, an detached accessory dwelling, and retain an existing single family home for a total of 8 dwelling units. The proposed road access for the development will be from the existing alley and extend to Alder Ave for emergency access.

The development consists of townhome units, ADU, driveways, homes, drive aisle and stormwater facilities.

Highly permeably sandy soils are found throughout the site and surrounding area. These sandy soils are representative of Recessional Outwash deposits commonly found in the Marysville Trough.

Infiltration will be utilized in the site for stormwater management. An initial infiltration rate of 64 inches per hour is recommended based on the results of field testing (Earth Solutions NW, LLC, 2023). A 12.0 in/hr infiltration rate will be used for facility sizing.

The entire developable project area is in a single natural discharge area with a single discharge location to the ROW. Stormwater BMPs will be employed to mitigate polluted and unpolluted surface water flows.

## Summary Stormwater Management

The project qualifies as 'new development' because there are no existing impervious areas. The proposed condition of the fully developed site will have more than 5,000sf impervious areas. Per Figure I-3.1 Vol. 1 of the 2019 SMMWW, all minimum requirements shall apply for this project.

This project triggers MRs 1-9 and is within the City's UGA. The project will choose to adhere to List #2 of MR #5. On-site stormwater BMPs will consist only of BMP T5.13. Feasibility analysis for individual lot BMPs is provided in MR #5 of the report. However, the overall site stormwater management will mirror the requirements and intent of MR #5.

Flow control requirements for the site will be met by infiltration. The majority of runoff from impervious surfaces and converted surfaces will be infiltrated. BMP T5.10A Infiltration Trench is sized to infiltrate 100% of stormwater generated on the units. Bioretention BMPs are sized to infiltrate 100% of the stormwater generated on driveways and aisle. The proposed infiltration facility will provide full infiltration.

The site creates less than 5,000 sf of PGIS, therefore runoff treatment BMPs are not required. Stormwater treatment will be provided through infiltration BMPs however.

## 1.2 Project Data Summary

Existing and proposed project areas are presented for determination of stormwater management requirements based on prescribed thresholds as outlined in the Marysville Municipal Code (MMC 22C) and the 2019 SMMWW Vol-I, Section I-3 are summarized in the following tables.

### Table 1 - Project Parcel Summary

| **Project Data:** | |
|---|---|
| Applicant | 927 Alder LLC |
| Site Owner | 927 Alder LLC |
| Project Name | 927 Alder Ave Townhomes |
| Project T.S.R. Location | Twn 30 N, Rng 5 E, Sec 28, Qtr-SW |
| Project Address | 927 Alder Ave, Marysville, WA 98270 |
| Parcel ID(s) | 005648-002-010-00 |
| Watershed | Snohomish |
| Basin | Snohomish |
| Sub-Basin | Quilceda Creek |
| WRIA Number | 7-Snohomish |
| Analysis Standard | 2019 DOE SMMWW |

### Table 2 - Project Area Analysis & Activities Summary

| | | | |
|---|---|---|---|
| **Existing Conditions:** | | | |
| Total Site Area | 19,478 | sf (0.45 ac) | |
| Existing Impervious Area | 4,614 | sf (0.11 ac) | 23.69% |
| | | | |
| **Proposed Activity:** | | | |
| Proposed Activity | SFR - Townhomes | | |
| Total Proposed Disturbance Area | 13,877 | sf (0.32 ac) | |
| Proposed Grading Area | 13,877 | sf (0.32 ac) | |
| Proposed New NPGIS Onsite (Roof) | 5,272 | sf (0.12 ac) | |
| Proposed New PGIS Onsite (Driveway) | 1,910 | sf (0.04 ac) | |
| Proposed Replaced Impervious Area | 0 | sf (0.00 ac) | |
| Native Vegetation convert to Lawn | 0 | sf (0.00 ac) | |
| Native Vegetation convert to Pasture | 0 | sf (0.00 ac) | |
| Total New Impervious Area Onsite | 7,182 | sf (0.16 ac) | |
| Grading is ≤ 2 feet from P/L | No | | |
| Any excavation 4+' at <1:1 slope to P/L | No | | |
| Fill Slopes 4+' and >33% slope | No | | |

# Section 2 - Minimum Requirements

## 2.1 Assessment of Minimum Requirements and Thresholds

Minimum requirements and thresholds are established by City of Marysville Municipal Code 14.15.050 – Minimum Requirements. Minimum Requirements for new development and Redevelopment are based on a development's disturbance area. Existing and proposed project areas for determination of stormwater management requirements are presented in Table 2.

The existing impervious area is less than 35% so this project qualifies as 'new development'. The proposed condition of the fully developed site will have impervious area in excess of 5,000 sf. This requires construction activities and stormwater management to comply with Minimum Requirements 1 through 9. A full construction SWPPP is also required.

Minimum Requirements per the SCMD:

MR-1: Prepare Stormwater Site Plan. MMC 14.15.050 (1)

MR-2: Stormwater Pollution Prevention Plan (SWPPP). MMC 14.15.050 (2)

MR-3: Water pollution source control for new development. MMC 14.15.050 (3)

MR-4: Preservation of natural drainage systems and outfalls. MMC 14.15.050 (4)

MR-5: On-site stormwater management. MMC 14.15.050 (5)

MR-6: Runoff treatment. MMC 14.15.050 (6)

MR-7: Flow control requirements. MMC 14.15.050 (7)

MR-8: Detention or treatment in wetlands and wetland buffers. MMC 14.15.050 (8)

MR-9: Inspection, operation and maintenance requirements. MMC 14.15.050 (9)

Each Minimum Requirements is described in the following sections. There are no additional requirements to be met.

## 2.2 MR #1: Preparation of Stormwater Site Plans

This document is the Stormwater Site Plan Report that addresses the requirements of MR-1. This section presents the portion of the Stormwater Site Plan that includes recommendations, calculations, and procedures required to adhere to Minimum Requirement #1. The evaluation of the existing site conditions follows.

### 2.2.1 Site Location

The site is located in the SW quarter of Section 28 of Township 30 North, Range 5 East. The street address is 927 Alder Ave, Marysville, WA 98270 and the parcel is located on the west side of Alder NE. See Figure 1 for a vicinity map.

### 2.2.2 Site Description, Existing Conditions

The project site is a 0.45-*acres* parcel. The parcel is owned by 927 Alder LLC. The Snohomish County parcel number is 005648-002-010-00. It is zoned MH1 Middle Housing 1 and is located in Snohomish County.

The site has a single family home that will be retained. The existing drainage system(s) are underdetermined but largely surface runoff to infiltration. Surface runoff overall flows west.

The majority of the site is lawn.

All maps and figures are presented in the Support Data section of this document.

A vicinity map that shows the site location is shown as Figure 1.

A site map that shows the property lines is shown in Figure 2.

A topographic map that shows the site boundaries, study area boundaries, and the downstream flow-paths is also presented in Figure 4.

### 2.2.3 Existing Basin Analysis

The project is defined by the development within the subject parcel. Existing project flow paths are shown in Figure 2.

The study area is located in the Quilceda Creek sub-basin of the Snohomish Basin in the Snohomish watershed (WRIA-7-Snohomish), which drains to the Puget Sound.

All existing flow assessment and site related basin delineations were established by tracing analysis of a LIDAR surface model.

### 2.2.4 Other Information on the Study Area

The site is not in or adjacent to a USEPA Sole Source Aquifer.

The site is not in a well-head protection area.

The site is not in a floodway or floodplain.

### 2.2.5 Critical Areas

No critical areas are known to occur onsite or directly offsite.

### 2.2.6 Topography

The site and surrounding topography was analyzed using survey topographic points provided by Pacific Coast Surveys, Inc. A 3D surface model was generated.

The site has mostly flat slopes with a low point around 33.5 feet MSL at southwest corner of the site. The site has an average 34 feet MSL.

Slopes average in the range of 0 to 2 percent for the majority of the developable area. The site has an average slope of 0.5%.

### 2.2.7 Soils

Per NRCS mappings, Ragnar fine sandy loam soils are found throughout the site. The soils are related with outwash plains. The site is situated within the Marysville Trough, a well-known and mapped Recessional outwash feature in Puget Sound. Ragnar fine sandy loam soils have a 0-2 *inch* first layer of ashy fine sandy loam, 2-24 *inch* ashy sandy loam with the remaining profile being sand. Per Earth Solutions NW, LLC, 64 in/hr infiltration rate was determined. A conservative 20 *in/hr* infiltration rate is calculated based from a CFv = 0.9, CFt = 0.4 and CFm = 0.9. A rate of 12 *in/hr* is used for design.

Detailed physical and chemical properties of these soils are presented in Section 4.1. The NRCS mapping can be seen in Figure 5.

### 2.2.8 Field Inspection

The site has not been visited recently. All site inspection has been performed via digital tools and remote sensing along with Pacific Coast Survey.

### 2.2.9 Upstream Analysis

There is no upstream area tributary to the site. The site and neighboring lots are flat with a high point of 34.5 ft.

### 2.2.10 Downstream Analysis

The downstream area was established by tracing analysis of a LIDAR surface model and evaluation of various GIS data, aerial imagery, and City of Marysville Drainage Inventory. One onsite basin is present on site. There is no stormwater conveyance systems located around the property or in the vicinity of the site. Stormwater generated onsite is infiltrated. Stormwater runoff overwhelming the capacity of the site soil would be conveyed to the south through the Alder Ave ROW. Stormwater is collected in a catch basin in the Alder Ave in a 12-inch pipe before traveling west along 8$^{th}$ St. Stormwater flows to the intersection of 8$^{th}$ and Delta Ave before traveling south in a 48-inch pipe. The 48-inch pipe eventually discharges to a municipal stormwater facility adjacent to the Ebey Slough Divergence and to the Puget Sound. Figure 4 shows a portion of the downstream flow path.

## 2.3 MR #2: Stormwater Pollution Prevention Plans (SWPPPs)

MMC 14.15.050 (2) specifies the requirements for development and redevelopment projects are responsible for preventing erosion and discharge of sediment and other pollutants into receiving waters. Volume I, Section I-3 of the 2019 SMMWW specifies that all new development and redevelopment implement a Stormwater Pollution Prevention Plans (SWPPP), which is a list of 13 elements that present measures and methods for all permanent and temporary erosion and sediment control (TESC), pollution prevention, inspection/monitoring activities, and recordkeeping required during the proposed construction project.

Based on the MR#2 thresholds, this project generates more than 2,000 *square feet* of impervious area, so a full SWPPP is required. Required elements for the SWPPP:

- SWPPP element 1: Preserve vegetation/mark clearing limits
- SWPPP element 2: Establish construction access
- SWPPP element 3: Control flow rates
- SWPPP element 4: Install sediment controls
- SWPPP element 5: Stabilize soils
- SWPPP Element 6: Protect slopes
- SWPPP element 7: Protect permanent drain inlets
- SWPPP element 8: Stabilize channels and outlets
- SWPPP element 9: Control pollutants
- SWWP element 10: Control dewatering
- SWPPP element 11: Maintain best management practices
- SWPPP element 12: Manage the project
- SWPPP element 13: Protect On-Site Stormwater Management BMPs for Runoff from Roofs and Other Hard Surfaces

The SWPPP is assembled as a separate document for portability and reproduction purposes. The document is titled "**Stormwater Pollution Prevention Plan for 927 Alder LLC**", dated 3 September 2024.

## 2.4 MR #3: Source Control of Pollution

MMC 14.15.050 (3) specifies the requirements for water pollution source control for new development or redevelopment activities in accordance with Volume IV of the SMMWW. These activities are primarily commercial industrial developments that represent significant pollutant generation potential and the associated source control BMPs are designed to suit those activities.

Per Chapter 2.5.3, MR#3 does not apply to residential development, hence such source controls are not specified for this project.

## 2.5 MR #4: Preservation of Natural Drainage Systems and Outfalls

MMC 14.15.050 (4) specifies the requirements for preservation of natural drainage systems or outfalls for all new development and redevelopment activities under Minimum Requirement 4 in the 2019 SMMWW.

Natural drainage patterns as they once existed shall be retained. Pre-developed conditions experience a sheet drainage pattern to the site's west property boundary. Stormwater generated onsite reaches the property boundary through infiltration and surface runoff. Existing discharge location shall be maintained.

## 2.6 MR #5: On-Site Stormwater Management

MMC 14.15.050 (5) specifies requirements for on-site stormwater BMPs. This requirement mandates that on-site stormwater runoff be infiltrated, dispersed, and/or retained to the maximum extent feasible without causing flooding or erosion impacts. Projects triggering Minimum Requirements 1 through 5 must use On-site stormwater management BMPs from List #1 for all surfaces or demonstrate compliance with the LID Performance Standard. Projects triggering Minimum Requirements 1 through 9 must meet the requirements of Table I-3.1 in Vol. 1 of the 2019 SMMWW. Table I-3.1 specifies the requirements for new or redevelopment depending on UGA and parcel size to meet the requirements of the LID Performance Standard and/or List #2. List #1 and List #2 specify stormwater BMPs in order of preference. The first BMP determined feasible is required.

This project trigger MR's 1-9. This project is within the City's UGA. This project is required to adhere to the LID Performance Standard or List #2 per Table 2.5.1.

List #1 and #2 contain appropriate BMPs to mitigate a particular developed surface. The surfaces included in the list are Lawn and Landscaped Areas, Roofs, and other hard surfaces (road/driveway/parking).

> Lawn/Landscape is required to utilize BMP T5.13, Post-Construction Soil Quality and Depth.
>
> Roofs are required to employ BMP T5.30 Full Dispersion or Downspout Infiltration, Rain Gardens or Bioretention, BMP T5.10A Downspout Dispersion Systems, or perforated stub-out connections. The first feasible BMP in this list must be used.
>
> Other Hard surfaces (Roads, Driveways, Parking Lots, Etc.) must utilize BMP T5.30 Full Dispersion, BMP T5.15 Permeable Pavement, Bioretention, Sheet Flow Dispersion, or Concentrated Flow Dispersion. The first feasible BMP in this list must be used.

Lawn/landscape will utilize BMP T5.13, Post Construction Soil Quality and Depth.

Roofs will not be able to provide BMP T5.30 Full Dispersion. Full Dispersion requires 100 *foot* flow paths within native areas. The project will not be able to maintain 65% open space while also complying with the Growth Management Act.

Roofs will be drained to Downspout infiltration trenches per BMP T5.10 A on this small project site. The trenches are sized per Coarse Sand with 20lf of trench per 1,000sf of rooftop. 89.3-ft or 90-ft of trench will be positioned beneath the drive aisle to accept stormwater from the rooftops. The trench is required to be 2-ft wide and only 18-inches tall. Three to four times the required footprint will be provided for emergency overflow of the bioretention cells.

Stormwater generated on roofs that are routed to infiltration systems will not use individual dispersion BMPs or perforated stub-outs due to the extensive infrastructure required in these urban developments. Perforated pipes are not allowed beneath driveways. Perforated stub-out are infeasible. Dispersion BMPs are infeasible as there is not enough space to accommodate flow paths and meet the goal and policy of Growth Management Act (GMA).

Other hard surfaces (Roads, driveways and parking) may not provide BMP T5.30 Full Dispersion. Full dispersion requires 100 *foot* flow path within native areas. The project will not be able to maintain 65% open space while also complying with the GMA.

Permeable pavement is the next preferred on-site stormwater BMP. Infeasibility criteria within the 2019 DOE SMMWW states that where installation of permeable pavement would threaten the safety or reliability of preexisting underground utilities, pre-existing underground storage tanks, or pre-existing road sub-grades. The installation of the BMP would threaten the existing road, alley and driveway sub-grades.

Bioretention is the next feasible alternative. All stormwater generated from pollution generating hard surfaces are routed to bioretention cells for treatment. Stormwater through bioretention cells is to be 100% fully infiltrated. Stormwater is treated through the amended soils later before reaching the native sand soils. Full (100%) infiltration is achieved with only the bioretention cells. If these systems are overwhelmed or rain events exceeding the 100-yr storm event occur, an overflow pipe system is directed to the rooftop infiltration BMP trench as a safety factor. This should not be construed as a required connection or duplicative system as the two systems function independently within the Precipitation and Analysis thresholds they are required to satisfy.

MR #5 – is essentially the requirement to expose stormwater to the native soil profile to the maximum extent feasible. The Downspout Infiltration Trench BMP and Bioretention Cell BMPs are required BMPs provided within the 2019 DOE SMMWW.

A site plan showing the stormwater management and development can be seen in Figure 3.

## 2.7 MR #6: Runoff Treatment

Minimum Requirement #6 in MMC 14.15.050 (6) specifies the requirements for providing runoff treatment. The threshold for requiring a treatment BMP is 5,000 *square feet* of PGIS (Pollution Generating Impervious Surface) or a total of more than ¾ of an acre of PGPS (Pollution Generating Pervious Surface).

This project is expected to generate 1,910 *square feet* (0.04 *acres*) of PGIS based on road, sidewalk and driveway areas, therefore treatment facility BMPs are not required for this project. However, stormwater generated from roads and driveways are infiltrated through a bioretention cell system that provides nearly 100% treatment through filtering of the bioretention soil media.

## 2.8 MR #7: Flow Control

Minimum Requirement #7 in MMC 14.15.050 (7) specifies the requirements for runoff flow control. The threshold for requiring Minimum Requirement #7 is 5,000 *square feet* of impervious surface. Flow control shall be provided if the project creates more than 10,000 *square feet* of effective impervious area in a threshold discharge area, converts ¾ of an acre or more of native vegetation to lawn, 2.5 *acres* or more native vegetation is converted to pasture, or a combination of impervious and converted pervious surfaces cause a 0.1 *cfs* increase in the 100-*year* flow frequency from a continuous simulation runoff model.

The project exceeds this requirement and is required to provide flow control.

All runoff from impervious surfaces and converted surfaces is preferred to be infiltrated if feasible. Standard flow control requires that stormwater discharges match pre-developed discharge durations for the range of pre-developed discharge rates from 50% of the 2-year peak flow to the 50-year peak flow. The pre-developed condition shall be matched to the fully-forested condition (soils and vegetation) to which the Western Washington Hydrologic Model (WWHM) is calibrated, unless reasonable, historic information is provided that indicates the site was prairie prior to Euro-American settlement. This requirement may also be met by Full dispersion and infiltration. This standard requirement is waived for sites that will reliably infiltrate all the runoff from hard surface and converted vegetation areas.

The site stormwater management practices infiltration of stormwater generated on site runoff will be generated in extreme storm scenarios. The site as a whole still meets the flow control threshold requirement.

The project uses a BMP T5.10A infiltration trenches which fully infiltrate the rooftop stormwater. The administration of BMP T5.10A does not require modeling. Bioretention cells managing stormwater from the pollution generating impervious surfaces is below the threshold of effective impervious surface requiring modeling. However, model report is provided to show adequacy.

See Section 7 for the rock infiltration chamber and rooftop modeling parameters.

## 2.9 MR #8: Wetlands Protection

MMC 14.15.050 (8) specifies requirements for discharge of stormwater in wetlands and wetland buffers as well as discharge of stormwater to a stream.

Since there is no detention or treatment in the critical areas, MR-8 does not apply to this project.

## 2.10 MR # 9: Operation and Maintenance

Minimum Requirement #9 specified MMC 14.15.050 (9) contains requirements for inspection, operation and maintenance of stormwater facilities and BMPs. Specific maintenance standards and requirements are outlined in Volume V of the 2019 SMMWW. The 2019 SMMWW requires the regular maintenance and inspection of drainage facilities.

For portability and reproduction purposes, the Operations and Maintenance Manual is presented in a separate stand-alone document titled "**Operations and Maintenance Manual for 927 Alder Ave Townhomes"**, dated **3 September 2024.** This document will be provided with the construction plan submittal.

# Section 3 - Maps & Figures

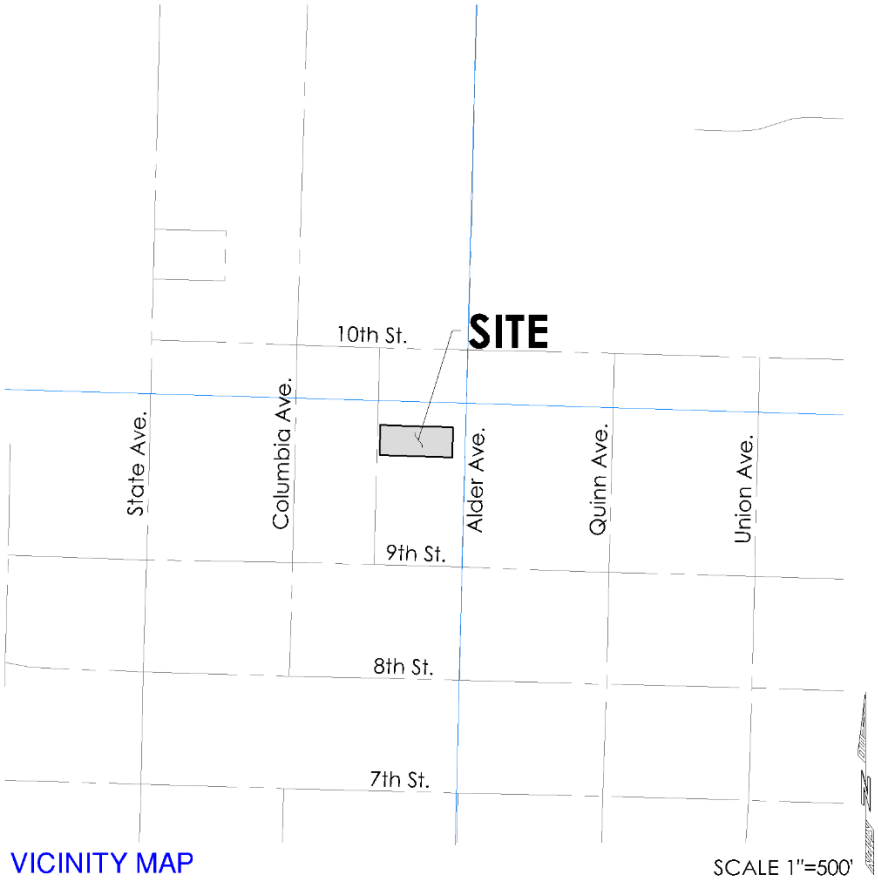


**Figure 1 - Vicinity Map**


**Figure 2 - Existing Conditions (not to scale)**


**Figure 3 - Site Plan**


**Figure 4 – Topographic Plan**

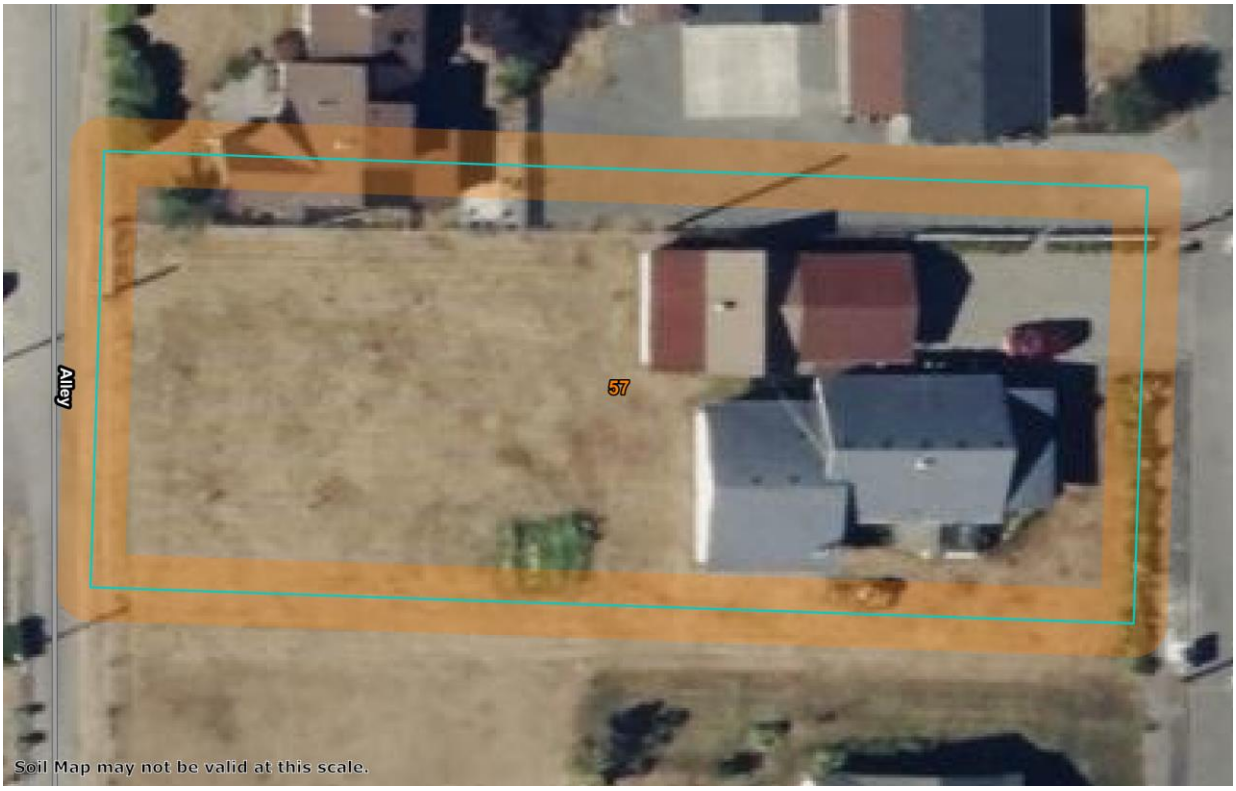


**Figure 5 – Soil Map (Not to Scale)**

# Section 4 - Support Data

## 4.1 Soils Data

### 57—Ragnar fine sandy loam, 0 to 8 percent slopes

**Map Unit Setting**
*National map unit symbol:* 2hzk
*Elevation:* 300 to 1,000 feet
*Mean annual precipitation:* 35 to 65 inches
*Mean annual air temperature:* 50 to 54 degrees F
*Frost-free period:* 150 to 210 days
*Farmland classification:* All areas are prime farmland
**Map Unit Composition**
*Ragnar and similar soils:*100 percent
*Estimates are based on observations, descriptions, and transects of the mapunit.*
**Description of Ragnar**
**Setting**
*Landform:*Outwash plains
*Parent material:*Glacial outwash
**Typical profile**
*H1 - 0 to 2 inches:* ashy fine sandy loam
*H2 - 2 to 24 inches:* ashy sandy loam
*H3 - 24 to 60 inches:* loamy sand
**Properties and qualities**
*Slope:*0 to 8 percent
*Depth to restrictive feature:*20 to 40 inches to strongly contrasting textural stratification
*Drainage class:*Well drained
*Capacity of the most limiting layer to transmit water (Ksat):*High (1.98 to 5.95 in/hr)
*Depth to water table:*More than 80 inches
*Frequency of flooding:*None
*Frequency of ponding:*None
*Available water supply, 0 to 60 inches:* Low (about 3.4 inches)
**Interpretive groups**
*Land capability classification (irrigated):* None specified
*Land capability classification (nonirrigated):* 2e
*Hydrologic Soil Group:* A
*Ecological site:* F002XA004WA - Puget Lowlands Forest
*Forage suitability group:* Droughty Soils (G002XN402WA)
*Other vegetative classification:* Droughty Soils (G002XN402WA)

*Hydric soil rating:* No

# Section 5 Works Cited

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Puget Sound LIDAR Consortium. (2003, April). LIDAR Bare Earth DEM File. q47121h24be.e00. Snohomish County, Washington. Retrieved May 2013, from http://pugetsoundlidar.ess.washington.edu/index.htm

Snohomish County Planning and Development Services. (2007, October 1). Aquifer Recharge/Wellhead Protection. Everett, WA.

Snohomish County Surface Water Management Division. (2002, December). Snohomish UGA Drainage Needs Report. Everett, Washington.

## 5.1 Topographic Data

- The various on and off site topography, utilities, and drainage elements were professionally surveyed by Pacific Coast Surveying in 2023.

- Snohomish County 2003 LiDAR survey was used to augment the existing site topography and the downstream and surrounding areas.

The modeled coordinate system:
Lateral - Washington State Plan Plane - North, FIPS 4601;
Vertical – NAVD 88

# Section 6 - Continuous Simulation Modeling

## 6.1 Continuous Simulation Background

HSPF based continuous simulation modeling was used to evaluate the hydrologic performances of the pre-developed and developed sub-basins in order to accurately assess flow rates.

The currently adopted continuous simulation models use the HSPF (Hydraulic Simulation Program in FORTRAN) software engine. The HSPF model uses a robust and detail accounting of the 'water budget', including evaporation, evapotranspiration, interception, interflow, and groundwater. The modeling accounts for and assesses land segment areas that include vegetation or impervious cover, soil types, and slopes. The modeling also uses utilized over 50 years of continuous rainfall data (precipitation) and evaporation data for the area. The HSPF continuous modeling is considered the best available science for hydrologic analysis.

## 6.2 Modeling Methodology

HSPF modeling was managed via the Western Washington Hydrology Model (WWHM) interface program. The current professional version of WWHM by Clearcreek Solutions, Inc., WWHM-2012 was used. The current data precipitation and evaporation set provided by DOE with the WWHM-2012 software interface was used that includes quantized data in 15-minute time steps from October 1948 to October 2009.

The WWHM program comes packaged with generic, well considered HSPF modeling parameters. These settings allow for the modeling of the majority of the topological conditions found in the Puget Sound area. Where conditions fall reasonably outside the range of the default HSPF parameters, adjustments should be made to more accurately reflect those conditions. These is generally limited to the pervious land segments (IMPLNDS) and are mostly limited to slopes (SLSUR), infiltration rates (INFILT), and length of flow path (LSUR). For this project, HSPF parameters were not adjusted to reflect site conditions.

### 6.2.1 Existing Conditions

The surface vegetative cover is assumed fully forested with an average slope of 5% in the area of development, based on the LIDAR based TIN analysis. The LIDAR model represents the pre-graded conditions and is in accordance with the predeveloped requirements to be represented as native vegetation and soils that existed at a site prior to the influence of Euro-American settlement.

The NRCS soil mapping of Ragnar fine sandy loam within the modeled area is listed as Type A hydrologic soils.

### 6.2.2 Developed Conditions

Default mapping for flat road was used for the road areas. Roof was for the rooftop areas. Driveway was for the driveway areas and sidewalk for the paths. Pasture was used for the amended soils from DOE recommendations for amended soils modeling. The intent of the modeling of this site was to determine the infiltration and treatment efficiencies of the bio-retention cell. Flow control modeling took place for the bypass area that is unable to be introduced to street system.

Stormwater generated on rooftops will be fully infiltrated through BMP T5.10A Downspout infiltration trenches. Rooftops managed via MR#5 prescribed BMPs are discounted from the WWHM model.

Stormwater generated from the driveways and aisles Lots will be fully infiltrated through bioretention cells.

A 12 in/hr infiltration rate was used for facility sizing.

It should be noted that when ponds, bio-swales, or other open detention facilities are used, the corresponding WWHM analysis module includes the ponded area. Consequently, this area is not included in the basin land segment mappings so the total area is often different between the developed and pre-developed conditions.

The current DOE specification for amended soils in 2019 is labeled as 'SMMWW' in the Bio-Swale and other WWHM modules that employ amended soils. The parameters for modeling the SMMWW are preset and based on current state-of-the-art modeling using a combination of the Darcy's and Van Genuchten's equations to account for the variability of permeability and water content as the soils transition from dry or partly damp to saturated conditions as the bio-cell cycles through the process of filling, emptying, and drying out. The SMMWW settings based on the WSU amended soils.

# Section 7 - Software Output

The following WWHM reports in this section represent individual sub-basin analysis for hydrologic flow evaluations. The following heading is common to all reports.

**Project Name:** Driveways to biocell
**Site Name:**
**Site Address:**
**City :**
**Report Date:** 8/2/2024
**Gage :** Everett
**Data Start :** 1948/10/01
**Data End :** 2009/09/30
**Precip Scale:** 1.00
**Version Date:** 2023/03/31
**Version :** 4.2.19

---

**Low Flow Threshold for POC 1 :** 50 Percent of the 2 Year

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**High Flow Threshold for POC 1:** 50 year

---

**PREDEVELOPED LAND USE**

**Name :** Basin 1
**Bypass:** No
**GroundWater:** No

| Pervious Land Use | acre |
|---|---|
| A B, Forest, Flat | .248 |
| Pervious Total | 0.248 |

| Impervious Land Use | acre |
|---|---|
| Impervious Total | 0 |
| Basin Total | 0.248 |

---

**Element Flows To:**

| Surface | Interflow | Groundwater |
|---|---|---|

---

**MITIGATED LAND USE**

**Name :** Basin 2
**Bypass:** No
**GroundWater:** No

| Pervious Land Use | acre |
|---|---|
| Pervious Total | 0 |

| Impervious Land Use | acre |
|---|---|
| ROADS FLAT | 0.067 |
| DRIVEWAYS FLAT | 0.022 |

**Impervious Total** **0.089**

**Basin Total** **0.089**

---

**Element Flows To:**

| Surface | Interflow | Groundwater |
|---|---|---|
| Surface retention 1 | Surface retention 1 | |

---

**Name** : Bioretention 1
**Bottom Length:** 15.00 ft.
**Bottom Width:** 10.00 ft.
**Material thickness of first layer:** 1.5
**Material type for first layer:** SMMWW
**Material thickness of second layer:** 0
**Material type for second layer:** Sand
**Material thickness of third layer:** 0
**Material type for third layer:** GRAVEL
**Infiltration On**
**Infiltration rate:** 12
**Infiltration safety factor:** 1
**Wetted surface area On**
**Total Volume Infiltrated (ac-ft.):** 14.04
**Total Volume Through Riser (ac-ft.):** 0.002
**Total Volume Through Facility (ac-ft.):** 14.042
**Percent Infiltrated:** 99.99
**Total Precip Applied to Facility:** 0.418
**Total Evap From Facility:** 0.23
**Underdrain not used**
**Discharge Structure**
**Riser Height:** 0.375 ft.
**Riser Diameter:** 12 in.

**Element Flows To:**

| Outlet 1 | Outlet 2 |
|---|---|

---

**Bioretention 1 Hydraulic Table**

| Stage(feet) | Area(ac.) | Volume(ac-ft.) | Discharge(cfs) | Infilt(cfs) |
|---|---|---|---|---|
| 0.0000 | 0.0034 | 0.0000 | 0.0000 | 0.0000 |
| 0.0261 | 0.0034 | 0.0000 | 0.0000 | 0.0000 |
| 0.0522 | 0.0034 | 0.0001 | 0.0000 | 0.0000 |
| 0.0783 | 0.0034 | 0.0001 | 0.0000 | 0.0000 |
| 0.1044 | 0.0034 | 0.0001 | 0.0000 | 0.0000 |
| 0.1305 | 0.0034 | 0.0002 | 0.0000 | 0.0000 |
| 0.1566 | 0.0034 | 0.0002 | 0.0000 | 0.0001 |
| 0.1827 | 0.0034 | 0.0003 | 0.0000 | 0.0001 |
| 0.2088 | 0.0034 | 0.0003 | 0.0000 | 0.0002 |
| 0.2349 | 0.0034 | 0.0003 | 0.0000 | 0.0002 |
| 0.2610 | 0.0034 | 0.0004 | 0.0000 | 0.0003 |
| 0.2871 | 0.0034 | 0.0004 | 0.0000 | 0.0004 |
| 0.3132 | 0.0034 | 0.0004 | 0.0000 | 0.0004 |
| 0.3393 | 0.0034 | 0.0005 | 0.0000 | 0.0005 |
| 0.3654 | 0.0034 | 0.0005 | 0.0000 | 0.0006 |
| 0.3915 | 0.0034 | 0.0005 | 0.0000 | 0.0008 |
| 0.4176 | 0.0034 | 0.0006 | 0.0000 | 0.0009 |
| 0.4437 | 0.0034 | 0.0006 | 0.0000 | 0.0010 |
| 0.4698 | 0.0034 | 0.0006 | 0.0000 | 0.0012 |

| | | | | |
|---|---|---|---|---|
| 0.4959 | 0.0034 | 0.0007 | 0.0000 | 0.0013 |
| 0.5220 | 0.0034 | 0.0007 | 0.0000 | 0.0015 |
| 0.5481 | 0.0034 | 0.0008 | 0.0000 | 0.0017 |
| 0.5742 | 0.0034 | 0.0008 | 0.0000 | 0.0019 |
| 0.6003 | 0.0034 | 0.0008 | 0.0000 | 0.0022 |
| 0.6264 | 0.0034 | 0.0009 | 0.0000 | 0.0024 |
| 0.6525 | 0.0034 | 0.0009 | 0.0000 | 0.0026 |
| 0.6786 | 0.0034 | 0.0009 | 0.0000 | 0.0029 |
| 0.7047 | 0.0034 | 0.0010 | 0.0000 | 0.0032 |
| 0.7308 | 0.0034 | 0.0010 | 0.0000 | 0.0035 |
| 0.7569 | 0.0034 | 0.0010 | 0.0000 | 0.0038 |
| 0.7830 | 0.0034 | 0.0011 | 0.0000 | 0.0041 |
| 0.8091 | 0.0034 | 0.0011 | 0.0000 | 0.0045 |
| 0.8352 | 0.0034 | 0.0012 | 0.0000 | 0.0049 |
| 0.8613 | 0.0034 | 0.0012 | 0.0000 | 0.0052 |
| 0.8874 | 0.0034 | 0.0012 | 0.0000 | 0.0056 |
| 0.9135 | 0.0034 | 0.0013 | 0.0000 | 0.0061 |
| 0.9396 | 0.0034 | 0.0013 | 0.0000 | 0.0065 |
| 0.9657 | 0.0034 | 0.0013 | 0.0000 | 0.0070 |
| 0.9918 | 0.0034 | 0.0014 | 0.0000 | 0.0074 |
| 1.0179 | 0.0034 | 0.0014 | 0.0000 | 0.0079 |
| 1.0440 | 0.0034 | 0.0014 | 0.0000 | 0.0084 |
| 1.0701 | 0.0034 | 0.0015 | 0.0000 | 0.0090 |
| 1.0962 | 0.0034 | 0.0015 | 0.0000 | 0.0095 |
| 1.1223 | 0.0034 | 0.0016 | 0.0000 | 0.0101 |
| 1.1484 | 0.0034 | 0.0016 | 0.0000 | 0.0107 |
| 1.1745 | 0.0034 | 0.0016 | 0.0000 | 0.0113 |
| 1.2005 | 0.0034 | 0.0017 | 0.0000 | 0.0119 |
| 1.2266 | 0.0034 | 0.0017 | 0.0000 | 0.0126 |
| 1.2527 | 0.0034 | 0.0017 | 0.0000 | 0.0132 |
| 1.2788 | 0.0034 | 0.0018 | 0.0000 | 0.0139 |
| 1.3049 | 0.0034 | 0.0018 | 0.0000 | 0.0147 |
| 1.3310 | 0.0034 | 0.0018 | 0.0000 | 0.0154 |
| 1.3571 | 0.0034 | 0.0019 | 0.0000 | 0.0161 |
| 1.3832 | 0.0034 | 0.0019 | 0.0000 | 0.0169 |
| 1.4093 | 0.0034 | 0.0019 | 0.0000 | 0.0177 |
| 1.4354 | 0.0034 | 0.0020 | 0.0000 | 0.0185 |
| 1.4615 | 0.0034 | 0.0020 | 0.0000 | 0.0194 |
| 1.4876 | 0.0034 | 0.0021 | 0.0000 | 0.0202 |
| 1.5000 | 0.0034 | 0.0021 | 0.0000 | 0.0260 |

**Surface retention 1 Hydraulic Table**

| Stage(feet) | Area(ac.) | Volume(ac-ft.) | Discharge(cfs) | To Amended(cfs) | Wetted Surface |
|---|---|---|---|---|---|
| 1.5000 | 0.0034 | 0.0021 | 0.0000 | 0.0208 | 0.0011 |
| 1.5261 | 0.0035 | 0.0022 | 0.0000 | 0.0208 | 0.0022 |
| 1.5522 | 0.0036 | 0.0023 | 0.0000 | 0.0216 | 0.0033 |
| 1.5783 | 0.0037 | 0.0024 | 0.0000 | 0.0219 | 0.0045 |
| 1.6044 | 0.0038 | 0.0025 | 0.0000 | 0.0223 | 0.0056 |
| 1.6305 | 0.0039 | 0.0026 | 0.0000 | 0.0226 | 0.0068 |
| 1.6566 | 0.0040 | 0.0027 | 0.0000 | 0.0230 | 0.0079 |
| 1.6827 | 0.0041 | 0.0028 | 0.0000 | 0.0234 | 0.0091 |
| 1.7088 | 0.0042 | 0.0029 | 0.0000 | 0.0237 | 0.0103 |
| 1.7349 | 0.0043 | 0.0030 | 0.0000 | 0.0241 | 0.0116 |
| 1.7610 | 0.0044 | 0.0031 | 0.0000 | 0.0245 | 0.0128 |
| 1.7871 | 0.0045 | 0.0032 | 0.0000 | 0.0248 | 0.0140 |
| 1.8132 | 0.0046 | 0.0033 | 0.0000 | 0.0252 | 0.0153 |
| 1.8393 | 0.0047 | 0.0035 | 0.0000 | 0.0255 | 0.0166 |
| 1.8654 | 0.0048 | 0.0036 | 0.0000 | 0.0259 | 0.0178 |

| | | | | | |
|---|---|---|---|---|---|
| 1.8915 | 0.0049 | 0.0037 | 0.0225 | 0.0260 | 0.0191 |
| 1.9176 | 0.0050 | 0.0038 | 0.0932 | 0.0260 | 0.0205 |
| 1.9437 | 0.0051 | 0.0040 | 0.1905 | 0.0260 | 0.0218 |
| 1.9698 | 0.0052 | 0.0041 | 0.3080 | 0.0260 | 0.0231 |
| 1.9959 | 0.0054 | 0.0042 | 0.4414 | 0.0260 | 0.0245 |
| 2.0220 | 0.0055 | 0.0044 | 0.5873 | 0.0260 | 0.0258 |
| 2.0481 | 0.0056 | 0.0045 | 0.7421 | 0.0260 | 0.0272 |
| 2.0742 | 0.0057 | 0.0047 | 0.9026 | 0.0260 | 0.0286 |
| 2.1003 | 0.0058 | 0.0048 | 1.0650 | 0.0260 | 0.0300 |
| 2.1264 | 0.0059 | 0.0050 | 1.2259 | 0.0260 | 0.0314 |
| 2.1525 | 0.0060 | 0.0051 | 1.3818 | 0.0260 | 0.0329 |
| 2.1786 | 0.0062 | 0.0053 | 1.5292 | 0.0260 | 0.0343 |
| 2.2047 | 0.0063 | 0.0055 | 1.6654 | 0.0260 | 0.0358 |
| 2.2308 | 0.0064 | 0.0056 | 1.7879 | 0.0260 | 0.0373 |
| 2.2569 | 0.0065 | 0.0058 | 1.8950 | 0.0260 | 0.0388 |
| 2.2830 | 0.0066 | 0.0060 | 1.9862 | 0.0260 | 0.0403 |
| 2.3091 | 0.0068 | 0.0061 | 2.0620 | 0.0260 | 0.0418 |
| 2.3352 | 0.0069 | 0.0063 | 2.1244 | 0.0260 | 0.0433 |
| 2.3613 | 0.0070 | 0.0065 | 2.1774 | 0.0260 | 0.0441 |
| 2.3750 | 0.0071 | 0.0066 | 2.2545 | 0.0260 | 0.0000 |

---

**Name** : Surface retention 1

**Element Flows To:**

| **Outlet 1** | **Outlet 2** |
|---|---|
| Bioretention 1 | |

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**ANALYSIS RESULTS**
**Stream Protection Duration**

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**Predeveloped Landuse Totals for POC #1**
**Total Pervious Area:0.248**
**Total Impervious Area:0**

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**Mitigated Landuse Totals for POC #1**
**Total Pervious Area:0**
**Total Impervious Area:0.089**

---

**Flow Frequency Return Periods for Predeveloped. POC #1**

| **Return Period** | **Flow(cfs)** |
|---|---|
| **2 year** | 0.000196 |
| **5 year** | 0.000239 |
| **10 year** | 0.000266 |
| **25 year** | 0.000301 |
| **50 year** | 0.000327 |
| **100 year** | 0.000352 |

**Flow Frequency Return Periods for Mitigated. POC #1**

| **Return Period** | **Flow(cfs)** |
|---|---|
| **2 year** | 0 |
| **5 year** | 0 |
| **10 year** | 0 |
| **25 year** | 0 |
| **50 year** | 0 |
| **100 year** | 0 |

**Stream Protection Duration**
**POC #1**
**The Facility PASSED**
**The Facility PASSED.**

| Flow(cfs) | Predev | Mit | Percentage | Pass/Fail |
|---|---|---|---|---|
| 0.0001 | 2488 | 7 | 0 | Pass |
| 0.0001 | 2389 | 7 | 0 | Pass |
| 0.0001 | 2310 | 7 | 0 | Pass |
| 0.0001 | 2233 | 7 | 0 | Pass |
| 0.0001 | 2116 | 7 | 0 | Pass |
| 0.0001 | 2053 | 7 | 0 | Pass |
| 0.0001 | 1967 | 7 | 0 | Pass |
| 0.0001 | 1862 | 7 | 0 | Pass |
| 0.0001 | 1778 | 7 | 0 | Pass |
| 0.0001 | 1719 | 7 | 0 | Pass |
| 0.0001 | 1648 | 7 | 0 | Pass |
| 0.0001 | 1600 | 7 | 0 | Pass |
| 0.0001 | 1540 | 7 | 0 | Pass |
| 0.0001 | 1450 | 7 | 0 | Pass |
| 0.0001 | 1389 | 7 | 0 | Pass |
| 0.0001 | 1337 | 7 | 0 | Pass |
| 0.0001 | 1254 | 7 | 0 | Pass |
| 0.0001 | 1198 | 7 | 0 | Pass |
| 0.0001 | 1130 | 7 | 0 | Pass |
| 0.0001 | 1079 | 7 | 0 | Pass |
| 0.0001 | 998 | 7 | 0 | Pass |
| 0.0001 | 945 | 7 | 0 | Pass |
| 0.0001 | 908 | 7 | 0 | Pass |
| 0.0002 | 846 | 7 | 0 | Pass |
| 0.0002 | 798 | 7 | 0 | Pass |
| 0.0002 | 755 | 7 | 0 | Pass |
| 0.0002 | 691 | 7 | 1 | Pass |
| 0.0002 | 651 | 7 | 1 | Pass |
| 0.0002 | 614 | 7 | 1 | Pass |
| 0.0002 | 561 | 7 | 1 | Pass |
| 0.0002 | 521 | 7 | 1 | Pass |
| 0.0002 | 475 | 7 | 1 | Pass |
| 0.0002 | 435 | 7 | 1 | Pass |
| 0.0002 | 402 | 7 | 1 | Pass |
| 0.0002 | 370 | 7 | 1 | Pass |
| 0.0002 | 343 | 7 | 2 | Pass |
| 0.0002 | 308 | 7 | 2 | Pass |
| 0.0002 | 283 | 7 | 2 | Pass |
| 0.0002 | 242 | 7 | 2 | Pass |
| 0.0002 | 185 | 7 | 3 | Pass |
| 0.0002 | 163 | 7 | 4 | Pass |
| 0.0002 | 134 | 7 | 5 | Pass |
| 0.0002 | 86 | 7 | 8 | Pass |
| 0.0002 | 53 | 7 | 13 | Pass |
| 0.0002 | 18 | 7 | 38 | Pass |
| 0.0002 | 10 | 7 | 70 | Pass |
| 0.0002 | 10 | 7 | 70 | Pass |
| 0.0002 | 10 | 7 | 70 | Pass |
| 0.0002 | 10 | 7 | 70 | Pass |

| | | | | |
|---|---|---|---|---|
| 0.0002 | 10 | 7 | 70 | Pass |
| 0.0002 | 9 | 7 | 77 | Pass |
| 0.0002 | 9 | 7 | 77 | Pass |
| 0.0002 | 9 | 7 | 77 | Pass |
| 0.0002 | 9 | 7 | 77 | Pass |
| 0.0002 | 9 | 7 | 77 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0002 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |
| 0.0003 | 8 | 7 | 87 | Pass |

**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.**

**Perlnd and Implnd Changes**

No changes have been made.

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