RAY TOWNHOMES

Drainage Report

Prepared For:

Custom Comfort Homes, LLC
8324 59th Ave NE
Marysville, WA 98270

October 3, 2019

Prepared By:

PACE Engineers, Inc.
1724 W. Marine View Dr. #140
Everett, WA 98201
p. 425.486.6533

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PACE Project No. 415-001-18

PROJECT CERTIFICATION

The technical material and data contained in this report was prepared by PACE Engineers, Inc., under the supervision of the below listed individuals. Those responsible staff members who are registered professional engineers are licensed in the State of Washington.

10-03-18

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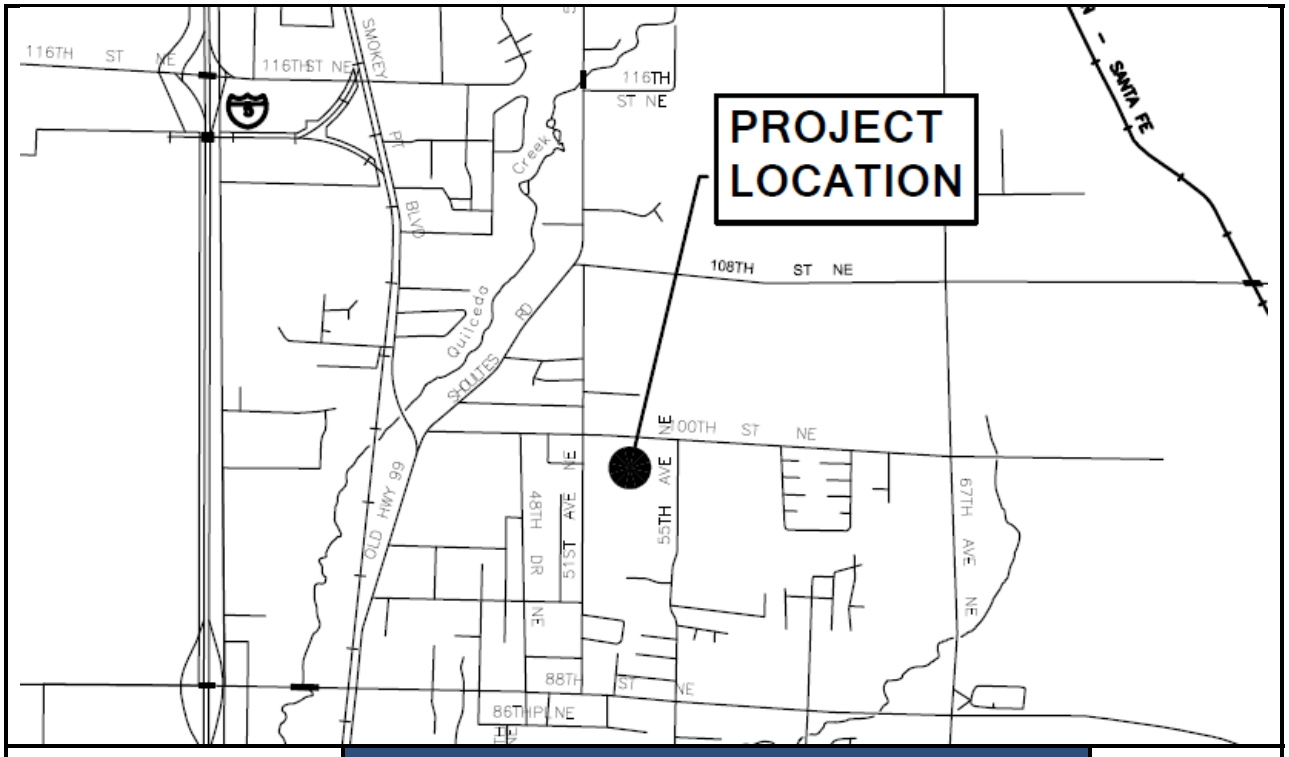
1. PROJECT OVERVIEW

The Ray Townhomes project proposes the development of two existing parcels into a Planned Residential Development which maintains two existing homes near the east edge of the site and adds 23 new townhome units further to the west. The project lies within the City of Marysville's Low Density Multiple Family (R-12) zone.

The project is located within the SW ¼ of Section 15, Township 30 N, Range 05 E, W.M. More specifically, the project lies at 9820 55th Ave NE, in the City of Marysville, and occupies the Snohomish County Tax Parcels identified in the table below. A vicinity map is also provided below.

Table 1: Property Summary

Snohomish County Tax Lot #	Size
30051500302100	1.91 ac
30051500302100	1.00 ac



PACE

Figure 1: Vicinity Map

The project has approximately 200 feet of frontage on the west side of 55th Ave NE, which is classified as a neighborhood collector. The project proposes a local access road interior to the site, in order to provide access to the proposed lots and townhome units. The proposed local access road will terminate in a cul-de-sac to provide a means of turn-around for delivery, trash collection, and emergency service vehicles. The surrounding parcels to the north and west have previously been developed, and the surrounding parcel to the south remains undeveloped, so there are currently no other access points available to the site.

The project is subject to the provisions of the Marysville Municipal Code, the City's Design and Construction Standards, and the 2014 edition of the WA State Department of Ecology's *Stormwater Management Manual for Western Washington* (SWMMWW).

2. MINIMUM REQUIREMENTS

The project is a new development which proposes more than 5,000 square feet of new/replaced hard surface area, and therefore is required to satisfy all nine of the minimum requirements stipulated by the 2014 edition of the WA Dept of Ecology's *Stormwater Management Manual for Western* Washington (SWMMWW).

2.1 MINIMUM REQUIREMENT #1: PREPARATION OF STORMWATER SITE PLANS

This report, along with the accompanying plans are intended to satisfy the stormwater site plan requirements. This requirement includes research of applicable site information, evaluation of any upstream tributary drainage basins and the downstream flowpath. These items are addressed in Chapter 3 of this report.

2.1 MINIMUM REQUIREMENT #2: CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN (SWPPP)

A temporary erosion & sediment control plan will be provided with the final engineering drawings and a separate SWPPP report will also be provided. A preliminary stormwater pollution prevention discussion is provided in Section 4 of this report.

2.2 MINIMUM REQUIREMENT #3: SOURCE CONTROL OF POLLUTION

The project is not a high-use site and is not expected to have many significant point-sources of pollution requiring source control methods. Due to the multi-family nature of the proposed development, the City is requiring a centralized trash-collection area. This area shall be contained within a roofed enclosure as a source control measure.

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

The topography of the site is relatively flat, with a subtle high-point located near the middle of the site, and gradual fall in all directions. The geotechnical report for the site identifies a shallow layer of fill material near the surface, so it is likely that this high-point was raised artificially at some point in the past. The general topography of the region is flat, but appears to fall gently to the south. The lowest portion of the site lies along the west half of the southern property boundary. A large off-site wetland begins at this location, and it appears that site runoff probably collects in this wetland area and continues flowing southerly. There is also a drainage pipe network in the fronting roadway (55th Ave NE), which conveys runoff southerly, which seems to corroborate flow to the south. The project is underlain by a sandy soil unit that is expected to support infiltration of surface runoff, so it is likely that much of the runoff that originates on-site simply infiltrates before discharging as surface runoff. With this in mind, the project is proposing a storm drainage facility along the southern edge of the site, with an overflow route that utilizes the storm pipe in the fronting street.

2.4 MINIMUM REQUIREMENT #5: ONSITE STORMWATER MANAGEMENT

The project is required to either meet the low-impact flow control standard or evaluate a series of low-impact stormwater management features, as outlined in the SWMMWW. This project is electing to evaluate the low-impact stormwater management features, and that evaluation is provided in Section 7 of this report.

2.5 MINIMUM REQUIREMENT #6: RUNOFF TREATMENT

The project is subject to “basic” treatment requirements, as outlined in the SWMMWW. A more detailed discussion of stormwater treatment is provided in Section 8 of this report.

2.6 MINIMUM REQUIREMENT #7: FLOW CONTROL

The project is subject to the flow control requirements outlined in the SWMMWW. A more detailed discussion of the proposed flow control measures is provided in Section 9 of this report.

2.7 MINIMUM REQUIREMENT #8: WETLANDS PROTECTION

The SWMMWW requests an evaluation of wetland hydrology to minimize the effects of urbanization. A critical areas study and mitigation plan is provided separate from this document which discusses the measures being taken to mitigate disturbance proposed within the existing wetland buffer areas. Wetland protection is also discussed further in Section 10 of this report.

2.8 MINIMUM REQUIREMENT #9: OPERATIONS & MAINTENANCE

General operations and maintenance recommendations are provided in Section 11 of this report.

3. PREPARATION OF STORMWATER SITE PLANS

This section of the report is intended to address Minimum Requirement #1, as outlined in the SWMMWW.

3.1 RESOURCE REVIEW SUMMARY

A geotechnical report has been prepared for the project, issued on August 21, 2019 by Geotest Engineers. The report generally classifies the underlying soil as a "Marysville Sand" recessional outwash. The report goes on to recommend that the underlying soil is suitable for stormwater infiltration and treatment. The geotechnical report will be submitted to the City of Marysville under separate cover.

The federal Emergency Management Agency (FEMA) identifies the project site on Flood Insurance Rate Map (FIRM) panel #53061C0708E and is not shown to be in a flood hazard area. A FEMA map has been provided in **Appendix 'A'** of this report.

A wetland delineation report for the project was prepared by Altmann Oliver Associates, LLC on February 12, 2018, which identified an existing wetland that primarily lies south of the project site, but extends slightly across the southern border of the project site. The report identifies a 35-ft buffer from this wetland that occupies a portion of the south edge of the project site.

The WA State Dept. of Ecology's Water Quality Assessment map was consulted to determine if the project may contribute to a 303(d) assessed waterway. There are no 303(d) listed waterways in the ¼-mile downstream flowpath required to be evaluated for this project. A portion of the Water Quality Atlas Map is provided in **Appendix 'A'** of this report.

3.2 UPSTREAM BASIN ANALYSIS

There appears to be a localized high-point on the site, and does not appear to be upstream runoff tributary from the adjacent parcels. The site is bounded on the north by an existing subdivision which collect and convey runoff away from the site. The project is bounded on the west by Cascade Elementary School. While that parcel is fairly flat, it appears from local GIS topography maps that the school property falls gently to the west. The project is bounded to the east by 55th Ave NE, which contains a public storm drainage collection/conveyance system. Finally, the project is bounded to the south by an undeveloped parcel which lies slightly lower than the site itself. With this in mind, there does not appear to be a significant upstream runoff contribution to the site.

3.3 DOWNSTREAM FIELD INSPECTION

A downstream investigation of the site was conducted on September 24, 2019. The conditions at the time of the visit were cloudy and cool, with no significant rainfall having occurred within the previous couple of days. No surface runoff was observed at the site or downstream flowpath during the visit. The downstream system extends southerly along the west edge of 55th Ave NE for the full ¼-mile analysis distance. A map and photos of the downstream flowpath are provided in **Appendix 'B'** of this report.

3.4 DOWNSTREAM DRAINAGE SYSTEM DESCRIPTION

There is a subtle high point near the center of the site. The geotechnical report for the site indicated a shallow layer of fill material in this vicinity, and the surrounding topography appears to gently fall to the south. The lowest point on the site is the edge of an off-site wetland along the south boundary of the site, and it appears that surface runoff flows toward this wetland and continues southeasterly toward 55th Ave SE. The project proposes a storm drainage infiltration facility along the south edge of the property with an overflow that connects to the public storm drainage network in 55th Ave SE.

The public storm drainage network in 55th Ave NE lies along the west side of the right-of-way and conveys runoff southerly beyond the ¼-mile downstream analysis length. The entire downstream system within this zone lies within a series of underground pipes and catch basins.

4. STORMWATER POLLUTION PREVENTION PLAN (SWPPP)

A formal stormwater pollution prevention plan report will be submitted under separate cover, but the discussion below is intended to provide an overview of how the 13 required SWPPP elements will be addressed.

4.1 ELEMENT 1 – PRESERVE VEGETATION/MARK CLEARING LIMITS

The project will identify the intended clearing limits and mark them in the field with high-visibility construction fencing or silt fencing. Critical areas and buffers will also be clearly identified in the field, and the project will retain and stockpile the duff-layer, replacing it on the completed site to the greatest practical extent.

4.2 ELEMENT 2 – ESTABLISH CONSTRUCTION ACCESS

A rock-stabilized construction access will be provided at the entrance to the site. Sediment that is tracked off-site shall be swept at the end of each day, or as determined necessary by the project's erosion/sediment control lead.

4.3 ELEMENT 3 – CONTROL FLOW RATES

A temporary sediment trap will be constructed for the project, and site runoff will be routed to that facility until the permanent stormwater management facility is constructed.

4.4 ELEMENT 4 – INSTALL SEDIMENT CONTROLS

Sediment control is expected to be provided via a temporary sediment trap near the entrance to the site. A series of interceptor trenches will be proposed to route site runoff to this facility. Perimeter silt-fencing will also be installed on the downhill portions of the site, and adjacent to the existing wetland.

4.5 ELEMENT 5 – STABILIZE SOILS

Exposed soils which are expected to remain unworked for an extended period will be stabilized with mulch, seed, or other measures. Soil stockpiles are expected to be covered with plastic or protected with other soil-trapping measures.

4.6 ELEMENT 6 – PROTECT SLOPES

The project is relatively flat and is not expected to construct or expose any steep slopes. No slope protection is expected to be warranted.

4.7 ELEMENT 7 – PROTECT DRAIN INLETS

Catch basin inlet protection devices will be placed in all nearby downstream catch basin grates, as identified on the project's TESC plan.

4.8 ELEMENT 8 – STABILIZE CHANNELS & OUTFALLS

All temporary channels proposed for the project shall be stabilized with rock or vegetation if signs of erosion are observed by the project's erosion/sediment control lead. There are no free outlets proposed that warrant stabilization measures.

4.9 ELEMENT 9 – CONTROL POLLUTANTS

The project is relatively small and is not expected to store contaminants on-site for an extended period of time. Any contaminants that are stored on-site should be protected from vandalism or theft. Maintenance, fueling, and repair of construction equipment should be conducted off-site to the greatest practical extent to reduce the potential for a spill. A concrete washout area shall be provided to keep concrete wash-water from entering the public storm drainage system.

4.10 ELEMENT 10 – CONTROL DE-WATERING

No significant de-watering is expected to be needed on this project.

4.11 ELEMENT 11 – MAINTAIN BMPS

The project shall identify personnel to serve as an erosion/sediment control lead, who can monitor all BMPs at the site and recommend revisions and new BMPs as needed.

4.12 ELEMENT 12 – MANAGE THE PROJECT

The project shall identify personnel to serve as an erosion/sediment control lead, who can monitor site conditions and BMP performance. That person shall recommend revisions as site conditions change.

4.13 ELEMENT 13 – PROTECT LOW-IMPACT DEVELOPMENT BMPS

The project is proposing infiltration-based low-impact stormwater management features. Areas where infiltration facilities are proposed shall be protected from compaction from construction equipment while the site is being developed. These areas will be identified at the onset of construction and disturbance to those areas shall be limited as much as possible.

5. SOURCE CONTROL OF POLLUTION

The project is not an industrial or high-use site, and few significant point sources of pollution are expected to be present. Due to the multi-family nature of the proposed development, the City is requiring a centralized trash-collection facility, which shall be contained within a roofed enclosure, in order to prevent stormwater pollution from the trash collection area.

6. PRESERVATION OF NATURAL DRAINAGE SYSTEMS AND OUTFALL

The topography of the site is relatively flat, with a subtle high-point located near the middle of the site, and gradual fall in all directions. The geotechnical report for the site identifies a shallow layer of fill material near the surface, so it is likely that this high-point was raised artificially at some point in the past. The general topography of the region is flat, but appears to fall gently to the south. The lowest portion of the site lies along the west half of the southern property boundary. A large off-site wetland begins at this location, and it appears that site runoff probably collects in this wetland area and continues flowing southerly. There is also a drainage pipe network in the fronting roadway (55th Ave NE), which conveys runoff southerly, which seems to corroborate flow to the south. The project is underlain by a sandy soil unit that is expected to support infiltration of surface runoff, so it is likely that much of the runoff that originates on-site simply infiltrates before discharging as surface runoff. With this in mind, the project is proposing a storm drainage facility along the southern edge of the site, with an overflow route that utilizes the storm pipe in the fronting street.

7. ON-SITE STORMWATER MANAGEMENT

7.1 SITE HYDROLOGY

7.1.1 Existing Hydrologic Conditions

The site is currently occupied by a couple of homes near the east edge of the site, a detached shed building, and a gravel driveway. The two homes will be retained as part of the development.

The underlying topography is relatively flat, with a localized high point near the middle of the site. The high-point consists of a shallow layer of non-native fill material, as identified in the geotechnical report. The topography of the surrounding region appears to fall gently to the south. In fact, the lowest portion of the site is the edge of an off-site wetland area along the west half of the south property boundary. Once runoff reaches this wetland, it appears that it continues to flow southeasterly toward 55th Ave NE.

The underlying soil has been identified as a sandy soil unit with the capacity to infiltrate surface runoff, so most runoff originating at the project site is expected to infiltrate into the underlying soil before discharging as surface runoff.

For hydrologic modeling purposes, historic conditions for the project site are represented as “forest”, since that’s what likely existed at the site prior to initial settlement of the area. There is a strip of pavement in the frontage that is tributary to the project site, but will not be disturbed down to subgrade, and therefore is not considered to be “new/replaced” impervious surface. This is not considered part of the project site, as defined in the SWMMWW, so it is represented as existing pavement area. An existing conditions map is provided in **Appendix ‘C’** of this report.

7.1.2 Developed Hydrologic Conditions

The project is proposing construction of an internal roadway and a number of townhome units along the north side and west end of the roadway. Runoff from the site will generally be collected and conveyed to a central bioretention facility on the south side of the proposed internal roadway. The bioretention cell will also act as an infiltration gallery to meet the flow control, water quality, and on-site stormwater management requirements. A developed conditions map is provided in **Appendix ‘C’** of this report.

7.1.3 Hydrologic Modeling

Hydrologic modeling for the project was performed in order to design the proposed detention/infiltration system. The model was performed using WWHM2012 which is a locally calibrated continuous simulation runoff model approved for use by the Washington State Department of Ecology. The calculations demonstrate that the project complies with applicable flow-control and treatment regulations. Hydrologic modeling calculations are provided in **Appendix ‘D’** and **Appendix ‘E’** of this report. Input parameters for the hydrologic model are summarized on the basin maps provided in **Appendix ‘C’**.

7.2 LOW IMPACT DEVELOPMENT

The proposed project occupies less than 5-acres and is located within the urban growth area. The project is also required to satisfy all nine minimum requirements outlined in the SWMMWW. Therefore, the project is required to either meet the Low Impact Development Performance Standard or evaluate a series of low-impact stormwater management BMPs as specified in List #2 of the SWMMWW. This project is electing to evaluate the low-impact BMPs from List #2. Minimum Requirement #5 requires evaluation of those BMP options in a specific order of preference and implement those BMPs to the greatest feasible extent. The required evaluation is provided below:

Roof Areas:	
Full Dispersion (BMP T5.30)	Not Feasible – The project was cleared of native vegetation at some point in the past, and the required vegetated flowpaths are not available at the project site.
Bioretention (Vol. V, Ch. 7)	Feasible – Runoff from the new roof areas will be directed to a bioretention cell near the southern portion of the site. The existing homes lie too low for the roof drains to be connected to the bioretention cell, so they will be conveyed to infiltration trenches instead.
Downspout Dispersion (BMP T5.10B)	Not evaluated – Bioretention will be utilized
Perforated Stub-Out (BMP T5.10C)	Not evaluated – Bioretention will be utilized

Other Hard Surfaces:	
Full Dispersion (BMP T5.30)	Not Feasible – The project was cleared of native vegetation at some point in the past, and the required vegetated flowpaths are not available at the project site.
Permeable Pavement (BMP T5.15)	Not Feasible – The project does not propose a significant amount of pavement outside of the right-of-way. Permeable driveways may be proposed as part of future building permit applications.
Bioretention (Vol. V, Ch. 7)	Feasible – Runoff from most hard surface areas will be directed to a bioretention cell near the southern portion of the site. The project frontage and a portion of the interior roadway lies at an elevation too low to be conveyed to this facility, and will be conveyed to a conventional detention facility instead.
Sheet Flow Dispersion (BMP T5.12)	Not evaluated – Bioretention will be utilized

Lawn & Landscaped Areas:	
Post-Construction Soil Quality and Depth (BMP T5.13)	Feasible - The existing duff layer will be stripped and stockpiled on-site, and replaced to the greatest possible extent prior to final stabilization of the project.

8. RUNOFF TREATMENT

Volume V, Chapter 2 of the SWMMWW provides a step-by-step selection process for determining the required level of treatment for the project site. That step-by-step process is provided below:

- Step 1 – Determine the receiving waters and pollutants of concern.

  From the City of Marysville's GIS drainage inventory, it appears that the downstream flowpath is ultimately tributary to Allen Creek, roughly 1-mile downstream of the site. The WA State Dept. of Ecology's Water Quality Atlas identifies a bacteria issue within Allen Creek in the vicinity where the downstream flowpath is tributary. The Dept. of Ecology has issued a TMDL implementation plan for fecal coliform bacteria in the Lower Snohomish River Tributaries, which includes this portion of Allen Creek. It generally indicates two primary sources of contamination as agricultural runoff from the upper portions of the basin, and urban surface runoff. This project site intends to utilize infiltration for flow control and treatment and is only expected to discharge surface runoff during overflow events for which treatment is not required. There is no specific treatment requirement for urban runoff specified in the TMDL implementation plan.

- Step 2 – Determine if an oil control facility/device is required.

  Oil control is required when a site has "high-use" characteristics, such as a commercial/industrial area, heavy vehicle storage, or arterial roadways with a high traffic count. This project does not meet the high-use criteria, so oil control is not required.

- Step 3 – Determine if infiltration for pollutant removal is practicable.

  The project is underlain by an outwash soil unit, and the geotechnical report suggests it has sufficient capacity for infiltration and meets the soil suitability criteria for treatment. With this in mind, the project intends to utilize a bioretention facility and utilize the underlying soil unit for infiltration.

- Step 4 – Determine if control of phosphorus is required.

  The project is ultimately tributary to Allen Creek, which has a TMDL implementation plan for fecal coliform, but no specific direction to implement phosphorus control.

- Step 5 – Determine if enhanced treatment is required.

  The project is not required to provide enhanced treatment if it is subject to 'basic' flow control requirements a stipulated in Step 6 (see below). This project meets the requirements outlined in Step 6, so enhanced treatment is not required.

- Step 6 – Select a basic treatment facility.

  The Ray Townhomes project is a residential project not otherwise needing phosphorus control, and therefore, is subject to the 'basic' treatment requirements outlined in Step 6. Most site runoff will be conveyed to a bioretention cell, which qualifies for both 'basic' and 'enhanced' treatment. The remainder of the site runoff will be conveyed to an underground vault with a wetpool storage component, which is an appropriate 'basic' treatment mechanism.

Water quality treatment design calculations were performed using WWHM2012 hydrologic modeling software and are provided in **Appendix 'D'** & **Appendix 'E'** of this report. The

calculations in **Appendix 'D'** are the flow-control design calculations for the full site. In these calculations, the input parameters show that 100% of the runoff tributary to the bioretention cell (West Basin) are filtered and infiltrated. Runoff that is filtered through the amended soil layer of a bioretention cell is considered to be treated. Additionally, the geotechnical report for the project has indicated that the underlying soil meets the soil-suitability criteria for treatment outlined in the SWMMWW.

A separate model is provided in **Appendix 'E'** which only reflect the east basin. This is provided in order to determine the wetpool storage requirements in the east vault. One of the limitations of WWHM2012 is that it is not able to calculate the wetpool volume requirements for multiple facilities within the same model, so a separate model for the East Basin was needed. This model is only provided to determine the required wetpool volume in the vault, so the flow-control results in this appendix are not applicable. Project compliance with the flow control requirement is demonstrated in **Appendix 'D'**.

9. FLOW CONTROL

The project is required to satisfy the flow control requirement outlined in Minimum Requirement #7 of the SWMMWW. This involves evaluating the site using a continuous runoff simulation model and verifying that the predeveloped discharge durations match the historic discharge durations for a range of pre-developed discharge rates (50% of 2-yr peak to full 50-yr peak). For this analysis, the historic runoff conditions for the project site are assumed as "forest", to represent the land cover conditions that existed prior to initial settlement of the area.

In the developed condition, the site has been split into two distinct basins. Runoff from most of the site (West Basin) will be collected and conveyed to a bioretention cell for treatment and infiltration. This bioretention cell has been situated at an elevation that provides 3-ft of separation between the bottom of the bioretention cell and the anticipated seasonal-high groundwater elevation. Groundwater elevations will be monitored through the wet-season to verify that sufficient separation is being provided and a mounding analysis is expected to be provided as part of the final design package.

The frontage improvement area and eastern portion of the site (East Basin) have been routed to a separate underground stormwater vault because those areas lie at an elevation that is too low to be conveyed to the bioretention facility. The geotechnical report for the project identified relatively shallow groundwater near the east edge of the site, and a bioretention facility at this location would not be able to achieve the required separation from groundwater. Groundwater elevations will be monitored through the wet-season and if the seasonal-high groundwater elevation is found to be lower than was initially indicated in the geotechnical report, the final design may be adjusted to accommodate more of the site in a bioretention cell.

Existing and developed basin maps are provided in **Appendix 'C'**, which tabulate the historic and anticipated land cover conditions. Those tabulated values are used as input for the hydrologic model provided in **Appendix 'D'**. The model demonstrates that the proposed facilities meet the flow-control requirement.

10. WETLANDS PROTECTION

As stipulated in Minimum Requirement #8 of the SWMMWW, this requirement applies only to projects whose stormwater discharges into a wetland, either directly or indirectly through a conveyance system. The proposed project is intending to infiltrate runoff near the existing wetland and does not discharge to the neighboring wetland area through a conveyance system. With this in mind, the requirement does not appear to be applicable.

The underlying soil at the project site is an outwash variety, and a vast majority of the rain that currently falls on the site is expected to infiltrate into the underlying soil before discharging as surface runoff. The project is proposing an underground infiltration system adjacent to the wetland, which is likely to contribute groundwater to the adjacent wetland, which is expected to recharge the wetland through groundwater, similar to what is likely to occur currently

11. OPERATION & MAINTENANCE

Operations and maintenance recommendations pertinent to the site have been selected from the SWMMWW and provided on the following pages. The proposed bioretention cell will impound water similar to a stormwater detention pond, so the detention pond recommendations are provided for that facility in addition to the bioretention O&M recommendations.

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	Any trash and debris which exceed 1 cubic feet per 1,000 square feet. In general, there should be no visual evidence of dumping. If less than threshold all trash and debris will be removed as part of next scheduled maintenance.	Trash and debris cleared from site.
	Poisonous Vegetation and noxious weeds	Any poisonous or nuisance vegetation which may constitute a hazard to maintenance personnel or the public. Any evidence of noxious weeds as defined by State or local regulations. (Apply requirements of adopted IPM policies for the use of herbicides).	No danger of poisonous vegetation where maintenance personnel or the public might normally be. (Coordinate with local health department) Complete eradication of noxious weeds may not be possible. Compliance with State or local eradication policies required
	Contaminants and Pollution	Any evidence of oil, gasoline, contaminants or other pollutants (Coordinate removal/cleanup with local water quality response agency).	~~No contaminants or pollutants present.~~
	Rodent Holes	Any evidence of rodent holes if facility is acting as a dam or berm, or any evidence of water piping through dam or berm via rodent holes.	Rodents destroyed and dam or berm repaired. (Coordinate with local health department; coordinate with Ecology Dam Safety Office if pond exceeds 10 acre-feet.)

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
	Beaver Dams	Dam results in change or function of the facility.	Facility is returned to design function. (Coordinate trapping of beavers and removal of dams with appropriate permitting agencies)
	Insects	When insects such as wasps and hornets interfere with maintenance activities.	Insects destroyed or removed from site. Apply insecticides in compliance with adopted IPM policies
	Tree Growth and Hazard Trees	Tree growth does not allow maintenance access or interferes with maintenance activity (i.e., slope mowing, silt removal, vactoring, or equipment movements). If trees are not interfering with access or maintenance, do not remove If dead, diseased, or dying trees are identified (Use a certified Arborist to determine health of tree or removal requirements)	Trees do not hinder maintenance activities. Harvested trees should be recycled into mulch or other beneficial uses (e.g., alders for firewood). Remove hazard Trees
Side Slopes of Pond	Erosion	Eroded damage over 2 inches deep where cause of damage is still present or where there is potential for continued erosion. Any erosion observed on a compacted berm embankment.	Slopes should be stabilized using appropriate erosion control measure(s); e.g., rock reinforcement, planting of grass, compaction. If erosion is occurring on compacted berms a licensed civil engineer should be consulted to resolve source of erosion.
Storage Area	Sediment	Accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects inletting or outletting condition of the facility.	Sediment cleaned out to designed pond shape and depth; pond reseeded if necessary to control erosion.
	Liner (If Applicable)	Liner is visible and has more than three 1/4-inch holes in it.	Liner repaired or replaced. Liner is fully covered.
Pond Berms (Dikes)	Settlements	Any part of berm which has settled 4 inches lower than the design elevation. If settlement is apparent, measure berm to determine amount of settlement. Settling can be an indication of more severe problems with the berm or outlet works. A licensed civil engineer should be consulted to determine the source of the settlement.	Dike is built back to the design elevation.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.

No. 1 – Detention Ponds

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
Emergency Overflow/ Spillway and Berms over 4 feet in height.	Tree Growth	Tree growth on emergency spillways creates blockage problems and may cause failure of the berm due to uncontrolled overtopping. Tree growth on berms over 4 feet in height may lead to piping through the berm which could lead to failure of the berm.	Trees should be removed. If root system is small (base less than 4 inches) the root system may be left in place. Otherwise the roots should be removed and the berm restored. A licensed civil engineer should be consulted for proper berm/spillway restoration.
	Piping	Discernable water flow through pond berm. Ongoing erosion with potential for erosion to continue. (Recommend a Goethechnical engineer be called in to inspect and evaluate condition and recommend repair of condition.	Piping eliminated. Erosion potential resolved.
Emergency Overflow/ Spillway	Emergency Overflow/ Spillway	Only one layer of rock exists above native soil in area five square feet or larger, or any exposure of native soil at the top of out flow path of spillway. (Rip-rap on inside slopes need not be replaced.)	Rocks and pad depth are restored to design standards.
	Erosion	See "Side Slopes of Pond"	

No. 2 – Infiltration

Maintenance Component	Defect	Conditions When Maintenance Is Needed	Results Expected When Maintenance Is Performed
General	Trash & Debris	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Poisonous/Noxious Vegetation	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Contaminants and Pollution	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Rodent Holes	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1)
Storage Area	Sediment	Water ponding in infiltration pond after rainfall ceases and appropriate time allowed for infiltration. Treatment basins should infiltrate Water Quality Design Storm Volume within 48 hours, and empty within 24 hours after cessation of most rain events. (A percolation test pit or test of facility indicates facility is only working at 90% of its designed capabilities. Test every 2 to 5 years. If two inches or more sediment is present, remove).	Sediment is removed and/or facility is cleaned so that infiltration system works according to design.
Filter Bags (if applicable)	Filled with Sediment and Debris	Sediment and debris fill bag more than 1/2 full.	Filter bag is replaced or system is redesigned.
Rock Filters	Sediment and Debris	By visual inspection, little or no water flows through filter during heavy rain storms.	Gravel in rock filter is replaced.
Side Slopes of Pond	Erosion	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Emergency Overflow Spillway and Berms over 4 feet in height.	Tree Growth	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Piping	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Emergency Overflow Spillway	Rock Missing	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
	Erosion	See "Detention Ponds" (No. 1).	See "Detention Ponds" (No. 1).
Pre-settling Ponds and Vaults	Facility or sump filled with Sediment and/or debris	6" or designed sediment trap depth of sediment.	Sediment is removed.

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. 21 - Maintenance Standards and Procedures for Bioretention Facilities.

Note that the inspection and routine maintenance frequencies listed below are recommended by Ecology. They do not supersede or replace the municipal stormwater permit requirements for inspection frequency required of municipal stormwater permittees for "stormwater treatment and flow control BMPs/facilities."

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Facility Footprint				
Earthen side slopes and berms	B, S		Erosion (gullies/ rills) greater than 2 inches deep around inlets, outlet, and alongside slopes	• Eliminate cause of erosion and stabilize damaged area (regrade, rock, vegetation, erosion control matting) • For deep channels or cuts (over 3 inches in ponding depth), temporary erosion control measures should be put in place until permanent repairs can be made. • Properly designed, constructed and established facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems persist, the following should be reassessed: (1) flow volumes from contributing areas and bioretention facility sizing; (2) flow velocities and gradients within the facility; and (3) flow dissipation and erosion protection strategies at the facility inlet.
	A		Erosion of sides causes slope to become a hazard	Take actions to eliminate the hazard and stabilize slopes
	A, S		Settlement greater than 3 inches (relative to undisturbed sections of berm)	Restore to design height
	A, S		Downstream face of berm wet, seeps or leaks evident	Plug any holes and compact berm (may require consultation with engineer, particularly for larger berms)
	A		Any evidence of rodent holes or water piping in berm	• Eradicate rodents (see "Pest control") • Fill holes and compact (may require consultation with engineer, particularly for larger berms)
Concrete sidewalls	A		Cracks or failure of concrete sidewalls	• Repair/ seal cracks • Replace if repair is insufficient
Rockery sidewalls	A		Rockery side walls are insecure	Stabilize rockery sidewalls (may require consultation with engineer, particularly for walls 4 feet or greater in height)
Facility area		All maintenance visits (at least biannually)	Trash and debris present	Clean out trash and debris
Facility bottom area	A, S		Accumulated sediment to extent that infiltration rate is reduced (see "Ponded water") or surface storage capacity significantly impacted	• Remove excess sediment • Replace any vegetation damaged or destroyed by sediment accumulation and removal • Mulch newly planted vegetation • Identify and control the sediment source (if feasible) • If accumulated sediment is recurrent, consider adding presettlement or installing berms to create a forebay at the inlet
		During/after fall leaf drop	Accumulated leaves in facility	Remove leaves if there is a risk to clogging outlet structure or water flow is impeded
Low permeability check dams and weirs	A, S		Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, flow control weir or orifice	Clear the blockage
	A, S		Erosion and/or undercutting present	Repair and take preventative measures to prevent future erosion and/or undercutting
	A		Grade board or top of weir damaged or not level	Restore to level position

[a] Frequency: A = Annually; B = Biannually (twice per year); M = Monthly; W = At least one visit should occur during the wet season (for debris/clog related maintenance, this inspection/maintenance visit should occur in the early fall, after deciduous trees have lost their leaves); S = Perform inspections after major storm events (24-hour storm event with a 10-year or greater recurrence interval).

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No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Facility Footprint (cont'd)				
Ponded water	B, S		Excessive ponding water: Water overflows during storms smaller than the design event or ponded water remains in the basin 48 hours or longer after the end of a storm.	Determine cause and resolve in the following order: 1) Confirm leaf or debris buildup in the bottom of the facility is not impeding infiltration. If necessary, remove leaf litter/debris. 2) Ensure that underdrain (if present) is not clogged. If necessary, clear underdrain. 3) Check for other water inputs (e.g., groundwater, illicit connections). 4) Verify that the facility is sized appropriately for the contributing area. Confirm that the contributing area has not increas ed. If steps #1-4 do not solve the problem, the bioretention soil is likely clogged by sediment accumulation at the surface or has become overly compacted. Dig a small hole to observe soil profile and identify compaction depth or clogging front to help determine the soil depth to be removed or otherwise rehabilitated (e.g., tilled). Consultation with an engineer is recommended.
Bioretention soil media	As needed		Bioretention soil media protection is needed when performing maintenance requiring entrance into the facility footprint	• Minimize all loading in the facility footprint (foot traffic and other loads) to the degree feasible in order to prevent compaction of bioretention soils. • Never drive equipment or apply heavy loads in facility footprint. • Because the risk of compaction is higher during saturated soil conditions, any type of loading in the cell (including foot traffic) should be minimized during wet conditions. • Consider measures to distribute loading if heavy foot traffic is required or equipment must be placed in facility. As an example, boards may be placed across soil to distribute loads and minimize compaction. • If compaction occurs, soil must be loosened or otherwise rehabilitated to original design state.
Inlets/Outlets/Pipes				
Splash block inlet	A		Water is not being directed properly to the facility and away from the inlet structure	Reconfigure/ repair blocks to direct water to facility and away from structure
Curb cut inlet/outlet	M during the wet season and before severe storm is forecasted	Weekly during fall leaf drop	Accumulated leaves at curb outs	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
Pipe inlet/outlet	A		Pipe is damaged	Repair/ replace
	W		Pipe is clogged	Remove roots or debris
	A, S		Sediment, debris, trash, or mulch reducing capacity of inlet/outlet	• Clear the blockage • Identify the source of the blockage and take actions to prevent future blockages
		Weekly during fall leaf drop	Accumulated leaves at inlets/outlets	Clear leaves (particularly important for key inlets and low points along long, linear facilities)
		A	Maintain access for inspections	• Clear vegetation (transplant vegetation when possible) within 1 foot of inlets and outlets, maintain access pathways • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Erosion control at inlet	A		Concentrated flows are causing erosion	Maintain a cover of rock or cobbles or other erosion protection measure (e.g., matting) to protect the ground where concentrated water enters the facility (e.g., a pipe, curb cut or swale)

No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency a		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Inlets/Outlets/Pipes (cont'd)				
Trash rack	S		Trash or other debris present on trash rack	Remove/dispose
	A		Bar screen damaged or missing	Repair/replace
Overflow	A, S		Capacity reduced by sediment or debris	Remove sediment or debris/dispose
Underdrain pipe	Clean pipe as needed	Clean orifice at least biannually (may need more frequent cleaning during wet season)	• Plant roots, sediment or debris reducing capacity of underdrain • Prolonged surface ponding (see "Ponded water")	• Jet clean or rotary cut debris/roots from underdrain(s) • If underdrains are equipped with a flow restrictor (e.g., orifice) to attenuate flows, the orifice must be cleaned regularly.
Vegetation				
Facility bottom area and upland slope vegetation	Fall and Spring		Vegetation survival rate falls below 75% within first two years of establishment (unless project O&M manual or record drawing stipulates more or less than 75% survival rate).	• Determine cause of poor vegetation growth and correct condition • Replant as necessary to obtain 75% survival rate or greater. Refer to original planting plan, or approved jurisdictional species list for appropriate plant replacements (See Appendix 3 - Bioretention Plant List, in the LID Technical Guidance Manual for Puget Sound). • Confirm that plant selection is appropriate for site growing conditions • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Vegetation (general)	As needed		Presence of diseased plants and plant material	• Remove any diseased plants or plant parts and dispose of in an approved location (e.g., commercial landfill) to avoid risk of spreading the disease to other plants • Disinfect gardening tools after pruning to prevent the spread of disease • See Pacific Northwest Plant Disease Management Handbook for information on disease recognition and for additional resources • Replant as necessary according to recommendations provided for "facility bottom area and upland slope vegetation".
Trees and shrubs		All pruning seasons (timing varies by species)	Pruning as needed	• Prune trees and shrubs in a manner appropriate for each species. Pruning should be performed by landscape professionals familiar with proper pruning techniques • All pruning of mature trees should be performed by or under the direct guidance of an ISA certified arborist
	A		Large trees and shrubs interfere with operation of the facility or access for maintenance	• Prune trees and shrubs using most current ANSI A300 standards and ISA BMPs. • Remove trees and shrubs, if necessary.
	Fall and Spring		Standing dead vegetation is present	• Remove standing dead vegetation • Replace dead vegetation within 30 days of reported dead and dying plants (as practical depending on weather/planting season) • If vegetation replacement is not feasible within 30 days, and absence of vegetation may result in erosion problems, temporary erosion control measures should be put in place immediately. • Determine cause of dead vegetation and address issue, if possible • If specific plants have a high mortality rate, assess the cause and replace with appropriate species. Consultation with a landscape architect is recommended.
	Fall and Spring		Planting beneath mature trees	• When working around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). • Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.

No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation (cont'd)				
Trees and shrubs (cont'd)	Fall and Spring		Planting beneath mature trees	• When working around and below mature trees, follow the most current ANSI A300 standards and ISA BMPs to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil). • Planting of small shrubs or groundcovers beneath mature trees may be desirable in some cases; such plantings should use mainly plants that come as bulbs, bare root or in 4-inch pots; plants should be in no larger than 1-gallon containers.
	Fall and Spring		Presence of or need for stakes and guys (tree growth, maturation, and support needs)	• Verify location of facility liners and underdrain (if any) prior to stake installation in order to prevent liner puncture or pipe damage • Monitor tree support systems: Repair and adjust as needed to provide support and prevent damage to tree. • Remove tree supports (stakes, guys, etc.) after one growing season or maximum of 1 year. • Backfill stake holes after removal.
Trees and shrubs adjacent to vehicle travel areas (or areas where visibility needs to be maintained)	A		Vegetation causes some visibility (line of sight) or driver safety issues	• Maintain appropriate height for sight clearance • When continued, regular pruning (more than one time/ growing season) is required to maintain visual sight lines for safety or clearance along a walk or drive, consider relocating the plant to a more appropriate location. • Remove or transplant if continual safety hazard • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
Flowering plants		A	Dead or spent flowers present	Remove spent flowers (deadhead)
Perennials		Fall	Spent plants	Cut back dying or dead and fallen foliage and stems
Emergent vegetation		Spring	Vegetation compromises conveyance	• Hand rake sedges and rushes with a small rake or fingers to remove dead foliage before new growth emerges in spring or earlier only if the foliage is blocking water flow (sedges and rushes do not respond well to pruning)
Ornamental grasses (perennial)		Winter and Spring	Dead material from previous year's growing cycle or dead collapsed foliage	• Leave dry foliage for winter interest • Hand rake with a small rake or fingers to remove dead foliage back to within several inches from the soil before new growth emerges in spring or earlier if the foliage collapses and is blocking water flow
Ornamental grasses (evergreen)		Fall and Spring	Dead growth present in spring	• Hand rake with a small rake or fingers to remove dead growth before new growth emerges in spring • Clean, rake, and comb grasses when they become too tall • Cut back to ground or thin every 2-3 years as needed
Noxious weeds		M (March – October, preceding seed dispersal)	Listed noxious vegetation is present (refer to current county noxious weed list)	• By law, class A & B noxious weeds must be removed, bagged and disposed as garbage immediately • Reasonable attempts must be made to remove and dispose of class C noxious weeds • It is strongly encouraged that herbicides and pesticides not be used in order to protect water quality; use of herbicides and pesticides may be prohibited in some jurisdictions • Apply mulch after weed removal (see "Mulch")

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No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Vegetation (cont'd)				
Weeds		M (March – October, preceding seed dispersal)	Weeds are present	• Remove weeds with their roots manually with pincer-type weeding tools, flame weeders, or hot water weeders as appropriate • Follow IPM protocols for weed management (see "Additional Maintenance Resources" section for more information on IPM protocols)
Excessive vegetation		Once in early to mid-May and once in early- to mid-September	Low-lying vegetation growing beyond facility edge onto sidewalks, paths, or street edge poses pedestrian safety hazard or may clog adjacent permeable pavement surfaces due to associated leaf litter, mulch, and soil	• Edge or trim groundcovers and shrubs at facility edge • Avoid mechanical blade-type edger and do not use edger or trimmer within 2 feet of tree trunks • While some clippings can be left in the facility to replenish organic material in the soil, excessive leaf litter can cause surface soil clogging
	As needed		Excessive vegetation density inhibits stormwater flow beyond design ponding or becomes a hazard for pedestrian and vehicular circulation and safety	• Determine whether pruning or other routine maintenance is adequate to maintain proper plant density and aesthetics • Determine if planting type should be replaced to avoid ongoing maintenance issues (an aggressive grower under perfect growing conditions should be transplanted to a location where it will not impact flow) • Remove plants that are weak, broken or not true to form; replace in-kind • Thin grass or plants impacting facility function without leaving visual holes or bare soil areas • Consultation with a landscape architect is recommended for removal, transplant, or substitution of plants
	As needed		Vegetation blocking curb cuts, causing excessive sediment buildup and flow bypass	• Remove vegetation and sediment buildup
Mulch				
Mulch		Following weeding	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 • Replenish mulch per O&M manual. Often coarse compost is used in the bottom of the facility and arborist wood chips are used on side slopes and rim (above typical water levels) • Keep all mulch away from woody stems
Watering				
Irrigation system (if any)		Based on manufacturer's instructions	Irrigation system present	• Follow manufacturer's instructions for O&M
	A		Sprinklers or drip irrigation not directed/located to properly water plants	• Redirect sprinklers or move drip irrigation to desired areas
Summer watering (first year)		Once every 1-2 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in first year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas • Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system is not present o Pulse water to enhance soil absorption, when feasible o Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff • Add a tree bag or slow-release watering device (e.g., bucket with a perforated bottom) for watering newly installed trees when irrigation system is not present

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No. 21 (continued) - Maintenance Standards and Procedures for Bioretention Facilities.

Maintenance Component	Recommended Frequency [a]		Condition when Maintenance is Needed (Standards)	Action Needed (Procedures)
	Inspection	Routine Maintenance		
Watering (cont'd)				
Summer watering (second and third years)		Once every 2-4 weeks or as needed during prolonged dry periods	Trees, shrubs and groundcovers in second or third year of establishment period	• 10 to 15 gallons per tree • 3 to 5 gallons per shrub • 2 gallons water per square foot for groundcover areas • Water deeply, but infrequently, so that the top 6 to 12 inches of the root zone is moist • Use soaker hoses or spot water with a shower type wand when irrigation system is not present o Pulse water to enhance soil absorption, when feasible o Pre-moisten soil to break surface tension of dry or hydrophobic soils/mulch, followed by several more passes. With this method , each pass increases soil absorption and allows more water to infiltrate prior to runoff
Summer watering (after establishment)		As needed	Established vegetation (after 3 years)	• Plants are typically selected to be drought tolerant and not require regular watering after establishment; however, trees may take up to 5 years of watering to become fully established • Identify trigger mechanisms for drought-stress (e.g., leaf wilt, leaf senescence, etc.) of different species and water immediately after initial signs of stress appear • Water during drought conditions or more often if necessary to maintain plant cover
Pest Control				
Mosquitoes	B, S		Standing water remains for more than 3 days after the end of a storm	• Identify the cause of the standing water and take appropriate actions to address the problem (see "Ponded water") • To facilitate maintenance, manually remove standing water and direct to the storm drainage system (if runoff is from non pollution-generating surfaces) or sanitary sewer system (if runoff is from pollution-generating surfaces) after getting approval from sanitary sewer authority. • Use of pesticides or *Bacillus thuringiensis israelensis* (Bti)may be considered only as a temporary measure while addressing the standing water cause. If overflow to a surface water will occur within 2 weeks after pesticide use, apply for coverage under the Aquatic Mosquito Control NPDES General Permit.
Nuisance animals	As needed		Nuisance animals causing erosion, damaging plants, or depositing large volumes of feces	• Reduce site conditions that attract nuisance species where possible (e.g., plant shrubs and tall grasses to reduce open areas for geese, etc.) • Place predator decoys • Follow IPM protocols for specific nuisance animal issues (see "Additional Maintenance Resources" section for more information on IPM protocols) • Remove pet waste regularly • For public and right-of-way sites consider adding garbage cans with dog bags for picking up pet waste.
Insect pests	Every site visit associated with vegetation management		Signs of pests, such as wilting leaves, chewed leaves and bark, spotting or other indicators	• Reduce hiding places for pests by removing diseased and dead plants • For infestations, follow IPM protocols (see "Additional Maintenance Resources" section for more information on IPM protocols)

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Ray Townhomes
Marysville, WA

APPENDIX A
Resource Review Documents

APPENDIX B
Study Area Evaluation

Photo #1
Looking south toward site
from 241st St SE

Photo #2
Looking east along
241st St. SE

Photo #3
Looking east at intersection of
241st St. SE & 26th Dr. SE

Photo #4
Looking north along
26th Dr. SE

Photo #5

Looking east toward North
Creek Forest from 26th Dr SE

Photo #6

Looking west at bottom of tightline
Within North Creek Forest
(just west of I-405)

Photo #7

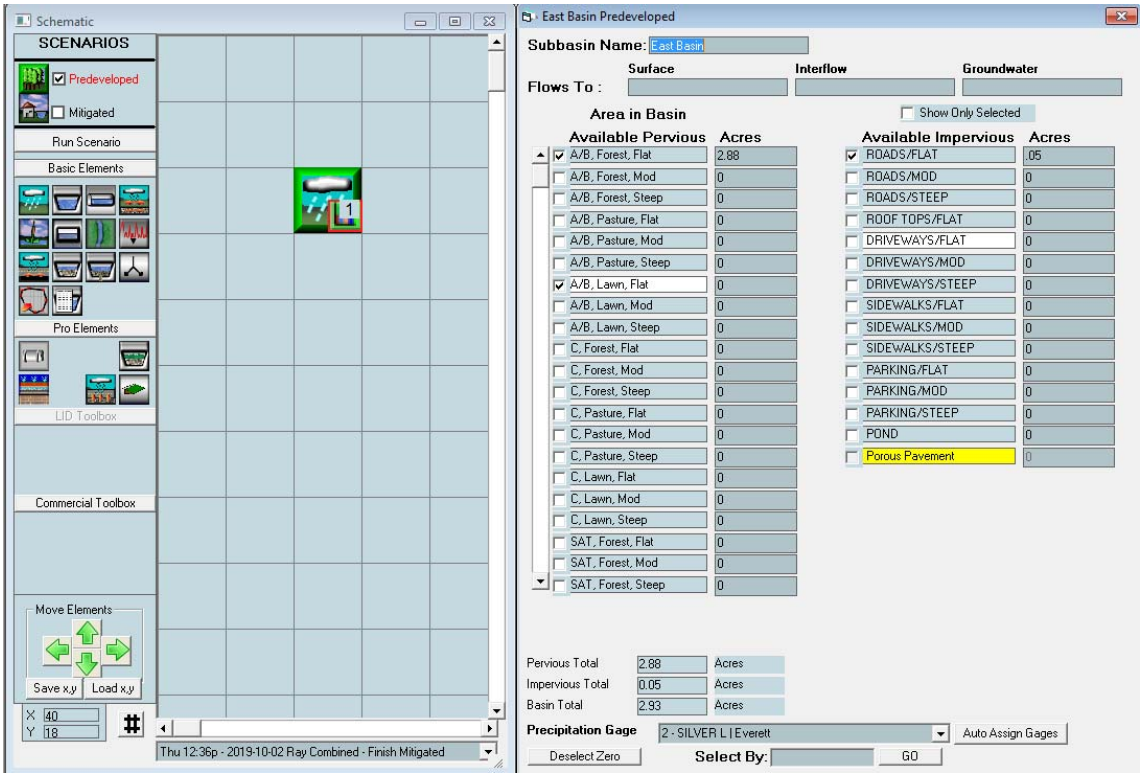
Looking east toward North Creek Forest from 26th Dr SE

APPENDIX C
Basin Mapping

Ray Townhomes
Marysville, WA

APPENDIX D
Hydrologic Modeling Calculations

INPUT PARAMETERS [PRE-DEVELOPED BASIN]



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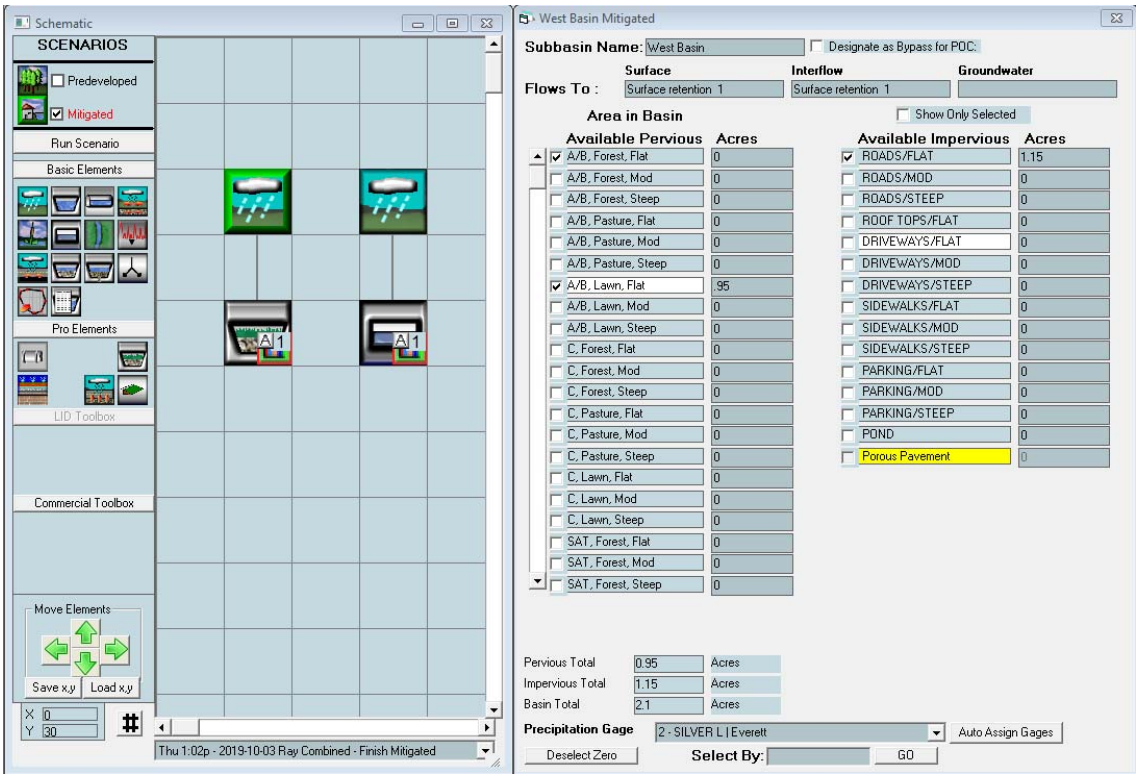

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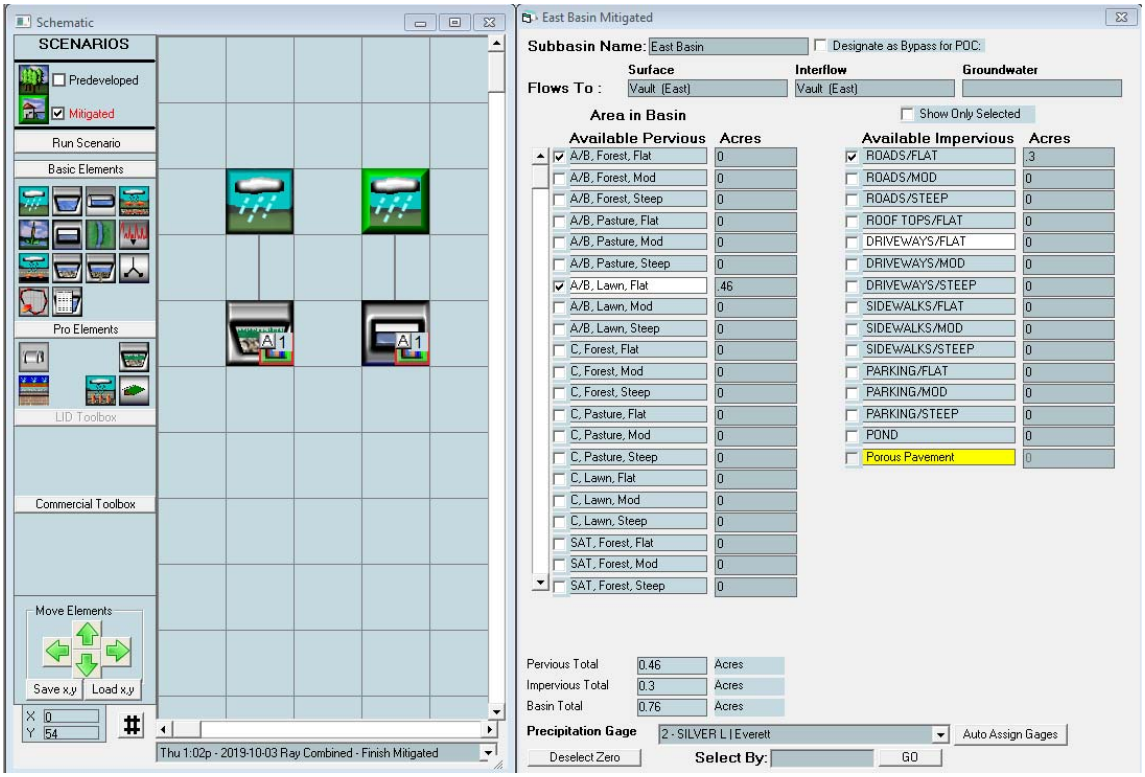

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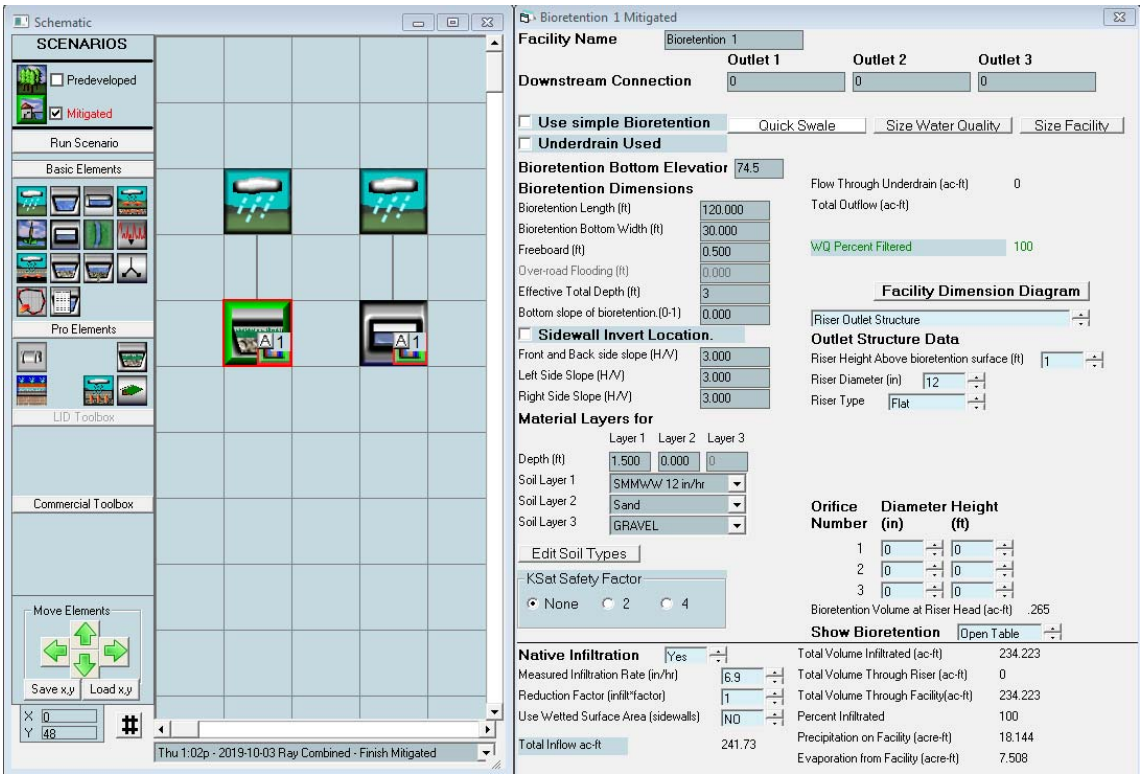

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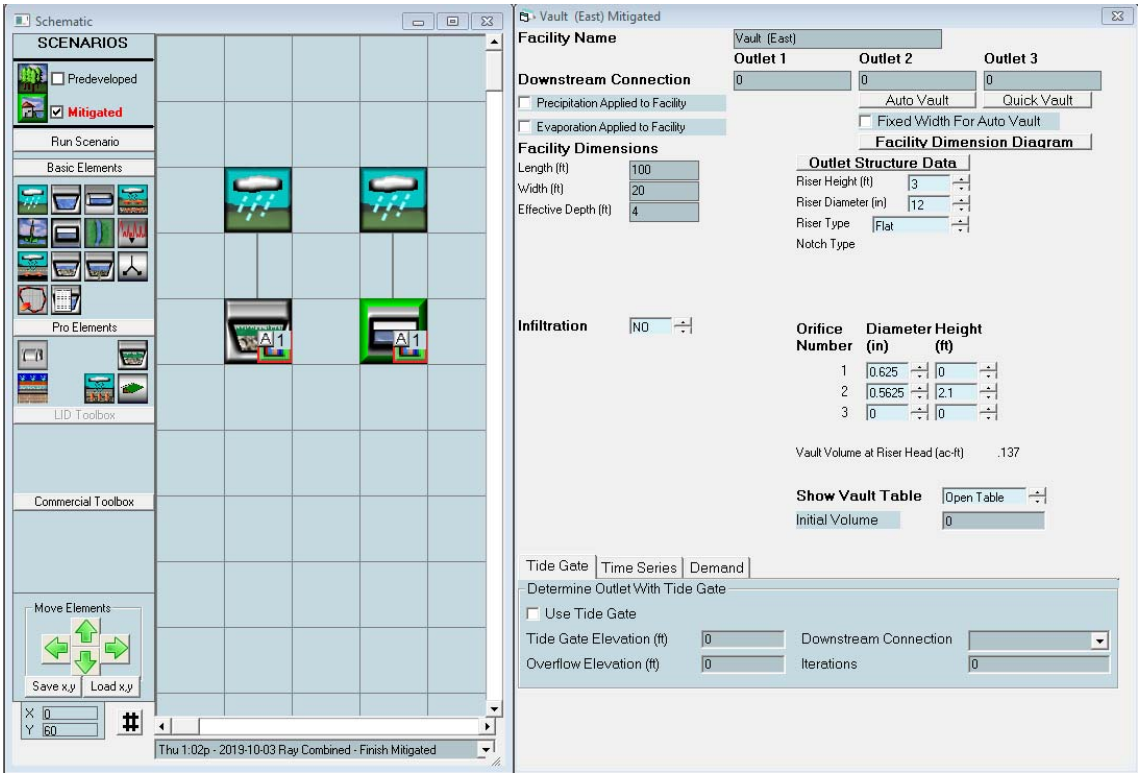
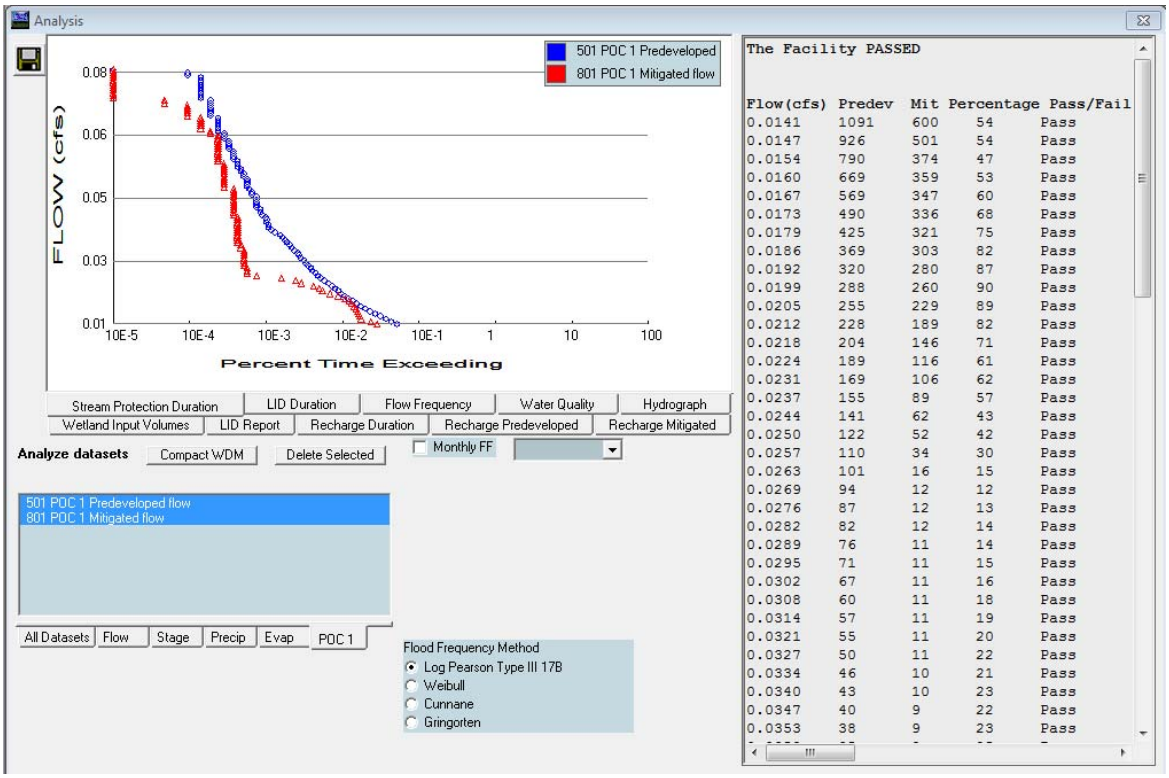


POC DURATION ANALYSIS



WWHM2012
PROJECT REPORT

Project Name: 2019-10-02 Ray Combined
Site Name:
Site Address:
City :
Report Date: 10/3/2019
Gage : Everett
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 1.20
Version Date: 2018/10/10
Version : 4.2.16

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

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : East Basin
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	2.88
Pervious Total	2.88

Impervious Land Use	acre
ROADS FLAT	0.05
Impervious Total	0.05
Basin Total	2.93

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : West Basin
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	.95
Pervious Total	0.95

Impervious Land Use	acre
ROADS FLAT	1.15
Impervious Total	1.15
Basin Total	2.1

Element Flows To:

Surface	Interflow	Groundwater
Trapezoidal Pond 1	Trapezoidal Pond 1	

Name : Trapezoidal Pond 1
Bottom Length: 120.00 ft.
Bottom Width: 30.00 ft.
Depth: 2 ft.
Volume at riser head: 0.1494 acre-feet.
Infiltration On
Infiltration rate: 6.9
Infiltration safety factor: 1
Total Volume Infiltrated (ac-ft.): 223.47
Total Volume Through Riser (ac-ft.): 0
Total Volume Through Facility (ac-ft.): 223.47
Percent Infiltrated: 100
Total Precip Applied to Facility: 0
Total Evap From Facility: 0
Side slope 1: 3 To 1
Side slope 2: 3 To 1
Side slope 3: 3 To 1
Side slope 4: 3 To 1
Discharge Structure
Riser Height: 1.5 ft.
Riser Diameter: 12 in.

Element Flows To:

Outlet 1	Outlet 2

Pond Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
74.500	0.082	0.000	0.000	0.000
74.522	0.083	0.001	0.000	0.575
74.544	0.083	0.003	0.000	0.575
74.567	0.084	0.005	0.000	0.575
74.589	0.084	0.007	0.000	0.575
74.611	0.085	0.009	0.000	0.575
74.633	0.085	0.011	0.000	0.575
74.656	0.085	0.013	0.000	0.575
74.678	0.086	0.015	0.000	0.575
74.700	0.086	0.016	0.000	0.575
74.722	0.087	0.018	0.000	0.575
74.744	0.087	0.020	0.000	0.575
74.767	0.088	0.022	0.000	0.575
74.789	0.088	0.024	0.000	0.575
74.811	0.089	0.026	0.000	0.575
74.833	0.089	0.028	0.000	0.575

74.856	0.090	0.030	0.000	0.575
74.878	0.090	0.032	0.000	0.575
74.900	0.091	0.034	0.000	0.575
74.922	0.091	0.036	0.000	0.575
74.944	0.092	0.038	0.000	0.575
74.967	0.092	0.040	0.000	0.575
74.989	0.092	0.042	0.000	0.575
75.011	0.093	0.045	0.000	0.575
75.033	0.093	0.047	0.000	0.575
75.056	0.094	0.049	0.000	0.575
75.078	0.094	0.051	0.000	0.575
75.100	0.095	0.053	0.000	0.575
75.122	0.095	0.055	0.000	0.575
75.144	0.096	0.057	0.000	0.575
75.167	0.096	0.059	0.000	0.575
75.189	0.097	0.061	0.000	0.575
75.211	0.097	0.064	0.000	0.575
75.233	0.098	0.066	0.000	0.575
75.256	0.098	0.068	0.000	0.575
75.278	0.099	0.070	0.000	0.575
75.300	0.099	0.072	0.000	0.575
75.322	0.100	0.075	0.000	0.575
75.344	0.100	0.077	0.000	0.575
75.367	0.101	0.079	0.000	0.575
75.389	0.101	0.081	0.000	0.575
75.411	0.102	0.084	0.000	0.575
75.433	0.102	0.086	0.000	0.575
75.456	0.103	0.088	0.000	0.575
75.478	0.103	0.090	0.000	0.575
75.500	0.104	0.093	0.000	0.575
75.522	0.104	0.095	0.000	0.575
75.544	0.105	0.097	0.000	0.575
75.567	0.105	0.100	0.000	0.575
75.589	0.106	0.102	0.000	0.575
75.611	0.106	0.105	0.000	0.575
75.633	0.107	0.107	0.000	0.575
75.656	0.107	0.109	0.000	0.575
75.678	0.108	0.112	0.000	0.575
75.700	0.108	0.114	0.000	0.575
75.722	0.109	0.116	0.000	0.575
75.744	0.109	0.119	0.000	0.575
75.767	0.110	0.121	0.000	0.575
75.789	0.110	0.124	0.000	0.575
75.811	0.111	0.126	0.000	0.575
75.833	0.111	0.129	0.000	0.575
75.856	0.112	0.131	0.000	0.575
75.878	0.112	0.134	0.000	0.575
75.900	0.113	0.136	0.000	0.575
75.922	0.113	0.139	0.000	0.575
75.944	0.114	0.141	0.000	0.575
75.967	0.114	0.144	0.000	0.575
75.989	0.115	0.146	0.000	0.575
76.011	0.115	0.149	0.012	0.575
76.033	0.116	0.152	0.064	0.575
76.056	0.116	0.154	0.138	0.575
76.078	0.117	0.157	0.229	0.575
76.100	0.117	0.159	0.333	0.575
76.122	0.118	0.162	0.448	0.575
76.144	0.118	0.165	0.572	0.575
76.167	0.119	0.167	0.703	0.575
76.189	0.119	0.170	0.838	0.575
76.211	0.120	0.173	0.976	0.575
76.233	0.120	0.175	1.115	0.575

76.256	0.121	0.178	1.251	0.575
76.278	0.122	0.181	1.383	0.575
76.300	0.122	0.183	1.509	0.575
76.322	0.123	0.186	1.627	0.575
76.344	0.123	0.189	1.736	0.575
76.367	0.124	0.192	1.834	0.575
76.389	0.124	0.194	1.921	0.575
76.411	0.125	0.197	1.996	0.575
76.433	0.125	0.200	2.060	0.575
76.456	0.126	0.203	2.114	0.575
76.478	0.126	0.206	2.160	0.575
76.500	0.127	0.208	2.203	0.575
76.522	0.127	0.211	2.276	0.575

Name : East Basin
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Lawn, Flat	**.46**
Pervious Total	**0.46**

Impervious Land Use	**acre**
ROADS FLAT	**0.3**
Impervious Total	**0.3**
Basin Total	**0.76**

Element Flows To:

Surface	**Interflow**	**Groundwater**
Vault 1	Vault 1	

Name : Vault 1
Width : 20 ft.
Length : 100 ft.
Depth: 4 ft.
Discharge Structure
Riser Height: 3 ft.
Riser Diameter: 12 in.
Orifice 1 Diameter: 0.625 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 0.5625 in. **Elevation:** 2.1 ft.

Element Flows To:

Outlet 1	**Outlet 2**

Vault Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.045	0.000	0.000	0.000
0.0444	0.045	0.002	0.002	0.000
0.0889	0.045	0.004	0.003	0.000

0.1333	0.045	0.006	0.003	0.000
0.1778	0.045	0.008	0.004	0.000
0.2222	0.045	0.010	0.005	0.000
0.2667	0.045	0.012	0.005	0.000
0.3111	0.045	0.014	0.005	0.000
0.3556	0.045	0.016	0.006	0.000
0.4000	0.045	0.018	0.006	0.000
0.4444	0.045	0.020	0.007	0.000
0.4889	0.045	0.022	0.007	0.000
0.5333	0.045	0.024	0.007	0.000
0.5778	0.045	0.026	0.008	0.000
0.6222	0.045	0.028	0.008	0.000
0.6667	0.045	0.030	0.008	0.000
0.7111	0.045	0.032	0.008	0.000
0.7556	0.045	0.034	0.009	0.000
0.8000	0.045	0.036	0.009	0.000
0.8444	0.045	0.038	0.009	0.000
0.8889	0.045	0.040	0.010	0.000
0.9333	0.045	0.042	0.010	0.000
0.9778	0.045	0.044	0.010	0.000
1.0222	0.045	0.046	0.010	0.000
1.0667	0.045	0.049	0.010	0.000
1.1111	0.045	0.051	0.011	0.000
1.1556	0.045	0.053	0.011	0.000
1.2000	0.045	0.055	0.011	0.000
1.2444	0.045	0.057	0.011	0.000
1.2889	0.045	0.059	0.012	0.000
1.3333	0.045	0.061	0.012	0.000
1.3778	0.045	0.063	0.012	0.000
1.4222	0.045	0.065	0.012	0.000
1.4667	0.045	0.067	0.012	0.000
1.5111	0.045	0.069	0.013	0.000
1.5556	0.045	0.071	0.013	0.000
1.6000	0.045	0.073	0.013	0.000
1.6444	0.045	0.075	0.013	0.000
1.6889	0.045	0.077	0.013	0.000
1.7333	0.045	0.079	0.014	0.000
1.7778	0.045	0.081	0.014	0.000
1.8222	0.045	0.083	0.014	0.000
1.8667	0.045	0.085	0.014	0.000
1.9111	0.045	0.087	0.014	0.000
1.9556	0.045	0.089	0.014	0.000
2.0000	0.045	0.091	0.015	0.000
2.0444	0.045	0.093	0.015	0.000
2.0889	0.045	0.095	0.015	0.000
2.1333	0.045	0.097	0.017	0.000
2.1778	0.045	0.100	0.018	0.000
2.2222	0.045	0.102	0.018	0.000
2.2667	0.045	0.104	0.019	0.000
2.3111	0.045	0.106	0.020	0.000
2.3556	0.045	0.108	0.020	0.000
2.4000	0.045	0.110	0.021	0.000
2.4444	0.045	0.112	0.021	0.000
2.4889	0.045	0.114	0.022	0.000
2.5333	0.045	0.116	0.022	0.000
2.5778	0.045	0.118	0.023	0.000
2.6222	0.045	0.120	0.023	0.000
2.6667	0.045	0.122	0.023	0.000
2.7111	0.045	0.124	0.024	0.000
2.7556	0.045	0.126	0.024	0.000
2.8000	0.045	0.128	0.024	0.000
2.8444	0.045	0.130	0.025	0.000
2.8889	0.045	0.132	0.025	0.000

2.9333	0.045	0.134	0.026	0.000
2.9778	0.045	0.136	0.026	0.000
3.0222	0.045	0.138	0.061	0.000
3.0667	0.045	0.140	0.209	0.000
3.1111	0.045	0.142	0.417	0.000
3.1556	0.045	0.144	0.665	0.000
3.2000	0.045	0.146	0.935	0.000
3.2444	0.045	0.149	1.211	0.000
3.2889	0.045	0.151	1.476	0.000
3.3333	0.045	0.153	1.712	0.000
3.3778	0.045	0.155	1.908	0.000
3.4222	0.045	0.157	2.058	0.000
3.4667	0.045	0.159	2.168	0.000
3.5111	0.045	0.161	2.281	0.000
3.5556	0.045	0.163	2.377	0.000
3.6000	0.045	0.165	2.470	0.000
3.6444	0.045	0.167	2.559	0.000
3.6889	0.045	0.169	2.645	0.000
3.7333	0.045	0.171	2.728	0.000
3.7778	0.045	0.173	2.809	0.000
3.8222	0.045	0.175	2.888	0.000
3.8667	0.045	0.177	2.964	0.000
3.9111	0.045	0.179	3.038	0.000
3.9556	0.045	0.181	3.111	0.000
4.0000	0.045	0.183	3.182	0.000
4.0444	0.045	0.185	3.252	0.000
4.0889	0.000	0.000	3.320	0.000

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:2.88
Total Impervious Area:0.05

Mitigated Landuse Totals for POC #1
Total Pervious Area:1.41
Total Impervious Area:1.45

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.028171
5 year	0.040555
10 year	0.050454
25 year	0.065102
50 year	0.07771
100 year	0.091899

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.010766
5 year	0.014116
10 year	0.016508
25 year	0.019734
50 year	0.02229

100 year 0.024981

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.029	0.010
1950	0.031	0.010
1951	0.033	0.010
1952	0.025	0.008
1953	0.032	0.009
1954	0.043	0.010
1955	0.041	0.011
1956	0.015	0.012
1957	0.025	0.012
1958	0.061	0.010
1959	0.024	0.011
1960	0.024	0.012
1961	0.077	0.011
1962	0.031	0.010
1963	0.033	0.010
1964	0.026	0.010
1965	0.024	0.010
1966	0.023	0.009
1967	0.053	0.010
1968	0.027	0.012
1969	0.053	0.010
1970	0.021	0.009
1971	0.029	0.011
1972	0.037	0.011
1973	0.031	0.010
1974	0.039	0.010
1975	0.029	0.009
1976	0.021	0.011
1977	0.023	0.010
1978	0.016	0.008
1979	0.037	0.011
1980	0.023	0.009
1981	0.021	0.010
1982	0.023	0.013
1983	0.028	0.010
1984	0.028	0.012
1985	0.037	0.012
1986	0.038	0.022
1987	0.031	0.013
1988	0.025	0.012
1989	0.025	0.007
1990	0.020	0.011
1991	0.026	0.011
1992	0.025	0.010
1993	0.019	0.009
1994	0.023	0.011
1995	0.019	0.012
1996	0.048	0.012
1997	0.087	0.071
1998	0.034	0.009
1999	0.015	0.011
2000	0.055	0.012
2001	0.019	0.008
2002	0.019	0.011
2003	0.025	0.010
2004	0.047	0.013
2005	0.024	0.011

2006	0.103	0.013
2007	0.026	0.010
2008	0.022	0.022
2009	0.024	0.010

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.1031	0.0710
2	0.0873	0.0224
3	0.0765	0.0217
4	0.0609	0.0134
5	0.0553	0.0133
6	0.0534	0.0129
7	0.0526	0.0129
8	0.0483	0.0124
9	0.0467	0.0124
10	0.0433	0.0124
11	0.0413	0.0123
12	0.0392	0.0119
13	0.0380	0.0118
14	0.0375	0.0116
15	0.0372	0.0116
16	0.0366	0.0116
17	0.0341	0.0115
18	0.0331	0.0114
19	0.0330	0.0114
20	0.0323	0.0112
21	0.0309	0.0112
22	0.0308	0.0111
23	0.0306	0.0111
24	0.0306	0.0110
25	0.0293	0.0109
26	0.0289	0.0107
27	0.0285	0.0107
28	0.0281	0.0107
29	0.0275	0.0106
30	0.0274	0.0106
31	0.0265	0.0105
32	0.0259	0.0105
33	0.0257	0.0104
34	0.0254	0.0104
35	0.0253	0.0103
36	0.0251	0.0102
37	0.0248	0.0101
38	0.0247	0.0101
39	0.0246	0.0101
40	0.0245	0.0101
41	0.0242	0.0100
42	0.0240	0.0100
43	0.0239	0.0099
44	0.0238	0.0099
45	0.0233	0.0099
46	0.0231	0.0098
47	0.0229	0.0098
48	0.0226	0.0097
49	0.0225	0.0097
50	0.0216	0.0095
51	0.0211	0.0095
52	0.0209	0.0093
53	0.0206	0.0091
54	0.0201	0.0090

55	0.0193	0.0089
56	0.0192	0.0088
57	0.0192	0.0087
58	0.0190	0.0082
59	0.0163	0.0081
60	0.0153	0.0080
61	0.0146	0.0075

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0141	1091	600	54	Pass
0.0147	926	501	54	Pass
0.0154	790	374	47	Pass
0.0160	669	359	53	Pass
0.0167	569	347	60	Pass
0.0173	490	336	68	Pass
0.0179	425	321	75	Pass
0.0186	369	303	82	Pass
0.0192	320	280	87	Pass
0.0199	288	260	90	Pass
0.0205	255	229	89	Pass
0.0212	228	189	82	Pass
0.0218	204	146	71	Pass
0.0224	189	116	61	Pass
0.0231	169	106	62	Pass
0.0237	155	89	57	Pass
0.0244	141	62	43	Pass
0.0250	122	52	42	Pass
0.0257	110	34	30	Pass
0.0263	101	16	15	Pass
0.0269	94	12	12	Pass
0.0276	87	12	13	Pass
0.0282	82	12	14	Pass
0.0289	76	11	14	Pass
0.0295	71	11	15	Pass
0.0302	67	11	16	Pass
0.0308	60	11	18	Pass
0.0314	57	11	19	Pass
0.0321	55	11	20	Pass
0.0327	50	11	22	Pass
0.0334	46	10	21	Pass
0.0340	43	10	23	Pass
0.0347	40	9	22	Pass
0.0353	38	9	23	Pass
0.0359	35	9	25	Pass
0.0366	33	9	27	Pass
0.0372	28	9	32	Pass
0.0379	25	9	36	Pass
0.0385	23	9	39	Pass
0.0391	23	9	39	Pass
0.0398	22	9	40	Pass
0.0404	22	9	40	Pass
0.0411	21	9	42	Pass
0.0417	19	8	42	Pass
0.0424	18	8	44	Pass
0.0430	18	8	44	Pass
0.0436	16	8	50	Pass

0.0443	16	8	50	Pass
0.0449	16	8	50	Pass
0.0456	16	8	50	Pass
0.0462	16	8	50	Pass
0.0469	14	8	57	Pass
0.0475	14	8	57	Pass
0.0481	13	8	61	Pass
0.0488	12	6	50	Pass
0.0494	12	6	50	Pass
0.0501	12	6	50	Pass
0.0507	12	6	50	Pass
0.0514	11	6	54	Pass
0.0520	11	6	54	Pass
0.0526	10	6	60	Pass
0.0533	10	6	60	Pass
0.0539	9	6	66	Pass
0.0546	9	6	66	Pass
0.0552	9	5	55	Pass
0.0559	8	5	62	Pass
0.0565	8	5	62	Pass
0.0571	8	5	62	Pass
0.0578	8	5	62	Pass
0.0584	7	5	71	Pass
0.0591	7	5	71	Pass
0.0597	7	5	71	Pass
0.0604	7	5	71	Pass
0.0610	6	5	83	Pass
0.0616	6	5	83	Pass
0.0623	6	4	66	Pass
0.0629	5	4	80	Pass
0.0636	5	3	60	Pass
0.0642	5	3	60	Pass
0.0649	5	3	60	Pass
0.0655	5	3	60	Pass
0.0661	5	3	60	Pass
0.0668	4	2	50	Pass
0.0674	4	2	50	Pass
0.0681	4	2	50	Pass
0.0687	4	2	50	Pass
0.0694	4	2	50	Pass
0.0700	4	1	25	Pass
0.0706	4	1	25	Pass
0.0713	3	0	0	Pass
0.0719	3	0	0	Pass
0.0726	3	0	0	Pass
0.0732	3	0	0	Pass
0.0739	3	0	0	Pass
0.0745	3	0	0	Pass
0.0751	3	0	0	Pass
0.0758	3	0	0	Pass
0.0764	3	0	0	Pass
0.0771	2	0	0	Pass
0.0777	2	0	0	Pass

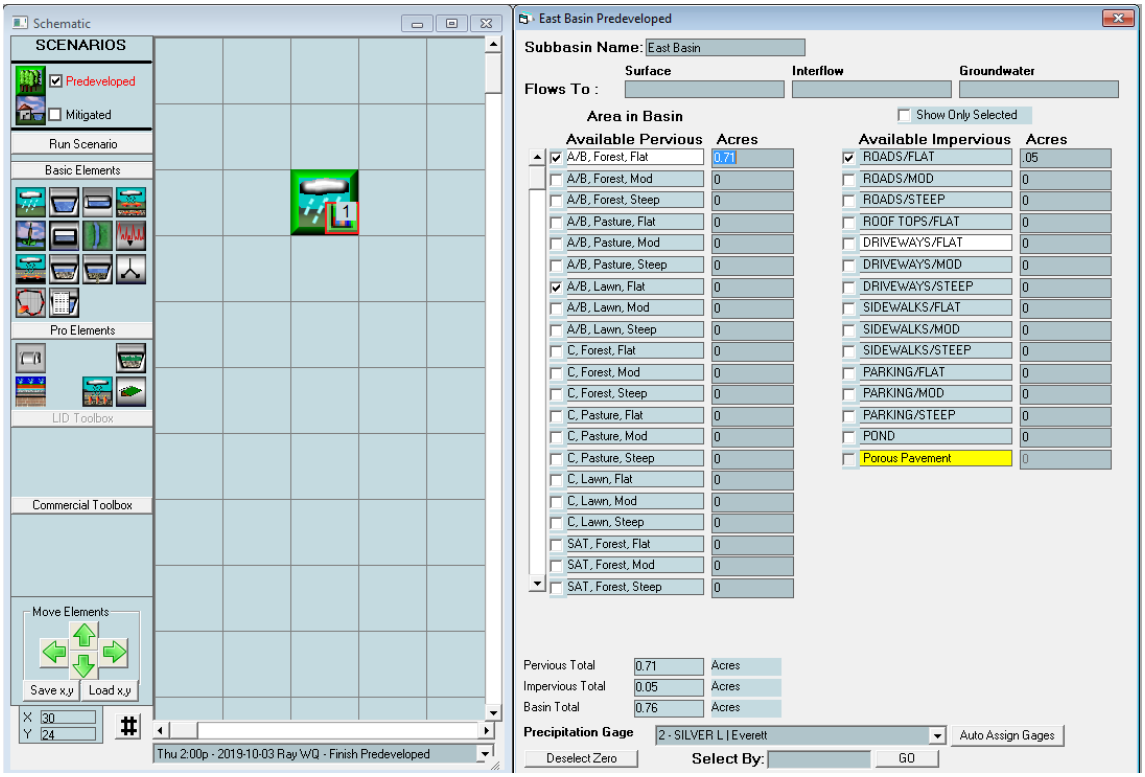
Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 0 **acre-feet**
On-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**
Off-line facility target flow: 0 **cfs.**
Adjusted for 15 min: 0 **cfs.**

Perlnd and Implnd Changes

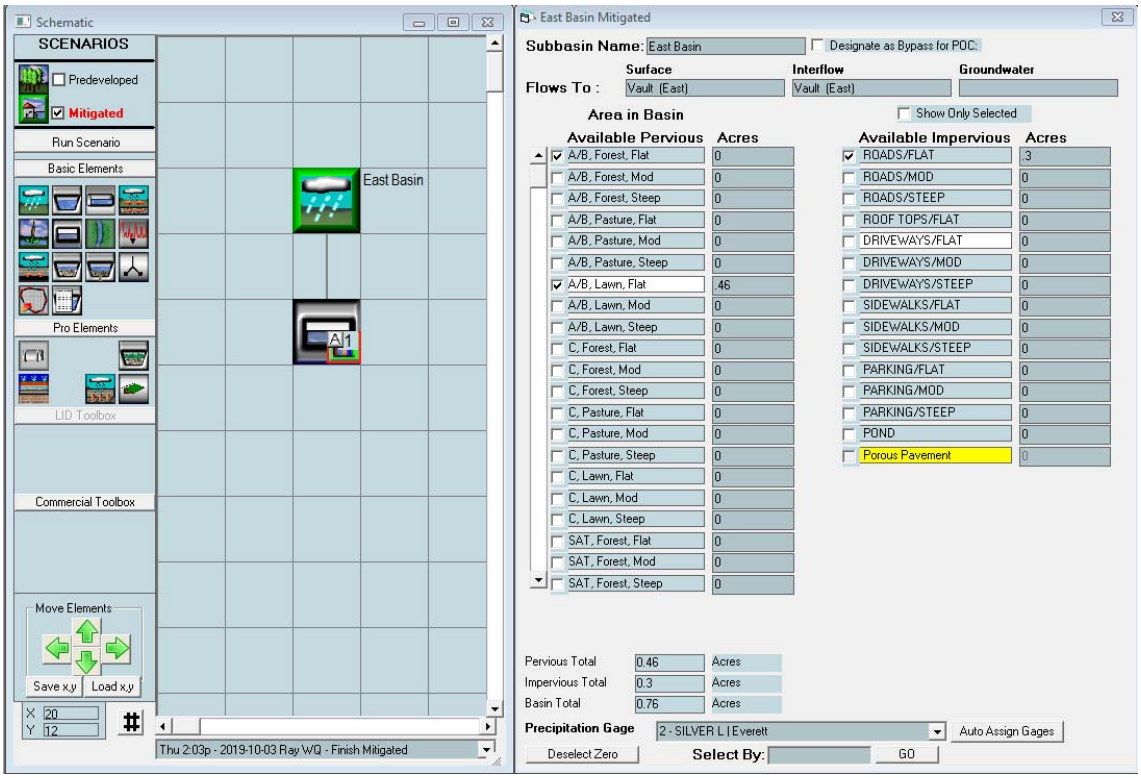
No changes have been made.

APPENDIX E
East Basin Wetpool Calculations

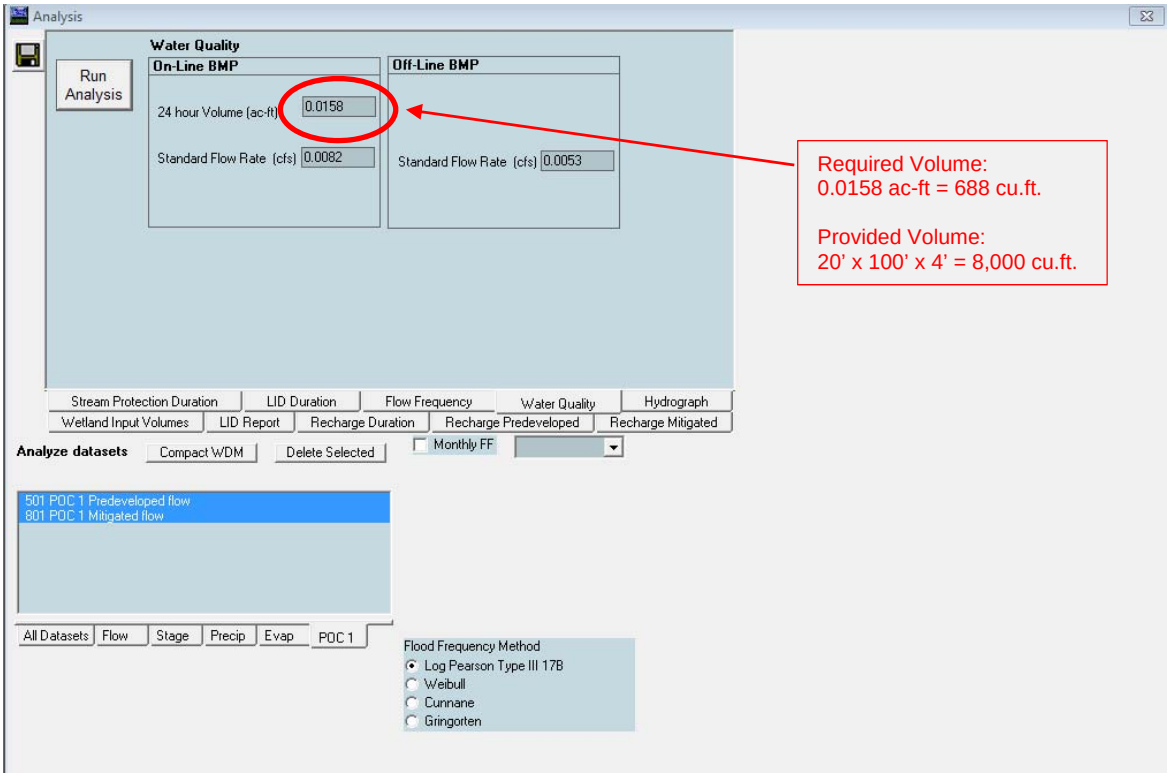
INPUT PARAMETERS [PRE-DEVELOPED EAST BASIN ONLY]



INPUT PARAMETERS [MITIGATED – EAST BASIN ONLY]



WATER QUALITY CALCULATION (EAST BASIN ONLY)



WWHM2012
PROJECT REPORT

Project Name: 2019-10-03 Ray WQ
Site Name:
Site Address:
City :
Report Date: 10/3/2019
Gage : Everett
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 1.20
Version Date: 2018/10/10
Version : 4.2.16

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

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : East Basin
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	.71
Pervious Total	**0.71**

Impervious Land Use	acre
ROADS FLAT	0.05
Impervious Total	**0.05**

Basin Total **0.76**

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : East Basin
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	.46
Pervious Total	**0.46**

Impervious Land Use	acre
ROADS FLAT	0.3
Impervious Total	**0.3**

Basin Total **0.76**

Element Flows To:

Surface	Interflow	Groundwater
Vault (East)	Vault (East)	

Name : Vault (East)
Width : 20 ft.
Length : 100 ft.
Depth: 4 ft.
Discharge Structure
Riser Height: 3 ft.
Riser Diameter: 12 in.
Orifice 1 Diameter: 0.625 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 0.5625 in. **Elevation:** 2.1 ft.

Element Flows To:

Outlet 1	Outlet 2

Vault Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.045	0.000	0.000	0.000
0.0444	0.045	0.002	0.002	0.000
0.0889	0.045	0.004	0.003	0.000
0.1333	0.045	0.006	0.003	0.000
0.1778	0.045	0.008	0.004	0.000
0.2222	0.045	0.010	0.005	0.000
0.2667	0.045	0.012	0.005	0.000
0.3111	0.045	0.014	0.005	0.000
0.3556	0.045	0.016	0.006	0.000
0.4000	0.045	0.018	0.006	0.000
0.4444	0.045	0.020	0.007	0.000
0.4889	0.045	0.022	0.007	0.000
0.5333	0.045	0.024	0.007	0.000
0.5778	0.045	0.026	0.008	0.000
0.6222	0.045	0.028	0.008	0.000
0.6667	0.045	0.030	0.008	0.000
0.7111	0.045	0.032	0.008	0.000
0.7556	0.045	0.034	0.009	0.000
0.8000	0.045	0.036	0.009	0.000
0.8444	0.045	0.038	0.009	0.000
0.8889	0.045	0.040	0.010	0.000
0.9333	0.045	0.042	0.010	0.000
0.9778	0.045	0.044	0.010	0.000
1.0222	0.045	0.046	0.010	0.000
1.0667	0.045	0.049	0.010	0.000
1.1111	0.045	0.051	0.011	0.000
1.1556	0.045	0.053	0.011	0.000
1.2000	0.045	0.055	0.011	0.000
1.2444	0.045	0.057	0.011	0.000
1.2889	0.045	0.059	0.012	0.000
1.3333	0.045	0.061	0.012	0.000
1.3778	0.045	0.063	0.012	0.000
1.4222	0.045	0.065	0.012	0.000
1.4667	0.045	0.067	0.012	0.000
1.5111	0.045	0.069	0.013	0.000
1.5556	0.045	0.071	0.013	0.000
1.6000	0.045	0.073	0.013	0.000
1.6444	0.045	0.075	0.013	0.000
1.6889	0.045	0.077	0.013	0.000
1.7333	0.045	0.079	0.014	0.000
1.7778	0.045	0.081	0.014	0.000
1.8222	0.045	0.083	0.014	0.000
1.8667	0.045	0.085	0.014	0.000
1.9111	0.045	0.087	0.014	0.000
1.9556	0.045	0.089	0.014	0.000
2.0000	0.045	0.091	0.015	0.000
2.0444	0.045	0.093	0.015	0.000
2.0889	0.045	0.095	0.015	0.000
2.1333	0.045	0.097	0.017	0.000
2.1778	0.045	0.100	0.018	0.000
2.2222	0.045	0.102	0.018	0.000
2.2667	0.045	0.104	0.019	0.000
2.3111	0.045	0.106	0.020	0.000
2.3556	0.045	0.108	0.020	0.000
2.4000	0.045	0.110	0.021	0.000
2.4444	0.045	0.112	0.021	0.000
2.4889	0.045	0.114	0.022	0.000
2.5333	0.045	0.116	0.022	0.000

2.5778	0.045	0.118	0.023	0.000
2.6222	0.045	0.120	0.023	0.000
2.6667	0.045	0.122	0.023	0.000
2.7111	0.045	0.124	0.024	0.000
2.7556	0.045	0.126	0.024	0.000
2.8000	0.045	0.128	0.024	0.000
2.8444	0.045	0.130	0.025	0.000
2.8889	0.045	0.132	0.025	0.000
2.9333	0.045	0.134	0.026	0.000
2.9778	0.045	0.136	0.026	0.000
3.0222	0.045	0.138	0.061	0.000
3.0667	0.045	0.140	0.209	0.000
3.1111	0.045	0.142	0.417	0.000
3.1556	0.045	0.144	0.665	0.000
3.2000	0.045	0.146	0.935	0.000
3.2444	0.045	0.149	1.211	0.000
3.2889	0.045	0.151	1.476	0.000
3.3333	0.045	0.153	1.712	0.000
3.3778	0.045	0.155	1.908	0.000
3.4222	0.045	0.157	2.058	0.000
3.4667	0.045	0.159	2.168	0.000
3.5111	0.045	0.161	2.281	0.000
3.5556	0.045	0.163	2.377	0.000
3.6000	0.045	0.165	2.470	0.000
3.6444	0.045	0.167	2.559	0.000
3.6889	0.045	0.169	2.645	0.000
3.7333	0.045	0.171	2.728	0.000
3.7778	0.045	0.173	2.809	0.000
3.8222	0.045	0.175	2.888	0.000
3.8667	0.045	0.177	2.964	0.000
3.9111	0.045	0.179	3.038	0.000
3.9556	0.045	0.181	3.111	0.000
4.0000	0.045	0.183	3.182	0.000
4.0444	0.045	0.185	3.252	0.000
4.0889	0.000	0.000	3.320	0.000

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:0.71
Total Impervious Area:0.05

Mitigated Landuse Totals for POC #1
Total Pervious Area:0.46
Total Impervious Area:0.3

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.027061
5 year	0.036671
10 year	0.043707
25 year	0.053393
50 year	0.061208
100 year	0.069553

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.010766
5 year	0.014116
10 year	0.016508
25 year	0.019734
50 year	0.02229
100 year	0.024981

Stream Protection Duration
Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.028	0.010
1950	0.031	0.010
1951	0.033	0.010
1952	0.025	0.008
1953	0.032	0.009
1954	0.041	0.010
1955	0.033	0.011
1956	0.014	0.012
1957	0.023	0.012
1958	0.060	0.010
1959	0.024	0.011
1960	0.024	0.012
1961	0.076	0.011
1962	0.031	0.010
1963	0.033	0.010
1964	0.020	0.010
1965	0.023	0.010
1966	0.023	0.009
1967	0.052	0.010
1968	0.027	0.012
1969	0.053	0.010
1970	0.021	0.009
1971	0.029	0.011
1972	0.037	0.011
1973	0.031	0.010
1974	0.038	0.010
1975	0.029	0.009
1976	0.021	0.011
1977	0.021	0.010
1978	0.016	0.008
1979	0.034	0.011
1980	0.023	0.009
1981	0.021	0.010
1982	0.022	0.013
1983	0.028	0.010
1984	0.026	0.012
1985	0.037	0.012
1986	0.035	0.022
1987	0.031	0.013
1988	0.025	0.012
1989	0.025	0.007
1990	0.020	0.011
1991	0.026	0.011
1992	0.025	0.010
1993	0.019	0.009
1994	0.022	0.011
1995	0.019	0.012
1996	0.031	0.012
1997	0.036	0.071

1998	0.034	0.009
1999	0.015	0.011
2000	0.055	0.012
2001	0.019	0.008
2002	0.018	0.011
2003	0.025	0.010
2004	0.047	0.013
2005	0.022	0.011
2006	0.045	0.013
2007	0.026	0.010
2008	0.022	0.022
2009	0.022	0.010

Stream Protection Duration
Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.0765	0.0710
2	0.0601	0.0224
3	0.0552	0.0217
4	0.0532	0.0134
5	0.0520	0.0133
6	0.0467	0.0129
7	0.0453	0.0129
8	0.0411	0.0124
9	0.0378	0.0124
10	0.0372	0.0124
11	0.0367	0.0123
12	0.0362	0.0119
13	0.0351	0.0118
14	0.0340	0.0116
15	0.0336	0.0116
16	0.0330	0.0116
17	0.0330	0.0115
18	0.0326	0.0114
19	0.0322	0.0114
20	0.0308	0.0112
21	0.0306	0.0112
22	0.0306	0.0111
23	0.0306	0.0111
24	0.0305	0.0110
25	0.0293	0.0109
26	0.0289	0.0107
27	0.0285	0.0107
28	0.0281	0.0107
29	0.0274	0.0106
30	0.0263	0.0106
31	0.0263	0.0105
32	0.0257	0.0105
33	0.0253	0.0104
34	0.0252	0.0104
35	0.0251	0.0103
36	0.0247	0.0102
37	0.0247	0.0101
38	0.0243	0.0101
39	0.0242	0.0101
40	0.0234	0.0101
41	0.0233	0.0100
42	0.0232	0.0100
43	0.0231	0.0099
44	0.0225	0.0099
45	0.0222	0.0099
46	0.0221	0.0098

47	0.0218	0.0098
48	0.0216	0.0097
49	0.0214	0.0097
50	0.0211	0.0095
51	0.0209	0.0095
52	0.0205	0.0093
53	0.0201	0.0091
54	0.0201	0.0090
55	0.0193	0.0089
56	0.0190	0.0088
57	0.0187	0.0087
58	0.0183	0.0082
59	0.0157	0.0081
60	0.0152	0.0080
61	0.0141	0.0075

Stream Protection Duration
POC #1
The Facility FAILED

Facility FAILED duration standard for 1+ flows.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0135	1085	685	63	Pass
0.0140	950	610	64	Pass
0.0145	834	539	64	Pass
0.0150	744	460	61	Pass
0.0155	650	372	57	Pass
0.0159	580	361	62	Pass
0.0164	519	350	67	Pass
0.0169	468	343	73	Pass
0.0174	415	333	80	Pass
0.0179	366	322	87	Pass
0.0183	333	310	93	Pass
0.0188	305	297	97	Pass
0.0193	281	278	98	Pass
0.0198	260	262	100	Pass
0.0203	239	245	102	Fail
0.0208	218	217	99	Pass
0.0212	200	183	91	Pass
0.0217	181	149	82	Pass
0.0222	170	127	74	Pass
0.0227	154	112	72	Pass
0.0232	144	105	72	Pass
0.0236	131	93	70	Pass
0.0241	118	67	56	Pass
0.0246	115	58	50	Pass
0.0251	101	50	49	Pass
0.0256	91	39	42	Pass
0.0261	86	25	29	Pass
0.0265	83	12	14	Pass
0.0270	80	12	15	Pass
0.0275	76	12	15	Pass
0.0280	74	12	16	Pass
0.0285	70	12	17	Pass
0.0289	63	11	17	Pass
0.0294	60	11	18	Pass
0.0299	56	11	19	Pass
0.0304	55	11	20	Pass
0.0309	48	11	22	Pass
0.0313	45	11	24	Pass
0.0318	43	11	25	Pass

The calculations provided in this appendix are intended to determine the required wetpool size in the east vault, so the flow-control results are irrelevant. Please see Appendix D for flow control compliance calculations.

0.0323	37	11	29	Pass
0.0328	34	11	32	Pass
0.0333	31	10	32	Pass
0.0338	29	10	34	Pass
0.0342	26	9	34	Pass
0.0347	25	9	36	Pass
0.0352	22	9	40	Pass
0.0357	21	9	42	Pass
0.0362	18	9	50	Pass
0.0366	16	9	56	Pass
0.0371	15	9	60	Pass
0.0376	13	9	69	Pass
0.0381	12	9	75	Pass
0.0386	12	9	75	Pass
0.0391	12	9	75	Pass
0.0395	12	9	75	Pass
0.0400	12	9	75	Pass
0.0405	12	9	75	Pass
0.0410	12	9	75	Pass
0.0415	10	8	80	Pass
0.0419	10	8	80	Pass
0.0424	10	8	80	Pass
0.0429	10	8	80	Pass
0.0434	9	8	88	Pass
0.0439	9	8	88	Pass
0.0444	9	8	88	Pass
0.0448	9	8	88	Pass
0.0453	8	8	100	Pass
0.0458	8	8	100	Pass
0.0463	8	8	100	Pass
0.0468	7	8	114	Fail
0.0472	7	8	114	Fail
0.0477	6	8	133	Fail
0.0482	6	8	133	Fail
0.0487	6	6	100	Pass
0.0492	6	6	100	Pass
0.0496	6	6	100	Pass
0.0501	6	6	100	Pass
0.0506	6	6	100	Pass
0.0511	6	6	100	Pass
0.0516	6	6	100	Pass
0.0521	5	6	120	Fail
0.0525	5	6	120	Fail
0.0530	5	6	120	Fail
0.0535	4	6	150	Fail
0.0540	4	6	150	Fail
0.0545	4	6	150	Fail
0.0549	4	5	125	Fail
0.0554	3	5	166	Fail
0.0559	3	5	166	Fail
0.0564	3	5	166	Fail
0.0569	3	5	166	Fail
0.0574	3	5	166	Fail
0.0578	3	5	166	Fail
0.0583	3	5	166	Fail
0.0588	3	5	166	Fail
0.0593	3	5	166	Fail
0.0598	3	5	166	Fail
0.0602	2	5	250	Fail
0.0607	2	5	250	Fail
0.0612	2	5	250	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.

Water Quality BMP Flow and Volume for POC #1
On-line facility volume: 0.0158 **acre-feet**
On-line facility target flow: 0.0082 **cfs.**
Adjusted for 15 min: 0.0082 **cfs.**
Off-line facility target flow: 0.0053 **cfs.**
Adjusted for 15 min: 0.0053 **cfs.**

Required Volume:
0.0158 ac-ft = 688 cu.ft.

Provided Volume:
20' x 100' x 4' = 8,000 cu.ft.

Perlnd and Implnd Changes
No changes have been made.
