RESORT SEMIAHMOO ZONE 3
BLAINE, WASHINGTON

PRELIMINARY STORMWATER DESIGN REPORT

Prepared for:
M-KOV, Inc.
501 Fern Road
Bellingham, WA 98225

Prepared by:
CASCADE ENGINEERING GROUP.
119 Grand Avenue, Suite D
Bellingham, Washington 98225
(360) 306-8161

June 2016

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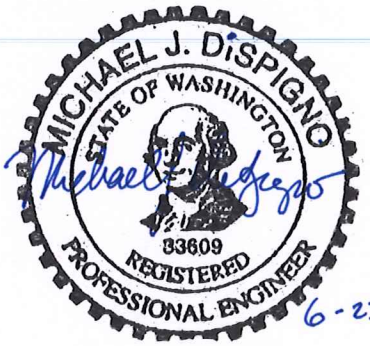

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June 2016

RAZR01

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1.0 VICINITY MAP

2.0 PROJECT DESCRIPTION

M-KOV Inc. is proposing to develop the Resort Semiahmoo Zone 3 site, formerly known as Burnside Village when the property was owned by Trillium Corporation, in Blaine, Washington. The 19.4 acre site is located in the southwest quadrant of the intersection of Semiahmoo Drive and Semiahmoo Parkway in Township 40N, Range R1W, Section 10 (Parcel Number 405110 510169).

The site has never been developed. The site was covered by a mature forest and had a majority of the trees harvested in 2013. Existing soils consist of six to 12 inches of topsoil covering a two to eight foot thick sand and gravel layer on top of glacial till. The site slopes to the northwest at approximately a 4.4% grade. The development site will include a mixture of single family lots, multifamily buildings, commercial and/or multi-use buildings, a commercial area, and supporting road, parking, open space and park land, and utility infrastructure. The proposed development will be in multiple phases. For this stormwater analysis Phase 1 is assumed to include 40 single family residences with the associated road and utility infrastructure in the eastern portion of the site and a commercial area in the southwest corner of the site. Subsequent phases will include the development of the central and northern portions of the site. Development in the future phases has not been specifically defined but is assumed to include commercial, multifamily residential and single family residential areas.

Some of the site's stormwater will be allowed to infiltrate while the surface runoff from the roadways and the multifamily and commercial areas will be collected and conveyed away from

the site. Based on the site topography, stormwater runoff from the developed site will be divided into East and West systems, with future phase improvements in each of the two systems. Runoff from the East system will be collected, treated, and routed to the roadside ditch on the west side of Semiahmoo Parkway where it will flow north and discharge at the existing Semiahmoo Bay stormwater outfall. Runoff from the West system will be collected, treated and detained, and routed northerly utilizing an existing 12-inch diameter culvert crossing under Semiahmoo Drive where it will enter the Boundary Ridge stormwater conveyance system. The combined runoff will flow north and discharge at the existing Semiahmoo Bay stormwater outfall.

This Preliminary Stormwater Design Report discusses the methodology used to design the post-developed stormwater runoff conveyances, treatment and infiltration facilities.

3.0 DESIGN CRITERIA AND ASSUMPTIONS

3.1 Governing Guidelines

In accordance with the City Standards, the Department of Ecology *Stormwater Management Manual for Western Washington*, 2014 addendum, (DOE Manual) will be used to establish the minimum drainage and erosion control requirements.

Since this project contains land-disturbing activities greater than 5,000 square feet, the requirements for large development apply. As described in the DOE Manual these requirements include compliance with Minimum Requirements #1 through #9. A list of the minimum requirements, together with a discussion of how each requirement will be met, is provided in Section 5 of this Preliminary Stormwater Site Plan.

3.2 Design Criteria

In accordance with the DOE Manual, the site's water quality treatment facilities hydrologic analysis was performed using the Western Washington Hydrologic Model (WWHM2012, version 4.2.12), a continuous simulation hydrologic model developed by the DOE. In accordance with the DOE Manual, runoff treatment Best Management Practices (BMPs) shall be sized to capture and treat the water quality design storm volume, defined as the six-month, 24 hour return storm event, or the flow rate at or below which 91% of the runoff volume, as estimated by an approved continuous runoff model, will be treated.

As directed in the DOE Manual Volume 1, Section 2.5.7 Minimum *Requirement #7: Flow Control*, project sites that discharge to flow control exempt bodies of water, such as Semiahmoo Bay, are not required to provide flow control for its runoff provided:

- The project site must be drained by a conveyance system that is comprised entirely of manmade conveyance elements (e.g., pipes, ditches, outfall protection) and extends to the ordinary high water line of the exempt receiving water; and,
- The conveyance system between the project site and the exempt receiving water shall have sufficient hydraulic capacity to convey discharges from future build-out conditions (under current zoning) of the site, and the existing condition from non-project areas from which runoff is or will be collected; and,
- Any erodible elements of the manmade conveyance system must be adequately stabilized to prevent erosion under the conditions noted above.

Based on this criteria, flow control is needed only if the site's runoff will exceed the capacity of the downstream conveyance system. A duration analysis, as provided by WWHM, is not needed since the duration design criteria is necessary to regulate flows discharging into streams and wetlands. Since only a flow rate analysis comparison is needed a single event model, such as SBUH (Santa Barbara Unit Hydrograph), may be utilized. For this analysis StormSHED 3G, a single event model with an integrated set of hydrology design tools such as level pool routing, pipe and ditch conveyance system analysis, and backwater computation, will be used for sizing any required detention facilities.

3.3 Design Assumptions

- Phase 1 development assumes 40 single family lots; future phased development assumes an additional 24 single family lots.
- The East system assumes 53 homes; the West system assumes 11 homes.
- Single family lots are assumed to have an impervious area of 2,500 SF (house plus driveway).
- The Phase 1 multifamily area along the Semiahmoo Parkway frontage (East system) is treated as four single family homes in this stormwater analysis and is counted as part of the 40 single family home total in Phase 1.
- The Phase 1 commercial area in the southwest corner of the site (West system) assumes an impervious area of 67,500 sf for this stormwater analysis.
- Future phased development of the multifamily and commercial areas along the Semiahmoo Drive frontage assumes three sites with impervious areas of 11,500 sf, 14,500 sf, and 8,500 sf for this stormwater analysis.
- The site contains a 20 ft. wide natural forested buffer along the south property line. All remaining non-impervious areas are assumed to be open space/landscaping.
- Each of the two storm systems has an assumed 6,100 sf (0.14 acre) area for water quality treatment and/or detention facilities assumed for this storm analysis. The actual area of these facilities may slightly vary based on final approvals and the associated modeling results.
- Since site slope is less than 5%, assume Land Use condition in WWHM modeling is Flat.

3.4 Site Information

A complete topographical survey of the site has not been completed at this time. Site topography and contour information used for this report was obtained from available LIDAR information.

4.0 BASIN ANALYSIS

4.1 Soil Information

Preliminary soil information at the project site was obtained from the Web Soil Survey website (http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx) published by United States Department of Agriculture Natural Resources Conservation Service (NRCS). The soils underlying the site are comprised of Everett gravely sandy loam (#48 - Hydrologic Group B) and

Everett complex (#51 - Hydrologic Group B). See Appendix A of this plan for copies of the soils map and properties.

A geotechnical investigation of the site was performed by GeoEngineers under the previous owner (the proposed site development project was also called Burnside Village). The results of their investigation are documented in two reports (copies are provided in Appendix A):

1. *Geotechnical Engineering Services, Zone 3 Semiahmoo Development, Blaine, Washington,* December 7, 2005.
2. *Semiahmoo Zone 3/Burnside Village, Summary of Soil and Groundwater Conditions Related to Stormwater Infiltration Considerations, Blaine, Washington*, April 1, 2009.

Their results are summarized as follows:

- Explorations typically encountered 0.5 to 1.0 foot of sod and topsoil overlying poorly graded medium to course sand with silt, gravel, cobbles, and boulders. The thickness of this layer varied between 2 and 4.5 feet in the southern test pits and between 6 and 9 feet in the northwest test pits. This layer has high permeability.
- Below this layer is a very low permeability layer representative of material commonly identified as glaciomarine drift.
- *"The regional topography and geology is such that the perched groundwater flows within the sand and gravel unit over the relatively impermeable glaciomarine drift toward the northeast and northwest. Increased infiltration in this area of Whatcom County has resulted in greater seepage along the shoreline bluff lots and adversely affected slope stability. Therefore, we recommend that only limited infiltration occur that does not result in an increase in infiltration compared to the present undeveloped conditions."*

4.2 Pre-Development Conditions

Figure 1: *Pre-Developed Condition* shows the existing site topography including contour elevations, surrounding roads, and offsite stormwater conveyance pipe. The site was forested until 2013 when many of the mature trees were harvested. The site slopes at an approximately 4.4% grade to the northwest, towards Semiahmoo Drive. There is a grade break in this road approximately 400 ft. southwest of the Semiahmoo Parkway intersection. Runoff east of this grade break flows east to the parkway and then north along the west side of the parkway. Runoff west of this grade break flows southwest in the roadside ditches along Semiahmoo Drive to a culvert opposite the cul-de-sac at the south end of Shearwater Road. Runoff enters the Boundary Ridge Division 2 stormwater conveyance system, which ties into the Division 1 system, and in turn flows to an existing outfall structure that discharges into Semiahmoo Bay.

The 19.37 acre pre-developed site was modeled as *A/B soils, Forested, Flat* for the infiltration analysis and *C soils, Forested* for the West system detention conveyance system analysis (see discussion in Section 5.7, *Minimum Requirement #7, Flow Control*).

4.3 Post-Development Conditions

Figure 2: *Developed Site* shows the proposed layout of the site. The grade break in Semiahmoo Drive divides the site into East and West systems. Due to the low ground elevation in the southwest corner of the site, all the stormwater runoff cannot be directed to Semiahmoo Parkway

without having some sections of a conveyance pipe over 15 feet deep. Instead runoff from the western portion of the site will be routed to the Boundary Ridge stormwater conveyance system (see Section 4.5 *Off-Site Conveyance* for additional discussion).

As discussed in Section 4.4 *Infiltration*, the DOE Manual requirements for onsite stormwater management are in conflict with the geotechnical recommendation to restrict stormwater infiltration. To minimize downstream bluff erosion, the infiltration of post-development stormwater will be limited to the pre-developed infiltration amount and as such, limited to runoff from all the pervious ground areas and the single family homes. (Roof and driveway runoff will be routed to infiltration trenches on each lot. Driveway runoff will be treated prior to release.) Runoff from the remaining areas (roads, parking, multifamily and commercial areas) will be captured and routed to bioretentions cells in either the East or West system for water quality treatment. The bioretention cells will be lined to prevent infiltration. Runoff routed to the West system will be detained to pre-development runoff rates and discharged into the Boundary Ridge storm system.

As shown in Figure 2 the developed site includes single and multifamily residential homes, commercial areas, open space, stormwater facilities, and road and utility infrastructure. The assumed breakdown of the East and West System is as shown in Table 1 below:

Table 1: Land Use Breakdown per Drainage Systems

	East System		West System		Total	
	sf	acres	sf	acres	sf	acres
Basin	487,391	11.19	356,252	8.18	843,643	19.37
Roads	**61,193**	**1.40**	**22,241**	**0.51**	**83,434**	**1.92**
Commercial/Multifamily	**-**	**-**	**102,000**	**2.34**	**102,000**	**2.34**
Homes	132,500	3.04	27,500	0.63	160,000	3.67
Forest	12,970	0.30	21,282	0.49	34,252	0.79
Landscape	274,628	6.30	177,129	4.07	451,757	10.37
Bioretention and Pond (assumed areas)	6,100	0.14	6,100	0.14	12,200	0.28

4.4 Infiltration

The current DOE Manual requirements, specifically Minimum Requirement #5, *On-site Stormwater Management*, requires projects infiltrate, disperse, and retain stormwater runoff on-site to the extent feasible without causing flooding or erosion impacts. As discussed in Section 4.1 *Soil Information*, despite the highly permeable soil layer at the surface of the site, only a limited amount of infiltration is recommended for the developed site. The GeoEngineers reports recommend that any infiltration be comparable to the present undeveloped conditions.

Using WWHM's *Low Impact Development (LID) Scenario Generator* module the volumes of surface runoff, interflow, groundwater infiltration, precipitation, evaporation, and total runoff based on soil type, area, and land use of the pre- and post-developed sites can be estimated. These volumes were estimated for the project site's pre- and post-developed conditions. Groundwater infiltration volume results for the pre- and post conditions for the site were

compared and used to determine how much of the post-developed site could infiltrate without exceeding the pre-developed forested condition volume. The LID Analysis models for the pre- and post-developed conditions were prepared based on the following information. (See Table 1 in Section 4.3 *Post-Development Conditions,* for a breakdown of the post-developed site land uses.)

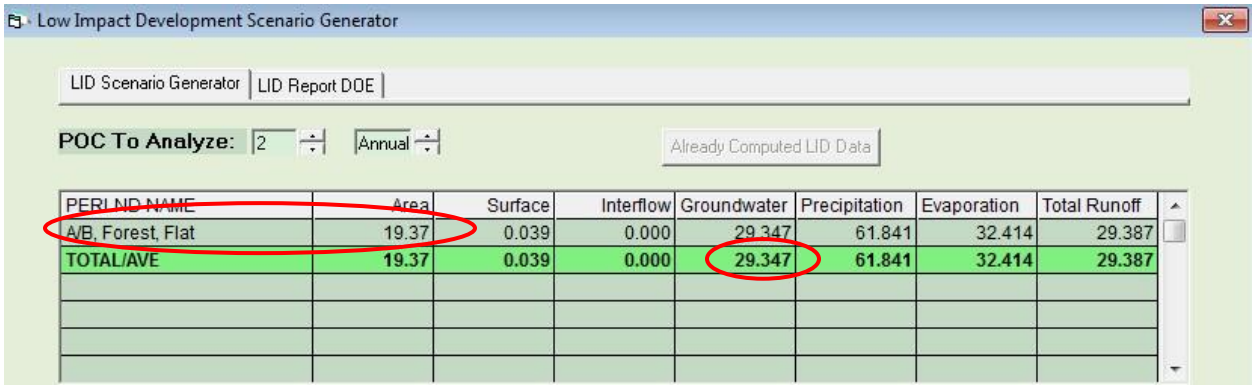
Table 2: LID Groundwater Infiltration Analysis Land Use Breakdown

	Area (acres)	WWHM Modeling Land Use
Pre-developed Condition		
PERLAND		
Forest	19.37	A/B, Forest, Flat
Post-developed Condition		
PERLAND		
Forest	0.79	A/B, Forest, Flat
Landscaping	10.37	A/B, Forest, Flat
Single Family Homes*	3.67	A/B, Forest, Flat
Total Landscape	14.04	
IMPLAND		
Roads	1.92	Roads/Flat
Commercial/Multifamily	2.34	Parking/Flat
Pond	0.28	Pond
Total Post-developed Condition Area	19.37	

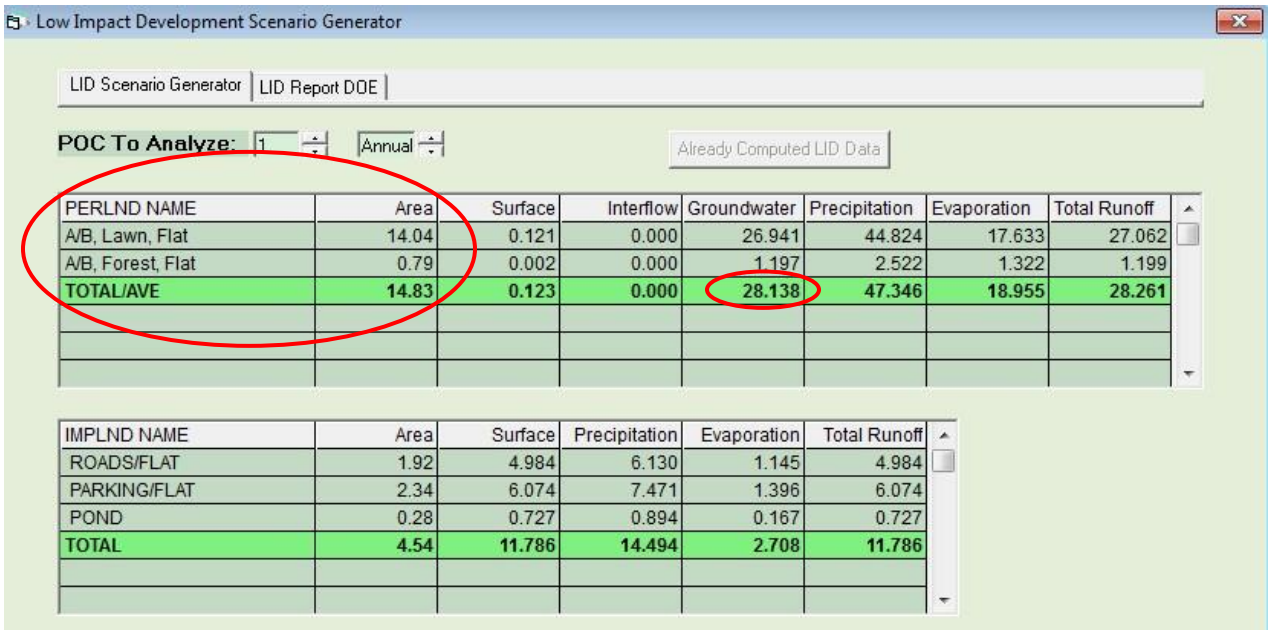
* Roof and driveway runoff to be directed to infiltration trenches - assumed to infiltrate under a lawn condition.

The results of the analysis (in acre-feet) are provided in the figures below. See Appendix B for a copy of the WWHM analysis model and report.

<u>Pre-Developed Condition</u>



Post-Developed Condition



PERLND NAME	Area	Surface	Interflow	Groundwater	Precipitation	Evaporation	Total Runoff
A/B, Lawn, Flat	14.04	0.121	0.000	26.941	44.824	17.633	27.062
A/B, Forest, Flat	0.79	0.002	0.000	1.197	2.522	1.322	1.199
TOTAL/AVE	**14.83**	**0.123**	**0.000**	**28.138**	**47.346**	**18.955**	**28.261**

IMPLND NAME	Area	Surface	Precipitation	Evaporation	Total Runoff
ROADS/FLAT	1.92	4.984	6.130	1.145	4.984
PARKING/FLAT	2.34	6.074	7.471	1.396	6.074
POND	0.28	0.727	0.894	0.167	0.727
TOTAL	**4.54**	**11.786**	**14.494**	**2.708**	**11.786**

The results show that under the pre-developed condition an estimated 29.347 acre-ft annually infiltrates as groundwater. Under the post-developed condition none of the impervious surfaces (IMPLAND) runoff infiltrates. The two pervious surfaces (PERLAND), which include the forested area and the combined landscape and roof and driveway runoff areas under the A/B, Lawn, Flat land use, have an estimated annual groundwater infiltration volume of 28.138 acre-ft. Based on the results of this analysis the infiltration of the stormwater runoff from the landscape areas and the 64 single family home roofs "*does not result in an increase in infiltration compared to the present undeveloped conditions.*"

4.5 Off-Site Conveyance

As previously discussed runoff east and west of the Semiahmoo Drive grade break are routed to either the Semiahmoo Parkway or Boundary Ridge system (via Semiahmoo Drive). Runoff from the site's East system will be routed to Semiahmoo Parkway's west roadside ditch. As discussed in Section 5.7, *Minimum Requirement 7 Flow Control*, the estimated flow rates to the parkway's ditch will have a minimal impact to that system. Runoff west of this grade break flows southwest in the roadside ditches along Semiahmoo Drive to a culvert opposite the cul-de-sac at the south end of Shearwater Road. Runoff enters the Boundary Ridge Division 2 stormwater conveyance system, which ties into the Division 1 system, which discharges into Semiahmoo Bay.

The Boundary Ridge stormwater conveyance system was evaluated to see if there is additional capacity for the runoff from the developed West system. Appendix C provides some drawings of the Boundary Ridge Division 1 and 2 stormwater conveyance system. Three sections of the Division 2 system totaling over 500 ft. were identified as 12-inch diameter pipe with slopes less than 1%. Pipe full flow capacity of these pipes is estimated at 3 cfs (see Appendix C for copies of calculations). Similarly, the northern section of Chickadee Way in Division 1 is shown with

220 ft. of 12-inch diameter pipe at a 0.4% slope, with an estimated pipe full flow capacity of 2.4 cfs.

Figure 3 shows the contributing areas to the Boundary Ridge stormwater system. Flow rates into this system were estimated based on the following assumptions:

- Surface runoff from a 90.8 acre forested area uphill of the site, east of Semiahmoo Drive, discharges into the Semiahmoo Drive ditch.
- Runoff from 1.13 acres of Semiahmoo Drive (2,000 ft. by 24 ft.) is collected in roadside ditches and conveyed to a crossing culvert at the cul-de-sac at the south end of Shearwater Road and into the Boundary Ridge stormwater conveyance system.
- Runoff from the roads in Boundary Ridge (26 ft. wide) is collected in the stormwater system.
- Runoff from the buildings and landscaped areas on the uphill (east) side of the road is routed to the storm system. (Runoff from areas on the west side of the road is assumed to infiltrate or surface flow downhill to the west.) Building roof, driveways, and hardscape area was assumed at 4,000 sf per lot. Lot areas were estimated from Figure 3.

Two sections of the Division 2 system, Pipe 3 and Pipe 7 (as identified in the Boundary Ridge Division 2 Jepson drawing shown in Appendix C) were evaluated using stormwater runoff flow rates estimated by WWHM. The results are shown below:

A: Offsite and Boundary Ridge Contributing Areas B: Boundary Ridge Area Only			25-Year Flow Rate (cfs)	100-Year Flow Rate (cfs)	Pipe Capacity (cfs)
Pipe 3	Shearwater Rd. (Lots 12-14)	A	1.47	2.04	3.1
		B	0.72	0.94	
Pipe 7	End of Div 2/Begin Div 1	A	3.38	4.59	3.0
		B	2.66	3.54	

As shown there is limited capacity in the Boundary Ridge stormwater conveyance system for the higher flow rates typically generated from a developed site with large amounts of impervious area. See Section 5.7, *Minimum Requirement #7, Flow Control*, for an additional discussion on how the site's runoff is addressed. Appendix C includes copies of the WWHM results and flow calculations.

5.0 SUMMARY OF MINIMUM DEVELOPMENT REQUIREMENTS

5.1 Minimum Requirement #1: Preparation of Stormwater Site Plans

This report serves as a Preliminary Stormwater Site Plan and it is prepared in accordance with Chapter 3 of Volume I of the DOE Manual. A Final Stormwater Site Plan will be prepared with the final design submittal package.

5.2 Minimum Requirement #2: Construction Stormwater Pollution Prevention

A Stormwater Pollution Prevention Plan (SWPPP) will be provided as part of the design drawings for the site improvements. The Final SWPPP will provide erosion and sediment

control information, locations where Best Management Practices (BMPs) shall be implemented, and requirements that the contractor must follow throughout construction. These BMPs typically include the use of a C233: *Silt Fenc*e and C105: *Stabilized Construction Entrance* and C220: *Storm Drain Inlet Protection* (catch basin inserts), with specific details for their construction.

The Final SWPP Plan will include Temporary Erosion and Sediment Control (TESC) measures that will become part of the contract documents for construction of the project.

5.3 Minimum Requirement #3: Source Control of Pollution

Other than the presences of the asphalt access road and driveways no improvements are proposed which will require source control BMPs. During the construction phase of the project source controls measures will be implemented. These measures will be covered under Minimum Requirement #2.

5.4 Minimum Requirement #4: Preservation of Natural Drainage Systems & Outfalls

The natural drainage pattern of runoff leaving the site will be maintained. Similar volumes of rainfall will be allowed to infiltrate as exists in the pre-developed condition. Surface runoff will continue to move both east and west along Semiahmoo Drive. See Section 4.5, *Off-Site Conveyance,* and Section 5.7, *Minimum Requirement #7: Flow Control*, for additional information.

5.5 Minimum Requirement #5: On-site Stormwater Management

This project involves new development inside the City limits and will have land-disturbing activities greater than 5,000 square feet. As such, the project triggers Minimum Requirements #1 through 9 thereby Low Impact Development Performance Standards and BMP T5.13, *Post-Construction Soil Quality and Depth***,** or List #2 Requirements will need to be addressed.

Stormwater infiltration will be utilized to the maximum extent recommend by the geotechnical evaluation. See Section 4.4 *Infiltration* for additional information.

5.6 Minimum Requirement #6: Runoff Treatment

The site is divided into East and West systems, each with their own bioretention cell to provide water quality treatment for runoff from pollution generating surfaces (roads and parking areas). Each cell will have an impermeable liner to prevent infiltration of runoff and will include an underdrain at the bottom of the treatment cell to collect the treated runoff. A closed conveyance system will capture runoff from the roads and parking areas, as well as roof runoff from the multifamily and commercial buildings. Runoff from the single family home driveways will be treated prior to infiltration. The exact treatment mechanism will be identified and its design provided in the Final Stormwater Site Plan.

The East system bioretention has been sized to treat runoff from a 1.40 acre area. A 35 ft. by 40 ft. cell has been sized to provide the required treatment. See Appendix B for a copy of the WWHM analysis and cell sizing.

The West system bioretention cell has been sized to treatment runoff from a 2.85 acre area. A 40 ft. by 70 ft. cell has been size to provide the required treatment. See Appendix B for a copy of the WWHM analysis and cell sizing.

Final facility design and construction drawings will be provided in the Final Stormwater Site Plan.

5.7 Minimum Requirement #7: Flow Control

As discussed in Section 3.2 *Design Criteria*, project sites that discharge to flow control exempt bodies of water, such as Semiahmoo Bay, are not required to provide flow control for its runoff provided downstream conveyance capacity and stability issues are addressed. The project proposes to discharge runoff into the Semiahmoo Parkway roadside ditch (East system) and the Boundary Ridge stormwater conveyance system (West system). As such, each system is comprised of manmade conveyance elements with existing outfalls that extend to the ordinary highwater line. Conveyance capacity and element stabilization are addressed below.

East System

The estimated runoff flow rates for the developed East system captured in its stormwater conveyance system (road areasmultifamily only), treated in the bioretention cell, and then released downstream of the bioretention cell are as follows:

Return Period	Flow Rate
2-year	0.44 cfs
10- year	0.75 cfs
25-year	0.90 cfs
100-year	1.12 cfs

The Semiahmoo Parkway grade north of the Semiahmoo Drive intersection varies between 3% and 10%. Assuming the road side ditch is a grass lined (n = 0.30), two feet wide, and has a flow depth of 1 foot, the ditch capacity at 3% gradient is 30.6 cfs. The East system's 100 year discharge flow at 1.12 cfs represents less than 5% of the ditches flow capacity.

From Mannings equation:

side slope X:1	b - width (ft)	flow depth (ft)	area (ft2)	wp (ft)	Type n	Slope (ft/ft)	V (ft/sec)	Q (ft3/sec)
3	2	1.00	5.00	8.32	0.03	0.030	6.1	30.6
3	2	1.00	5.00	8.32	0.03	0.100	11.2	55.9

Based on this evaluation the Semiahmoo Parkway ditch has sufficient capacity for conveying the flow from the site's East system. During the final design phase the ditch will be further evaluated to determine if additional erosion protection will be necessary.

West System

As discussed in Section 4.5 *Off-Site Conveyance*, the Boundary Ridge stormwater conveyance system has limited capacity for additional flow. Since runoff from the project site currently flows

into the Boundary Ridge system, if the peak runoff rates from the developed site were reduced through detention, the Boundary Ridges system could be utilized without overloading its system. Surface runoff off rates from a *Soil Type A/B, Forest* site are typically extremely low since the majority of the stormwater infiltrates and evaporates. Typically for sites such as this, where there are shallow highly permeable soils over an impermeable glacial till layer, the site's pre-developed condition is modeled as a *Soil Type C, Forest* and these flow rates are used to size the detention pond.

Runoff to the detention pond for the West system's developed site comes from the roads, parking areas, and commercial and multifamily building roof areas for a total of 2.85 acres. Runoff is directed to a combined bioretention cell (for water quality treatment) and detention pond. As discussed in Section 3.2 *Design Criteria*, the detention analysis was performed using StormSHED 3G. The estimated flow rates for the pre-developed site, the post-developed undetained site, and the detained flow rates are provided in Table 3.

Table 3: West System Flow Rates

Return Period	**Pre-Developed C Forest (cfs)**	Developed Undetained (cfs)	**Developed Detained (cfs)**
2-Year	**0.05**	1.27	**0.05**
25-Year	**0.31**	2.35	**0.31**
100-Year	**0.57**	2.95	**0.53**

The developed sites estimated undetained flow rates of the 25-year and 100-years storms, at 2.35 cfs and 2.95 cfs, respectively, has the potential to impact the downstream system since the pipe full capacity of the more restrictive sections is in the 2.4 cfs to 3.0 cfs range (see Section 4.5 *Off-Site Conveyance)*. While the actual flow rates through the existing system are difficult to estimate, detention will be provided to reduce the developed site's peak runoff off rates to pre-developed, forested, Type C soil flow rates.

The detained flow rates are based on routing the impervious area runoff into a 50 ft. by 75 ft. by 5 ft. deep (4 ft. live storage) detention pond with the following control structure configuration:

Control Structure:

First Orifice: 1.0 inch, El. 0.00 (assumed pond bottom)
Second Orifice: 3.5 inch, El. 3.10 ft.
Riser: 12 inch diameter, El. 4.0 ft.

At these detained release flow rates impacts to the Boundary Ridge stormwater conveyance system should be minimal.

The West system bioretention cell will be located at the bottom of the detention pond. The pond will be lined to prevent infiltration.

Copies of the WWHM and StormSHED 3G models and results are provided in Appendix B.

5.8 Minimum Requirement #8: Wetlands Protection

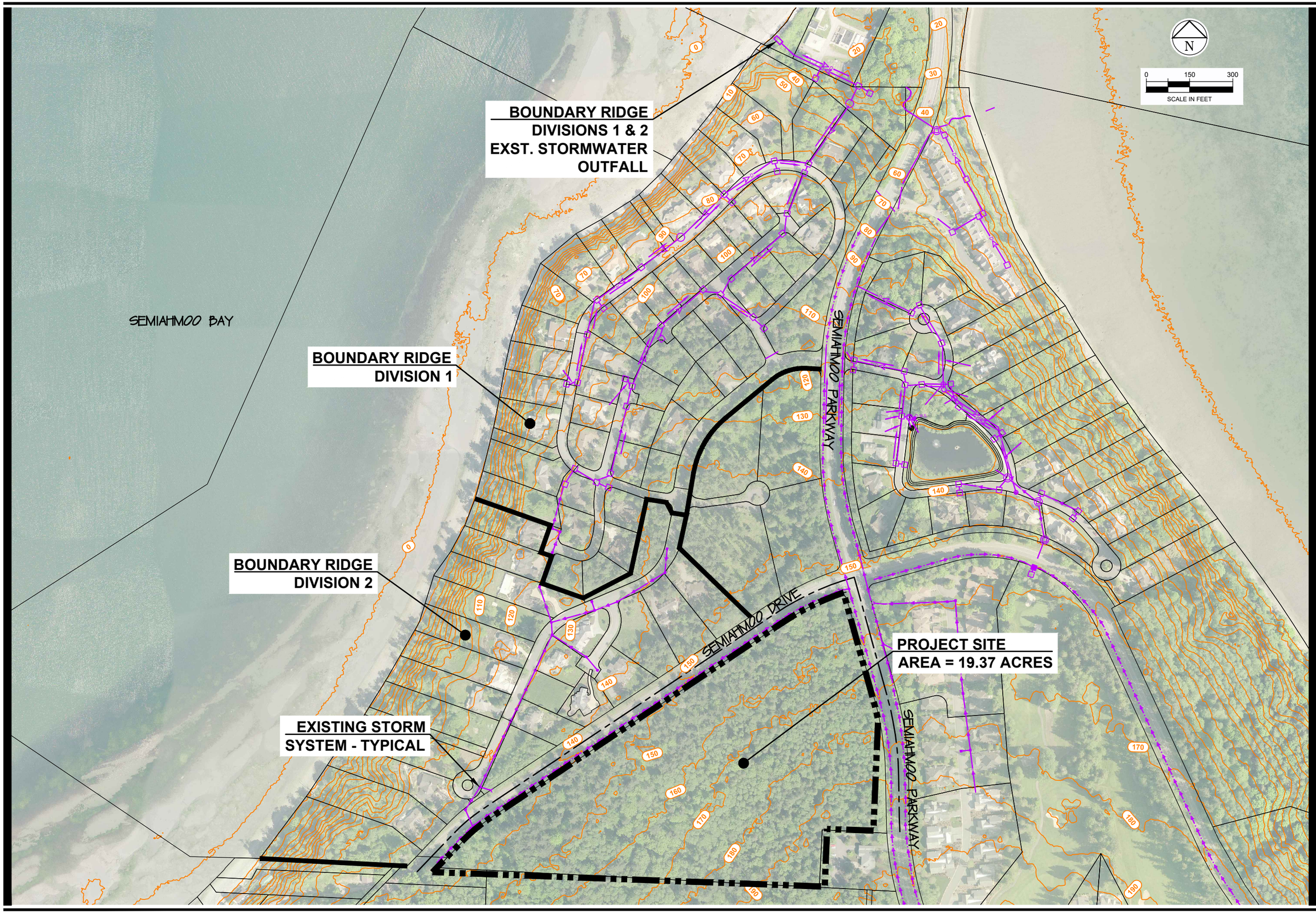
The site does not contain any wetlands nor are there any no known wetlands downstream of the site.

5.9 Minimum Requirement #9: Operation and Maintenance

A Stormwater Operation and Maintenance Plan will be provided with the Final Stormwater Site Plan. This development will be part of the Semiahmoo Resort Association or the Resort Semiahmoo Zone 3 Homeowners Association and as such, all necessary maintenance of the onsite stormwater treatment and conveyance facilities is anticipated to be performed by the appropriate association.

FIGURES

- Figure 1: Pre-Development Condition
- Figure 2: Post-Development Condition
- Figure 3: Boundary Ridge Storm System



BLAINE, WASHINGTON

RESORT SEMIAHMOO ZONE 3
PRE-DEVELOPED CONDITION

PRELIMINARY STORM REPORT

CASCADE ENGINEERING GROUP, P.S., INC.
119 Grand Avenue, Suite D
Bellingham, Washington 98225
(360) 306-8161

REVISIONS	DATE

DATE: 6/24/2016
DESIGN:
DRAWN: KVD
CHECKED:

SCALE: AS SHOWN

PROJECT NUMBER:

RAZR0001

SHEET NO.

Fig. 1

OF

06/23/2016 10:21AM P:\R\RAZR0001\0400CAD\DWG\Exhibits\Existing Storm Basins.dwg

1,400 SF BIORETENTION CELL FOR WATER QUALITY TREATMENT FOR EAST SYSTEM

OPEN SPACE/ LANDSCAPED AREA

FUTURE PHASE: ASSUME 11,500 SF FOR BUILDING AND PARKING

PHASE 1: MULTIFAMILY BUILDING ASSUMED AS 4 SINGLE FAMILY LOTS

FUTURE PHASE: ASSUME 14,500 SF FOR BUILDINGS AND PARKING

FUTURE PHASE: ASSUME 8,500 SF FOR BUILDING AND PARKING

PHASE 1: SINGLE FAMILY HOMES - 40 TOTAL

FUTURE PHASE: ASSUME 3 HOMES

OPEN SPACE

2,800 SF BIORETENTION CELL FOR WATER QUALITY TREATMENT AND 3,750 (BOTTOM AREA) DETENTION POND WITH 4' OF LIVE STORAGE AND 1' OF FREEBOARD

PHASE 1

FUTURE PHASES

FUTURE PHASE: ASSUME 5 HOMES

FUTURE PHASE: ASSUME 5 HOMES

FUTURE PHASE: ASSUME 6 HOMES

FUTURE PHASE: ASSUME 5 HOMES

PHASE 1: COMMERCIAL AREA

20' FORESTED LANDSCAPE BUFFER

STORM SYSTEMS GRADE BREAK

WEST SYSTEM

EAST SYSTEM

N

0 60 120

SCALE IN FEET

BLAINE, WASHINGTON

RESORT SEMIAHMOO ZONE 3 POST-DEVELOPED CONDITION

PRELIMINARY STORM REPORT

CASCADE ENGINEERING GROUP, P.S., INC.
119 Grand Avenue, Suite D
Bellingham, Washington 98225
(360) 306-8161

REVISIONS	DATE

DATE: 6/24/2016
DESIGN:
DRAWN: KVD
CHECKED:

SCALE: AS SHOWN

PROJECT NUMBER:

RAZR0001

SHEET NO.

Fig. 2

OF

PIPE #7

CONTRIBUTING AREA TO BOUNDARY RIDGE DIVISION 2 ROAD DRAINAGE BASIN

PIPE #3

SEMIAHMOO BAY

SHEARWATER RD

WINGED TEAL CT

GLENEAGLE DR

BASIN B
AREA =
10.0 ACRES

EXISTING CONDITION DRAINS TO SEMIAHMOO PARKWAY

EXISTING CONDITION DRAINS TO SEMIAHMOO DRIVE AND BOUNDARY RIDGE

BASIN A
AREA = 90.8 ACRES

N

0 200 400
SCALE IN FEET

BLAINE, WASHINGTON

RESORT SEMIAHMOO ZONE 3 OFFSITE CONVEYANCE

PRELIMINARY STORM REPORT

CASCADE ENGINEERING GROUP, P.S., INC.
119 Grand Avenue, Suite D
Bellingham, Washington 98225
(360) 306-8161

REVISIONS	DATE

DATE: 6/24/2016
DESIGN:
DRAWN: KVD
CHECKED:

SCALE: AS SHOWN

PROJECT NUMBER:

RAZR0001

SHEET NO.

Fig. 3

OF

APPENDIX A
Soils Information

- NRCS Soil number and Hydrologic Group (4 pages)
- *Geotechnical Engineering Services, Zone 3 Semiahmoo Development, Blaine, Washington*, GeoEngineers, December 7, 2005.
- *Semiahmoo Zone 3/Burnside Village, Summary of Soil and Groundwater Conditions Related to Stormwater Infiltration Considerations, Blaine, Washington,* GeoEngineers, April 1, 2009.

Soil Map—Whatcom County Area, Washington

Map Scale: 1:2,790 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 40 80 160 240

Feet: 0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 10N WGS84

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features

- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features

- Streams and Canals

Transportation

- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Whatcom County Area, Washington
Survey Area Data: Version 11, Sep 15, 2015

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Jul 9, 2010—Aug 28, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Whatcom County Area, Washington (WA673)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
48	Everett gravelly sandy loam, hard substratum, 2 to 8 percent slopes	3.0	14.4%
51	Everett complex, 2 to 8 percent slopes	18.0	85.6%
Totals for Area of Interest		**21.1**	**100.0%**

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Whatcom County Area, Washington (WA673)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
48	Everett gravelly sandy loam, hard substratum, 2 to 8 percent slopes	B	3.0	14.4%
51	Everett complex, 2 to 8 percent slopes	B	18.0	85.6%
Totals for Area of Interest			**21.1**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

REPORT
GEOTECHNICAL ENGINEERING SERVICES
ZONE 3 SEMIAHMOO DEVELOPMENT
SEMIAHMOO ROAD
BLAINE, WASHINGTON

DECEMBER 7, 2005

FOR
TRILLIUM CORPORATION

GeoEngineers

File No. 00381-020-00

GeoEngineers

December 7, 2005

Trillium Corporation
4350 Cordata Parkway
Bellingham, Washington 98226

Attention: Dan Baker

Subject: Report
Geotechnical Engineering Services
Zone 3 Semiahmoo Development
Semiahmoo Road
Blaine, Washington
File No. 00381-020-00

INTRODUCTION AND SCOPE

This report presents the results of our geotechnical engineering services regarding proposed infiltration systems for the planned Zone 3 Semiahmoo Development on Semiahmoo Road in Blaine, Washington as shown in the Vicinity Map, Figure 1. Our services were completed in general accordance with our proposal dated September 23, 2005 which was authorized by Wayne Schwandt of Trillium Corporation on September 30, 2005.

It is our understanding that stormwater infiltration is being considered for stormwater management in the new development, which is shown in the Site Plan, Figure 2. Any infiltration systems will be relatively shallow. Infiltration design is to be based on the Washington State Department of Ecology (Ecology) Stormwater Management Manual for the Puget Sound Basin (2001).

The purpose of our services is to explore subsurface soil and groundwater conditions at the seven potential locations identified by David Evans & Associates (DEA) as a basis for providing geotechnical engineering conclusions and recommendations criteria for potential infiltration. Our specific scope of services is described in our referenced proposal for the project. The scope included monitoring the excavation of seven test pits, laboratory testing, analyses in accordance with the Stormwater Manual, and preparation of this letter report.

SITE CONDITIONS

Site Description

The proposed development is a triangular shaped site at the southern corner of Semiahmoo Drive and Semiahmoo Parkway. The site, identified as Semiahmoo – Zone 3, is covered with dense growth of trees, plants, and underbrush. It has an approximate 4 percent downward gradient toward the northwest between elevation 180 and 140 feet above sea level.

600 Dupont Street
Bellingham, WA 98225
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facsimile 360.647.5044
website www.geoengineers.com

SUBSURFACE CONDITIONS

Subsurface Exploration and Laboratory Program

Subsurface conditions at the site were explored by completing seven test pits on October 19, 2005. The locations were chosen based on potential infiltration areas identified by DEA. The explorations were completed using a track-mounted excavator provided by Trillium Corporation. The test pits locations were measured by pacing and taping from known locations and should be considered approximate as implied by the method used.

The explorations were continuously monitored by a representative from our firm who examined and classified the soils encountered, obtained representative soil samples, observed groundwater conditions, and prepared a detailed log of each exploration. Soils were visually classified in general accordance with ASTM D-2488-90, which is described in Figure 3.

The logs of test pits are presented in Figures 4 through 10. The logs are based on our interpretation of the field and laboratory data and indicate the various types of soils encountered. They also indicate the depths at which these soils or their characteristics change, although the change might actually be gradual.

Representative laboratory testing was completed on selected samples from the explorations. The testing consisted of grain size distribution determinations to use the Ecology Stormwater Manual infiltration analyses. The soil samples were selected from the identified subsoil units. The pertinent results of the laboratory testing are provided on the logs and in Figure 11.

Geology

We reviewed a U.S. Geologic Survey (USGS) geologic map for the project area, "Geologic Map of Western Whatcom County, Washington" by Don J. Easterbrook (1976). The site lies within an area mapped as "Sand and Gravel overlying the Bellingham Drift." This unit is made up of stratified sand and gravel up to 10 feet thick. This material may be the result of wave action on the Bellingham (glaciomarine) Drift (GMD) which removed the fine sediment. A seasonally perched groundwater condition is typical within this unit because of the underlying silt/clay. When it extends to the nearby bluffs, the perched groundwater will exit the face of this unit over the bluffs.

Bellingham (glaciomarine) Drift underlies the Sand and Gravel. The glaciomarine drift consists of unsorted, unstratified silt and clay with varying amounts of sand, gravel, cobbles and occasional boulders. Bellingham Drift is derived from sediment melted out of floating glacial ice that was deposited on the sea floor. This material locally contains shells and wood. Glaciomarine drift was deposited during the Everson Interstade approximately 11,000 to 12,000 years ago. The relative sea level was as high as Elevation 600 feet MSL. The upper portion of this unit, sometimes to about 15 feet of depth, can be quite stiff as a result of desiccation or partial ice contact in upland areas. This material typically grades to medium stiff or soft with depth.

Soil Conditions

Our explorations typically encountered 0.5 to 1.0 foot of sod and topsoil overlying brown poorly graded medium to coarse sand with silt, gravel, cobbles and boulders. The thickness of this layer varied between 2 and 4.5 feet in the southern test pits (TP-1, TP-4, TP-5 and TP-7). The sand layer extended to depths of 8 feet in TP-2, 6 feet in TP-3, and the full 9 foot depth explored in TP-6. This upper soil unit has a

relatively high permeability and is representative of the Sand and Gravel overlying the Bellingham Drift as previously described.

The next layer encountered in all test pits, except TP-6, is brown-gray to gray sandy silt or silty sand with gravel, cobbles and occasional boulders. This stratigraphical unit has very low permeability and is representative of the glaciomarine drift. This unit is not considered suitable for infiltration purposes, and will represent the lower boundary surface of infiltrated water flow.

Groundwater Conditions

Groundwater was encountered only in test pit TP-2 at 5 feet below the ground surface. Groundwater levels will fluctuate as the result of precipitation, seasonal variations, and other factors. The groundwater conditions are seasonally perched within the sand and gravel unit over the silt/clay unit. Our test pits were not accomplished during the seasonal high groundwater period, so we do not have sufficient information to suggest seasonal high water levels. Because the sand and gravel unit is a relatively thin "mantling" over the impermeable glaciomarine drift, the perched groundwater flow direction is expected to mimic the regional topography.

CONCLUSIONS AND RECOMMENDATIONS

It is our opinion that the upper sand and gravel unit at the site is suitable for some stormwater infiltration. The Ecology Stormwater Manual requires at least 5 feet of separation between the base of an infiltration basin and the seasonal high water, allowing a separation of only 3 feet if the mounding of the groundwater table at the site does not impact the surrounding properties. Conclusions based on field observations and laboratory activities are as follows:

- The sand and gravel unit is too thin to be suitable for infiltration along the south margin of the site at test pits TP-1, TP-4, TP-5 and TP-7. It is likely that the groundwater rises at TP-2 such that this area is also not likely suitable for infiltration.
- At TP-3, the sand layer extends to 6 feet below ground surface. At TP-6, the sand layer extends beyond the depth explored, which was 9 feet. No groundwater was encountered. These areas are suitable for limited infiltration. The laboratory testing results indicate a range of long term infiltration rates between 3.5 to 9 inches per hour. We understand that a sand filter will be used to slow the infiltration rate to about 2 inches per hour.
- The regional topography and geology is such that the perched groundwater flows within the sand and gravel unit over the relatively impermeable glaciomarine drift toward the northeast and northwest. Increased infiltration in this area of Whatcom County has resulted in greater seepage along the shoreline bluff lots and adversely affected slope stability. Therefore, we recommend that only limited infiltration occur that does not result in an increase in infiltration compared to present undeveloped conditions.

LIMITATIONS

We have prepared this report for use by Trillium Corporation and other members of the design team for use in design of this portion of the project. This report may be made available to regulatory agencies. This report is not intended for use by others, and the information contained herein is not applicable to other sites.

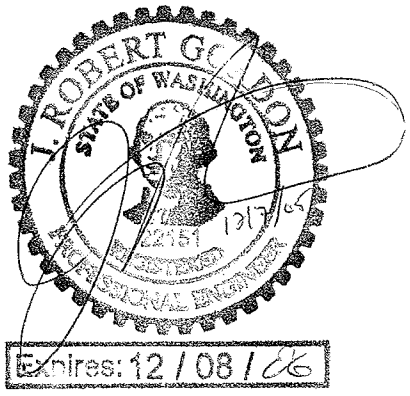
This geotechnical or geologic report is based on conditions encountered at specific locations at the time the study was performed. Actual subsurface conditions may differ, sometimes significantly, from those indicated in this report. Our report, conclusions and interpretations should not be construed as a warranty of the subsurface conditions. The findings and conclusions of this report may be affected by the passage of time, by man made events such as construction on or adjacent to the site, or by natural events such as floods, earthquakes, ground instability or ground water fluctuations. If important changes are made to the design assumptions after the date of this report, GeoEngineers should be given the opportunity to review our interpretations and recommendations and provide written modifications or confirmation, as appropriate. Sufficient monitoring, testing and consultation by GeoEngineers should be provided during construction to confirm that the conditions encountered are consistent with those indicated by the explorations, to provide recommendations for design changes should the conditions revealed during the work differ from those anticipated, and to evaluate whether or not earthwork activities are completed in accordance with our recommendations.

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

We appreciate the opportunity to be of service to you on this project. If you have any questions regarding this report or should you require additional information, please contact us.

Sincerely,

GeoEngineers, Inc.



J. Robert Gordon, PE
Principal

SZ:JRG:ims
BELL: P:\0\0381020\00\Working\38102000R.doc

List of Figures: Figure 1. Vicinity Map
Figure 2. Site Map
Figure 3. Key to Exploration Logs
Figures 4-10. Log of Test Pits
Figures 11. Sieve Analysis Results

Two copies submitted

cc: David Evans & Associates
119 Grand Avenue, Suite D
Bellingham, WA 98225
Attn: Garth Cray

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: Drawing reference information.

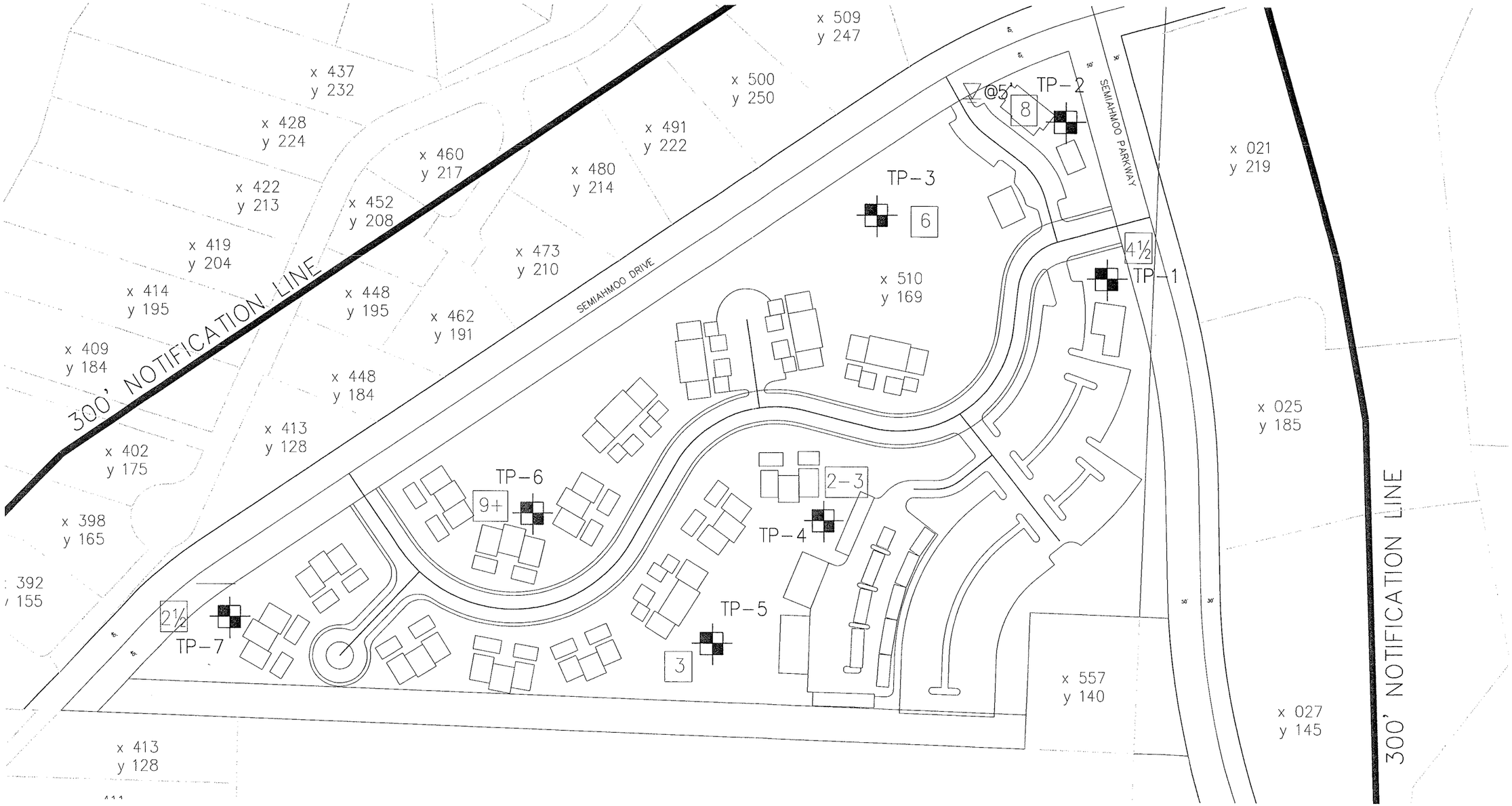
Vicinity Map

Semiahmoo - Zone 3
Blaine, Washington

GeoEngineers

Figure 1

BELL P:\0\00381-020\00\AutoCAD\38102000 F1.dwg SZ:IMS 10/21/2005



Legend

TP 1 - Test Pit Number and Approximate Location

6 - Depth of Surface Sand Layer

@5' - Depth of Groundwater

N W E S

150 0 150

Feet

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: Base drawing provided by David Evans & Associates, Inc., Bellingham, Washington

Site Map

Semiahmoo - Zone 3
Blaine, Washington

GeoEngineers

Figure 2

BELL P:\0\00381-020\00\AutoCAD\38102000 F2.dwg SZ:IMS 10/20/2005

SOIL CLASSIFICATION CHART

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

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	CC	Cement Concrete
	AC	Asphalt Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

- Measured groundwater level in exploration, well, or piezometer
- Groundwater observed at time of exploration
- Perched water observed at time of exploration
- Measured free product in well or piezometer

Stratigraphic Contact

- Distinct contact between soil strata or geologic units
- Gradual change between soil strata or geologic units
- Approximate location of soil strata change within a geologic soil unit

Sampler Symbol Descriptions

- 2.4-inch I.D. split barrel
- Standard Penetration Test (SPT)
- Shelby tube
- Piston
- Direct-Push
- Bulk or grab

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

GeoEngineers

Figure 3

Date Excavated: 10/19/2005 Logged by: S. Zemva

Equipment: Backhoe Surface Elevation (ft):

Depth feet	Sample	Sample Number	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	OTHER TESTS AND NOTES
0				SOD	Sod zone		
				SP	Brown poorly graded medium to coarse sand with gravel, cobbles, and boulders (medium dense, moist) (Sand and Gravel)		
	☒	1					
	☒	2					GS, %F=4, D_{10}=0.32mm
				ML	Brown-gray fine sandy silt with occasional gravel, cobbles, and boulders (very stiff, moist) (Bellingham Drift)		
5							
	☒	3					
	☒	4					
					No groundwater seepage observed No caving observed		
10							

Note: See Figure 3 for explanation of symbols. The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-1

GeoEngineers

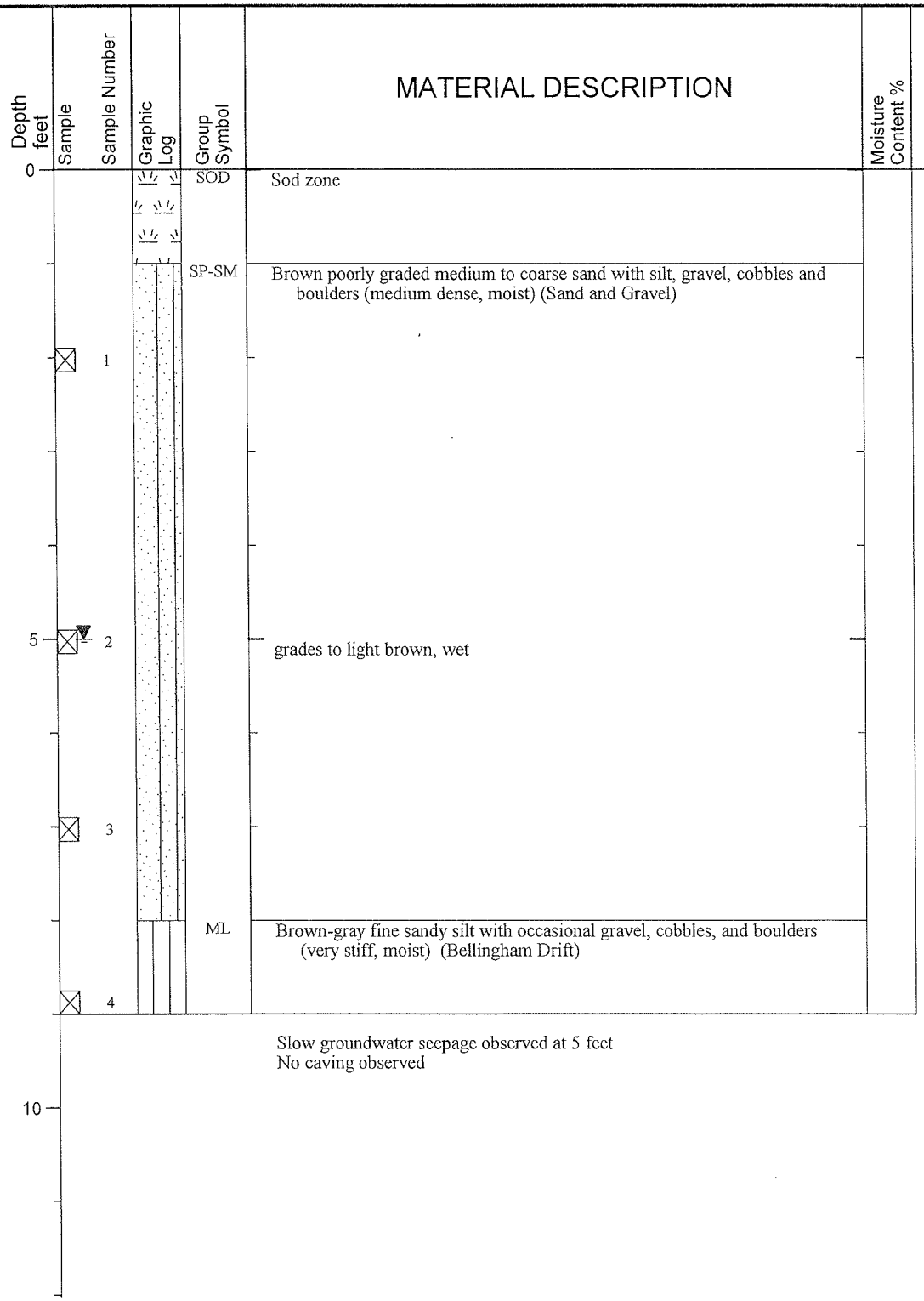
Project: Semiahmoo - Zone 3
Project Location: Blaine, Washington
Project Number: 00381-020-00

Figure: 4
Sheet 1 of 1

V6_GTTPIT P:\01\00381020000\WORKING\00381020000 TP.GPJ GEIV6_1.GDT 11/23/05

Date Excavated: 10/19/2005 Logged by: S. Zemva

Equipment: Backhoe Surface Elevation (ft):



Note: See Figure 3 for explanation of symbols. The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-2

GeoEngineers

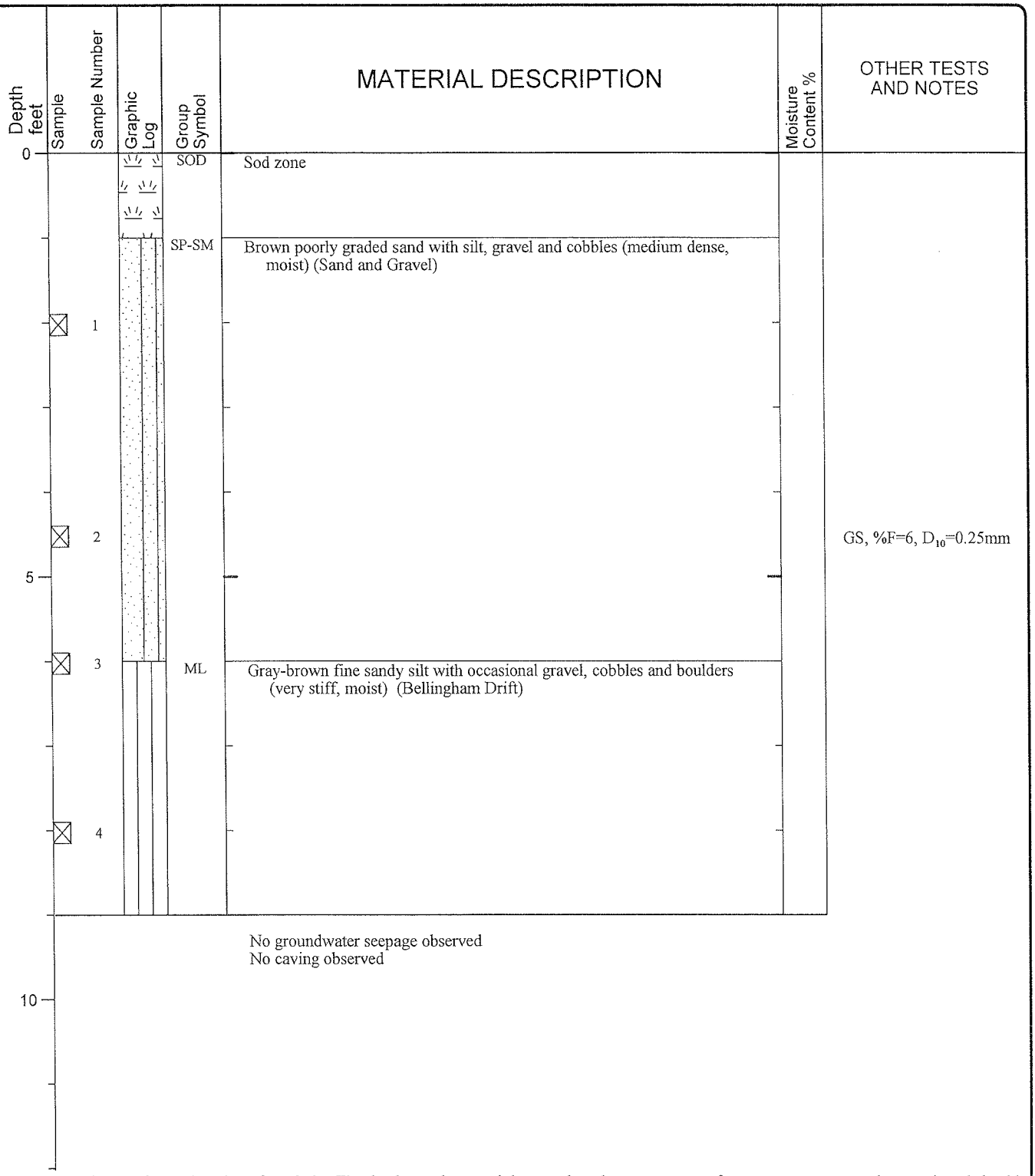
Project: Semiahmoo - Zone 3
Project Location: Blaine, Washington
Project Number: 00381-020-00

Figure: 5
Sheet 1 of 1

V6_GTTPIT P:\00381020\00\WORKING\00381020000 TP.GPJ GEIV6_1.GDT 11/23/05

Date Excavated: 10/19/2005 Logged by: S. Zemva

Equipment: Backhoe Surface Elevation (ft):



Note: See Figure 3 for explanation of symbols. The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

V6_GTTPIT P:\00381020\000\WORKING\00381020000 TP.GPJ GEIV6_1.GDT 11/23/05

LOG OF TEST PIT TP-3

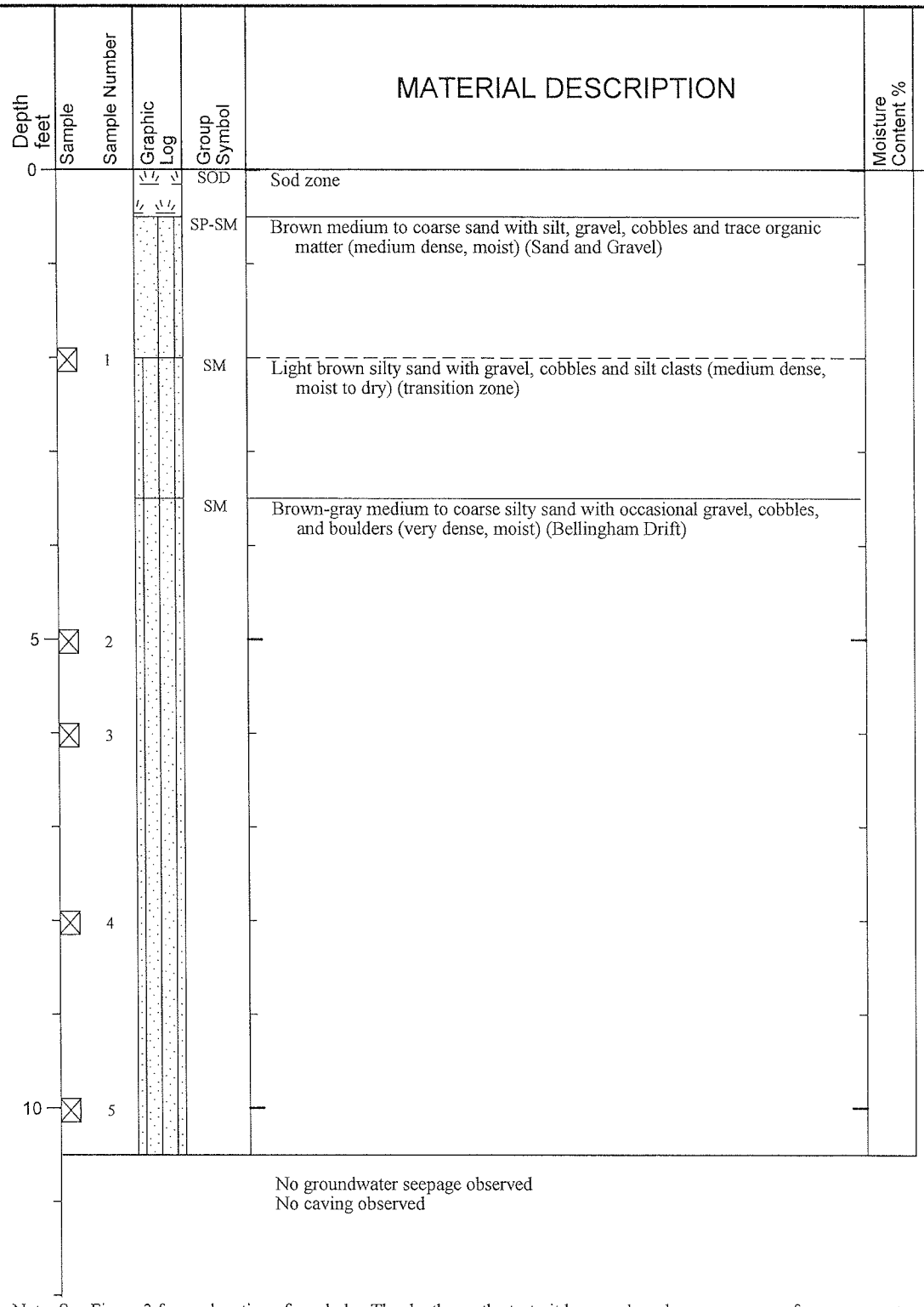
GeoEngineers

Project: Semiahmoo - Zone 3
Project Location: Blaine, Washington
Project Number: 00381-020-00

Figure: 6
Sheet 1 of 1

Date Excavated: 10/19/2005 Logged by: S. Zemva

Equipment: Backhoe Surface Elevation (ft):



Note: See Figure 3 for explanation of symbols. The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

V6_GTTPIT P:\00381020\00\WORKING\00381020000 TP.GPJ GEIV6_1.GDT 11/23/05

LOG OF TEST PIT TP-4

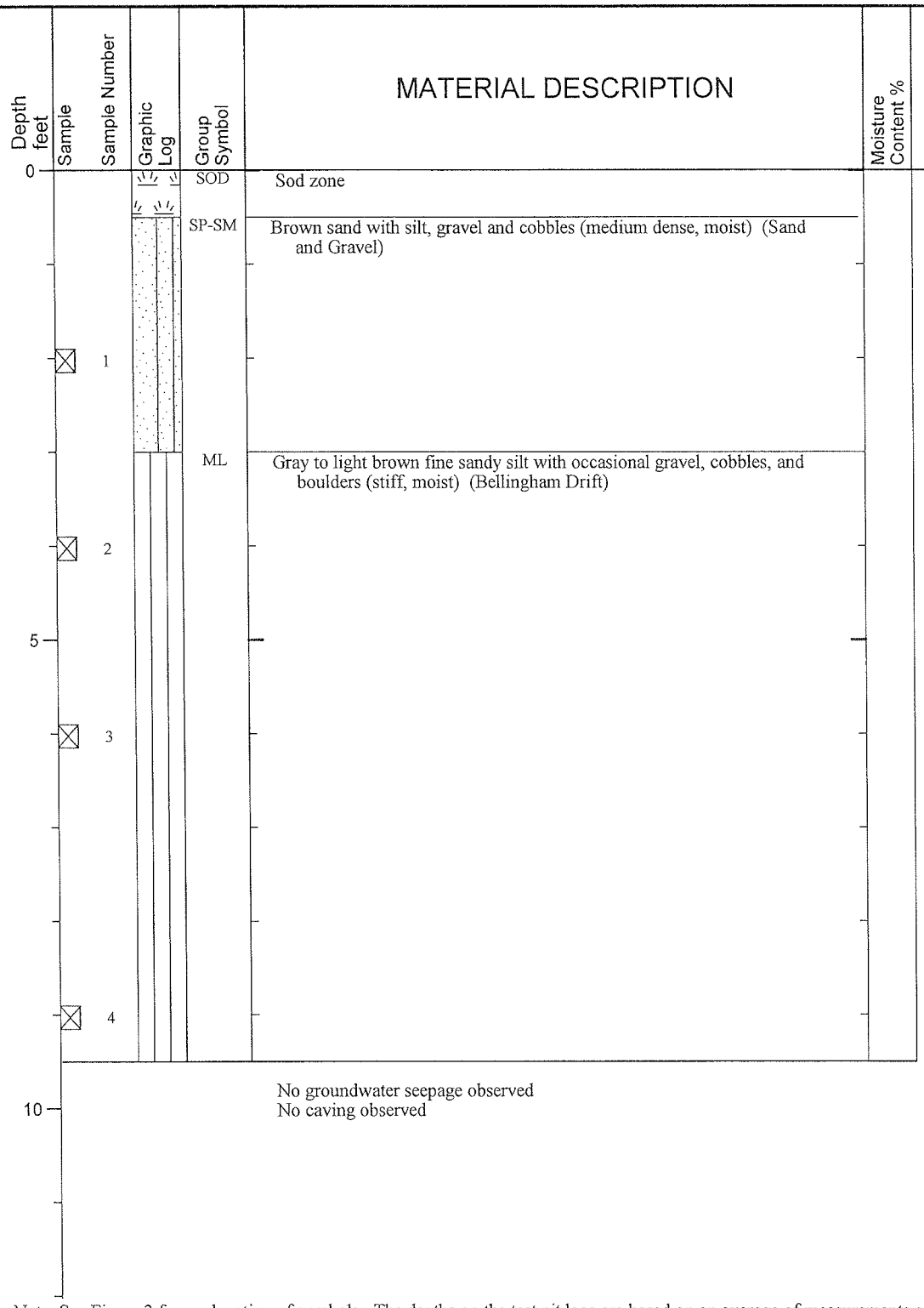
GeoEngineers

Project: Semiahmoo - Zone 3
Project Location: Blaine, Washington
Project Number: 00381-020-00

Figure: 7
Sheet 1 of 1

Date Excavated: 10/19/2005 Logged by: S. Zemva

Equipment: Backhoe Surface Elevation (ft):



Note: See Figure 3 for explanation of symbols. The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-5

GeoEngineers

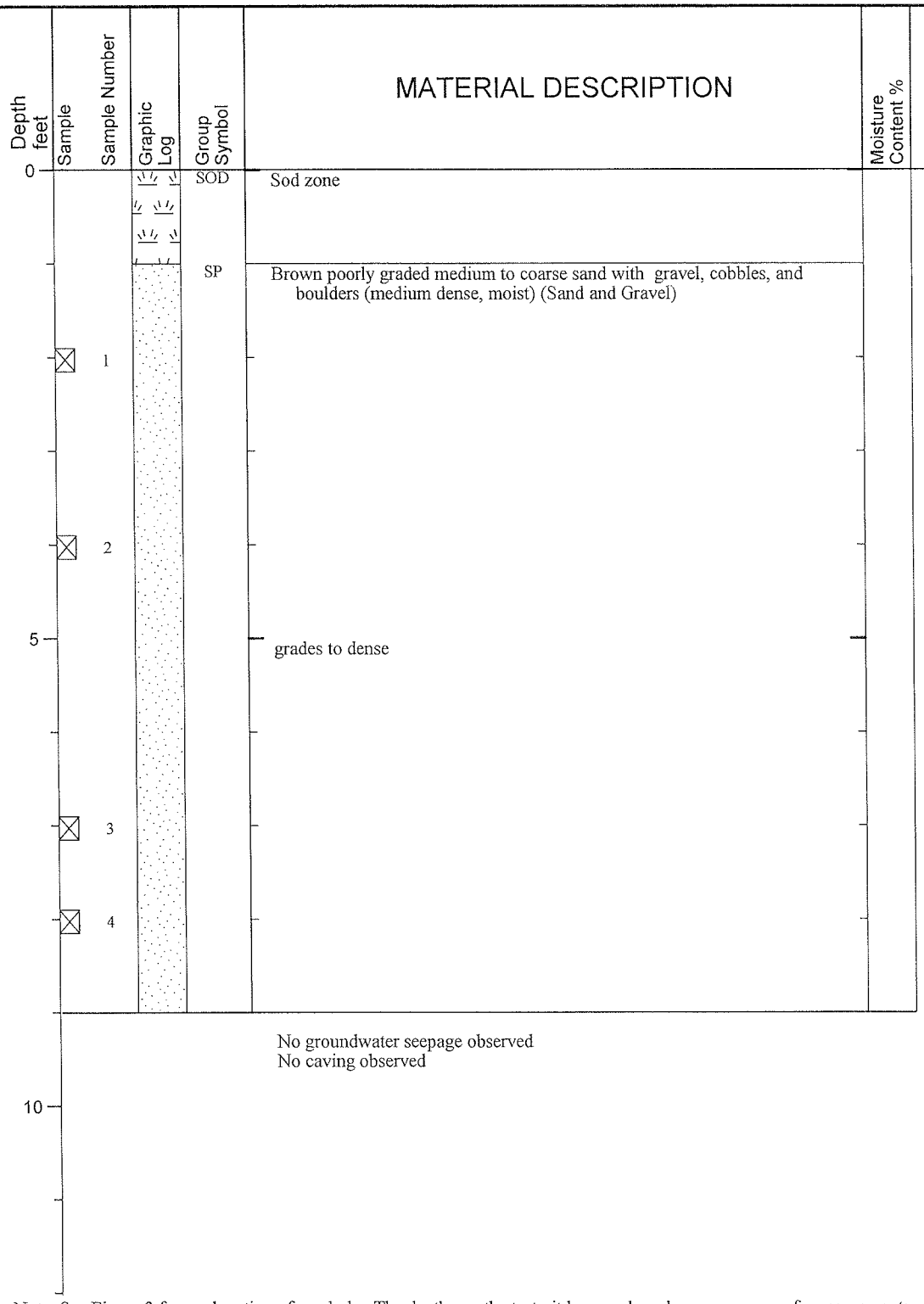
Project: Semiahmoo - Zone 3
Project Location: Blaine, Washington
Project Number: 00381-020-00

Figure: 8
Sheet 1 of 1

V6_GTTPIT P:\00381020\00\WORKING\00381020000 TP.GPJ GEIV6_1.GDT 11/23/05

Date Excavated: 10/19/2005 Logged by: S. Zemva

Equipment: Backhoe Surface Elevation (ft):



Note: See Figure 3 for explanation of symbols. The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-6

GeoEngineers

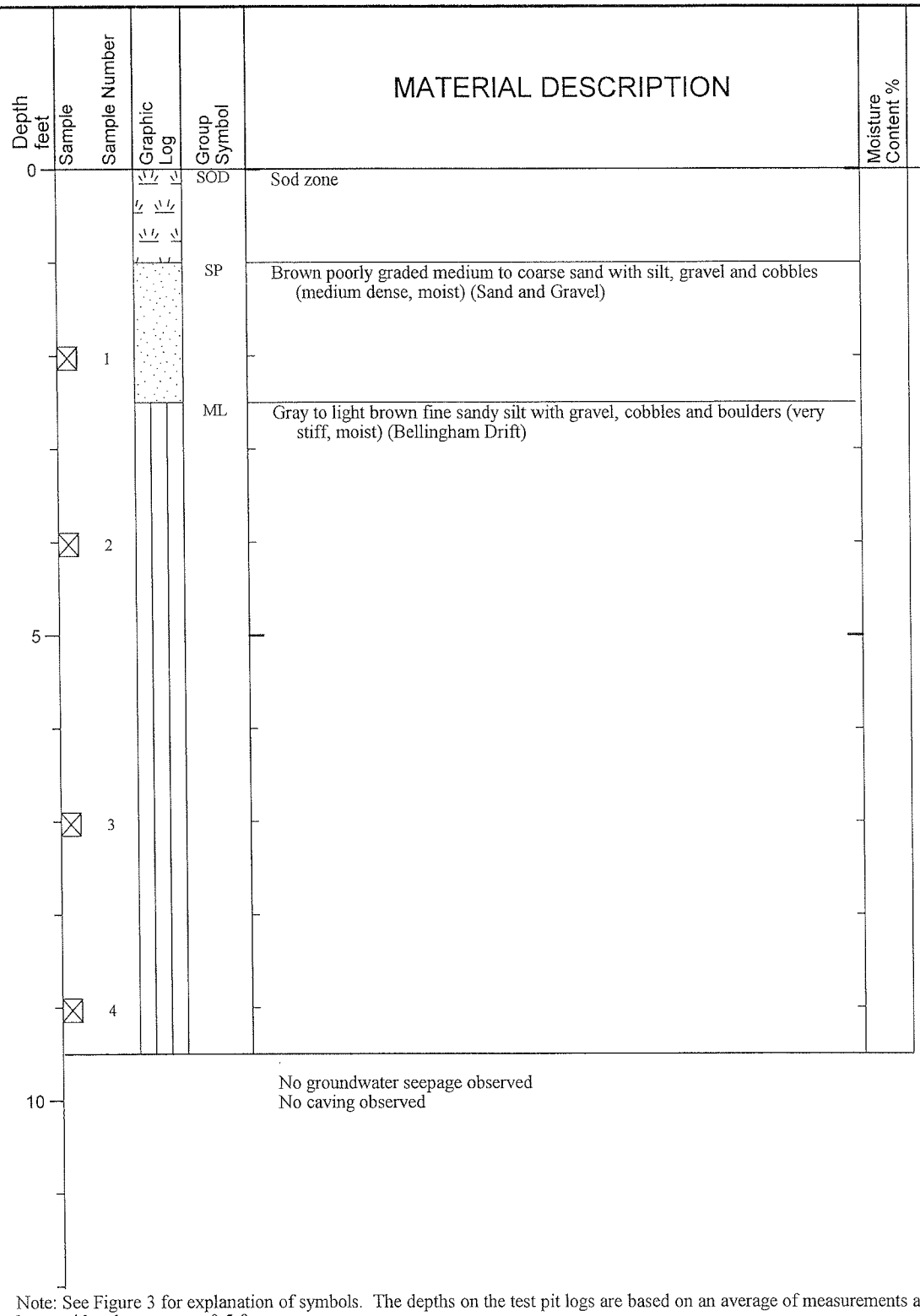
Project: Semiahmoo - Zone 3
Project Location: Blaine, Washington
Project Number: 00381-020-00

Figure: 9
Sheet 1 of 1

V6_GTTPIT P:\00381020000\WORKING\00381020000 TP.GPJ GEIV6_1.GDT 11/23/05

Date Excavated: 10/19/2005 Logged by: S. Zemva

Equipment: Backhoe Surface Elevation (ft):



Note: See Figure 3 for explanation of symbols. The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-7

GeoEngineers

Project: Semiahmoo - Zone 3
Project Location: Blaine, Washington
Project Number: 00381-020-00

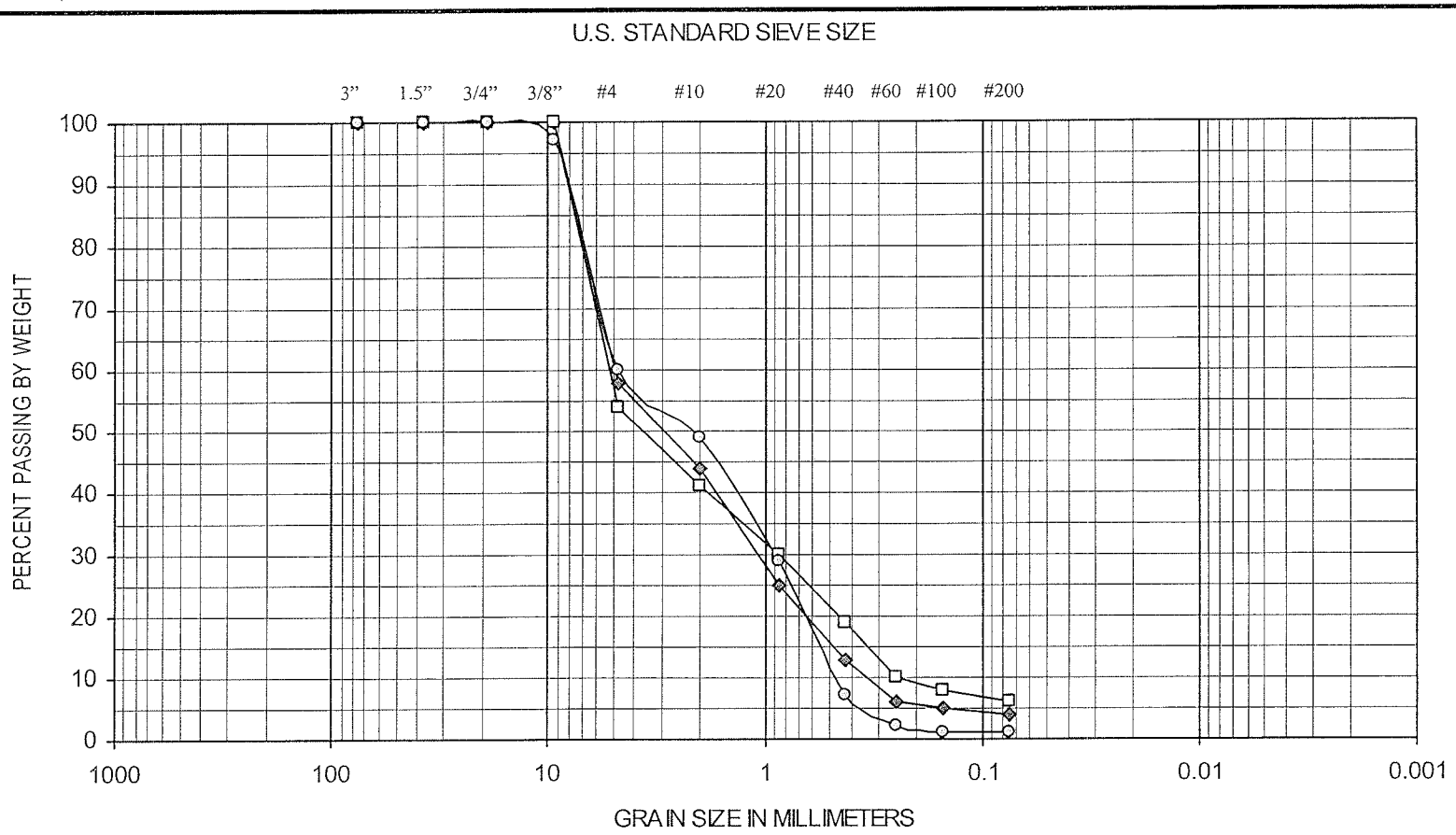
Figure: 10
Sheet 1 of 1

V6_GTTPIT P:\00381020\00WORKING\00381020000 TP.GPJ GEIV6_1.GDT 11/23/05

Geo Engineers

FIGURE 11

SIEVE ANALYSIS RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	3.5	TP-1	Brown poorly graded medium to coarse sand (SP)
□	6.0	TP-3	Brown poorly graded medium to coarse sand with silt (SP-SM)
○	4.0	TP-6	Brown poorly graded medium to coarse sand (SP)

GeoEngineers

600 Dupont Street, Bellingham, WA 98225, Telephone: (360) 647-1510, Fax: (360) 647-5044

Memorandum

www.geoengineers.com

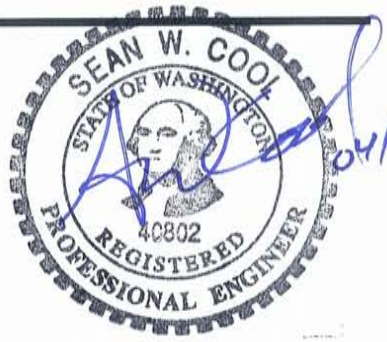
To: Pam Andrews, Trillium Corporation

From: Sean Cool, P.E. and J. Gordon, P.E.

Date: April 1, 2009

File: 0381-020-01

Subject: Semiahmoo Zone 3/Burnside Village
Summary of Soil and Groundwater Conditions related to Stormwater Infiltration Considerations
Blaine, Washington



This memorandum presents a summary of observed soil and groundwater conditions and a discussion of geotechnical considerations as they relate to the proposed infiltration systems for the above referenced project along Semiahmoo Drive in Blaine, Washington. The proposed development will be constructed on a triangular shaped site at the southwest corner of Semiahmoo Drive and Semiahmoo Parkway, as shown in the Site and Exploration Plan, Figure 1. GeoEngineers previously conducted explorations at the site and prepared a geotechnical engineering report, dated December 7, 2005, which included limited recommendations regarding infiltration at the site.

We understand the stormwater runoff from imperious surface in the eastern portion of the site will be directed to an existing stormwater system. As currently envisioned, stormwater from new impervious surfaces in the western portions of the site will be managed with a shallow infiltration trench located along the north boundary of the site near Semiahmoo Drive. Other shallow infiltration facilities, such as infiltration trenches and rain gardens for roof and paved surface run-off, may also be distributed in other areas across the site.

Subsurface Soil and Groundwater Conditions

GeoEngineers observed five test pits at the project site on February 25, 2009 with a backhoe provided by Trillium Corporation. The test pits were excavated to depths of 9.7 to 11 feet below ground surface (bgs) for the purpose of evaluating subsurface soil and groundwater conditions in the vicinity of the proposed infiltration trench along the north property boundary. The test pit locations were identified and field staked by David Evans & Associates (DEA). The approximate locations of the test pits are shown in Figure 1. Logs of the explorations and the results of laboratory grain size analyses conducted on representative samples are also attached to this memorandum. For reference, locations of the previous site explorations are also shown in Figure 1.

The surficial soil typically consists of 6 to 12 inches of topsoil overlying sand and gravel, overlying finer grained soils. The upper Sand and Gravel unit is interpreted to be wave reworked Bellingham (glaciomarine) Drift (GMD) and consists of sand or gravel with cobbles and minimal fines content. Test pit TP-8 encountered a disturbed zone that could be associated with past logging activities at the site. The Sand and Gravel unit extended to approximately 6 to 8 feet bgs. An approximately 2 to 3 feet thick transition zone consisting of medium dense to dense silty fine sand with gravel and cobbles was encountered at TP-8 and TP-9. GMD was encountered underlying either the sand and gravel or the transition zone in all five test pits. The GMD consisted of gray, medium dense to dense, silty fine sand with shells in TP-8 and TP-9 and gray, stiff, sandy, clayey silt with shell fragments in TP-10. In TP-11 and TP-12, the GMD consisted of brown, stiff to very stiff, silt with variable sand content, occasional gravel, and cobbles. All explorations terminated

GMD unit. Because of higher fines contents, the transitional unit and GMD are not considered suitable for infiltration purposes, and will represent the lower boundary surface for infiltrated water flow.

Relatively shallow groundwater was encountered in all test pits located along Semiahmoo Drive at depths ranging from 2.5 to 5 feet bgs, with the exception of TP-12, TP-3 (2005) and TP-6 (2005). Groundwater was not encountered at TP-12, TP-3 (2005) or TP-6 (2005). Groundwater levels will fluctuate as the result of precipitation, seasonal variations, and other factors. The groundwater conditions are seasonally perched within the sand and gravel unit over the glaciomarine drift unit. Our test pits were accomplished during the wetter winter months. We anticipate that the observed water levels are near the seasonal highs. Because the sand and gravel unit is a relatively thin "mantling" over the impermeable glaciomarine drift, the perched groundwater flow direction is expected to mimic the regional topography.

STORMWATER INFILTRATION CONSIDERATIONS

We understand that site stormwater management is to include shallow infiltration facilities such as trenches or rain gardens. Infiltration rates for planning purposes were estimated based on the guidelines in the Washington State Department of Ecology (Ecology) manual, *Stormwater Management in Western Washington* (Ecology 2005). Due to the generally granular nature of the soil deposits, we evaluated infiltration rates using Table 3.8 as outlined in Section 3.3.6, Design Infiltration Rate Determination – Guidelines and Criteria. The estimated long-term (design) infiltration rates for the samples and depths tested, including tests from the previous site explorations, are provided in the table below.

Table 1 – Estimated Design Infiltration Rate

Test Pit No.	Sample Depth (ft)	USCS Soil Type	D_{10} from ASTM D422 Soil Gradation Test (mm)	Estimated Long-Term (Design) Infiltration Rate (inches/hour)
TP-1*	3.5	SP	0.35	6.5-9
TP-3*	6	SP-SM	0.26	3.5-6.5
TP-6*	4	SP	0.39	6.5-9
TP-8	2	SM	<0.075	<0.8
TP-8	4.2	GP	0.43	9
TP-9	1.2	GP	0.54	9
TP-9	5	GP	0.41	9
TP-10	1.5	GP	0.46	9
TP-10	8	GP	0.28	3.5-6.5
TP-11	1.5	GP	0.37	6.5-9
TP-11	4.5	SP	0.42	9
TP-12	2	GP	0.42	9
TP-12	4	GP	0.53	9

* Results from 2005 GeoEngineers report.

Groundwater was observed during site explorations at depths ranging from 2.5 to 5 feet below existing site grades at some of the exploration locations. Accordingly, it may not be feasible to provide at least 5 feet of separation between the bottom of the infiltration system and the groundwater table, as preferred by the Ecology manual.

INFILTRATION TRENCHES/RAIN GARDENS

It is our opinion that the upper Sand and Gravel unit at the site is suitable for some limited stormwater infiltration, consistent with the findings in our previous report. Estimated long-term infiltration rates in this unit range from 3.5 to 9 inches per hour. However, the shallow thickness of this unit and relatively shallow groundwater conditions observed in places at the site will limit the use of infiltration. The Ecology Stormwater Manual requires at least 5 feet of separation between the base of an infiltration basin and the seasonal high water, allowing a separation of only 3 feet if the mounding of the groundwater table at the site does not impact the surrounding properties. Conclusions based on our supplemental field observations and laboratory activities are as follows:

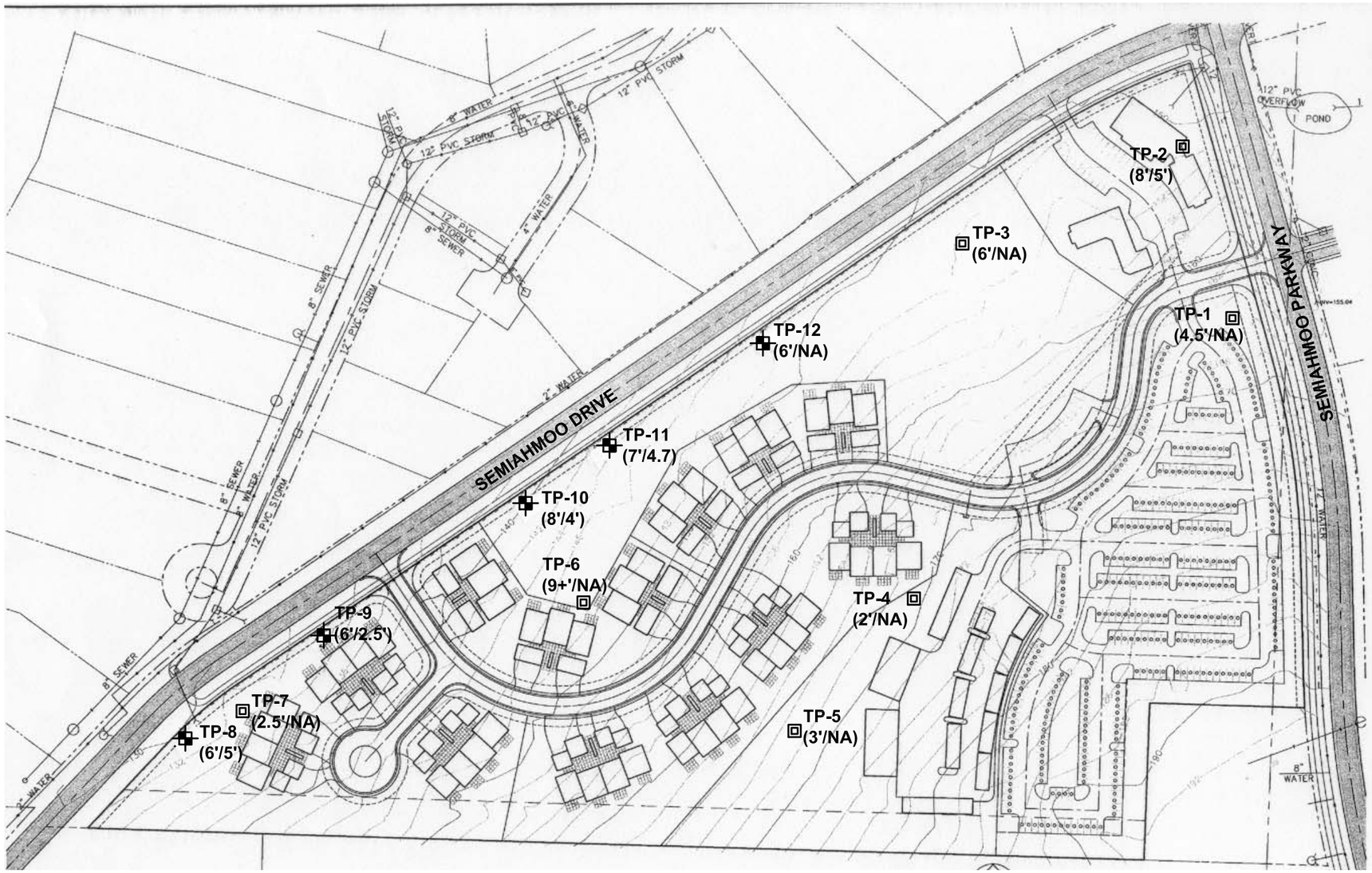
- The Sand and Gravel unit is too thin to be suitable for infiltration along the south margin of the site at test pit TP-7 (2005).
- Observed groundwater or anticipated groundwater fluctuation at TP-2, and TP-8 through TP-11 is at 5 feet or less below the existing ground surface, and is such that these areas are not preferred for infiltration, with the exception of rain gardens or downspout infiltration/dispersion systems.
- At TP-3 and TP-12, the sand layer extends to 6 feet below ground surface. At TP-6, the sand layer extends beyond the depth explored, which was 9 feet. No groundwater was encountered in these three test pits. These areas are likely suitable for limited infiltration. The laboratory testing results indicate a range of long term infiltration rates between 3.5 to 9 inches per hour at these locations. We understand that a sand filter will likely be used to slow the infiltration rate to about 2 inches per hour. Sizing infiltration trenches based on a rate of 2 inches per hour, a rate that is slower than the formational permeability of the soils, would limit the likelihood for significant groundwater mounding to occur.
- As discussed in our previous report, the regional topography and geology is such that the perched groundwater flows toward the northeast and northwest within the sand and gravel unit over the relatively impermeable glaciomarine drift. Increased infiltration in this area of Whatcom County has resulted in greater seepage along the shoreline bluff lots and adversely affected slope stability. Therefore, we recommend that only limited infiltration occur that does not result in an increase in infiltration compared to present undeveloped conditions.

LIMITATIONS

We have prepared this memorandum for the exclusive use of the Trillium Corporation, and David Evans & Associates, and their authorized agents and regulatory agencies, for the proposed Semiahmoo Zone 3/Burnside Village Development. Within the limitations of scope, schedule and budget, our services have been executed in accordance with the generally accepted practices for geotechnical engineering in this area at the time this report was prepared. No warranty or other conditions, express or implied, should be understood. This memorandum is subject to the same limitations as presented in our December 7, 2005 report.

Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

Attachments: Figure 1 - Site and Exploration Plan
Figure A-1 Key to Exploration Logs
Figure A-2 to A-6 - Logs of Test Pits TP-8 through TP-12
Figure A-7 to A-8 – Sieve Analysis Test Results



N
W E
S

NOT TO SCALE

Legend

TP-8 = GeoEngineers test pit number and approximate location (2009)

TP-1 = GeoEngineers test pit number and approximate location (2005)

(6'/5') = Depth of sand / depth to groundwater

Notes:
1. The locations of all features shown are approximate.
2. This drawing is for information purposes. It is intended to assist in showing features discussed in an attached document. GeoEngineers, Inc. can not guarantee the accuracy and content of electronic files. The master file is stored by GeoEngineers, Inc. and will serve as the official record of this communication.

Reference: Drawing reference information.

Site and Exploration Plan

Burnside Village - Semiahmoo
Blaine, Washington

GeoEngineers

Figure 1

BELL P:\0\000381-020\01\AutoCAD\38102001F1.dwg SWC:IMS 03/30/09

SOIL CLASSIFICATION CHART

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

NOTE: Multiple symbols are used to indicate borderline or dual soil classifications

ADDITIONAL MATERIAL SYMBOLS

SYMBOLS GRAPH	SYMBOLS LETTER	TYPICAL DESCRIPTIONS
	CC	Cement Concrete
	AC	Asphalt Concrete
	CR	Crushed Rock/ Quarry Spalls
	TS	Topsoil/ Forest Duff/Sod

Measured groundwater level in exploration, well, or piezometer

Groundwater observed at time of exploration

Perched water observed at time of exploration

Measured free product in well or piezometer

Stratigraphic Contact

Distinct contact between soil strata or geologic units

Gradual change between soil strata or geologic units

Approximate location of soil strata change within a geologic soil unit

Sampler Symbol Descriptions

2.4-inch I.D. split barrel

Standard Penetration Test (SPT)

Shelby tube

Piston

Direct-Push

Bulk or grab

Blowcount is recorded for driven samplers as the number of blows required to advance sampler 12 inches (or distance noted). See exploration log for hammer weight and drop.

A "P" indicates sampler pushed using the weight of the drill rig.

Laboratory / Field Tests

%F	Percent fines
AL	Atterberg limits
CA	Chemical analysis
CP	Laboratory compaction test
CS	Consolidation test
DS	Direct shear
HA	Hydrometer analysis
MC	Moisture content
MD	Moisture content and dry density
OC	Organic content
PM	Permeability or hydraulic conductivity
PP	Pocket penetrometer
SA	Sieve analysis
TX	Triaxial compression
UC	Unconfined compression
VS	Vane shear

Sheen Classification

NS	No Visible Sheen
SS	Slight Sheen
MS	Moderate Sheen
HS	Heavy Sheen
NT	Not Tested

NOTE: The reader must refer to the discussion in the report text and the logs of explorations for a proper understanding of subsurface conditions. Descriptions on the logs apply only at the specific exploration locations and at the time the explorations were made; they are not warranted to be representative of subsurface conditions at other locations or times.

KEY TO EXPLORATION LOGS

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Figure A-1

Date Excavated: 2/25/2009 Logged by: A. Fickeisen

Equipment: CAT 315 Excavator Surface Elevation (ft): 130

Elevation feet	Depth feet	Sample	Sample Number	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	OTHER TESTS AND NOTES
130	0				TS	Dark brown silty fine to medium sand with fine gravel and organic matter (loose, moist) (topsoil)		
		☒	1		SP-SM	Brown-gray fine to coarse sand with silt, gravel and cobbles (loose to medium dense, moist) (fill)	32	
		☒	2				13	
					SM	Rust brown to dark brown silty fine to medium sand with occasional gravel and organic matter (loose, moist) (relict topsoil/disturbed zone)		
		☒	3				40	%F=33, SA
		☒	4				35	
		☒	5		GP	Brown sandy fine to coarse gravel with cobbles (medium dense, moist to wet) (Sand and Gravel)	9	%F=1, SA
125	5	▽						
		☒	6		SM	Gray silty fine sand with gravel and cobbles (medium dense, moist) (transition zone)	20	
		☒	7			- with iron staining	28	
		☒	8		SM	Gray silty fine sand with shell fragments (medium dense to dense, moist) (Bellingham [glaciomarine] Drift)	19	
120	10	☒	9				15	
115	15							

Moderate groundwater seepage observed at 5 feet
Moderate caving observed at 5 feet

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

V6_GTTPIT P:\00381020\01\GINT\381020001.TP.GPJ GEIV6_1.GDT 4/2/09

LOG OF TEST PIT TP-8

GeoEngineers

Project: Semiahmoo Zone 3 Infiltration Study
Project Location: Semiahmoo, Washington
Project Number: 00381-020-01

Figure: A- 2
Sheet 1 of 1

Date Excavated: 2/25/2009 Logged by: A. Fickeisen

Equipment: CAT 315 Excavator Surface Elevation (ft): 133

Elevation feet	Depth feet	Sample	Sample Number	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	OTHER TESTS AND NOTES
	0				TS	Dark brown silty fine to medium sand with gravel and organic matter (loose moist) (topsoil)		
		☒	1		GP	Brown sandy fine to coarse gravel with cobbles (loose, moist to wet) (Sand and Gravel)	52	
		☒	2				11	%F=1, SA
					SP/GP	Brown fine to coarse sand and gravel with cobbles (loose, moist to wet)		
		☒	3				7	
					GP	Brown sandy fine to coarse gravel with cobbles (dense, wet)		
130								
	5	☒	4				9	%F=1, SA
					SM	Brown-gray silty fine sand with gravel and cobbles (medium dense to dense, moist to wet) (transition zone)		
		☒	5				26	
125					SM	Gray silty fine sand with gravel and shell fragments (medium dense to dense, moist to wet) (Bellingham [glaciomarine] Drift)		
		☒	6				20	
		☒	7				18	
	10					Rapid groundwater seepage observed at 2.5 feet Moderate caving observed below 2.5 feet		
120								
	15							

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-9

GeoEngineers

Project: Semiahmoo Zone 3 Infiltration Study
Project Location: Semiahmoo, Washington
Project Number: 00381-020-01

Figure: A- 3
Sheet 1 of 1

V6_GTTPIT P:\00381020\01\GINT\381020001.TP.GPJ GEIV6_1.GDT 4/2/09

Date Excavated: 2/25/2009 Logged by: A. Fickeisen

Equipment: CAT 315 Excavator Surface Elevation (ft): 140

Elevation feet	Depth feet	Sample	Sample Number	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	OTHER TESTS AND NOTES
140	0				TS	Dark brown silty fine to coarse sand with gravel and organic matter (loose, moist) (topsoil)		
		☒	1		GP	Rust brown sandy fine to coarse gravel (loose to medium dense, moist to wet) (Sand and Gravel)	42	
		☒	2				5	%F=1, SA
		☒	3		GP	Rust brown fine to coarse gravel with trace medium to coarse sand and occasional cobbles (dense, wet)	10	
135	5					- grades to gray		
						- grades with fine to coarse sand		
		☒	4				6	%F=1, SA
					ML	Gray fine sandy, clayey silt with occasional gravel and shell fragments (stiff, moist) (Bellingham [glaciomarine] Drift)		
		☒	5				18	
130	10					Rapid groundwater seepage observed at 4 feet Minor caving observed below 4 feet		
125	15							

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-10

GeoEngineers

Project: Semiahmoo Zone 3 Infiltration Study
Project Location: Semiahmoo, Washington
Project Number: 00381-020-01

Figure: A- 4
Sheet 1 of 1

V6_GTTPIT P:\00381020\01\GINT\381020001.TP.GPJ GEIV6_1.GDT 4/2/09

Date Excavated: 2/25/2009 Logged by: A. Fickeisen

Equipment: CAT 315 Excavator Surface Elevation (ft): 143

Elevation feet	Depth feet	Sample	Sample Number	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	OTHER TESTS AND NOTES
	0				TS	Dark brown silty fine to coarse sand with gravel and organic matter (loose, moist) (topsoil)		
		☒	1		GP	Rust-brown sandy fine gravel with cobbles, trace silt and iron staining (medium dense, moist) (Sand and Gravel)	53	
		☒	2				7	%F=2, SA
		☒	3			- with scattered organic matter	8	
140								
	5	☒	4		SP	Brown fine to coarse sand with gravel and cobbles (dense, wet)	8	%F=0, SA
		☒	5		ML	Brown silt with fine sand, occasional gravel and cobbles (stiff to very stiff, moist) (Bellingham [glaciomarine] Drift)	19	
135								
	10	☒	6				24	
130								
	15							

Moderate groundwater seepage observed at 4.5 feet
Minor caving observed at 4.5 feet

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-11

GeoEngineers

Project: Semiahmoo Zone 3 Infiltration Study
Project Location: Semiahmoo, Washington
Project Number: 00381-020-01

Figure: A- 5
Sheet 1 of 1

V6_GTTPIT P:\00381020\01\GINT\381020001.TP.GPJ GEIV6_1.GDT 4/2/09

Date Excavated: 2/25/2009 Logged by: A. Fickeisen

Equipment: CAT 315 Excavator Surface Elevation (ft): 147

Elevation feet	Depth feet	Sample	Sample Number	Graphic Log	Group Symbol	MATERIAL DESCRIPTION	Moisture Content %	OTHER TESTS AND NOTES
	0				TS	Dark brown silty fine to medium sand with gravel and organic matter (loose, moist) (topsoil)		
		☒	1		GP	Brown sandy fine to coarse gravel with cobbles and occasional pockets of organic matter; iron staining (medium dense, moist) (Sand and Gravel)	33	
145		☒	2				5	%F=1, SA
						- becomes dense		
		☒	3				3	%F=1, SA
	5							
					ML	Light brown fine sandy silt with occasional gravel and cobbles (stiff to very stiff, moist) (Bellingham [glaciomarine] Drift)		
140		☒	4				18	
		☒	5				20	
	10							
		☒	6				23	
135								
	15							

No groundwater seepage observed
No caving observed

Notes: See Figure A-1 for explanation of symbols.
The depths on the test pit logs are based on an average of measurements across the test pit and should be considered accurate to 0.5 foot.

LOG OF TEST PIT TP-12

GeoEngineers

Project: Semiahmoo Zone 3 Infiltration Study
Project Location: Semiahmoo, Washington
Project Number: 00381-020-01

Figure: A- 6
Sheet 1 of 1

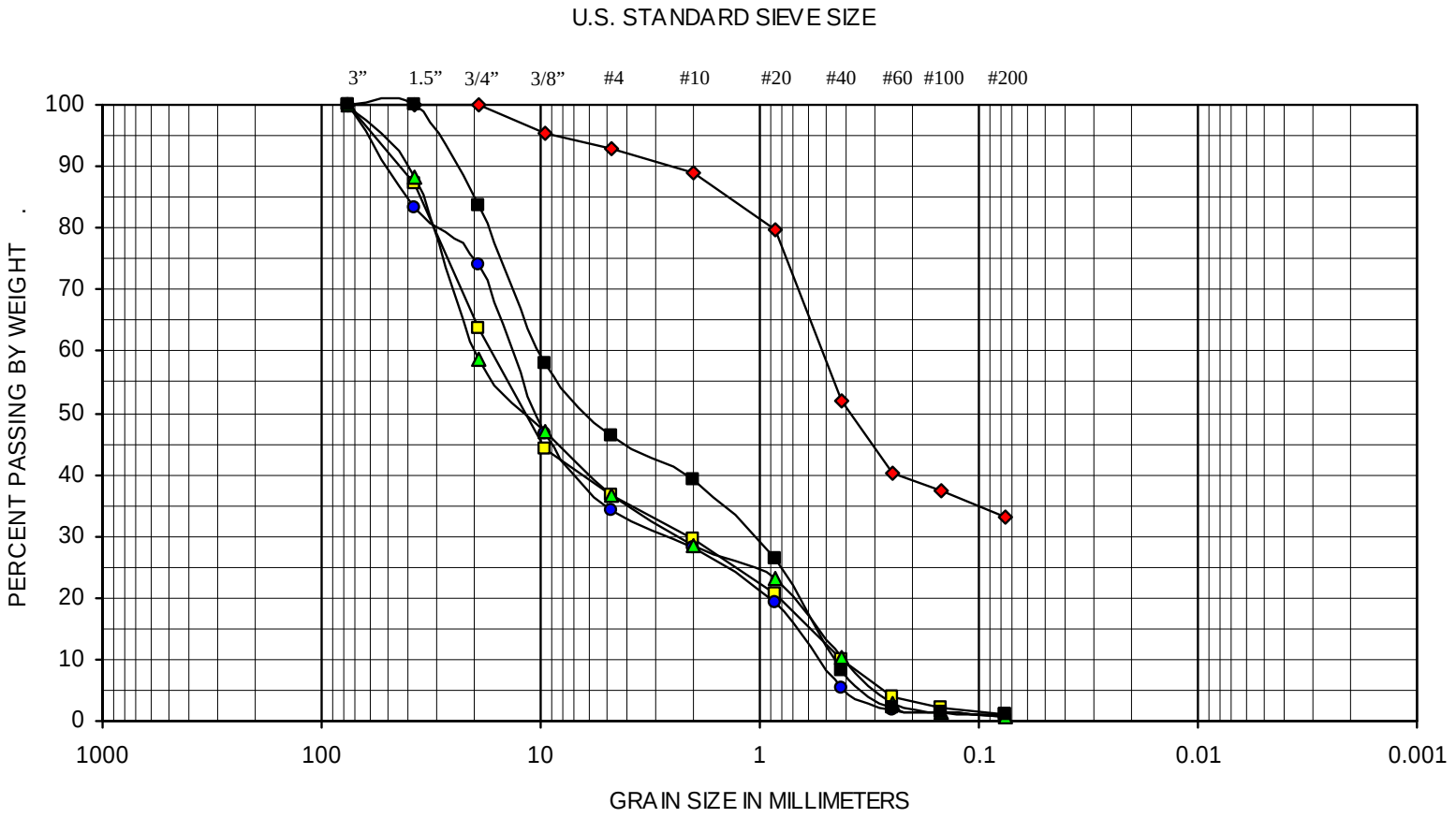
V6_GTTPIT P:\00381020\01\GINT\381020001.TP.GPJ GEIV6_1.GDT 4/2/09

0381-020-01 AF2 3/3/09 (Sieve1.ppt)

GEOENGINEERS

FIGURE A-7

SIEVE ANALYSIS RESULTS



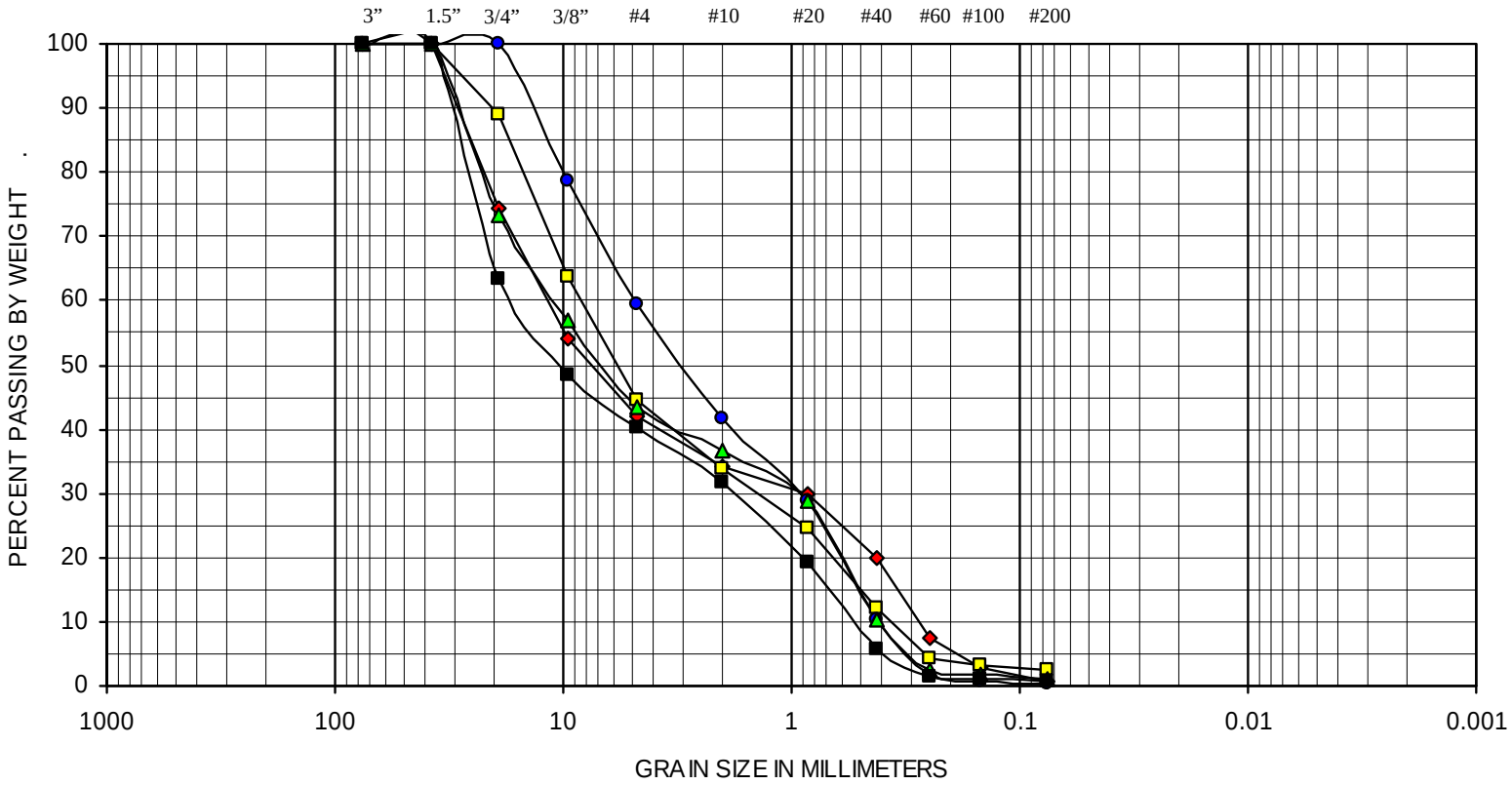
COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	2	TP-8	Brown silty fine to medium sand w/ occ. gravel (SM), D_{10} < 0.075 mm
□	4.2	TP-8	Brown sandy fine to coarse gravel (GP), D_{10} = 0.43 mm
●	1.2	TP-9	Brown sandy fine to coarse gravel (GP) D_{10} = 0.54 mm
▲	5	TP-9	Brown sandy fine to coarse gravel (GP), D_{10} = 0.41 mm
■	1.5	TP-10	Brown sandy fine to coarse gravel (GP), D_{10} = 0.46 mm

GEOENGINEERS

FIGURE A-8

SIEVE ANALYSIS RESULTS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

SYMBOL	DEPTH (FEET)	SOURCE	SOIL CLASSIFICATION
◆	8	TP-10	Brown sandy fine to coarse gravel (GP), D_{10} = 0.28 mm
□	1.5	TP-11	Brown sandy fine gravel w/ trace silt (GP), D_{10} = 0.37 mm
●	4.5	TP-11	Brown fine to coarse sand w/ gravel (SP) D_{10} = 0.42 mm
▲	2	TP-12	Brown sandy fine to coarse gravel (GP), D_{10} = 0.42 mm
■	4	TP-12	Brown sandy fine to coarse gravel (GP), D_{10} = 0.53 mm

APPENDIX B
Onsite Hydrologic and Hydraulic Analysis

- WWHM Results – Groundwater Infiltration Analysis
- WWHM Results – East System Bioretention Cell Analysis
- WWHM Results – West System Bioretention Cell Analysis
- StormSHED 3G Results – West System Detention Pond Analysis
- 2014 DOE Manual Curve Number Table

WWHM2012
PROJECT REPORT

Project Name: RAZR01-Bluff Analysis 2
Site Name: RAZR01: Semiahmoo Zone 3
Site Address: Bluff Flow Analysis - infiltrate 64 roofs
City : 6-22-2016
Report Date: 6/22/2016
Gage : Blaine
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 1.00
Version Date: 2016/03/03
Version : 4.2.12

PREDEVELOPED LAND USE

Name : Pre-Dev Forest 1
Bypass: No

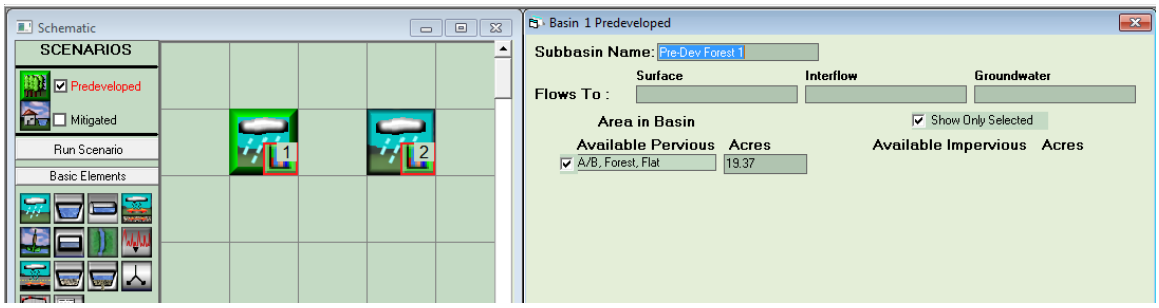
GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	19.37
Pervious Total	19.37

Impervious Land Use	acre
Impervious Total	0
Basin Total	19.37

Element Flows To:

Surface	Interflow	Groundwater



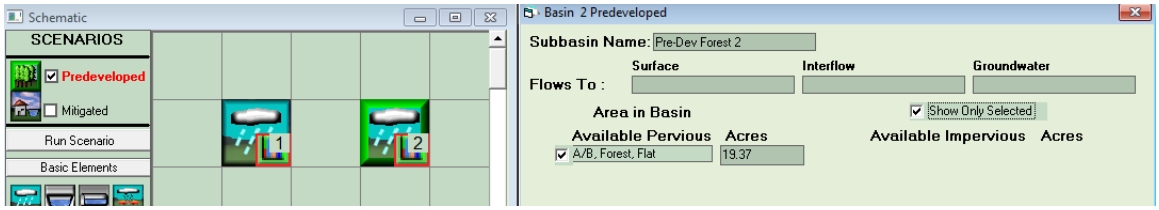
Name : Pre-Dev Forest 2
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	19.37
Pervious Total	19.37

Impervious Land Use	acre
Impervious Total	0
Basin Total	19.37

Element Flows To:
Surface **Interflow** **Groundwater**



MITIGATED LAND USE

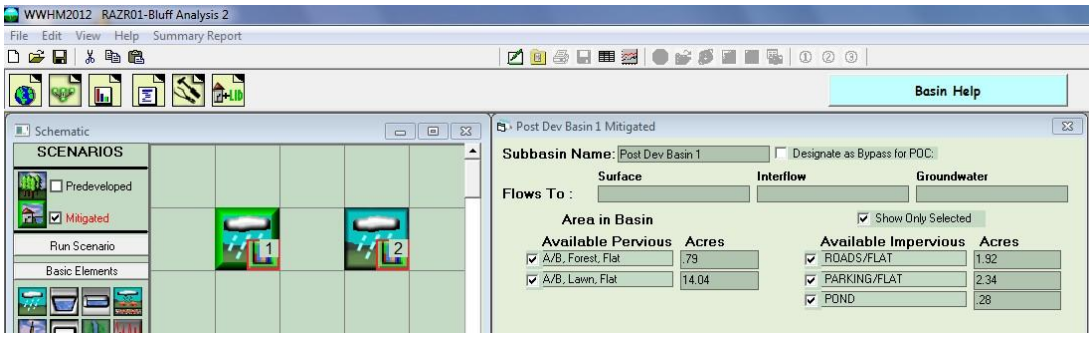
Name : Post Dev Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	14.04
A B, Forest, Flat	0.79
Pervious Total	14.83

Impervious Land Use	acre
ROADS FLAT	1.92
PARKING FLAT	2.34
POND	0.28
Impervious Total	4.54
Basin Total	19.37

Element Flows To:
Surface **Interflow** **Groundwater**



Name : Pre-Dev Forest 2
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	19.37
Pervious Total	19.37

Impervious Land Use	acre
Impervious Total	0
Basin Total	19.37

Element Flows To:

Surface	Interflow	Groundwater

ANALYSIS RESULTS
Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:19.37
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:14.83
Total Impervious Area:4.54

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.01758
5 year	0.036177
10 year	0.056198
25 year	0.094501
50 year	0.135987
100 year	0.192333

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	2.127442
5 year	3.140813
10 year	3.88354
25 year	4.902354
50 year	5.719477
100 year	6.586442

Stream Protection Duration

Predeveloped Landuse Totals for POC #2
Total Pervious Area:19.37
Total Impervious Area:0

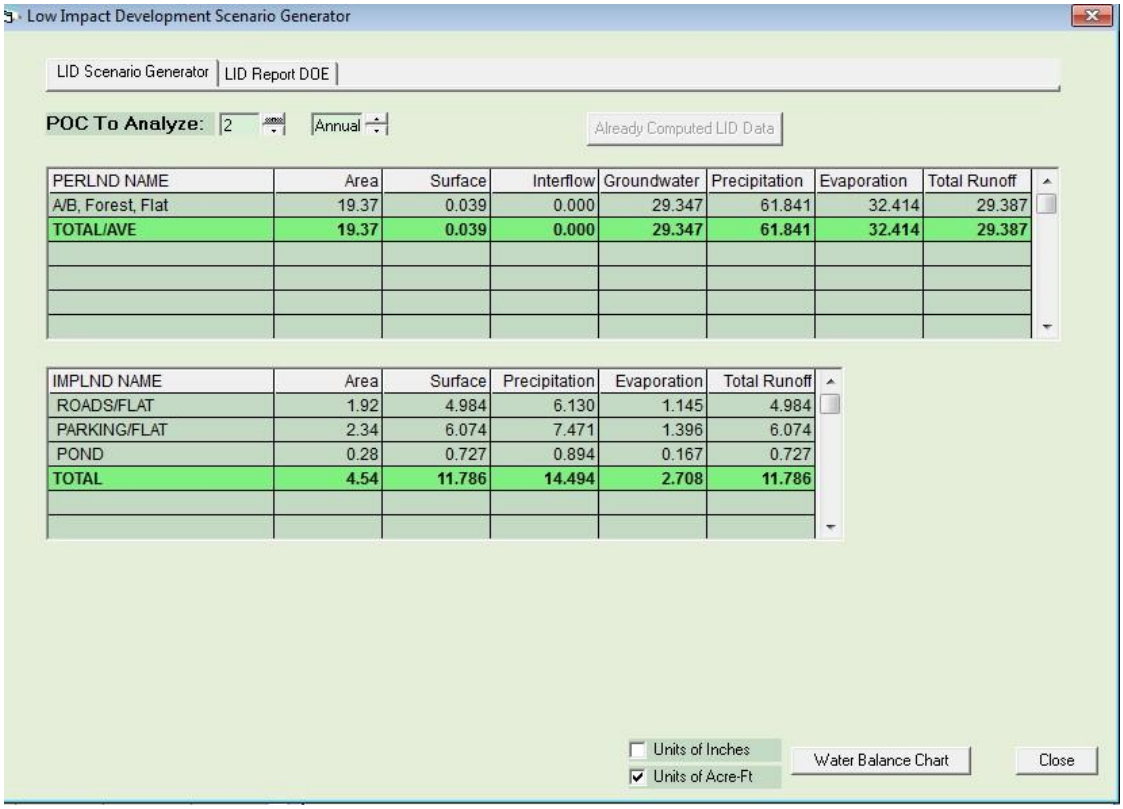
Mitigated Landuse Totals for POC #2
Total Pervious Area:19.37
Total Impervious Area:0

Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	Flow(cfs)
2 year	0.01758
5 year	0.036177
10 year	0.056198
25 year	0.094501
50 year	0.135987
100 year	0.192333

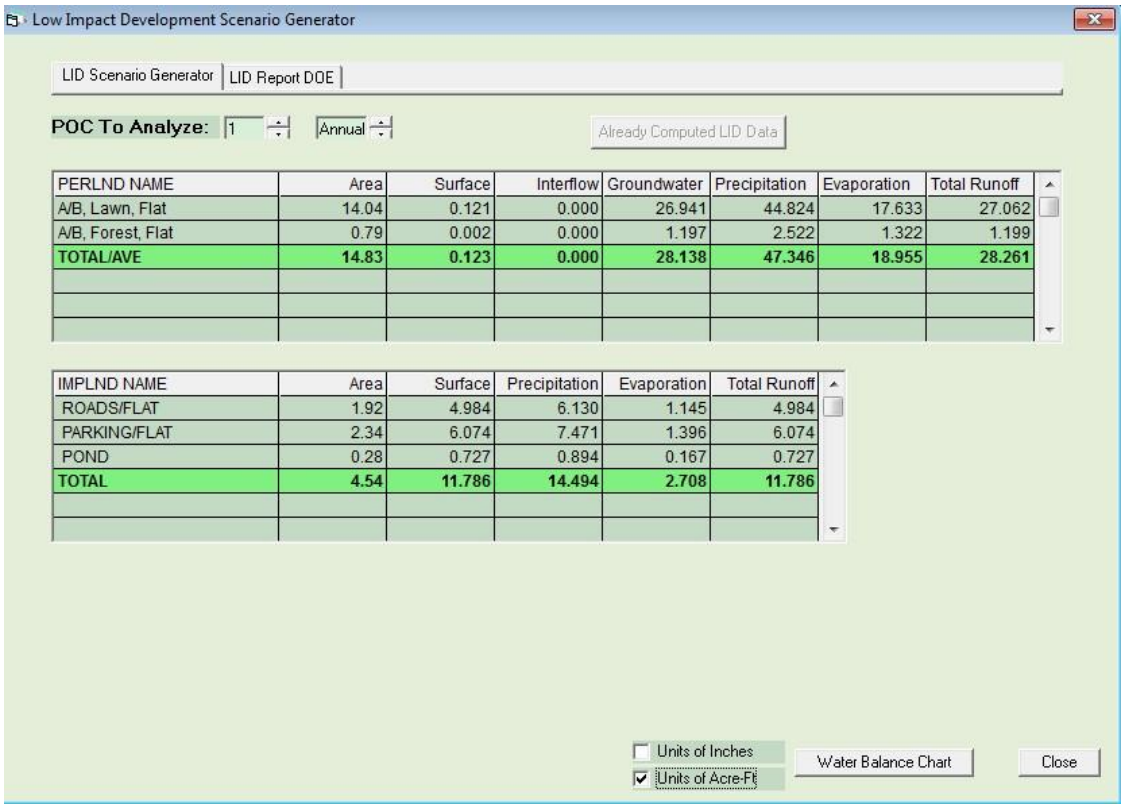
Flow Frequency Return Periods for Mitigated. POC #2

Return Period	Flow(cfs)
2 year	0.01758
5 year	0.036177
10 year	0.056198
25 year	0.094501
50 year	0.135987
100 year	0.192333



PERLND NAME	Area	Surface	Interflow	Groundwater	Precipitation	Evaporation	Total Runoff
A/B, Forest, Flat	19.37	0.039	0.000	29.347	61.841	32.414	29.387
TOTAL/AVE	**19.37**	**0.039**	**0.000**	**29.347**	**61.841**	**32.414**	**29.387**

IMPLND NAME	Area	Surface	Precipitation	Evaporation	Total Runoff
ROADS/FLAT	1.92	4.984	6.130	1.145	4.984
PARKING/FLAT	2.34	6.074	7.471	1.396	6.074
POND	0.28	0.727	0.894	0.167	0.727
TOTAL	**4.54**	**11.786**	**14.494**	**2.708**	**11.786**



PERLND NAME	Area	Surface	Interflow	Groundwater	Precipitation	Evaporation	Total Runoff
A/B, Lawn, Flat	14.04	0.121	0.000	26.941	44.824	17.633	27.062
A/B, Forest, Flat	0.79	0.002	0.000	1.197	2.522	1.322	1.199
TOTAL/AVE	**14.83**	**0.123**	**0.000**	**28.138**	**47.346**	**18.955**	**28.261**

IMPLND NAME	Area	Surface	Precipitation	Evaporation	Total Runoff
ROADS/FLAT	1.92	4.984	6.130	1.145	4.984
PARKING/FLAT	2.34	6.074	7.471	1.396	6.074
POND	0.28	0.727	0.894	0.167	0.727
TOTAL	**4.54**	**11.786**	**14.494**	**2.708**	**11.786**

Perlnd and Implnd Changes

No changes have been made.

WWHM2012
PROJECT REPORT

Project Name: RAZR01 East Bioretention
Site Name: RAZR01: Semiahmoo Zone 3
Site Address: East System Bioretention
City : 6-22-2016 MJD
Report Date: 6/22/2016
Gage : Blaine
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 1.00
Version Date: 2016/03/03
Version : 4.2.12

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

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	1.4
Pervious Total	1.4

Impervious Land Use	acre
Impervious Total	0
Basin Total	1.4

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre

Pervious Total **0**

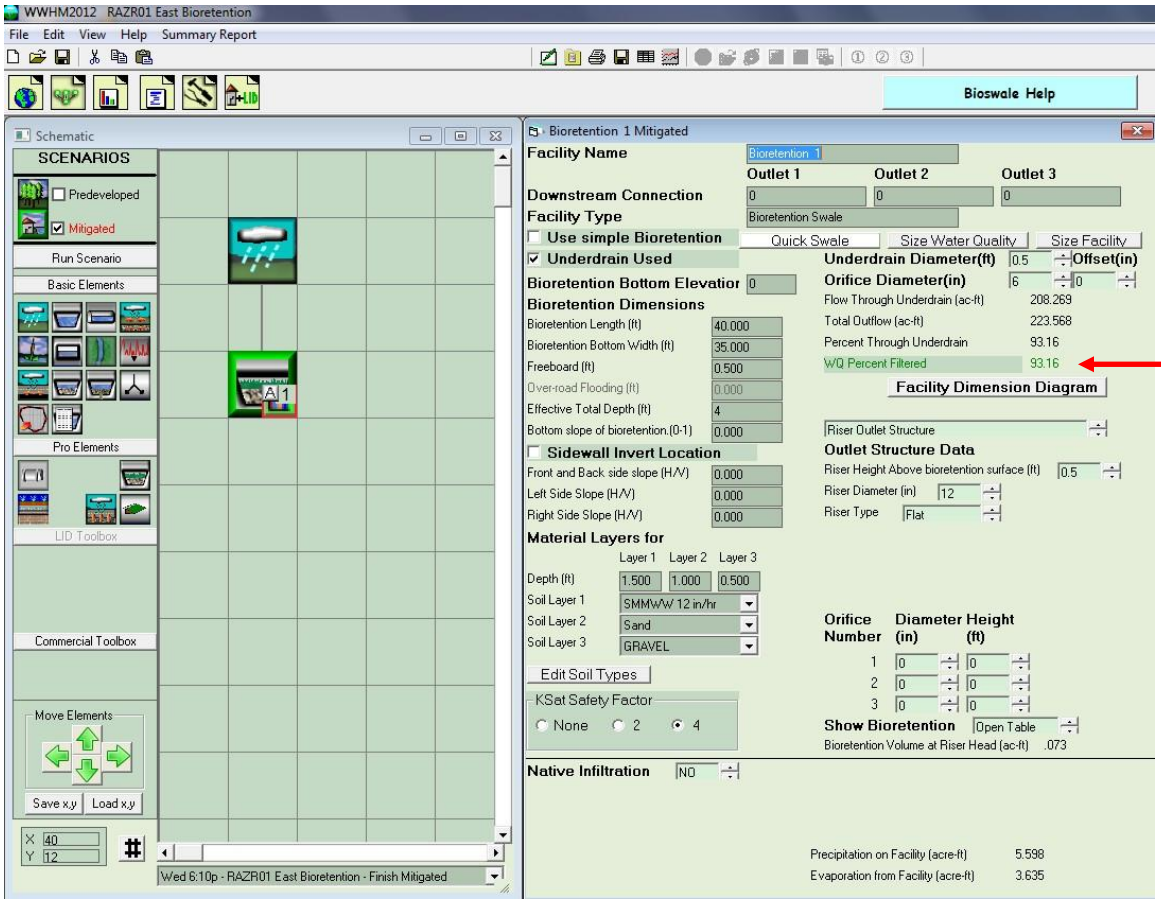
Impervious Land Use	**acre**
ROADS FLAT	**1.4**

Impervious Total **1.4**

Basin Total **1.4**

Element Flows To:

Surface	**Interflow**	**Groundwater**
Surface retention 1	Surface retention 1	



Name : Bioretention 1
Bottom Length: 40.00 ft.
Bottom Width: 35.00 ft.
Material thickness of first layer: 1.5
Material type for first layer: SMMWW 12 in/hr
Material thickness of second layer: 1
Material type for second layer: Sand
Material thickness of third layer: 0.5
Material type for third layer: GRAVEL

Underdrain used
Underdrain Diameter (feet): 0.5
Orifice Diameter (in.): 6
Offset (in.): 0
Flow Through Underdrain (ac-ft.): 208.269
Total Outflow (ac-ft.): 223.568
Percent Through Underdrain: 93.16
Discharge Structure
Riser Height: 0.5 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	0.0321	0.0000	0.0000	0.0000
0.0440	0.0321	0.0006	0.0000	0.0000
0.0879	0.0321	0.0013	0.0000	0.0000
0.1319	0.0321	0.0019	0.0000	0.0000
0.1758	0.0321	0.0026	0.0000	0.0000
0.2198	0.0321	0.0032	0.0000	0.0000
0.2637	0.0321	0.0039	0.0001	0.0000
0.3077	0.0321	0.0045	0.0002	0.0000
0.3516	0.0321	0.0052	0.0003	0.0000
0.3956	0.0321	0.0058	0.0005	0.0000
0.4396	0.0321	0.0065	0.0005	0.0000
0.4835	0.0321	0.0071	0.0009	0.0000
0.5275	0.0321	0.0078	0.0010	0.0000
0.5714	0.0321	0.0084	0.0013	0.0000
0.6154	0.0321	0.0090	0.0018	0.0000
0.6593	0.0321	0.0097	0.0019	0.0000
0.7033	0.0321	0.0103	0.0027	0.0000
0.7473	0.0321	0.0110	0.0028	0.0000
0.7912	0.0321	0.0116	0.0036	0.0000
0.8352	0.0321	0.0123	0.0041	0.0000
0.8791	0.0321	0.0129	0.0046	0.0000
0.9231	0.0321	0.0136	0.0056	0.0000
0.9670	0.0321	0.0142	0.0058	0.0000
1.0110	0.0321	0.0149	0.0072	0.0000
1.0549	0.0321	0.0155	0.0075	0.0000
1.0989	0.0321	0.0162	0.0088	0.0000
1.1429	0.0321	0.0168	0.0098	0.0000
1.1868	0.0321	0.0174	0.0106	0.0000
1.2308	0.0321	0.0181	0.0124	0.0000
1.2747	0.0321	0.0187	0.0126	0.0000
1.3187	0.0321	0.0194	0.0148	0.0000
1.3626	0.0321	0.0200	0.0154	0.0000
1.4066	0.0321	0.0207	0.0172	0.0000
1.4505	0.0321	0.0213	0.0187	0.0000
1.4945	0.0321	0.0220	0.0198	0.0000
1.5385	0.0321	0.0225	0.0225	0.0000
1.5824	0.0321	0.0231	0.0227	0.0000
1.6264	0.0321	0.0237	0.0257	0.0000

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
1.6703	0.0321	0.0242	0.0267	0.0000
1.7143	0.0321	0.0248	0.0291	0.0000
1.7582	0.0321	0.0254	0.0314	0.0000
1.8022	0.0321	0.0259	0.0326	0.0000
1.8462	0.0321	0.0265	0.0364	0.0000
1.8901	0.0321	0.0271	0.0365	0.0000
1.9341	0.0321	0.0276	0.0405	0.0000
1.9780	0.0321	0.0282	0.0421	0.0000
2.0220	0.0321	0.0287	0.0448	0.0000
2.0659	0.0321	0.0293	0.0481	0.0000
2.1099	0.0321	0.0299	0.0494	0.0000
2.1538	0.0321	0.0304	0.0543	0.0000
2.1978	0.0321	0.0310	0.0547	0.0000
2.2418	0.0321	0.0316	0.0595	0.0000
2.2857	0.0321	0.0321	0.0617	0.0000
2.3297	0.0321	0.0327	0.0649	0.0000
2.3736	0.0321	0.0333	0.0692	0.0000
2.4176	0.0321	0.0338	0.0721	0.0000
2.4615	0.0321	0.0344	0.0751	0.0000
2.5055	0.0321	0.0350	0.0751	0.0000
2.5495	0.0321	0.0356	0.0751	0.0000
2.5934	0.0321	0.0362	0.0751	0.0000
2.6374	0.0321	0.0367	0.0751	0.0000
2.6813	0.0321	0.0373	0.0751	0.0000
2.7253	0.0321	0.0379	0.0751	0.0000
2.7692	0.0321	0.0385	0.0751	0.0000
2.8132	0.0321	0.0391	0.0751	0.0000
2.8571	0.0321	0.0397	0.0751	0.0000
2.9011	0.0321	0.0403	0.0751	0.0000
2.9451	0.0321	0.0408	0.0751	0.0000
2.9890	0.0321	0.0414	0.0751	0.0000
3.0000	0.0321	0.0416	0.0751	0.0000

Surface retention 1 Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Wetted Surface
3.0000	0.0321	0.0416	0.0000	0.3059	0.0000
3.0440	0.0321	0.0430	0.0000	0.3059	0.0000
3.0879	0.0321	0.0444	0.0000	0.3112	0.0000
3.1319	0.0321	0.0458	0.0000	0.3165	0.0000
3.1758	0.0321	0.0472	0.0000	0.3217	0.0000
3.2198	0.0321	0.0486	0.0000	0.3270	0.0000
3.2637	0.0321	0.0501	0.0000	0.3323	0.0000
3.3077	0.0321	0.0515	0.0000	0.3376	0.0000
3.3516	0.0321	0.0529	0.0000	0.3429	0.0000
3.3956	0.0321	0.0543	0.0000	0.3482	0.0000
3.4396	0.0321	0.0557	0.0000	0.3535	0.0000
3.4835	0.0321	0.0571	0.0000	0.3587	0.0000
3.5275	0.0321	0.0585	0.0483	0.3640	0.0000
3.5714	0.0321	0.0599	0.2020	0.3693	0.0000
3.6154	0.0321	0.0614	0.4122	0.3746	0.0000
3.6593	0.0321	0.0628	0.6597	0.3799	0.0000
3.7033	0.0321	0.0642	0.9282	0.3852	0.0000
3.7473	0.0321	0.0656	1.2008	0.3904	0.0000
3.7912	0.0321	0.0670	1.4606	0.3957	0.0000
3.8352	0.0321	0.0684	1.6924	0.4010	0.0000

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Wetted
3.8791	0.0321	0.0698	1.8845	0.4063	0.0000
3.9231	0.0321	0.0712	2.0318	0.4116	0.0000
3.9670	0.0321	0.0727	2.1391	0.4169	0.0000
4.0000	0.0321	0.0737	2.2515	0.4208	0.0000

Name : Surface retention 1

Element Flows To:

Outlet 1	Outlet 2
Bioretention 1	

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:1.4
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:0
Total Impervious Area:1.4

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.001271
5 year	0.002615
10 year	0.004062
25 year	0.00683
50 year	0.009829
100 year	0.013901

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.445144
5 year	0.627344
10 year	0.747684
25 year	0.898944
50 year	1.010966
100 year	1.122424

Perlnd and Implnd Changes
No changes have been made.

WWHM2012
PROJECT REPORT

Project Name: RAZR01 Phase 2-W
Site Name: RAZR01: Semiahmoo Zone 3
Site Address: Phase 2 West Analysis
City : 6-17-2016 MJD
Report Date: 6/17/2016
Gage : Blaine
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 1.00
Version Date: 2016/03/03
Version : 4.2.12

Low Flow Threshold for POC 1 : 100 Percent of the 2 Year

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	2.85
Pervious Total	2.85

Impervious Land Use	acre
Impervious Total	0
Basin Total	2.85

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

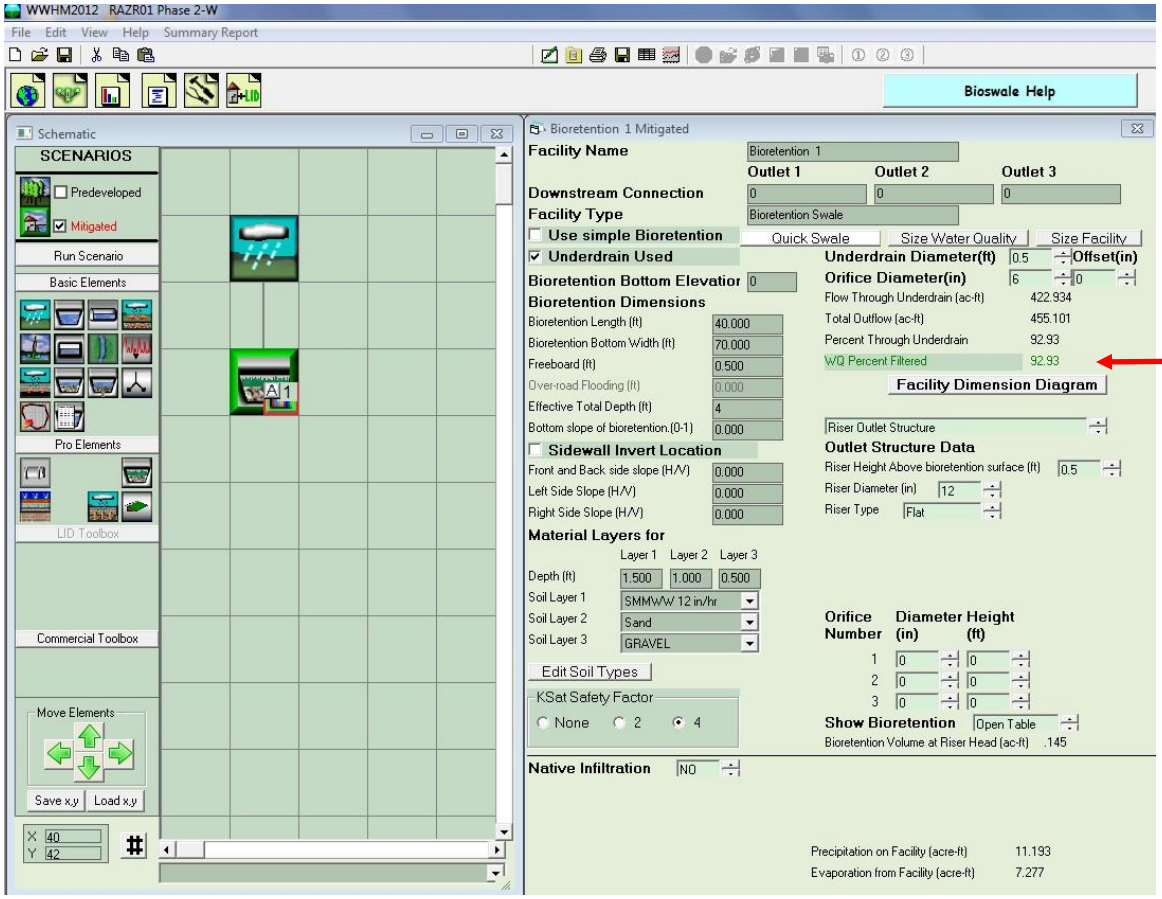
Pervious Land Use	acre

Pervious Total 0

Impervious Land Use	**acre**
ROADS FLAT	0.51
DRIVEWAYS FLAT	2.34
Impervious Total	2.85
Basin Total	2.85

Element Flows To:

Surface	**Interflow**	**Groundwater**
Surface retention 1	Surface retention 1	



Name : Bioretention 1
Bottom Length: 40.00 ft.
Bottom Width: 70.00 ft.
Material thickness of first layer: 1.5
Material type for first layer: SMMWW 12 in/hr
Material thickness of second layer: 1
Material type for second layer: Sand
Material thickness of third layer: 0.5
Material type for third layer: GRAVEL
Underdrain used

Underdrain Diameter (feet): 0.5
Orifice Diameter (in.): 6
Offset (in.): 0
Flow Through Underdrain (ac-ft.): 422.934
Total Outflow (ac-ft.): 455.101
Percent Through Underdrain: 92.93
Discharge Structure
Riser Height: 0.5 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	0.0643	0.0000	0.0000	0.0000
0.0440	0.0643	0.0013	0.0000	0.0000
0.0879	0.0643	0.0026	0.0000	0.0000
0.1319	0.0643	0.0039	0.0000	0.0000
0.1758	0.0643	0.0052	0.0001	0.0000
0.2198	0.0643	0.0065	0.0001	0.0000
0.2637	0.0643	0.0078	0.0002	0.0000
0.3077	0.0643	0.0090	0.0004	0.0000
0.3516	0.0643	0.0103	0.0005	0.0000
0.3956	0.0643	0.0116	0.0010	0.0000
0.4396	0.0643	0.0129	0.0011	0.0000
0.4835	0.0643	0.0142	0.0017	0.0000
0.5275	0.0643	0.0155	0.0021	0.0000
0.5714	0.0643	0.0168	0.0027	0.0000
0.6154	0.0643	0.0181	0.0036	0.0000
0.6593	0.0643	0.0194	0.0039	0.0000
0.7033	0.0643	0.0207	0.0053	0.0000
0.7473	0.0643	0.0220	0.0056	0.0000
0.7912	0.0643	0.0233	0.0071	0.0000
0.8352	0.0643	0.0245	0.0081	0.0000
0.8791	0.0643	0.0258	0.0092	0.0000
0.9231	0.0643	0.0271	0.0113	0.0000
0.9670	0.0643	0.0284	0.0117	0.0000
1.0110	0.0643	0.0297	0.0145	0.0000
1.0549	0.0643	0.0310	0.0151	0.0000
1.0989	0.0643	0.0323	0.0177	0.0000
1.1429	0.0643	0.0336	0.0196	0.0000
1.1868	0.0643	0.0349	0.0212	0.0000
1.2308	0.0643	0.0362	0.0248	0.0000
1.2747	0.0643	0.0375	0.0252	0.0000
1.3187	0.0643	0.0388	0.0296	0.0000
1.3626	0.0643	0.0401	0.0307	0.0000
1.4066	0.0643	0.0413	0.0344	0.0000
1.4505	0.0643	0.0426	0.0375	0.0000
1.4945	0.0643	0.0439	0.0396	0.0000
1.5385	0.0643	0.0451	0.0450	0.0000
1.5824	0.0643	0.0462	0.0453	0.0000
1.6264	0.0643	0.0473	0.0515	0.0000
1.6703	0.0643	0.0485	0.0535	0.0000

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
1.7143	0.0643	0.0496	0.0581	0.0000
1.7582	0.0643	0.0507	0.0628	0.0000
1.8022	0.0643	0.0518	0.0652	0.0000
1.8462	0.0643	0.0530	0.0729	0.0000
1.8901	0.0643	0.0541	0.0730	0.0000
1.9341	0.0643	0.0552	0.0810	0.0000
1.9780	0.0643	0.0564	0.0841	0.0000
2.0220	0.0643	0.0575	0.0897	0.0000
2.0659	0.0643	0.0586	0.0962	0.0000
2.1099	0.0643	0.0598	0.0989	0.0000
2.1538	0.0643	0.0609	0.1086	0.0000
2.1978	0.0643	0.0620	0.1093	0.0000
2.2418	0.0643	0.0631	0.1189	0.0000
2.2857	0.0643	0.0643	0.1234	0.0000
2.3297	0.0643	0.0654	0.1298	0.0000
2.3736	0.0643	0.0665	0.1385	0.0000
2.4176	0.0643	0.0677	0.1442	0.0000
2.4615	0.0643	0.0688	0.1503	0.0000
2.5055	0.0643	0.0700	0.1503	0.0000
2.5495	0.0643	0.0711	0.1503	0.0000
2.5934	0.0643	0.0723	0.1503	0.0000
2.6374	0.0643	0.0735	0.1503	0.0000
2.6813	0.0643	0.0747	0.1503	0.0000
2.7253	0.0643	0.0758	0.1503	0.0000
2.7692	0.0643	0.0770	0.1503	0.0000
2.8132	0.0643	0.0782	0.1503	0.0000
2.8571	0.0643	0.0793	0.1503	0.0000
2.9011	0.0643	0.0805	0.1503	0.0000
2.9451	0.0643	0.0817	0.1503	0.0000
2.9890	0.0643	0.0829	0.1503	0.0000
3.0000	0.0643	0.0832	0.1503	0.0000

Surface retention 1 Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Wetted Surface
3.0000	0.0643	0.0832	0.0000	0.6118	0.0000
3.0440	0.0643	0.0860	0.0000	0.6118	0.0000
3.0879	0.0643	0.0888	0.0000	0.6223	0.0000
3.1319	0.0643	0.0916	0.0000	0.6329	0.0000
3.1758	0.0643	0.0945	0.0000	0.6435	0.0000
3.2198	0.0643	0.0973	0.0000	0.6540	0.0000
3.2637	0.0643	0.1001	0.0000	0.6646	0.0000
3.3077	0.0643	0.1029	0.0000	0.6752	0.0000
3.3516	0.0643	0.1058	0.0000	0.6858	0.0000
3.3956	0.0643	0.1086	0.0000	0.6963	0.0000
3.4396	0.0643	0.1114	0.0000	0.7069	0.0000
3.4835	0.0643	0.1142	0.0000	0.7175	0.0000
3.5275	0.0643	0.1171	0.0483	0.7280	0.0000
3.5714	0.0643	0.1199	0.2020	0.7386	0.0000
3.6154	0.0643	0.1227	0.4122	0.7492	0.0000
3.6593	0.0643	0.1255	0.6597	0.7598	0.0000
3.7033	0.0643	0.1284	0.9282	0.7703	0.0000
3.7473	0.0643	0.1312	1.2008	0.7809	0.0000
3.7912	0.0643	0.1340	1.4606	0.7915	0.0000
3.8352	0.0643	0.1368	1.6924	0.8020	0.0000
3.8791	0.0643	0.1397	1.8845	0.8126	0.0000

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	To Amended(cfs)	Wetted Surface
3.9231	0.0643	0.1425	2.0318	0.8232	0.0000
3.9670	0.0643	0.1453	2.1391	0.8337	0.0000
4.0000	0.0643	0.1474	2.2515	0.8417	0.0000

Name : Surface retention 1

Element Flows To:

Outlet 1	Outlet 2
Bioretention 1	

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:2.85
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:0
Total Impervious Area:2.85

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.002587
5 year	0.005323
10 year	0.008269
25 year	0.013904
50 year	0.020008
100 year	0.028299

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.874823
5 year	1.227375
10 year	1.459462
25 year	1.750497
50 year	1.965614
100 year	2.179341

Perlnd and Implnd Changes
No changes have been made.

1.0 PROJECT PRECIPS

Event	Precip (in)
2 yr 24 hr	2.00
10 year	3.00
25 year	3.60
100 year	4.50

2.0 RECORD ID: PRE-DEV

Design Method	SCS	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	2.85 ac	**DCIA**	0.00 ac
Pervious CN	70.00	**DC CN**	0.00
Pervious TC	77.3503 min	**DC TC**	0.00 min

Pervious CN Calc

Description	SubArea	Sub cn
Forested Area	2.85 ac	70.00
Pervious Composited CN (AMC 2)		70.00

Pervious TC Calc

Type	Description	Length	Slope	Coeff	Misc	TT
Sheet	Woods or forest with dense underbrush.	300.00 ft	5.7%	0.8	2.00 in	74.9123 min
Shallow	thru forest	175.00 ft	5.0%	0.06		2.438 min
Pervious TC						77.3503 min

3.0 RECORD ID: POST-DEV

Design Method	SCS	**Rainfall type**	TYPE1A.RAC
Hyd Intv	10.00 min	**Peaking Factor**	484.00
Storm Duration	24.00 hrs	**Abstraction Coeff**	0.20
Pervious Area	0.00 ac	**DCIA**	2.85 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	0.00 min	**DC TC**	5.00 min

DCI - CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	2.85 ac	98.00
DC Composited CN (AMC 2)		98.00

DCI - TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet	Smooth Surfaces.	12.00 ft	2.0%	0.011	0.00 in	0.281 min
Shallow	Paved and gravel areas (n=0.012)	150.00 ft	1.5%	0.012		0.7631 min
Int Channel	Pipe flow to pond	300.00 ft	0.7%	0.012		1.4073 min
Pervious TC						2.4514 min

4.0 BASIN FLOW RATES

BasinID	Event	Peak Q (cfs)	Peak T (hrs)	Peak Vol (ac-cf)	Area (ac)	Method/Loss	Raintype
Pre-Dev	2 yr 24 hr	0.0484	17.64	0.0573	2.85	SCS	TYPE1A.RAC
Post-Dev	2 yr 24 hr	1.2675	8.01	0.4223	2.85	SCS	TYPE1A.RAC
Pre-Dev	25 year	0.3111	9.05	0.2547	2.85	SCS	TYPE1A.RAC
Post-Dev	25 year	2.3473	8.01	0.8011	2.85	SCS	TYPE1A.RAC
Pre-Dev	100 year	0.5727	8.96	0.3983	2.85	SCS	TYPE1A.RAC
Post-Dev	100 year	2.9496	8.01	1.0148	2.85	SCS	TYPE1A.RAC

5.0 RECORD ID: POND

Descrip:	Prototype Record	Increment	0.10 ft
Start El.	100.00 ft	Max El.	105.00 ft
Void Ratio	100.00		
Length	75.00 ft	Width	50.00 ft
Length ss1	3.00v:1h	Length ss2	3.00v:1h
Width ss1	3.00v:1h	Width ss2	3.00v:1h
Consider wetted surface for infiltration			
Trap Type Node			

6.0 RECORD ID: COMBO

Combination Discharge Structure			
Descrip:	Orifice & Riser	**Increment**	0.10 ft

Start El.	100.00 ft	**Max El.**	105.00 ft
List of Controls		Orifice Riser	

7.0 RECORD ID: ORIFICE

Multiple Orifice			
Descrip:	Prototype Structure	**Increment**	0.10 ft
Start El.	100.00 ft	**Max El.**	105.00 ft
Orif Coeff	0.62	**Lowest Orif El.**	100.00 ft
Lowest Diam	1.00 in	**Dist to next**	3.10 ft
D2	3.50 in	**Dist to next**	0.00 ft

8.0 RECORD ID: RISER

Overflow Riser			
Descrip:	Riser	**Increment**	0.10 ft
Start El.	104.00 ft	**Max El.**	105.00 ft
Riser Diam		12.00 in	
Weir Coeff	9.739	**Orif Coeff**	3.782

9.0 LPOOLCOMPUTE [RLP] SUMMARY USING PULS, 24 HR STORM EVENT

Start of live storage:100 ft

Event	Match Q (cfs)	Peak Q (cfs)	Max Depth (ft)	Vol (cf)	Vol (acft)	Time to Empty (hr)
2 yr 24 hr	0.0484	0.0477	3.0909	15528.4445	0.3565	149.6876
25 year	0.3111	0.3104	3.7032	19639.2362	0.4509	147.1293
100 year	0.5727	0.5316	4.0497	22134.9304	0.5081	146.0599

Appended on: Friday, June 17, 2016 3:14:57 PM

Table 2.3.2
Runoff Curve Numbers for Selected Agricultural, Suburban, and Urban Areas

(Sources: TR 55, 1986, and Stormwater Management Manual, 1992. See Section 2.1.1 for explanation)

Cover type and hydrologic condition.	CNs for hydrologic soil group A	B	C	D
Curve Numbers for Pre-Development Conditions				
Pasture, grassland, or range-continuous forage for grazing:				
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77
Curve Numbers for Post-Development Conditions				
Open space (lawns, parks, golf courses, cemeteries, landscaping, etc.)[1]				
Fair condition (grass cover on 50% - 75% of the area).	77	85	90	92
Good condition (grass cover on >75% of the area)	68	80	86	90
Impervious areas:				
Open water bodies: lakes, wetlands, ponds etc.	100	100	100	100
Paved parking lots, roofs[2], driveways, etc. (excluding right-of-way)	98	98	98	98
Permeable Pavement (See Appendix C to decide which condition below to use)				
Landscaped area	77	85	90	92
50% landscaped area/50% impervious	87	91	94	96
100% impervious area	98	98	98	98
Paved	98	98	98	98
Gravel (including right-of-way)	76	85	89	91
Dirt (including right-of-way)	72	82	87	89
Pasture, grassland, or range-continuous forage for grazing:				
Poor condition (ground cover <50% or heavily grazed with no mulch).	68	79	86	89
Fair condition (ground cover 50% to 75% and not heavily grazed).	49	69	79	84
Good condition (ground cover >75% and lightly or only occasionally grazed)	39	61	74	80
Woods:				
Poor (Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning).	45	66	77	83
Fair (Woods are grazed but not burned, and some forest litter covers the soil).	36	60	73	79
Good (Woods are protected from grazing, and litter and brush adequately cover the soil).	30	55	70	77

Single family residential[3]: Dwelling Unit/Gross Acre	Should only be used for subdivisions > 50 acres	Average Percent impervious area[3,4]	
1.0 DU/GA		15	Separate curve number
1.5 DU/GA		20	shall be selected for
2.0 DU/GA		25	pervious & impervious
2.5 DU/GA		30	portions of the site or
3.0 DU/GA		34	basin
3.5 DU/GA		38	
4.0 DU/GA		42	
4.5 DU/GA		46	
5.0 DU/GA		48	
5.5 DU/GA		50	
6.0 DU/GA		52	
6.5 DU/GA		54	
7.0 DU/GA		56	
7.5 DU/GA		58	

PUD's, condos, apartments, commercial businesses, industrial areas & & subdivisions < 50 acres	%impervious must be computed	Separate curve numbers shall be selected for pervious and impervious portions of the site

For a more detailed and complete description of land use curve numbers refer to chapter two (2) of the Soil Conservation Service's Technical Release No. 55 , (210-VI-TR-55, Second Ed., June 1986).

[1] Composite CN's may be computed for other combinations of open space cover type.

[2]Where roof runoff and driveway runoff are infiltrated or dispersed according to the requirements in Chapter 3, the average percent impervious area may be adjusted in accordance with the procedure described under "Flow Credit for Roof Downspout Infiltration" (Section 3.1.1), and "Flow Credit for Roof Downspout Dispersion" (Section 3.1.2).

[3]Assumes roof and driveway runoff is directed into street/storm system.

[4]All the remaining pervious area (lawn) are considered to be in good condition for these curve numbers.

APPENDIX C
Boundary Ridge System

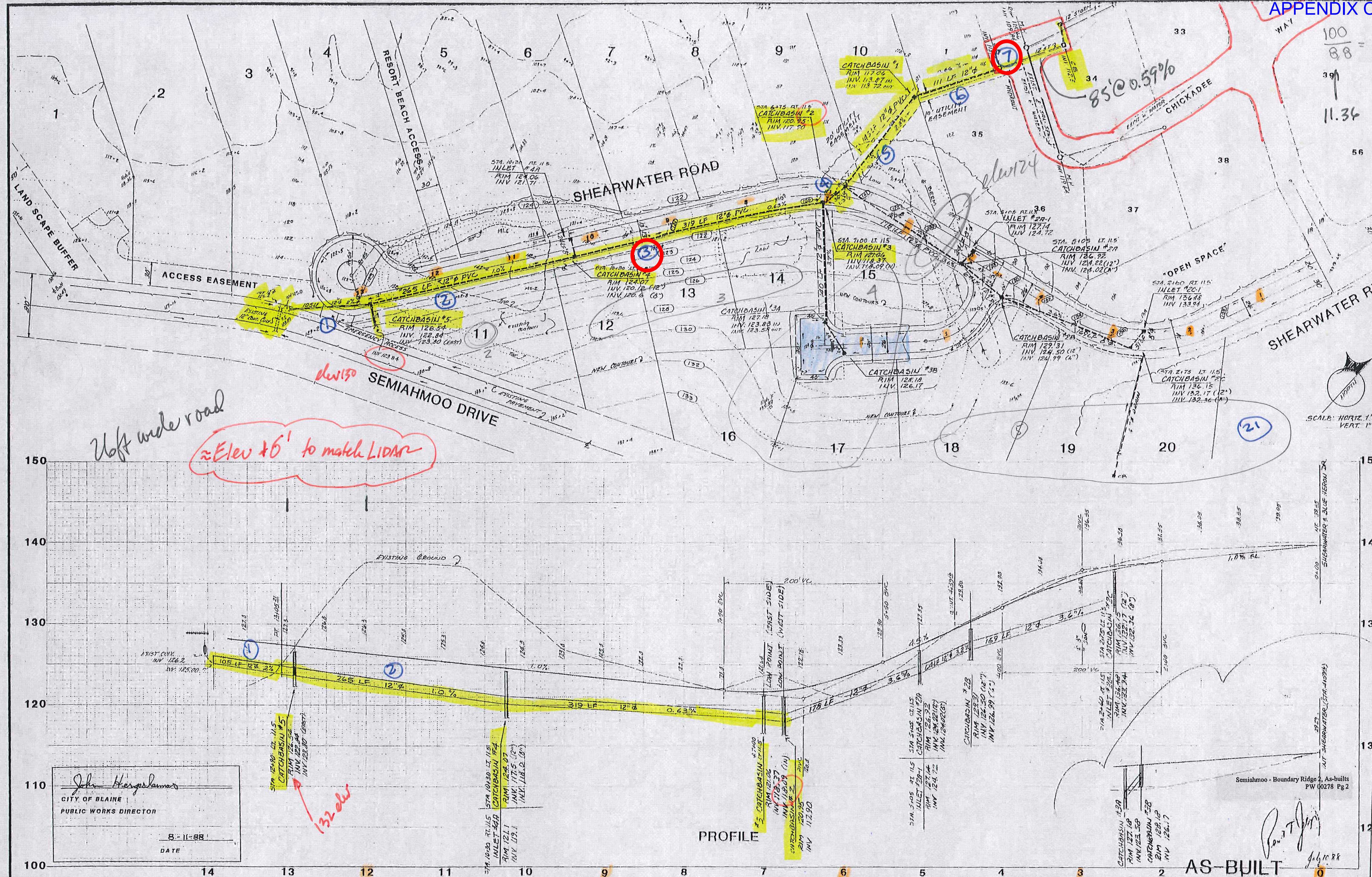
- Drawing: *Boundary Ridge Division 2, Roadway & Drainage, As-Built*, Ronald T. Jepson & Associates, August 11, 1988. (one sheet)

- Drawings: Boundary Ridge (Division 1), Street Plan & Profiles, Record Drawings Sheets 1 and 2, George H. Raper & Associates, April 1984.

- Boundary Ridge Division 2 Pipe Capacity Analysis

- Boundary Ridge WWHM Analysis – Model and Summary of Results Table

APPENDIX C



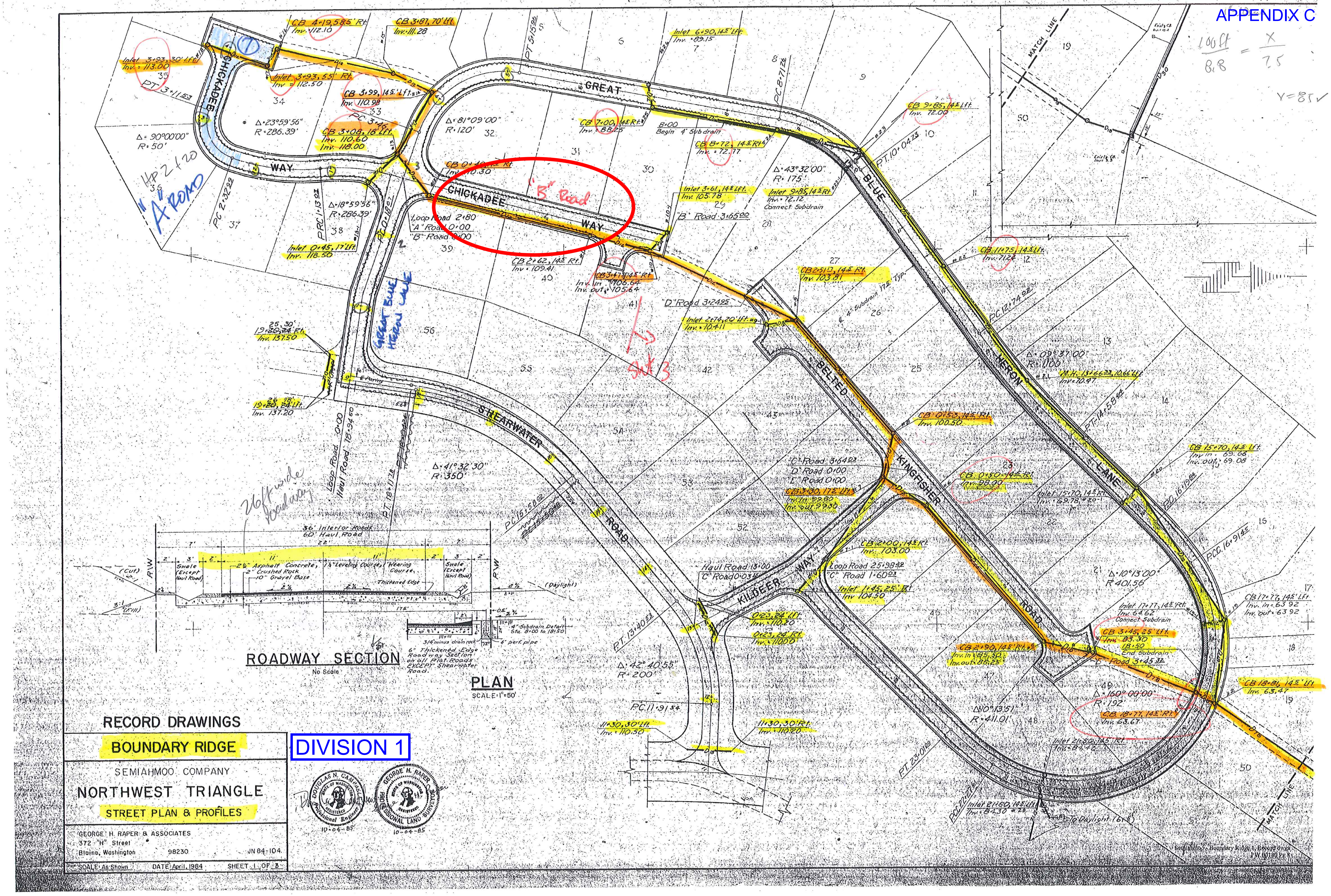
RONALD T. JEPSON & ASSOC

REGISTERED PROFESSIONAL ENGINEERS AND LAND SURVEYORS 322 COMMERCIAL, SUITE 301, BELLINGHAM WASHINGTON

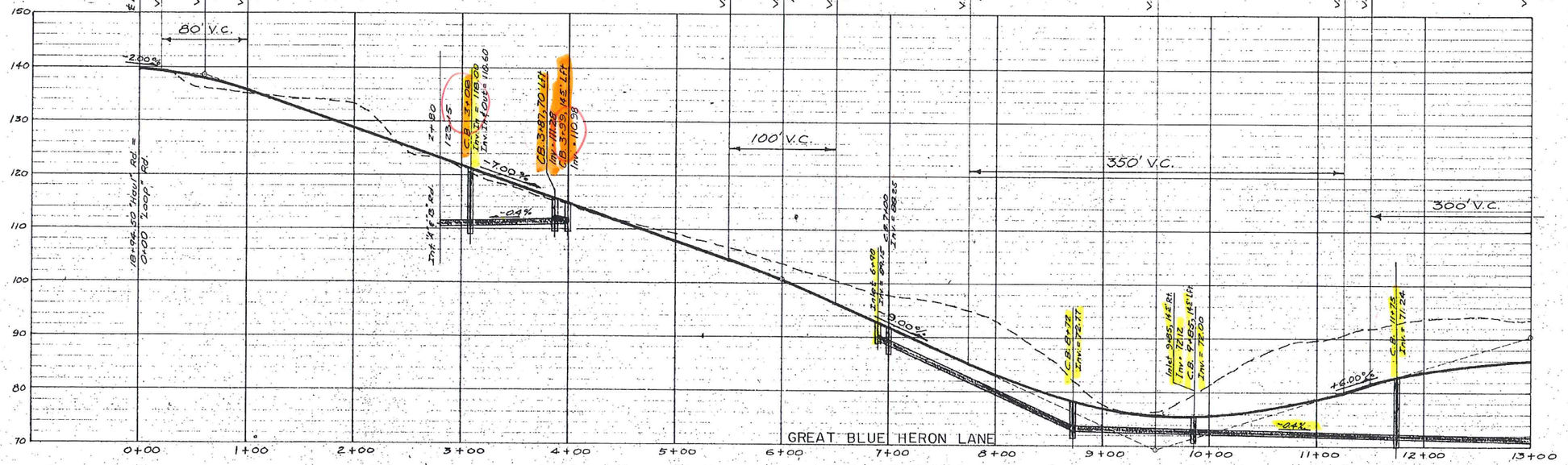
ROADWAY & DRAINAGE

"RESORT SEMIAHMOO" BOUNDARY RIDGE DIV. 2

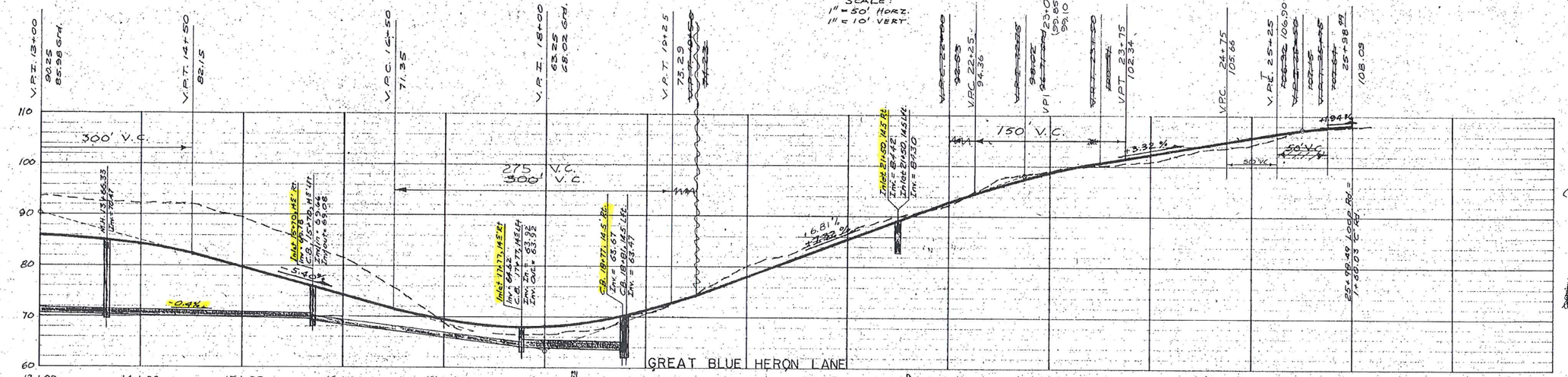
APPENDIX C


CHICKADEE WAY
GREAT BLUE HERON LANE
SHEARWATER ROAD
KILDEER WAY
BELTED KINGFISHER ROAD
MATCH LINE
"A" ROAD
"B" Road
ROADWAY SECTION
No Scale
PLAN
SCALE: 1"=50'
RECORD DRAWINGS
BOUNDARY RIDGE
DIVISION 1
SEMIAHMOO COMPANY
NORTHWEST TRIANGLE
STREET PLAN & PROFILES
GEORGE H. RAPER & ASSOCIATES
372 "H" Street
Blaine, Washington 98230
JN 84-104
SCALE: As Shown
DATE: April, 1984
SHEET 1 OF 3

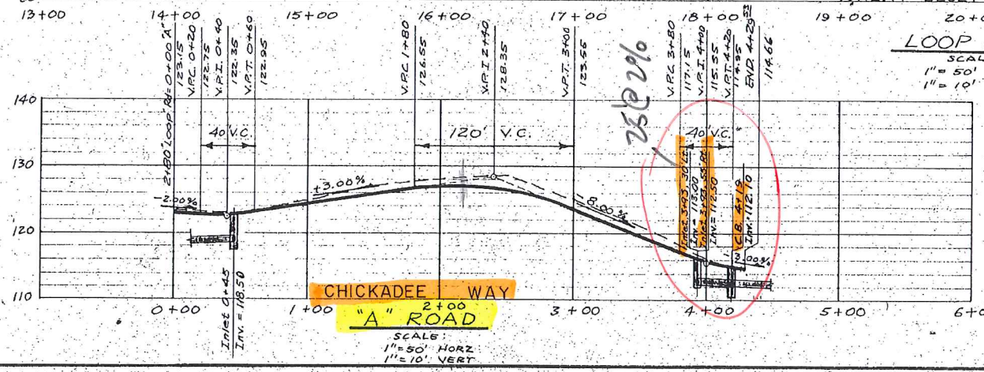
APPENDIX C

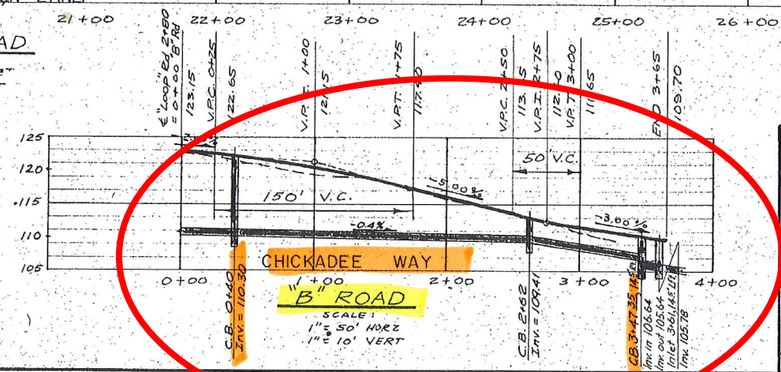


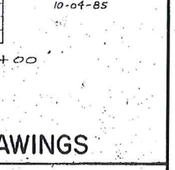
LOOP ROAD
SCALE:
1" = 50' HORZ.
1" = 10' VERT.



LOOP ROAD
SCALE:
1" = 50' HORZ.
1" = 10' VERT.







RECORD DRAWINGS

BOUNDARY RIDGE

SEMIAHMOO COMPANY

NORTHWEST TRIANGLE

STREET PLAN & PROFILES

GEORGE H. RAPER & ASSOCIATES
372 "H" Street
Blaine, Washington 98230 JN 84-104

SCALE: As Shown DATE: April, 1984 SHEET 2 OF 3

RAZR01: Semiahmoo Zone 3

Boundary Ridge Stormwater Conveyance System Analysis

June 20, 2016

Manning Pipe Flow: $Q = (1.49/n)(A)(R^{2/3})(s^{1/2})$

		Pipe						Actual Flow						
	Pipe Section	Dia. (in)	C S Area (full) (ft2)	Type n	Slope (ft/ft)	V_F (pipe full) (ft/sec)	Q_F (pipe full) (cfs)	y (in)	CS Area (actual) (ft2)	a	Perimeter (actual) (ft)	HR (actual) (ft)	V (actual) (ft/sec)	Q (actual) (cfs)
BR Div 2	1	12	0.785	0.012	0.02	6.97	5.47	11.26	0.765	151.24	2.64	0.29	7.7	5.89
BR Div 2	2	12	0.785	0.012	0.01	4.93	3.87	11.26	0.765	151.24	2.64	0.29	5.4	4.16
BR Div 2	3	12	0.785	0.012	0.0063	3.91	3.07	11.26	0.765	151.24	2.64	0.29	4.3	3.30
BR Div 2	4	12	0.785	0.012	0.013	5.62	4.41	11.26	0.765	151.24	2.64	0.29	6.2	4.75
BR Div 2	5	12	0.785	0.012	0.028	8.25	6.48	11.26	0.765	151.24	2.64	0.29	9.1	6.97
BR Div 2	6	12	0.785	0.012	0.0066	4.00	3.14	11.26	0.765	151.24	2.64	0.29	4.4	3.38
BR Div 1	7	12	0.785	0.012	0.0059	3.78	2.97	11.26	0.765	151.24	2.64	0.29	4.2	3.20
BR Div 1	CW-N	12	0.785	0.012	0.004	3.12	2.45	11.26	0.765	151.24	2.64	0.29	3.4	2.63

IMPERVIOUS AREA											Road + Homes		Cumulative Area
	Pipe Section	Start	Finish	Length*	Road Area Width	Area	# of Homes	House Area	Driveway Area	Total Area (sf)	(sf)	(acres)	(acres)
BR Div 2	1	Semiahmoo Drive	Shearwater Rd	0	26	-	0			-	-	0.000	0.000
BR Div 2	2	Shearwater Rd	Shearwater Rd	265	26	6,890	1	3,000	1,000	4,000	10,890	0.250	0.250
BR Div 2	3	Shearwater Rd	Shearwater Rd	319	26	8,294	3	3,000	1,000	12,000	20,294	0.466	0.716
BR Div 2	4	Shearwater Rd	Shearwater Rd	36	26	6,076	3	3,000	1,000	12,000	18,076	0.415	1.131
BR Div 2	5	Shearwater Rd	Lot 10	790	26	20,540	4	3,000	1,000	16,000	36,540	0.839	1.970
BR Div 2	6	Lot 10	Chickadee Ct.	0	0	-	0			-	-	0.000	1.970
BR Div 1	7	Chickadee Ct.	Chickadee Ct.	235	26	18,148	2	3,000	1,000	8,000	26,148	0.600	2.570
							13			52,000			

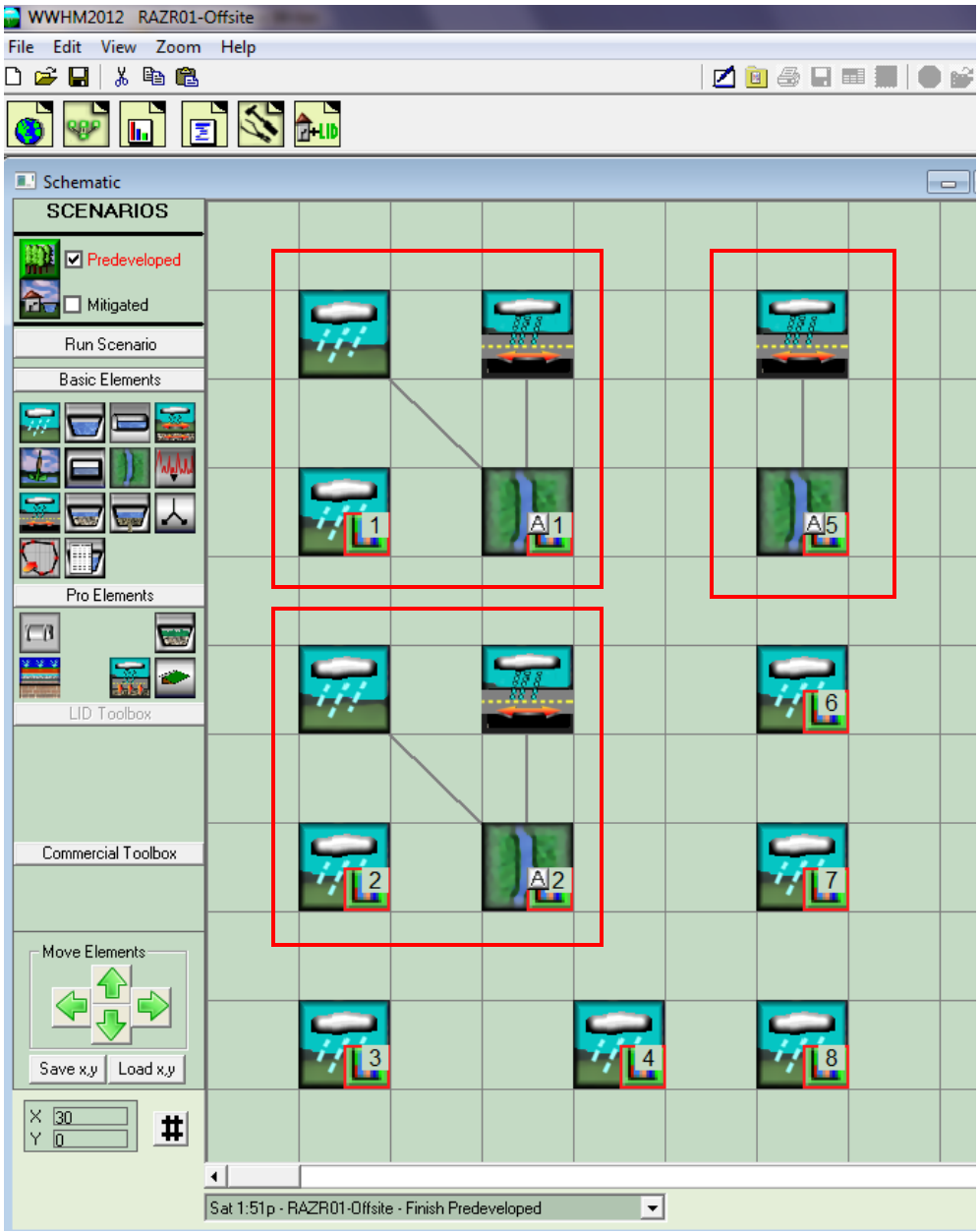
* Includes road lengths from upstream areas

LATERAL BASIN	Semiahmoo Drive	1900	26	49,400	0			-	49,400	1.134	1.134

PERVIOUS AREA (LOTS)			Lot Area	Total Home Area	Landscape	
Pipe Section	Start	Finish	(sf)	(sf)	Area	(acres)
1	Semiahmoo Drive	Shearwater Rd		-		
2	Shearwater Rd	Shearwater Rd				
3	Shearwater Rd	Shearwater Rd	90,000	16,000	74,000	1.699
4	Shearwater Rd	Shearwater Rd				
5	Shearwater Rd	Lot 10				
6	Lot 10	Chickadee Ct.				
7	Chickadee Ct.	Chickadee Ct.	352,500	52,000	300,500	6.899

WWHM2012
PROJECT REPORT

Project Name: RAZR01-Offsite
Site Name: RAZR01: Semiahmoo Zone 3
Site Address: Offsite Conveyance Analysis
City : 6-9-2016
Report Date: 6/18/2016
Gage : Blaine
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 1.00
Version Date: 2016/03/03
Version : 4.2.12



NOTE: SINCE ONLY PRE-DEVELOPMENTS FLOW RATES ARE TO BE DETERMINED FOR THIS EVALUATION NO POST-DEVELOPMENT BASINS AND DETENTION FACILITIES ARE NEEDED.

SCENARIO 1/POC 1: AREA TO PIPE 3

PREDEVELOPED LAND USE

Name : Offsite Upstream Forest 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	90.8
Pervious Total	90.8

Impervious Land Use	acre
Impervious Total	0
Basin Total	90.8

Element Flows To:

Surface	Interflow	Groundwater
Channel 1	Channel 1	

Name : Semiahmoo Drive Runoff 1
Bypass: No

Impervious Land Use	acre
ROADS FLAT LAT	1.134

Element Flows To:

Outlet 1	Outlet 2
Channel 1	

Name : Channel 1
Bottom Length: 1900.00 ft.
Bottom Width: 2.00 ft.
Manning's n: 0.03
Channel bottom slope 1: 0.01 To 1
Channel Left side slope 0: 3 To 1
Channel right side slope 2: 3 To 1
Infiltration On
Infiltration rate: 0.5
Infiltration safety factor: 1
Total Volume Infiltrated (ac-ft.): 121.049
Total Volume Through Riser (ac-ft.): 69.785
Total Volume Through Facility (ac-ft.): 190.833
Percent Infiltrated: 63.43
Total Precip Applied to Facility: 0

Total Evap From Facility: 0
Discharge Structure
Riser Height: 0 ft.
Riser Diameter: 0 in.

Element Flows To:
Outlet 1 **Outlet 2**

Channel Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.087	0.000	0.000	0.000
0.0111	0.090	0.001	0.005	0.044
0.0222	0.093	0.002	0.017	0.044
0.0333	0.096	0.003	0.034	0.044
0.0444	0.098	0.004	0.056	0.044
0.0556	0.101	0.005	0.082	0.044
0.0667	0.104	0.006	0.112	0.044
0.0778	0.107	0.007	0.146	0.044
0.0889	0.110	0.008	0.183	0.044
0.1000	0.113	0.010	0.224	0.044
0.1111	0.116	0.011	0.269	0.044
0.1222	0.119	0.012	0.318	0.044
0.1333	0.122	0.014	0.370	0.044
0.1444	0.125	0.015	0.426	0.044
0.1556	0.127	0.016	0.485	0.044
0.1667	0.130	0.018	0.548	0.044
0.1778	0.133	0.019	0.615	0.044
0.1889	0.136	0.021	0.685	0.044
0.2000	0.139	0.022	0.758	0.044
0.2111	0.142	0.024	0.836	0.044
0.2222	0.145	0.025	0.917	0.044
0.2333	0.148	0.027	1.002	0.044
0.2444	0.151	0.029	1.090	0.044
0.2556	0.154	0.030	1.182	0.044
0.2667	0.157	0.032	1.279	0.044
0.2778	0.159	0.034	1.378	0.044
0.2889	0.162	0.036	1.482	0.044
0.3000	0.165	0.037	1.590	0.044
0.3111	0.168	0.039	1.701	0.044
0.3222	0.171	0.041	1.816	0.044
0.3333	0.174	0.043	1.936	0.044
0.3444	0.177	0.045	2.059	0.044
0.3556	0.180	0.047	2.187	0.044
0.3667	0.183	0.049	2.318	0.044
0.3778	0.186	0.051	2.454	0.044
0.3889	0.189	0.053	2.593	0.044
0.4000	0.191	0.055	2.737	0.044
0.4111	0.194	0.058	2.885	0.044
0.4222	0.197	0.060	3.037	0.044
0.4333	0.200	0.062	3.194	0.044
0.4444	0.203	0.064	3.355	0.044
0.4556	0.206	0.066	3.520	0.044
0.4667	0.209	0.069	3.690	0.044
0.4778	0.212	0.071	3.864	0.044
0.4889	0.215	0.073	4.042	0.044

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.5000	0.218	0.076	4.225	0.044
0.5111	0.221	0.078	4.413	0.044
0.5222	0.223	0.081	4.605	0.044
0.5333	0.226	0.083	4.801	0.044
0.5444	0.229	0.086	5.003	0.044
0.5556	0.232	0.088	5.209	0.044
0.5667	0.235	0.091	5.419	0.044
0.5778	0.238	0.094	5.635	0.044
0.5889	0.241	0.096	5.855	0.044
0.6000	0.244	0.099	6.080	0.044
0.6111	0.247	0.102	6.310	0.044
0.6222	0.250	0.104	6.545	0.044
0.6333	0.253	0.107	6.784	0.044
0.6444	0.255	0.110	7.029	0.044
0.6556	0.258	0.113	7.278	0.044
0.6667	0.261	0.116	7.533	0.044
0.6778	0.264	0.119	7.793	0.044
0.6889	0.267	0.122	8.057	0.044
0.7000	0.270	0.125	8.327	0.044
0.7111	0.273	0.128	8.602	0.044
0.7222	0.276	0.131	8.882	0.044
0.7333	0.279	0.134	9.168	0.044
0.7444	0.282	0.137	9.459	0.044
0.7556	0.285	0.140	9.755	0.044
0.7667	0.287	0.143	10.05	0.044
0.7778	0.290	0.147	10.36	0.044
0.7889	0.293	0.150	10.67	0.044
0.8000	0.296	0.153	10.99	0.044
0.8111	0.299	0.156	11.31	0.044
0.8222	0.302	0.160	11.64	0.044
0.8333	0.305	0.163	11.97	0.044
0.8444	0.308	0.167	12.31	0.044
0.8556	0.311	0.170	12.66	0.044
0.8667	0.314	0.173	13.01	0.044
0.8778	0.317	0.177	13.37	0.044
0.8889	0.319	0.180	13.73	0.044
0.9000	0.322	0.184	14.10	0.044
0.9111	0.325	0.188	14.47	0.044
0.9222	0.328	0.191	14.85	0.044
0.9333	0.331	0.195	15.24	0.044
0.9444	0.334	0.199	15.63	0.044
0.9556	0.337	0.202	16.02	0.044
0.9667	0.340	0.206	16.43	0.044
0.9778	0.343	0.210	16.84	0.044
0.9889	0.346	0.214	17.25	0.044
1.0000	0.348	0.218	17.67	0.044
1.0111	0.351	0.222	18.10	0.044

Name : Lot Areas Up to Pipe 3
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	1.699
Pervious Total	1.699

Impervious Land Use	acre
ROADS FLAT	0.716
Impervious Total	0.716
Basin Total	2.415

Element Flows To:

Surface	Interflow	Groundwater

SCENARIO 2/POC 2: AREA TO PIPE 7

Name : Offsite Upstream Forest 2
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Forest, Flat	90.8
Pervious Total	90.8

Impervious Land Use	acre
Impervious Total	0
Basin Total	90.8

Element Flows To:

Surface	Interflow	Groundwater
Channel 2	Channel 2	

Name : Semiahmoo Drive Runoff 2
Bypass: No

Impervious Land Use	acre
ROADS FLAT LAT	1.134

Element Flows To:

Outlet 1	Outlet 2
Channel 2	

Name : Lot Areas up to Pipe 7
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	6.899
Pervious Total	6.899

Impervious Land Use	acre
ROADS FLAT	2.57
Impervious Total	2.57
Basin Total	9.469

Element Flows To:
Surface Interflow Groundwater

SCENARIO 3/POC 3: BOUNDARY RIDGE ONLY AREA TO PIPE 3

Name : Boundary Ridge Only
Bypass: No

GroundWater: No

Pervious Land Use	acre
A B, Lawn, Flat	1.699
Pervious Total	1.699

Impervious Land Use	acre
DRIVEWAYS FLAT	0.716
Impervious Total	0.716
Basin Total	2.415

Element Flows To:
Surface Interflow Groundwater

SCENARIO 4/POC 4: BOUNDARY RIDGE ROADS ONLY TO PIPE 3

Name : Basin 6
Bypass: No

GroundWater: No

Pervious Land Use	acre
Pervious Total	0

Impervious Land Use	acre
ROADS FLAT	0.716

Impervious Total 0.716

Basin Total 0.716

Element Flows To:
Surface **Interflow** **Groundwater**

SCENARIO 5/POC 5: SEMIAHMOO PARKWAY ONLY

Name : Lateral I Basin 3
Bypass: No

Impervious Land Use	**acre**
ROADS FLAT LAT	**1.134**

Element Flows To:
Outlet 1 **Outlet 2**
Channel 3

SCENARIO 6/POC 6: OFFSITE FOREST AREA ONLY

Name : Basin 7
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Forest, Flat	**90.8**

Pervious Total 90.8

Impervious Land Use	**acre**

Impervious Total 0

Basin Total 90.8

Element Flows To:
Surface **Interflow** **Groundwater**

SCENARIO 7/POC 7: BOUNDARY RIDGE AREA ONLY TO PIPE 7

Name : BOUNDARY RIDGE 7
Bypass: No

GroundWater: No

Pervious Land Use	**acre**
A B, Lawn, Flat	**6.899**

Pervious Total 6.899

Impervious Land Use	acre
ROADS FLAT	2.57
Impervious Total	2.57
Basin Total	9.469

Element Flows To:
Surface Interflow Groundwater

SCENARIO 8/POC 8: BOUNDARY RIDGE ROADS ONLY TO PIPE 7

Name : Boundary Ridge 7 - imperv
Bypass: No

GroundWater: No

Pervious Land Use	acre
Pervious Total	0

Impervious Land Use	acre
ROADS FLAT	2.57
Impervious Total	2.57
Basin Total	2.57

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.6216
5 year	0.9189
10 year	1.1468
25 year	1.4718
50 year	1.7422
100 year	2.0379

Flow Frequency Return Periods for Predeveloped. POC #2

Return Period	Flow(cfs)
2 year	1.4613
5 year	2.1484
10 year	2.6615
25 year	3.3775
50 year	3.9611
100 year	4.5886

Flow Frequency Return Periods for Predeveloped. POC #3

Return Period	Flow(cfs)
2 year	0.3273
5 year	0.4725
10 year	0.5771

25 year	0.7188
50 year	0.8312
100 year	0.9495

Flow Frequency Return Periods for Predeveloped. POC #4

Return Period	Flow(cfs)
2 year	0.3005
5 year	0.4018
10 year	0.4692
25 year	0.5549
50 year	0.6193
100 year	0.6842

Flow Frequency Return Periods for Predeveloped. POC #5

Return Period	Flow(cfs)
2 year	0.3156
5 year	0.4362
10 year	0.5203
25 year	0.6315
50 year	0.7178
100 year	0.8071

Flow Frequency Return Periods for Predeveloped. POC #6

Return Period	Flow(cfs)
2 year	0.0824
5 year	0.1696
10 year	0.2634
25 year	0.4430
50 year	0.6375
100 year	0.9016

Flow Frequency Return Periods for Predeveloped. POC #7

Return Period	Flow(cfs)
2 year	1.1873
5 year	1.7308
10 year	2.1254
25 year	2.6626
50 year	3.0909
100 year	3.5431

Flow Frequency Return Periods for Predeveloped. POC #8

Return Period	Flow(cfs)
2 year	1.0786
5 year	1.4421
10 year	1.6841
25 year	1.9918
50 year	2.2229
100 year	2.4558

Perlnd and Implnd Changes

No changes have been made.

Boundary Ridge Stormwater Conveyance System Analysis
Summary of WWHM Results

June 20, 2016

			Land Use	Area	25-Year Flow Rate (cfs)	100-Year Flow Rate (cfs)
Scenario - PIPE #3					1.47	2.04
1	Offsite Upstream Area	Pervious	A/B, Forest, Flat	90.8		
	Lateral Basin - Semiahmoo Drive	Impervious	Roads/Flat	1.134		
	Onsite Landscaping	Pervious	A/B, Lawn, Flat	1.699		
	Onsite Roads & Buildings	Impervious	Roads/Flat	0.716		
Scenario - PIPE #7					3.38	4.59
2	Offsite Upstream Area	Pervious	A/B, Forest, Flat	90.8		
	Lateral Basin - Semiahmoo Drive	Impervious	Roads/Flat	1.134		
	Onsite Landscaping	Pervious	A/B, Lawn, Flat	6.899		
	Onsite Roads & Buildings	Impervious	Roads/Flat	2.57		
Scenario - PIPE #3					0.72	0.94
3	Onsite Landscaping	Pervious	A/B, Lawn, Flat	1.699		
	Onsite Roads & Buildings	Impervious	Roads/Flat	0.716		
Scenario - PIPE #3					0.55	0.68
4	Onsite Roads & Buildings	Impervious	Roads/Flat	0.716		
Scenario - Semiahmoo Drive					0.63	0.81
5	Lateral Basin - Semiahmoo Drive	Impervious	Roads/Flat	1.134		
Scenario - Offsite Upstream Forest					0.44	0.90
6	Offsite Upstream Area	Pervious	A/B, Forest, Flat	90.8		
Scenario - Boundary Ridge Only to Pipe 7					2.66	3.54
7	Onsite Landscaping	Pervious	A/B, Lawn, Flat	6.899		
	Onsite Roads & Buildings	Impervious	Roads/Flat	2.57		
Scenario - Boundary Ridge Only to Pipe 7					1.99	2.46
8	Onsite Roads & Buildings	Impervious	Roads/Flat	2.57		