STORMWATER DRAINAGE REPORT

NELSON 43
MUKILTEO, WA

October 11, 2019 *Initial: October 11, 2019*	**Prepared for:** City of Mukilteo	**Reviewed by:** Spencer Humphrey, P.E. Project Engineer shumphrey@navixeng.com

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PROJECT OVERVIEW

PROPOSED IMPROVEMENTS

The proposed development consists of the construction of a single commercial building with parking for trucks and cars, an access roadway, stormwater management facilities, utilities, and on-site landscaping on a 4.04-acre site in Mukilteo, Washington. The property is currently zoned as planned industrial.

DESIGN CRITERIA

The City of Mukilteo utilizes the 2012 Washington State Department of Ecology Stormwater Management Manual for Western Washington (DOE Manual) drainage requirements with 2014 amendments. Stormwater discharges shall match developed discharge durations to existing durations for the range of existing discharge rates from 50% of the 2-year peak flow up to the full 50-year peak flow. The existing condition to be matched shall be largely forested land cover. Additionally, the site is tributary to an existing wetland and shall meet the Wetland Protection Guidelines Criterion 1 and 2.

JURISDICTIONAL REQUIREMENTS

Table 1 below summarizes City of Mukilteo stormwater requirements.

TABLE 1

Jurisdictional Requirements	
Duration Analysis:	
2-year:	Reduce to ½ existing duration
50-year:	Match existing
Downstream Wetland Protection:	Criteria 1: ±20% of daily volume Criteria 2: ±15% of monthly volume
Water Quality Volume:	n/a
Water Quality Flow Rate:	0.23 CFS
Downstream Analysis:	
Level 1:	¼ mile downstream

SUBBASINS, AND SITE CHARACTERISTICS:

SUBBASIN

The site is located within a single basin with a portion of the adjacent ROW draining to a roadside ditch on the property. The proposed drainage system consists of a network of catch basins and underground storm drainage pipes that will convey stormwater runoff from the paved surfaces to a water quality facility. Roof runoff and the treated stormwater will drain to a detention/infiltration vault located in the northeast portion of the site. Pollution generating impervious surface (PGIS) runoff will receive water quality treatment and be infiltrated. The portion of high intensity storm runoff that does not infiltrate will be control-released to the downstream depressional wetland to maintain the existing hydrology.

SOILS

Per the Geotechnical Investigation Report by Earth Solutions NW Geotechnical Engineering Study, dated December 27, 2018, the site has a topsoil layer of 6 to 18 inches underlain by glacial till consisting of a non-sorted mixture of clay, silt, sand, pebbles, cobbles, and boulders. Below the glacial till approximately 13 feet below grade, advance outwash consisting of dense to very dense, fine sand with a variable amount of silt was encountered. The advance outwash sand is typically relatively permeable and is the proposed receptor for the infiltration of treated stormwater runoff at the site, as recommended in the Associated Earth Science Inc.

(AESI) Infiltration Feasibility Study, dated May 8, 2019. The Soil Conservation Service has mapped the site as Alderwood-Urban land complex, 2-15% slope, classified as Type B soils for stormwater runoff but will be modeled as C type soils per geotechnical report recommendation. The long term design infiltration rate of stormwater in the advance outwash 15 feet to 20 feet below the subgrade is limited to two inches/hour per the AESI Feasibility Study. Groundwater was encountered at a depth of 43 feet.

PROJECT LOCATION

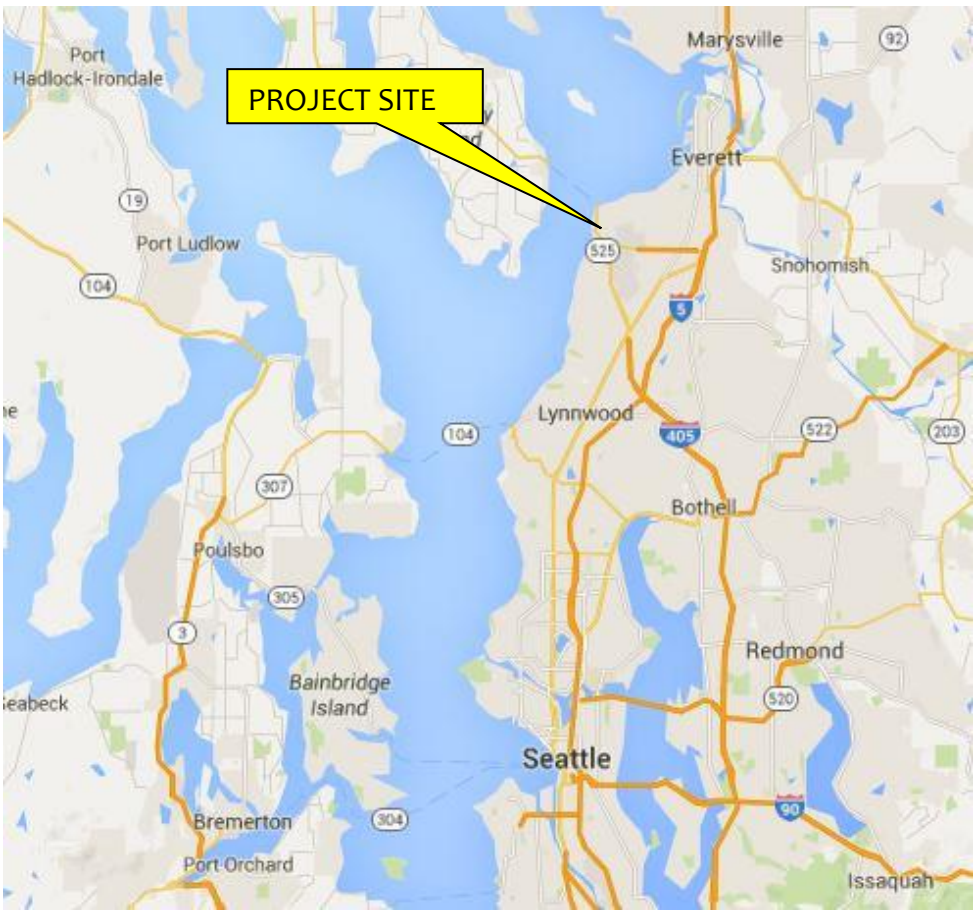


Figure 1: Vicinity Map

Location: 4301 78th Street Southwest Mukilteo, WA, 98275

Section, Township, Range: SEC10, T28N, R4E, WM

Tax Account Number: 28041000300100, 28041000300400, 28041000300500, 28041000300600

Size: 176,141 SF (4.04 AC)

City, County, State: Mukilteo, Snohomish County, Washington State

Governing Agency: City of Mukilteo

Design Criteria: 2012 Washington State Department of Ecology Stormwater Management Manual for Western Washington as Amended in December 2014

Zoning: PI (Planned Industrial)

MINIMUM REQUIREMENTS

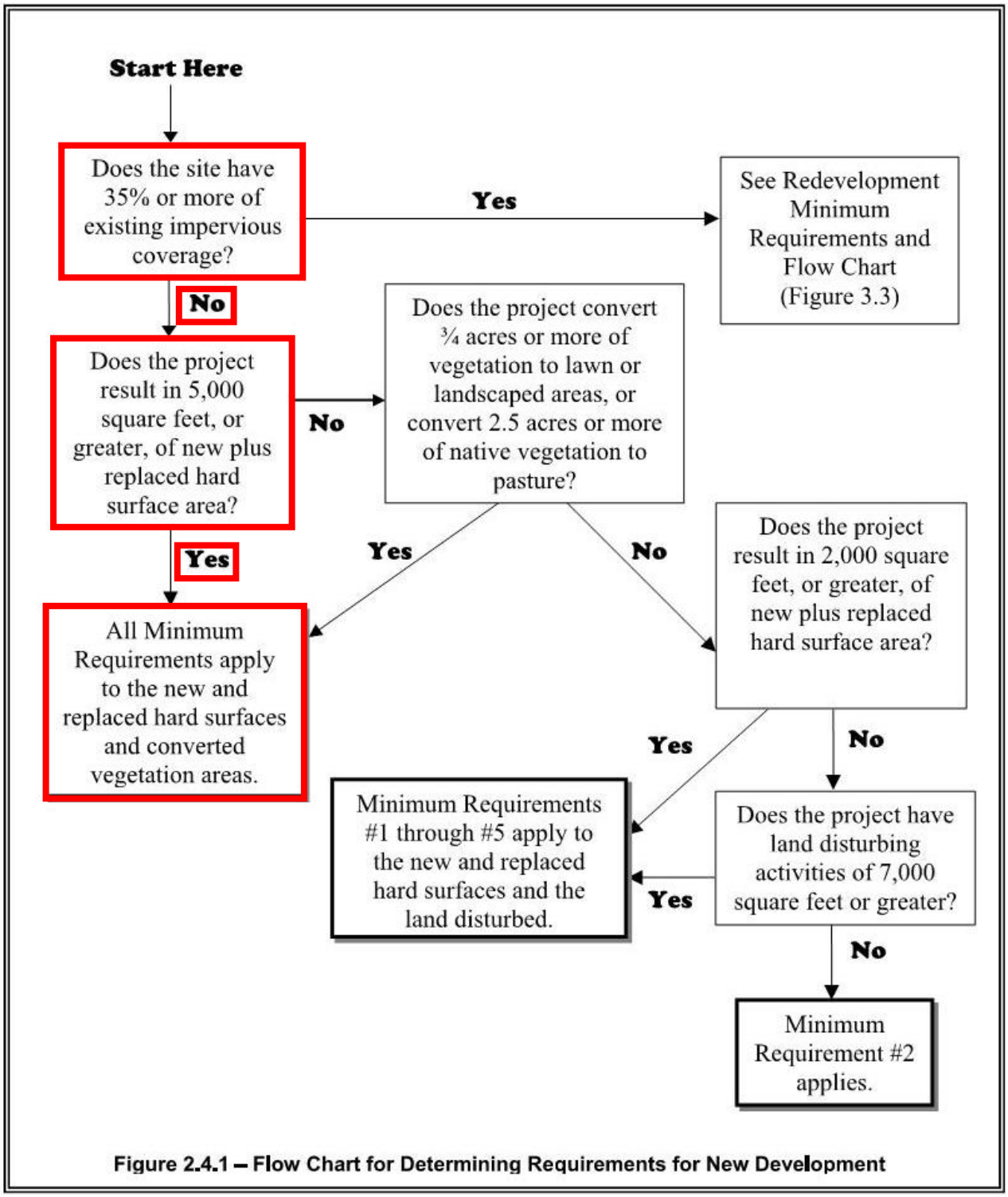


Figure 2.4.1 – Flow Chart for Determining Requirements for New Development

Minimum Requirement #1: Preparation of Stormwater Site Plans
All projects meeting the thresholds in Section 2.4 shall prepare a Stormwater Site Plan for local government review. Stormwater Site Plans shall use site-appropriate development principles, as required and encouraged by local development codes, to retain native vegetation and minimize impervious surfaces to the extent feasible.

> **Response:** *A stormwater site plan has been prepared for the development in the form of this report. The stormwater site plan includes the existing and proposed stormwater conditions, WWHM output report, and supporting reports.*

Minimum Requirement #2: Construction Stormwater Pollution Prevention (SWPPP)
All new development and redevelopment projects are responsible for preventing erosion and discharge of sediment and other pollutants into receiving waters.
Projects which result in 2,000 square feet or more of new plus replaced hard surface area, or which disturb 7,000 square feet or more of land must prepare a Construction Stormwater Pollution Prevention Plan (SWPPP) as part of the Stormwater Site Plan (see Section 2.5.1). Projects that result in less than 2,000 square feet of new plus replaced hard surface area, or disturb less than 7,000 square feet of land are not required to prepare a Construction SWPPP, but must consider all of the 13 Elements of Construction Stormwater Pollution Prevention and develop controls for all elements that pertain to the project site.

> **Response:** *The 13 elements of the SWPPP are addressed below in this report. A full Construction will be prepared and the NPDES permit will be obtained from DOE.*

Minimum Requirement #3: Source Control of Pollution
All known, available and reasonable source control BMPs shall be applied to all projects. Source control BMPs shall be selected, designed, and maintained according to the manual.

> **Response:** *All available and reasonable source control BMPs have applied to this project. These include Dust Control at Disturbed Land Areas, Landscaping and Lawn/Vegetation Management and Maintenance of Stormwater Drainage and Treatment Systems.*

Minimum Requirement #4: Preservation of Natural Drainage Systems and Outfalls
Natural drainage patterns shall be maintained, and discharges from the project site shall occur at the natural location, to the maximum extent practicable. The manner by which runoff is discharged from the project site must not cause a significant adverse impact to downstream receiving waters and downgradient properties. All outfalls require energy dissipation.

> **Response:** *Runoff from the proposed project will discharge from a new on-site infiltration vault that will discharge north to the existing wetlands. To maintain existing hydrologic conditions to the wetlands north of the site the right-of-way stormwater is treated by two separate water quality systems. A portion of the right-of-way stormwater is treated and discharged to the existing wetland northwest of the site. The remaining portion of right-of-way stormwater is treated on-site, drains to the infiltration vault where it ultimately discharges to the existing wetlands to the north.*

Minimum Requirement #5: On-site Stormwater Management
Projects shall employ On-site Stormwater Management BMPs in accordance with the following projects thresholds, standards, and lists to infiltrate, disperse, and retain stormwater runoff on-site to the extent feasible without causing flooding or erosion impacts. Projects qualifying as flow control exempt in accordance with Section 2.5.7 of this chapter do not have to achieve the LID performance standard, nor consider bioretention, rain gardens, permeable pavement, and full dispersion if using List #1 or List #2. However, those projects must implement BMP T5.13; BMPs T5.10A, B, or C; and BMP T5.11 or T5.12, if feasible.

Project Thresholds:
Projects triggering only Minimum Requirements #1 through #5 shall either:

a. Use On-site Stormwater Management BMPs from List #1 for all surfaces within each type of surface in List #1; or
b. Demonstrate compliance with the LID Performance Standard. Projects selecting this option cannot use Rain Gardens. They may choose to use Bioretention BMPs as described in Chapter 7 of Volume V to achieve the LID Performance Standard.

Projects triggering Minimum Requirements #1 through #9, must meet the requirements in Table 2.5.1.

Response: *On-site stormwater runoff will be collected and conveyed via a system of catch basins and underground storm pipes to an onsite water quality facility, then routed to a stormwater vault. The roof area will discharge directly in to the stormwater vault. Stormwater will then infiltrate into the below soils at a rate of 2" per hour. Excess stormwater during high intensity storms will discharge from the vault at the historical discharge rate to the existing downstream wetland.*

Minimum Requirement #6: Runoff Treatment
Thresholds
When assessing a project against the following thresholds, only consider those hard and pervious surfaces that are subject to this minimum requirement as determined in Section 2.4 of this chapter.
The following require construction of stormwater treatment facilities:

- Projects in which the total of, pollution-generating hard surface (PGHS) is 5,000 square feet or more in a threshold discharge area of the project, or
- Projects in which the total of pollution-generating pervious surfaces (PGPS) – not including permeable pavements – is three-quarters (3/4) of an acre or more in a threshold discharge area, and from which there will be a surface discharge in a natural or man-made conveyance system from the site.

Response: *Stormwater will be treated with the use of a Perk-Filter Vault which meets the Washington State Ecology GULD Standard for basic treatment.*

Minimum Requirement #7: Flow Control
Projects must provide flow control to reduce the impacts of stormwater runoff from hard surfaces and land cover conversions. The requirement below applies to projects that discharge stormwater directly, or indirectly through a conveyance system, into a fresh waterbody. Flow Control is not required for projects that discharge directly to, or indirectly to a water listed in Appendix I-E.

Response: *The proposed stormwater system includes an infiltration/detention vault that is sized for the entire project area, using the WWHM2012 program.*

Minimum Requirement #8: Wetlands Protection
The requirements below apply only to projects whose stormwater discharges into a wetland, either directly or indirectly through a conveyance system.
Thresholds:
The thresholds identified in Minimum Requirement #6 – Runoff Treatment, and Minimum Requirement #7 – Flow Control shall also be applied to determine the applicability of this requirement to discharges to wetlands.
Standard Requirement:
Projects shall comply with Guide Sheets #1 through #3 in Appendix I-D. They hydrologic analysis shall use the existing hydrologic conditions unless directed otherwise by a regulatory agency with jurisdiction.

Response: *The stormwater vault is sized to meet the guide sheets to the maximum extent feasible as described in more detail below in the Flow Control System section.*

Minimum Requirement #9: Operation and Maintenance

An operation and maintenance manual that is consistent with the provisions in Volume V of this manual shall be provided for all proposed stormwater facilities and BMPs, and the party (or parties) responsible for maintenance and operation shall be identified. At private facilities, a copy of the manual shall be retained onsite or within reasonable access to the site, and shall be transferred with the property to the new owner. For public facilities, a copy of the manual shall be retained in the appropriate department. A log of maintenance activity that indicates what actions were taken shall be kept and be available for inspection by the local government.

Response: *Operations and Maintenance checklists for the proposed storm drainage system facilities have been included in Appendix E.*

EXISTING CONDITIONS

The project site is located at NE corner of the intersection of 44th Ave West and 78th Street Southwest in Mukilteo, Washington. The site is approximately 176,141 SF (4.04 acres) and is currently undeveloped. The is site is predominately forested.

The site is bordered to the east by the First Slavic Church Awakening, to the west by 44th Avenue West, to the north by the Japanese Gulch Conservation Area, and to the south by 78th St SW. The majority of the project site is generally sloping to the northeast corner of the site at an average rate of 5 to 10 percent.

SOILS CONDITIONS

Per the Geotechnical Engineering Study by Earth Solutions NW, dated December 27, 2018, the site is one to one and a half feet of top soil with approximately 11 feet of glacial till (Qvt) underneath. Per the Infiltration Feasibility Study by AESI, dated May 8, 2019, the glacial till is underlain by advance outwash consisting of dense to very dense, fine sand with a variable amount of silt and trace amounts of gravel.

DEVELOPED CONDITIONS

The proposed development consists of the construction of a single industrial building totaling approximately 55,032± SF (1.26 acres) with parking stalls, stormwater management facilities, utilities and on-site landscaping. The property is currently zoned as planned industrial.

On-site stormwater runoff will be collected and conveyed via a system of catch basins and underground storm pipes to an onsite water quality facility, then routed to a stormwater vault. The roof area will discharge directly into the stormwater vault bypassing the water quality system. Stormwater will then infiltrate into the below soils at a rate of two inches per hour. Excess stormwater during high intensity storms will discharge from the vault at the historical discharge rate to the existing downstream wetland.

See the Permanent Stormwater Control Plan section for further information about the conveyance system.

DOWNSTREAM POINT OF COMPLIANCE

The downstream point of compliance is at the wetland located north of the property in the Japanese Gulch.

PERMANENT STORMWATER CONTROL PLAN

EXISTING SITE HYDROLOGY

The project site is approximately 176,141 SF (4.04 acres) and is largely forested, undeveloped land. The existing conditions are modeled as C, Forest, Flat/Mod/Steep. See table 2 below, for existing conditions onsite. The upstream existing tributary basin was modeled with the on-site basin for the wetland protection/WWHM requirements.

Table 2 –Pre-developed Drainage Basins

Basin Area (AC)	Description	Grade
0.8699	C, Forest	Flat
1.6074	C, Forest	Moderate
1.8055	C, Forest	Steep
4.2828	**Total Site**	

DEVELOPED SITE HYDROLOGY

The proposed on-site development will consist of paved parking and drive aisles, concrete walkways, a building, and landscaping/pervious surface. The right-of-way improvements consist of ½ street widening and curb, gutter, and sidewalk along the sites frontage. See Table 3 for proposed conditions.

Table 3 -Developed Drainage Basin

Basin Area (AC)	Description	Grade
1.263	Parking	Flat
1.257	Roof tops	Flat
0.407	Parking	Mod
0.2332	Roads	Flat
0.0549	Sidewalks	Flat
0.0405	Parking	Steep
0.9134	C, Lawn	Flat
0.0632	C, Forest	Mod
0.0506	C, Forest	Steep
4.2828	**Total (3.2556 ac imp, 1.0272 ac lawn/forest)**	

HYDROLOGIC MODELING

The hydrologic analysis for the project was performed using the computer-modeling program, Western Washington Hydrology Model (WWMH2012), based on matching flow durations and wetland protection volumes. The program effectively models predeveloped, existing in this case, and post-developed runoff conditions using basins for a given area. An infiltration rate of 2.00" per hour has been used at the bottom of the vault (bottomless). The WWHM2012 model for the project site states that current stormwater conveyance system meets 2012 Department of Ecology Stormwater Management Manual standards and City of Mukilteo development standards. See Appendix C for the WWHM report.

FLOW CONTROL SYSTEM

In the developed condition, onsite stormwater runoff will be drained in several areas.

- The building (1.26 acres) will be directly connected to the vault.
- The remaining portion of the right-of-way area and on-site area is 3.02 acres which drains to a Perk-Filter Vault located in the northeast portion of the parking lot. Stormwater will be treated by the Perk-Filter Vault prior to entering the infiltration vault where it will then discharge directly to the wetland.
- The total basin area (23.81 acres + 4.28 = **28.09 acres**) is used for the wetland modeling in WWHM.
- The entire site and a portion of the right-of-way is tributary to the underground vault (4.28 acres) that discharges stormwater north of the property to an existing wetland. The vault has a live storage volume of 19,200 cubic feet (20' wide x 60' long x 16' tall).

Existing Drainage Basin

Name : Ext Site

Pervious Land Use	acre
C, Forest, Flat	0.87
C, Forest, Mod	1.61
C, Forest, Steep	1.81
Pervious Total	4.28
Impervious Total	0.00
Basin Total	4.28

Developed Drainage Basin

Name : Dev Site

Pervious Land Use	acre
C, Forest, Mod	0.06
C, Forest, Steep	0.05
C, Lawn, Mod	0.91
Pervious Total	1.02
Impervious Land Use	**acre**
ROADS/FLAT	0.23
ROOF TOPS/FLAT	1.26
SIDEWALKS/FLAT	0.06
PARKING/FLAT	1.26
PARKING/MOD	0.41
PARKING/STEEP	0.04
Impervious Total	3.26
Basin Total	4.28

Existing Wetland Basin

Name : Ext Wetland Basin

Pervious Land Use	acre
C, Forest, Flat	0.87
C, Forest, Mod	19.65
C, Forest, Steep	1.81
C, Lawn, Mod	0.31
Pervious Total	22.64
Impervious Land Use	**acre**
ROADS/MOD	1.16
ROOF TOPS/FLAT	0.78
SIDEWALKS/MOD	0.11
PARKING/MOD	3.41
Impervious Total	5.46
Basin Total	28.10

Developed Wetland Basin

Name : Dev Wetland Basin

Pervious Land Use	acre
C, Forest, Mod	18.10
C, Forest, Steep	0.05
C, Lawn, Mod	1.23
Pervious Total	19.38
Impervious Land Use	**acre**
ROADS/FLAT	0.23
ROADS/MOD	1.16
ROOF TOPS/FLAT	2.04
SIDEWALKS/FLAT	0.06
SIDEWALKS/MOD	0.11
PARKING/FLAT	1.26
PARKING/MOD	3.82
PARKING/STEEP	0.04
Impervious Total	8.71
Basin Total	28.10

Stormwater Vault

Name : Vault 1
Width : 40 ft.
Length : 60 ft.
Depth: 161 ft.
Infiltration On
Infiltration rate: 2.00
Infiltration safety factor: 1

Point of Compliance (discharge to wetland)

The WWHM model was initially set up based on a point of compliance just for the project site (4.28 acres). A vault was sized using the stream protection duration that did not include upstream or downstream basins. The orifices and vault size were not altered so it would still meet site discharge compliance alone. Modeling for the wetland includes the groundwater elements of the project site as well as the upstream and downstream basins for a total of 28.10 acres. The flows, durations, monthly volumes and daily volumes are shown below for the entire site portion to the wetland basin. The results of the analysis are shown below.

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.065502
5 year	0.100414
10 year	0.123106
25 year	0.150805
50 year	0.170621
100 year	0.189706

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.049723
5 year	0.103660
10 year	0.162309
25 year	0.275502
50 year	0.399056
100 year	0.567937

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Point of Compliance (wetland)

Per Guide Sheet 3B of the 2014 SMMWW, the following criteria need to also be met:

- Criteria 1: Total volume of water into a wetland during a single precipitation event should not be more than 20% higher or lower than the pre-project volumes.
- Criteria 2: Total volume of water into a wetland on a monthly basis should not be more than 15% higher or lower than the pre-project volumes.

Using the same vault and orifice control structure as described above, the Guide Sheet 3B criteria was applied, which requires groundwater flow (in addition to the traditional surface flow and interflow) to be accounted for in pervious surface areas in the pre-project and post-project conditions.

Infiltration is the means by which groundwater flow to the mitigated wetland is simulated. Per the geotechnical engineer, the site is underlain by glacial till soils with advance outwash beneath. The advance outwash provides infiltration in the order of 2.00"/hour. Groundwater flow was assigned to the on-site pervious surface areas in the pre- and post-project conditions. In the pre-project conditions, all on-site landscaped areas (forest) are assigned groundwater flow through infiltration. In the post-project condition, there are several means by which infiltration, and therefore groundwater flow, is accounted for:

- All landscaped areas allow for infiltration
- The proposed detention vault is bottomless and, therefore, allows for infiltration (2.00"/hr)

Using the pre-project and post-project conditions described above, we ran the WWHM model using the 20' wide x 60' long x 16' deep bottomless vault with a 3-orifice control structure. The results, shown below, show that we are able to meet the criteria 1 and 2.

Criterion #1:

Day	Pre-dev	Mitigated	Percent	Pass/Fail					
Jan1	0.1704	0.1659	97.4	Pass	16	0.1663	0.1588	95.5	Pass
2	0.1496	0.1430	95.6	Pass	17	0.1950	0.1895	97.2	Pass
3	0.1403	0.1337	95.3	Pass	18	0.1798	0.1694	94.2	Pass
4	0.1804	0.1736	96.2	Pass	19	0.1608	0.1518	94.4	Pass
5	0.1576	0.1508	95.7	Pass	20	0.1525	0.1448	95.0	Pass
6	0.1668	0.1614	96.7	Pass	21	0.1560	0.1480	94.9	Pass
7	0.1845	0.1785	96.8	Pass	22	0.1687	0.1616	95.8	Pass
8	0.1690	0.1613	95.4	Pass	23	0.1852	0.1767	95.5	Pass
9	0.1536	0.1464	95.3	Pass	24	0.1462	0.1381	94.4	Pass
10	0.1363	0.1294	94.9	Pass	25	0.1434	0.1350	94.2	Pass
11	0.1374	0.1299	94.5	Pass	26	0.1323	0.1238	93.6	Pass
12	0.1440	0.1367	95.0	Pass	27	0.1524	0.1440	94.5	Pass
13	0.1774	0.1708	96.3	Pass	28	0.1741	0.1661	95.4	Pass
14	0.1679	0.1596	95.1	Pass	29	0.1753	0.1683	96.0	Pass
15	0.1727	0.1649	95.5	Pass	30	0.1641	0.1556	94.8	Pass
					31	0.1539	0.1450	94.2	Pass
Feb1	0.1429	0.1334	93.4	Pass					
2	0.1294	0.1199	92.6	Pass	16	0.1562	0.1476	94.6	Pass
3	0.1493	0.1401	93.9	Pass	17	0.1614	0.1517	94.0	Pass
4	0.1498	0.1405	93.8	Pass	18	0.1515	0.1405	92.7	Pass
5	0.1495	0.1409	94.3	Pass	19	0.1412	0.1309	92.7	Pass
6	0.1388	0.1299	93.6	Pass	20	0.1594	0.1504	94.3	Pass
7	0.1643	0.1539	93.6	Pass	21	0.1432	0.1342	93.7	Pass
8	0.1311	0.1224	93.3	Pass	22	0.1405	0.1309	93.2	Pass
9	0.1232	0.1153	93.6	Pass	23	0.1738	0.1632	93.9	Pass
10	0.1281	0.1195	93.3	Pass	24	0.1675	0.1588	94.8	Pass
11	0.1508	0.1427	94.6	Pass	25	0.1530	0.1434	93.7	Pass
12	0.1484	0.1400	94.4	Pass	26	0.1418	0.1329	93.7	Pass
13	0.1409	0.1322	93.8	Pass	27	0.1512	0.1417	93.7	Pass
14	0.1429	0.1334	93.4	Pass	28	0.1427	0.1324	92.8	Pass
15	0.1495	0.1408	94.1	Pass	29	0.1544	0.1449	93.8	Pass
Mar1	0.1515	0.1418	93.7	Pass	16	0.1302	0.1213	93.1	Pass
2	0.1531	0.1438	93.9	Pass	17	0.1346	0.1253	93.1	Pass
3	0.1488	0.1394	93.7	Pass	18	0.1292	0.1206	93.4	Pass
4	0.1361	0.1268	93.2	Pass	19	0.1269	0.1193	94.0	Pass
5	0.1095	0.1007	92.0	Pass	20	0.1091	0.1012	92.8	Pass
6	0.1307	0.1233	94.3	Pass	21	0.1345	0.1273	94.6	Pass
7	0.1263	0.1188	94.0	Pass	22	0.1349	0.1276	94.6	Pass
8	0.1542	0.1464	94.9	Pass	23	0.1273	0.1184	93.0	Pass
9	0.1378	0.1286	93.3	Pass	24	0.1236	0.1150	93.1	Pass
10	0.1467	0.1371	93.5	Pass	25	0.1342	0.1260	93.9	Pass
11	0.1422	0.1324	93.1	Pass	26	0.1142	0.1060	92.9	Pass
12	0.1301	0.1206	92.7	Pass	27	0.1228	0.1150	93.6	Pass
13	0.1256	0.1171	93.3	Pass	28	0.1154	0.1074	93.1	Pass
14	0.1329	0.1239	93.2	Pass	29	0.1060	0.0985	92.9	Pass
15	0.1306	0.1219	93.4	Pass	30	0.1117	0.1041	93.2	Pass
					31	0.1129	0.1055	93.4	Pass

Apr1	0.1084	0.1010	93.1	Pass	16	0.0969	0.0903	93.2	Pass
2	0.1107	0.1042	94.1	Pass	17	0.0893	0.0825	92.4	Pass
3	0.1195	0.1126	94.2	Pass	18	0.1089	0.1031	94.6	Pass
4	0.1159	0.1088	93.9	Pass	19	0.0953	0.0885	92.8	Pass
5	0.1091	0.1020	93.5	Pass	20	0.0730	0.0659	90.2	Pass
6	0.0965	0.0894	92.6	Pass	21	0.0784	0.0720	91.9	Pass
7	0.1158	0.1092	94.3	Pass	22	0.1050	0.0986	93.9	Pass
8	0.0989	0.0913	92.3	Pass	23	0.0960	0.0909	94.6	Pass
9	0.1005	0.0930	92.5	Pass	24	0.0824	0.0768	93.1	Pass
10	0.1115	0.1046	93.8	Pass	25	0.0739	0.0681	92.1	Pass
11	0.1144	0.1076	94.0	Pass	26	0.0907	0.0854	94.1	Pass
12	0.1043	0.0980	93.9	Pass	27	0.0903	0.0853	94.5	Pass
13	0.0890	0.0822	92.4	Pass	28	0.0860	0.0812	94.4	Pass
14	0.0970	0.0909	93.7	Pass	29	0.0847	0.0797	94.1	Pass
15	0.1125	0.1060	94.2	Pass	30	0.0740	0.0682	92.2	Pass
May1	0.0748	0.0695	92.9	Pass	16	0.0532	0.0488	91.7	Pass
2	0.0753	0.0708	94.0	Pass	17	0.0596	0.0555	93.1	Pass
3	0.0702	0.0654	93.1	Pass	18	0.0661	0.0626	94.8	Pass
4	0.0769	0.0728	94.7	Pass	19	0.0645	0.0615	95.4	Pass
5	0.0680	0.0635	93.3	Pass	20	0.0589	0.0556	94.5	Pass
6	0.0556	0.0506	90.9	Pass	21	0.0530	0.0490	92.3	Pass
7	0.0626	0.0581	92.8	Pass	22	0.0560	0.0523	93.4	Pass
8	0.0628	0.0586	93.3	Pass	23	0.0615	0.0588	95.6	Pass
9	0.0820	0.0780	95.1	Pass	24	0.0558	0.0525	94.1	Pass
10	0.0826	0.0800	96.8	Pass	25	0.0614	0.0584	95.2	Pass
11	0.0643	0.0599	93.2	Pass	26	0.0697	0.0678	97.2	Pass
12	0.0695	0.0656	94.4	Pass	27	0.0607	0.0584	96.3	Pass
13	0.0713	0.0673	94.3	Pass	28	0.0657	0.0628	95.5	Pass
14	0.0607	0.0576	94.8	Pass	29	0.0596	0.0582	97.5	Pass
15	0.0662	0.0631	95.2	Pass	30	0.0819	0.0801	97.9	Pass
					31	0.0561	0.0536	95.6	Pass
Jun1	0.0636	0.0607	95.4	Pass	16	0.0626	0.0606	96.8	Pass
2	0.0719	0.0696	96.9	Pass	17	0.0585	0.0563	96.2	Pass
3	0.0588	0.0568	96.5	Pass	18	0.0558	0.0533	95.6	Pass
4	0.0575	0.0543	94.5	Pass	19	0.0451	0.0415	92.1	Pass
5	0.0572	0.0537	93.9	Pass	20	0.0484	0.0450	92.9	Pass
6	0.0639	0.0609	95.3	Pass	21	0.0547	0.0514	94.0	Pass
7	0.0589	0.0558	94.9	Pass	22	0.0534	0.0507	94.9	Pass
8	0.0569	0.0545	95.7	Pass	23	0.0642	0.0624	97.3	Pass
9	0.0794	0.0775	97.6	Pass	24	0.0570	0.0554	97.3	Pass
10	0.0607	0.0592	97.6	Pass	25	0.0483	0.0463	95.7	Pass
11	0.0622	0.0604	97.0	Pass	26	0.0492	0.0461	93.8	Pass
12	0.0521	0.0494	94.7	Pass	27	0.0435	0.0404	93.0	Pass
13	0.0430	0.0394	91.7	Pass	28	0.0556	0.0531	95.6	Pass
14	0.0486	0.0452	93.0	Pass	29	0.0478	0.0452	94.7	Pass
15	0.0563	0.0536	95.3	Pass	30	0.0560	0.0538	96.1	Pass

Jul1	0.0554	0.0543	97.9	Pass	16	0.0381	0.0363	95.3	Pass
2	0.0507	0.0484	95.4	Pass	17	0.0323	0.0295	91.2	Pass
3	0.0416	0.0383	92.0	Pass	18	0.0419	0.0398	95.1	Pass
4	0.0476	0.0454	95.3	Pass	19	0.0375	0.0350	93.4	Pass
5	0.0376	0.0350	92.9	Pass	20	0.0305	0.0274	90.1	Pass
6	0.0392	0.0359	91.6	Pass	21	0.0370	0.0345	93.2	Pass
7	0.0452	0.0431	95.2	Pass	22	0.0312	0.0283	90.6	Pass
8	0.0490	0.0465	95.0	Pass	23	0.0312	0.0282	90.3	Pass
9	0.0373	0.0342	91.8	Pass	24	0.0341	0.0313	91.9	Pass
10	0.0423	0.0392	92.7	Pass	25	0.0414	0.0395	95.5	Pass
11	0.0361	0.0336	93.0	Pass	26	0.0331	0.0307	92.9	Pass
12	0.0440	0.0419	95.1	Pass	27	0.0355	0.0330	93.0	Pass
13	0.0381	0.0360	94.5	Pass	28	0.0330	0.0307	93.1	Pass
14	0.0343	0.0313	91.4	Pass	29	0.0284	0.0254	89.6	Pass
15	0.0534	0.0520	97.4	Pass	30	0.0291	0.0261	90.0	Pass
					31	0.0288	0.0259	90.2	Pass
Aug1	0.0294	0.0266	90.5	Pass	16	0.0324	0.0310	95.4	Pass
2	0.0309	0.0283	91.3	Pass	17	0.0394	0.0383	97.2	Pass
3	0.0315	0.0289	91.8	Pass	18	0.0454	0.0447	98.6	Pass
4	0.0311	0.0286	92.1	Pass	19	0.0309	0.0299	96.7	Pass
5	0.0439	0.0423	96.3	Pass	20	0.0286	0.0262	91.6	Pass
6	0.0421	0.0413	98.0	Pass	21	0.0465	0.0459	98.8	Pass
7	0.0273	0.0259	94.7	Pass	22	0.0533	0.0529	99.3	Pass
8	0.0306	0.0284	92.9	Pass	23	0.0400	0.0404	100.9	Pass
9	0.0276	0.0250	90.4	Pass	24	0.0349	0.0342	98.1	Pass
10	0.0286	0.0261	91.3	Pass	25	0.0464	0.0459	98.8	Pass
11	0.0311	0.0286	92.0	Pass	26	0.0433	0.0440	101.5	Pass
12	0.0395	0.0378	95.9	Pass	27	0.0353	0.0345	97.8	Pass
13	0.0328	0.0311	94.9	Pass	28	0.0326	0.0306	94.0	Pass
14	0.0442	0.0427	96.8	Pass	29	0.0329	0.0311	94.8	Pass
15	0.0363	0.0353	97.0	Pass	30	0.0374	0.0363	97.1	Pass
					31	0.0446	0.0436	97.7	Pass
Sep1	0.0324	0.0318	98.1	Pass	16	0.0561	0.0579	103.2	Pass
2	0.0328	0.0317	96.7	Pass	17	0.0300	0.0301	100.4	Pass
3	0.0324	0.0309	95.2	Pass	18	0.0382	0.0376	98.4	Pass
4	0.0324	0.0308	95.0	Pass	19	0.0414	0.0410	99.1	Pass
5	0.0459	0.0456	99.2	Pass	20	0.0311	0.0306	98.2	Pass
6	0.0340	0.0335	98.6	Pass	21	0.0483	0.0485	100.3	Pass
7	0.0386	0.0382	98.8	Pass	22	0.0424	0.0435	102.7	Pass
8	0.0429	0.0432	100.6	Pass	23	0.0371	0.0381	102.6	Pass
9	0.0480	0.0488	101.8	Pass	24	0.0334	0.0329	98.4	Pass
10	0.0441	0.0456	103.4	Pass	25	0.0370	0.0363	98.2	Pass
11	0.0245	0.0229	93.3	Pass	26	0.0355	0.0347	97.6	Pass
12	0.0337	0.0323	95.9	Pass	27	0.0350	0.0344	98.5	Pass
13	0.0405	0.0399	98.4	Pass	28	0.0351	0.0342	97.5	Pass
14	0.0369	0.0370	100.4	Pass	29	0.0424	0.0423	99.7	Pass
15	0.0457	0.0456	99.8	Pass	30	0.0433	0.0431	99.5	Pass

Oct1	0.0355	0.0353	99.5	Pass	16	0.0609	0.0630	103.4	Pass
2	0.0415	0.0416	100.2	Pass	17	0.0452	0.0474	104.8	Pass
3	0.0511	0.0515	100.6	Pass	18	0.0643	0.0673	104.7	Pass
4	0.0445	0.0458	102.9	Pass	19	0.0732	0.0789	107.7	Pass
5	0.0551	0.0582	105.5	Pass	20	0.0589	0.0628	106.6	Pass
6	0.0411	0.0433	105.3	Pass	21	0.0559	0.0590	105.6	Pass
7	0.0565	0.0586	103.7	Pass	22	0.0552	0.0574	104.0	Pass
8	0.0475	0.0495	104.1	Pass	23	0.0625	0.0651	104.2	Pass
9	0.0466	0.0473	101.5	Pass	24	0.0587	0.0622	105.9	Pass
10	0.0443	0.0455	102.6	Pass	25	0.0726	0.0759	104.6	Pass
11	0.0387	0.0386	99.8	Pass	26	0.0640	0.0681	106.4	Pass
12	0.0436	0.0436	99.9	Pass	27	0.0675	0.0718	106.4	Pass
13	0.0442	0.0443	100.1	Pass	28	0.0474	0.0484	102.0	Pass
14	0.0384	0.0385	100.2	Pass	29	0.0546	0.0557	102.1	Pass
15	0.0500	0.0515	103.0	Pass	30	0.0486	0.0500	102.8	Pass
					31	0.0637	0.0655	102.8	Pass
Nov1	0.0557	0.0587	105.3	Pass	16	0.0857	0.0899	104.8	Pass
2	0.0744	0.0776	104.3	Pass	17	0.0855	0.0882	103.2	Pass
3	0.0825	0.0887	107.6	Pass	18	0.1202	0.1264	105.2	Pass
4	0.0610	0.0650	106.6	Pass	19	0.1267	0.1322	104.4	Pass
5	0.0602	0.0629	104.5	Pass	20	0.0976	0.1029	105.4	Pass
6	0.0630	0.0649	103.0	Pass	21	0.0823	0.0848	103.0	Pass
7	0.0636	0.0658	103.6	Pass	22	0.1048	0.1052	100.4	Pass
8	0.0723	0.0756	104.7	Pass	23	0.1451	0.1475	101.6	Pass
9	0.0840	0.0887	105.6	Pass	24	0.1434	0.1487	103.7	Pass
10	0.0878	0.0930	105.9	Pass	25	0.0924	0.0945	102.3	Pass
11	0.1002	0.1069	106.7	Pass	26	0.1102	0.1113	101.0	Pass
12	0.0925	0.0991	107.2	Pass	27	0.0914	0.0913	99.9	Pass
13	0.0761	0.0809	106.3	Pass	28	0.1161	0.1166	100.4	Pass
14	0.0844	0.0871	103.2	Pass	29	0.1316	0.1329	100.9	Pass
15	0.0836	0.0875	104.6	Pass	30	0.1324	0.1341	101.3	Pass
Dec1	0.1196	0.1208	101.0	Pass	16	0.1309	0.1276	97.5	Pass
2	0.1552	0.1613	103.9	Pass	17	0.1215	0.1177	96.9	Pass
3	0.1405	0.1418	100.9	Pass	18	0.1418	0.1362	96.0	Pass
4	0.1459	0.1458	100.0	Pass	19	0.1518	0.1471	96.9	Pass
5	0.1332	0.1324	99.4	Pass	20	0.1469	0.1432	97.5	Pass
6	0.1099	0.1084	98.6	Pass	21	0.1305	0.1277	97.9	Pass
7	0.1119	0.1105	98.7	Pass	22	0.1409	0.1367	97.0	Pass
8	0.1218	0.1205	98.9	Pass	23	0.1499	0.1456	97.1	Pass
9	0.1305	0.1286	98.6	Pass	24	0.1514	0.1463	96.6	Pass
10	0.1381	0.1363	98.7	Pass	25	0.1471	0.1422	96.7	Pass
11	0.1545	0.1526	98.8	Pass	26	0.1581	0.1535	97.1	Pass
12	0.1313	0.1286	97.9	Pass	27	0.1293	0.1256	97.2	Pass
13	0.1515	0.1469	96.9	Pass	28	0.1501	0.1445	96.3	Pass
14	0.1865	0.1833	98.3	Pass	29	0.1408	0.1358	96.4	Pass
15	0.1571	0.1552	98.8	Pass	30	0.1434	0.1420	99.0	Pass
					31	0.1875	0.1845	98.4	Pass

Passing 365/365 days

Criterion #2:

Wetlands Fluctuation for POC 1

Month	PRE-DEV	MITIGATED	Percent	Pass/Fail
Jan	5.0474	4.8222	95.5	Pass
Feb	4.1710	3.9107	93.8	Pass
Mar	4.0649	3.8006	93.5	Pass
Apr	2.9681	2.7743	93.5	Pass
May	2.0444	1.9313	94.5	Pass
Jun	1.6911	1.6126	95.4	Pass
Jul	1.2220	1.1447	93.7	Pass
Aug	1.1151	1.0689	95.9	Pass
Sep	1.1525	1.1434	99.2	Pass
Oct	1.6116	1.6691	103.6	Pass
Nov	2.7382	2.8403	103.7	Pass
Dec	4.3545	4.2790	98.3	Pass

Passing 12/12 months

WATER QUALITY SYSTEM

Onsite stormwater from PGIS will be routed through a Perk-Filter Vault for basic treatment and outlet into the infiltration vault. The Perk-Filter Vault is sized to meet the Ecology Washington State GULD Standard. WWHM modeling of the developed conditions flowrate prior to entering the vault gives an offline water quality flowrate (WQF) of 0.1319 cfs. Based on the offline WQF and our available depth, a 6-18" cartridge and 4'x10.5' Perk-Filter Vault was selected to meet Basic Enhanced Treatment.

ROW water to existing wetland will be treated by a single 12" cartridge 3'x6' Perk Filter Concrete Catchbasin. See Appendix D for details.

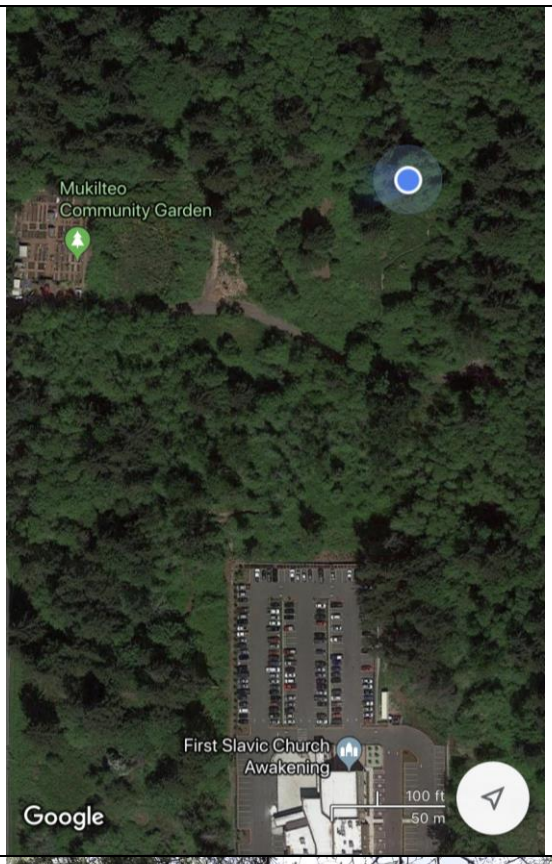
CONVEYANCE SYSTEM ANALYSIS AND DESIGN

A full conveyance system analysis and design will be provided with the final land use and site development permit submittal.

DOWNSTREAM ANALYSIS

A downstream analysis was completed on April 10, 2019. Figure C in Appendix A shows the downstream analysis path from the project site to ¼ mile downstream. The site slopes towards the northeast and drains offsite to the north/northeast via surface runoff. An existing wetland located northwest of the site receives runoff from the existing right-of-way. In the event of an overflow, the northwestern wetland overflows northeast into the Japanese Gulch. Runoff from the rest of the site drains east onto the nearby Slavic Church property or northeast towards an existing wetland in the Japanese Gulch. Stormwater from the Slavic Church property drains northeast to the Japanese Gulch. Runoff from the Japanese Gulch ultimately discharges to Puget Sound.

#	Photo	Description
1		Southern front of Nelson 43 property
2		Slavic Church Property to the east.

3		Location of the wetland on google maps.
4		Wetland located in Japanese Gulch.

5		Japanese Gulch south of the Nelson 43 property, ultimately drains to Puget Sound.

100-YEAR FLOOD/OVERFLOW CONDITION

The stormwater conveyance system for this project has been designed to address storm events in accordance with common industry practices. In the event of a larger storm, the system may fail. In this case, the runoff from larger events will overflow the control structure in the proposed detention vault, and flow to the intended discharge point, the wetlands to the north.

CONSTRUCTION STORMWATER POLLUTION PREVENTION PLAN

All erosion and sediment control measures shall be governed by the requirements of the City of Mukilteo. A temporary erosion and sedimentation control plan has been prepared to assist the contractor in complying with these requirements. The Erosion and Sediment Control (ESC) plan is included with the construction plans.

Element 1: Preserve Vegetation/Mark Clearing Limits

- Before beginning land disturbing activities, including clearing and grading, clearly mark all clearing limits, sensitive areas and their buffers, and trees that are to be preserved within the construction area.
- Retain the duff layer, native top soil, and natural vegetation in an undisturbed state to the maximum degree practicable.

Element 2: Establish Construction Access

- Limit construction vehicle access and exit to one route, if possible.
- Stabilize access points with a pad of quarry spalls, crushed rock, or other equivalent BMP's, to minimize tracking of sediment onto public roads.
- Locate wheel wash or tire baths on site, if stabilized construction entrance is not effective in preventing tracking sediment onto public roads.
- If sediment is tracked off site, clean the affected roadway thoroughly at the end of the say, or more frequently as necessary (for example, during wet weather). Remove sediment from roads by shoveling, sweeping, or pick up and transport the sediment to a controlled sediment disposal area.
- Conduct street washing only after sediment is removed in accordance with the above bullet.
- Control street wash wastewater by pumping back on-site, or otherwise prevent it from discharging into systems tributary to waters of the State.

Element 3: Control Flow Rates

- Protect properties and waterways downstream of development sites from erosion and the associated discharge of turbid waters due to increases in the velocity and peak volumetric flow rate of stormwater runoff from the project site.
- Where necessary to comply with the bullet above, construct stormwater retention or detention facilities s one of the first steps in grading. Assure that detention facilities function properly before constructing site improvements (e.g. impervious surfaces).
- If permanent infiltration ponds are used for flow control during construction, protect these facilities from siltation during the construction phase.

Element 4: Install Sediment Controls

- Design, install, and maintain effective erosion controls and sediment controls to minimize the discharge of pollutants.
- Construct sediment control BMPs (sediment ponds, traps, filters, etc.) as one of the first steps in grading. These BMPs shall be functional before other land disturbing activities take place.
- Minimize sediment discharges from the site. The design, installation and maintenance of erosion and sediment controls must address factors such as the amount, frequency, intensity and duration of precipitation, the nature of resulting stormwater runoff, and soil characteristics, including the range of soil particle sizes expected to be present on the site.
- Direct stormwater runoff from disturbed areas through a sediment pond or other appropriate sediment removal BMP, before the runoff leaves a construction site or before discharge to an infiltration facility. Runoff from fully stabilized areas may be discharged without a sediment removal BMP, but must meet the flow control performance standard in Element #3, bullet #1.

- Locate BMPs intended to trap sediment on-site in a manner to avoid interference with the movement of juvenile salmonids attempting to enter off-channel areas or drainages.
- Where feasible, design outlet structures that withdraw impounded stormwater from the surface to avoid discharging sediment that is still suspended lower in the water column.

Element 5: Stabilize Soils

- Stabilize exposed and unworked soils by application of effective BMPs that prevent erosion. Applicable BMPs include, but are not limited to: temporary and permanent seeding, sodding, mulching, plastic covering, erosion control fabrics and matting, soil application of polyacrylamide (PAM), the early application of gravel base early on areas to be paved, and dust control.
- Control stormwater volume and velocity within the site to minimize soil erosion.
- Control stormwater discharges, including both peak flow rates and total stormwater volume, to minimize erosion at outlets and to minimize downstream channel and stream bank erosion.
- Soils must not remain exposed and unworked for more than the time periods set forth below to prevent erosion:
    - During the dry season (May 1 - Sept. 30): 7 days
    - During the wet season (October 1 - April 30): 2 days
- Stabilize soils at the end of the shift before a holiday or weekend if needed based on the weather forecast.
- Stabilize soil stockpiles from erosion, protected with sediment trapping measures, and where possible, be located away from storm drain inlets, waterways and drainage channels.
- Minimize the amount of soil exposed during construction activity.
- Minimize the disturbance of steep slopes.
- Minimize soil compaction and, unless infeasible, preserve topsoil.

Element 6: Protect Slopes

- Design and construct cut-and-fill slopes in a manner to minimize erosion. Applicable practices include, but are not limited to, reducing continuous length of slope with terracing and diversions, reducing slope steepness, and roughening slope surfaces (for example, track walking).
- Divert off-site stormwater (run-on) or ground water away from slopes and disturbed areas with interceptor dikes, pipes and/or swales. Off-site stormwater should be managed separately from stormwater generated on the site.
- At the top of slopes, collect drainage in pipe slope drains or protected channels to prevent erosion.
    - Temporary pipe slope drains must handle the peak 10-minute velocity of flow from a Type 1A, 10-year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year and 1-hour flow rate predicted by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis must use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped" area.
- Place excavated material on the uphill side of trenches, consistent with safety and space considerations.
- Place check dams at regular intervals within constructed channels that are cut down a slope.

Element 7: Protect Drain Inlets

- Protect all storm drain inlets made operable during construction so that stormwater runoff shall not enter the conveyance system without first being filtered or treated to remove sediment.
- Clean or remove and replace inlet protection devices when sediment has filled one-third of the available storage (unless a different standard is specified by the product manufacturer).

Element 8: Stabilize Channels and Outlets

- Design, construct, and stabilize all on-site conveyance channels to prevent erosion from the following expected peak flows:
    - Channels must handle the peak 10-minute velocity of flow from a Type 1A, 10- year, 24-hour frequency storm for the developed condition. Alternatively, the 10-year, 1-hour flow rate indicated by an approved continuous runoff model, increased by a factor of 1.6, may be used. The hydrologic analysis must use the existing land cover condition for predicting flow rates from tributary areas outside the project limits. For tributary areas on the project site, the analysis must use the temporary or permanent project land cover condition, whichever will produce the highest flow rates. If using the Western Washington Hydrology Model (WWHM) to predict flows, bare soil areas should be modeled as "landscaped area.
- Provide stabilization, including armoring material, adequate to prevent erosion of outlets, adjacent stream banks, slopes and downstream reaches at the outlets of all conveyance systems.

Element 9: Control Pollutants

- Design, install, implement and maintain effective pollution prevention measures to minimize the discharge of pollutants.
- Handle and dispose of all pollutants, including waste materials and demolition debris that occur on-site in a manner that does not cause contamination of stormwater.
- Provide cover, containment, and protection from vandalism for all chemicals, liquid products, petroleum products, and other materials that have the potential to pose a threat to human health or the environment. On-site fueling tanks must include secondary containment. Secondary containment means placing tanks or containers within an impervious structure capable of containing 110% of the volume contained in the largest take within the containment structure. Double-walled tanks do not require additional secondary containment.
- Conduct maintenance, fueling, and repair of heavy equipment and vehicles using spill prevention and control measures. Clean contaminated surfaces immediately following any spill incident.
- Discharge wheel wash or tire bath wastewater to a separate on-site treatment system that prevents discharge to surface water, such as closed-loop recirculation or upland application, or to the sanitary sewer, with local sewer district approval.
- Apply fertilizers and pesticides in a manner and at application rates that will not result in loss of chemical to stormwater runoff. Follow manufacturers' label requirements for application rates and procedures.
- Use BMPs to prevent contamination of stormwater runoff by pH modifying sources. The sources for this contamination include, but are not limited to: bulk cement, cement kiln dust, fly ash, new concrete washing and curing waters, waste streams generated from concrete grinding and sawing, exposed aggregate processes, dewatering concrete vaults, concrete pumping and mixer washout waters.
- Adjust the pH of stormwater if necessary to prevent violations of water quality standards.
- Assure that washout of concrete trucks is performed off-site or in designated concrete washout areas only. Do not wash out concrete trucks onto the ground, or into storm drains, open ditches, streets, or

streams. Do not dump excess concrete on-site, except in designated concrete washout areas. Concrete spillage or concrete discharge to surface waters of the State is prohibited.

- Obtain written approval from Ecology before using chemical treatment other than CO_2 or dry ice to adjust pH.

Element 10: Control De-Watering

- Discharge foundation, vault, and trench de-watering water, which has similar characteristics to stormwater runoff at the site, into a controlled conveyance system before discharge to a sediment trap or sediment pond.
- Discharge clean, non-turbid de-watering water, such as well-point ground water, to systems tributary to, or directly into surface waters of the State, as specified in Element #8, provided the dewatering flow does not cause erosion or flooding of receiving waters. Do not route clean dewatering water through stormwater sediment ponds. Note that "surface waters of the State" may exist on a construction site as well as off site; for example, a creek running through a site.
- Handle highly turbid or otherwise contaminated dewatering water separately from stormwater.
- Other treatment or disposal options may include: 1. Infiltration, 2. Transport off-site in a vehicle, such as a vacuum flush truck, for legal disposal in a manner that does not pollute state waters, 3. Ecology-approved on-site chemical treatment or other suitable treatment technologies, 4. Sanitary or combined sewer discharge with local sewer district approval, if there is no other option, and 5. Use of a sedimentation bag with outfall to a ditch or swale for small volumes of localized dewatering.

Element 11: Maintain BMPs

- Maintain and repair all temporary and permanent erosion and sediment control BMPs as needed to assure continued performance of their intended function in accordance with BMP specifications.
- Remove all temporary erosion and sediment control BMPs within 30 days after achieving final site stabilization or after the temporary BMPs are no longer needed.

Element 12: Manage the Project

- Phase development projects to the maximum degree practicable and take into account seasonal work limitations.
- Inspection and monitoring – Inspect, maintain and repair all BMPs as needed to assure continued performance of their intended function. Projects regulated under the Construction Stormwater General Permit must conduct site inspections and monitoring in accordance with Special Condition S4 of the Construction Stormwater General Permit.
- Maintaining an updated construction SWPPP – Maintain, update, and implement the SWPPP.
- Projects that disturb one or more acres must have site inspections conducted by a Certified Erosion and Sediment Control Lead (CESCL). Project sites disturbing less than one acre may have a CESCL or a person without CESCL certification conduct inspections. By the initiation of construction, the SWPPP must identify the CESCL or inspector, who must be present on-site or on-call at all times.
- The CESCL or inspector (project sites less than one acre) must have the skills to assess the:
    - Site conditions and construction activities that could impact the quality of stormwater.
    - Effectiveness of erosion and sediment control measures used to control the quality of stormwater discharges.
- The CESCL or inspector must examine stormwater visually for the presence of suspended sediment, turbidity, discoloration, and oil sheen. They must evaluate the effectiveness of BMPs and determine if it is necessary to install, maintain, or repair BMPs to improve the quality of stormwater discharges.

Based on the results of the inspection, construction site operators must correct the problems identified by:
  - Reviewing the SWPPP for compliance with the 13 construction SWPPP elements and making appropriate revisions within 7 days of the inspection.
  - Immediately beginning the process of fully implementing and maintaining appropriate source control and/or treatment BMPs as soon as possible, addressing the problems not later than within 10 days of the inspection. If installation of necessary treatment BMPs is not feasible within 10 days, the construction site operator may request an extension within the initial 10-day response period.
  - Documenting BMP implementation and maintenance in the site log book (sites larger than 1 acre).
- The CESCL or inspector must inspect all areas disturbed by construction activities, all BMPs, and all stormwater discharge points at least once every calendar week and within 24 hours of any discharge from the site. (For purposes of this condition, individual discharge events that last more than one day do not require daily inspections. For example, if a stormwater pond discharges continuously over the course of a week, only one inspection is required that week.) The CESCL or inspector may reduce the inspection frequency for temporary stabilized, inactive sites to once every calendar month.

ESC ANALYSIS AND DESIGN

Trapping Sediment

Structural control measures will be used to reduce erosion and retain sediment on the construction site. The control measures will be selected to fit specific site and seasonal conditions.

The following structural items will be used to control erosion and sedimentation processes:

- Stabilized construction entrances
- Filter fabric fences
- Catch Basin Inlet Sediment Protection
- Proper Cover measures
- Temporary swales
- Sediment pond/vault
- Rock check dam

Weekly inspection of the erosion control measures will be required during construction. Any sediment buildup shall be removed and disposed of off-site.

Vehicle tracking of mud off-site shall be avoided. Installation of a stabilized construction entrance will be installed at a location to enter the site. The entrances are a minimum requirement and may be supplemented if tracking of mud onto public streets becomes excessive. In the event that mud is tracked off site, it shall be swept up and disposed of off-site on a daily basis. Depending on the amount of tracked mud, a vehicle road sweeper may be required.

Because vegetative cover is the most important form of erosion control, construction practices must adhere to stringent cover requirements. More specifically, the contractor will not be allowed to leave soils open for more than 14 days and, in some cases, immediate seeding will be required season dependent.

<u>Sediment Pond/Vault:</u>

A temporary sediment pond and vault are proposed during construction to collect, contain and control release of any site runoff during construction. The pond will be constructed prior to construction of the permanent vault. The entire 4.28-acre site is tributary to the temporary pond. The sediment structure is sized according to

design specifications per Section BMPC241: Temporary Sediment Pond of the DOE Manual. Using WWHM2012, the 10-year, flow based on the post development cleared conditions (lawn). Below are the results:

TESC Pond Tributary Area: 4.28 acres

Flow Frequency
Flow(cfs) 0501

Return Period	Flow(cfs)
2 year	0.182181
5 year	0.348854
10 year	0.500557
25 year	0.747957
50 year	0.978490
100 year	1.253777

The required surface area was calculated using the following equation:

$SA = 2 \times Q_{10} / 0.00096$

$= 2 \times 0.501 / 0.00096$

$= 1{,}042$ *sf*

This equation results in a surface area of 1,042 SF. The pond was designed with a surface area of 1,050 SF at the top of the sediment storage, which exceeds the minimum requirements for the 2-year flow. The required area of the orifice was calculated using the following equation:

$A_o = A_s(2h)^{0.5} / 0.6 \times 3600Tg^{0.5}$

$=1{,}042 \times (2(3.5))^{0.5} / [0.6 \times 3600 \times 24 \times 32.2^{0.5}]$

$= 0.00935$ *sf*

Converted to the required diameter using the following calculation:

$D = 13.54 \times Ao^{0.5}$

$= 13.54 \times 0.00935^{0.5}$

$= 1.31'' \approx 1 - 1/4''$

The sediment pond will have a 3.5' minimum depth from top of riser to bottom of live pond along with 1' of free board and 1.5' of sediment storage for a total depth of 6.0'.

SPECIAL REPORTS AND STUDIES OTHER PERMITS

Geotechnical Engineering Study by Earth Solutions NW, LLC dated December 27th, 2018 is included in Appendix B. Also included is the Infiltration Feasibility report by Associated Earth Sciences dated May 8th, 2019.

OTHER PERMITS

Dry utility and building permits will be applied for at a later date.

OPERATION AND MAINTENANCE

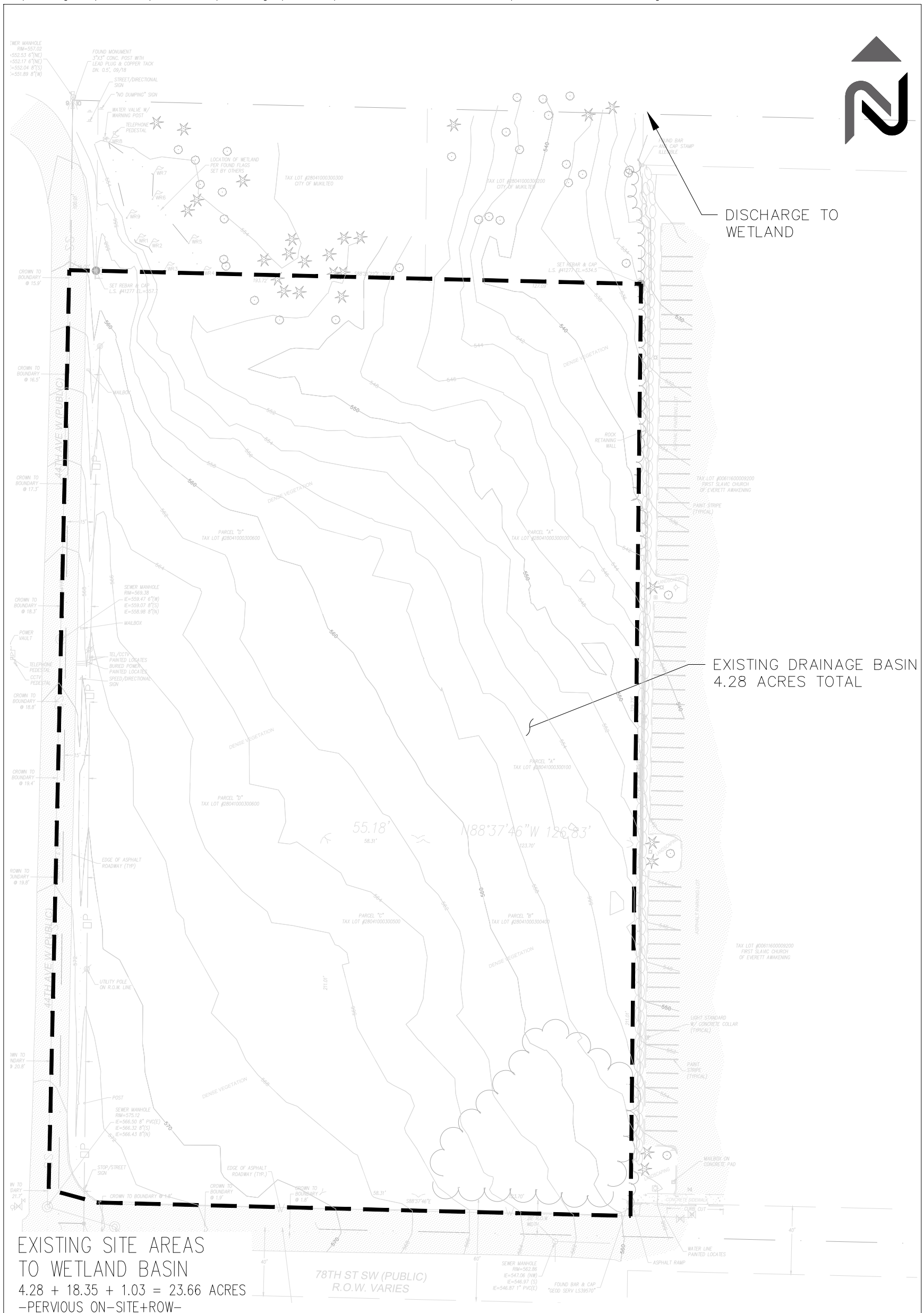
The owner or operator of the project shall be responsible for maintaining the stormwater facilities in accordance with local requirements. Proper maintenance is important for adequate functioning of the stormwater facilities. Operations and maintenance guidelines have been provided in Appendix E.

APPENDIX A

FIGURES

Figure A – Existing Conditions Exhibit
Figure B – Developed Conditions Exhibit
Figure C – Downstream Conditions Exhibit
Figure D – Drainage Plan, reduced sheet C-2.0
Figure E – Detention Vault Details, reduced sheet C-2.3

B:\Washington\Mukilteo\Nelson 43\2Drawings\Exhibits\190906 downstream exhibits\EXISTING CONDITIONS.dwg Oct 11, 2019 - 9:22am



EXISTING SITE AREAS TO WETLAND BASIN

4.28 + 18.35 + 1.03 = 23.66 ACRES

-PERVIOUS ON-SITE+ROW-

4.28 AC PERVIOUS TOTAL

-PERVIOUS OFF-SITE-

19.38 AC OFF-SITE

23.66 AC TOTAL

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MUKILTEO, WA
EXISTING CONDITIONS

EXHIBIT A

10/15/19

SCALE: 1" = 60'

B:\Washington\Mukilteo\Nelson 43\2Drawings\Exhibits\190906 downstream exhibits\DEVELOPED CONDITIONS.dwg Oct 11, 2019 - 9:22am

DEVELOPED AREAS TO DETENTION VAULT

-IMPERVIOUS-

1.99 AC PARKING/DRIVE/WALK/ROW

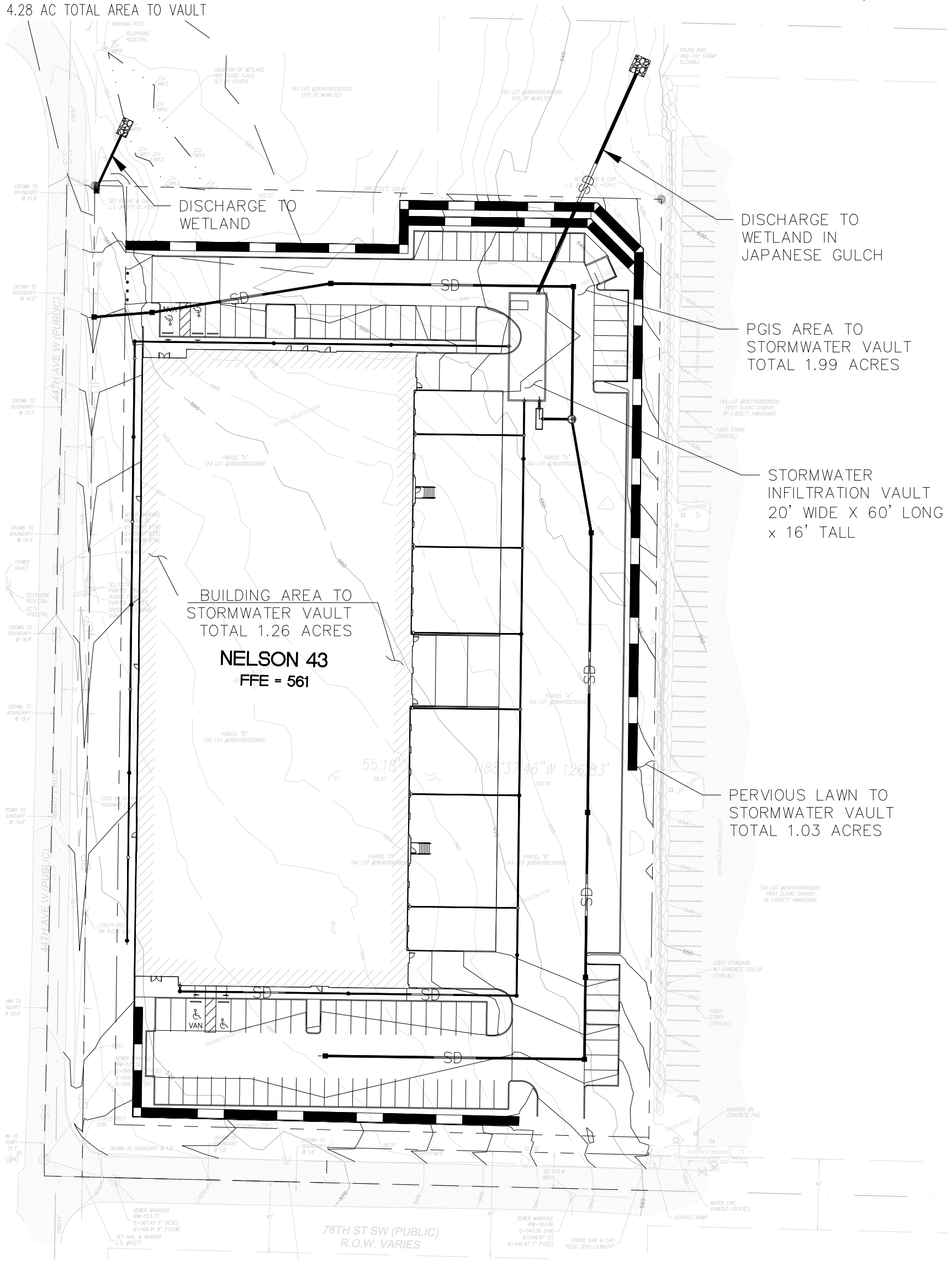
1.26 AC BUILDING

3.25 AC IMPERVIOUS TOTAL

-PERVIOUS LAWN-

1.03 AC DEVELOPED SITE AREA

4.28 AC TOTAL AREA TO VAULT



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NELSON 43
MUKILTEO, WA
DEVELOPED CONDITIONS

EXHIBIT B

10/11/19

SCALE: 1" = 60'

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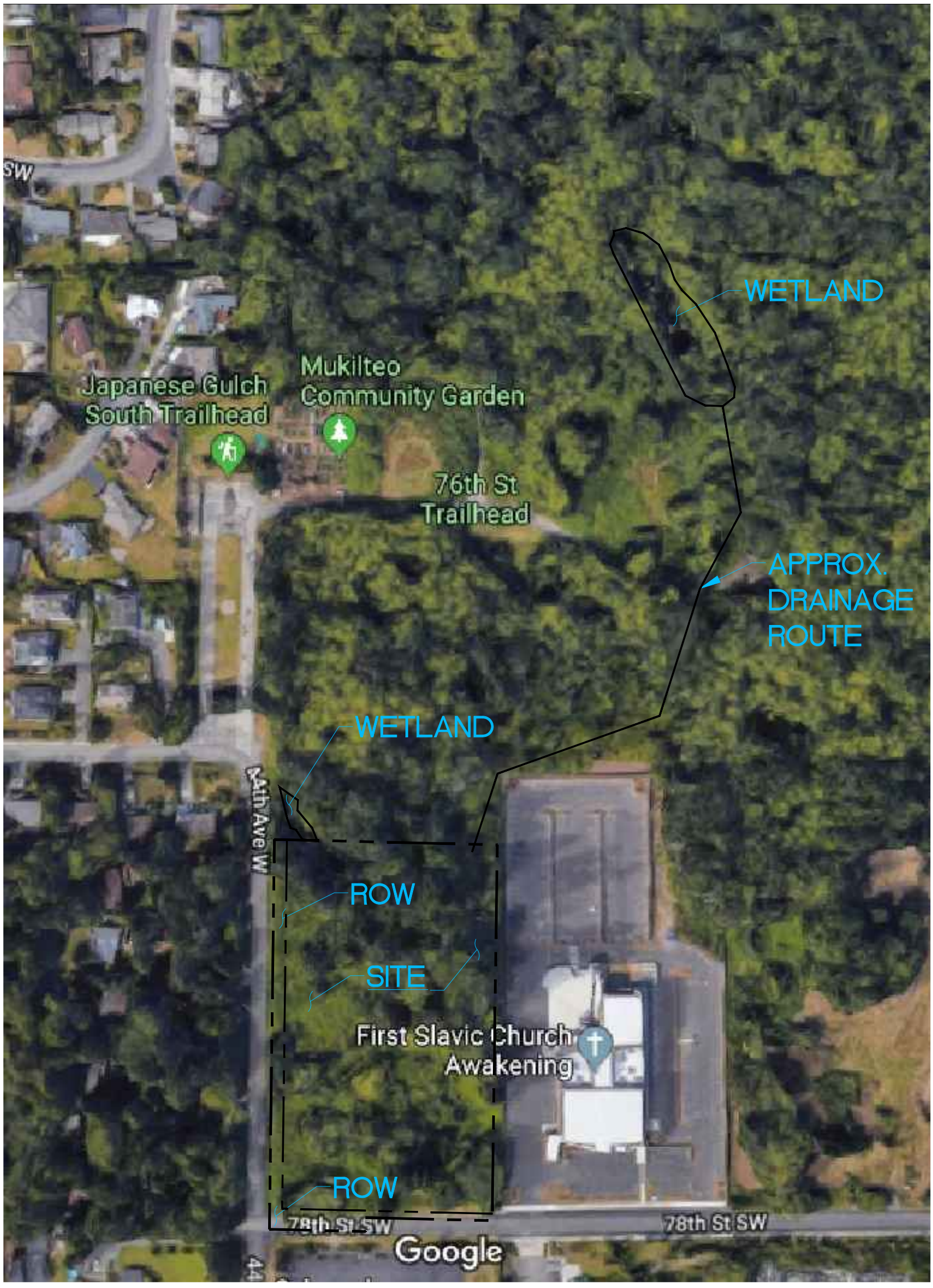

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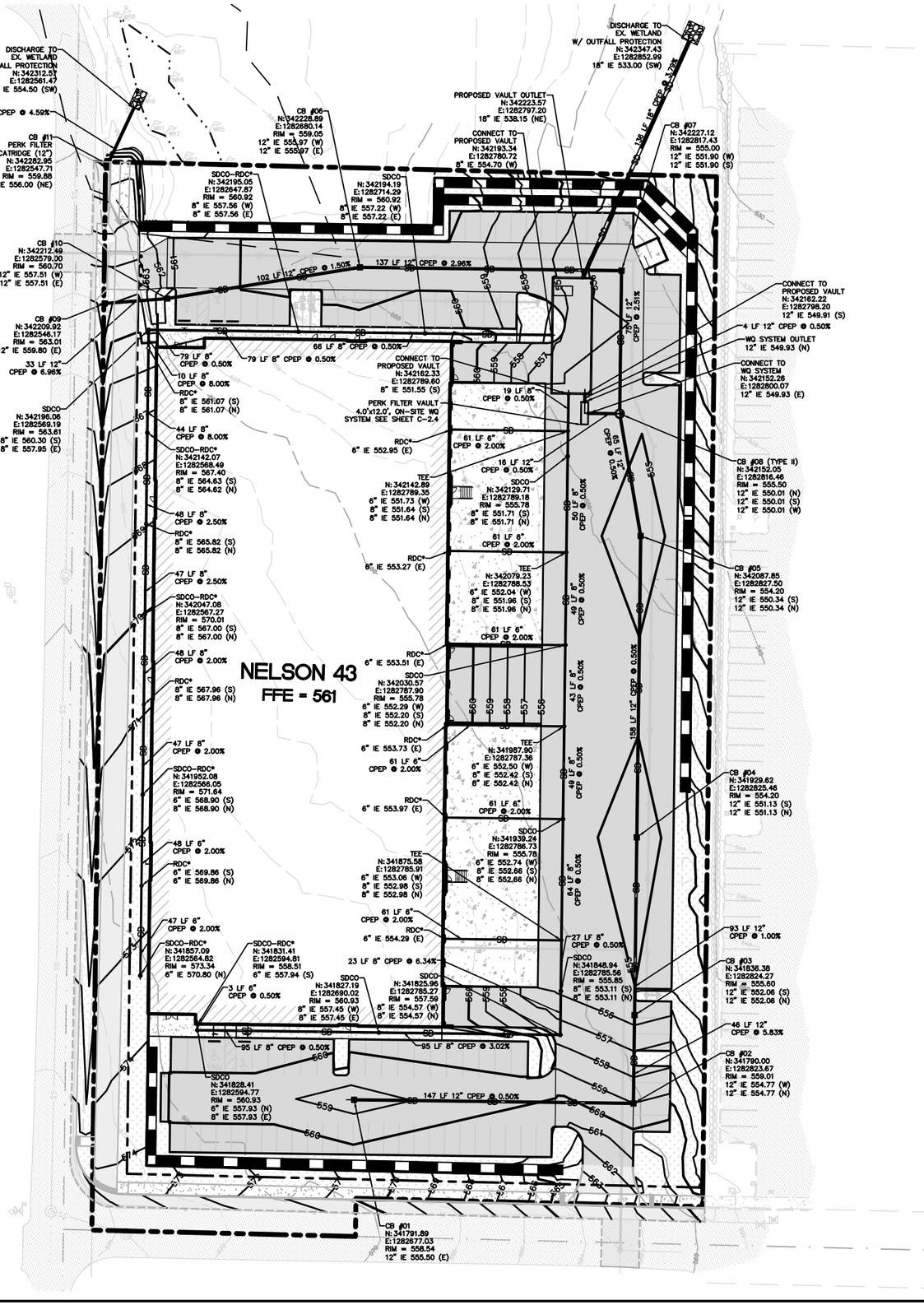
NELSON 43
MUKILTEO, WA
DOWNSTREAM CONDITIONS

EXHIBIT C

10/11/19

SCALE: 1" = 150'



0 15 30 60

SCALE: 1 INCH = 30 FT.

LEGEND

- PROPERTY LINE
- PROPOSED BUILDING
- STORM PIPE (1 C-22)
- PERFORATED PIPE
- ROOF DRAIN LINE
- TRENCH DRAIN (ZURN OR APPROVED EQUAL SEE PLAN FOR MODEL NUMBER)
- RIDGE LINE
- TYPE II CATCH BASIN W/ HERRINGBONE GRATE (UNLESS OTHERWISE NOTED) (4,5 C-21)
- TYPE II CATCH BASIN W/ THRU CURB INLET (UNLESS OTHERWISE NOTED) (4,6 C-21)
- TYPE I CATCH BASIN W/ HERRINGBONE GRATE (UNLESS OTHERWISE NOTED) (1–3,5 C-21)
- TYPE 1 CATCH BASIN W/ COMBINATION INLET (1–3,6 C-21)
- PERK FILTER CONCRETE CATCH BASIN (3 C-24)
- AREA DRAIN (6 C-22)
- STORM DRAIN CLEANOUT (SDCO) (6 C-22)
- WYE/ROOF DOWNSPOUT CONNECTION (2 C-22)

CB	CATCH BASIN
MH	MANHOLE
CPEP	CORRUGATED POLYETHYLENE PIPE
RCP	REINFORCED CONCRETE PIPE
RDL	ROOF DRAIN LINE
RDC	ROOF DRAIN CONNECTION
D.I.	DUCTILE IRON PIPE

NOTE

1. ALL STORM STRUCTURES LOCATED FROM CENTER OF STRUCTURE.
2. CONTRACTOR SHALL CONNECT ROOF DRAIN LEADERS TO PROPOSED STORM DRAINS AS SHOWN. SEE ARCHITECTURAL PLAN FOR LOCATION OF DOWNSPOUTS FOR ROOF DRAIN CONNECTIONS.
3. CONTRACTOR TO INSTALL TEMPORARY INTERCEPTOR SWALES, AS NECESSARY, TO PROMOTE POSITIVE DRAINAGE AWAY FROM ROUGH GRADING TO DESIGNATED SEDIMENT PONDS.
4. ADJUST ALL RIMS (EXISTING/PROPOSED) TO FINISHED GRADE.

* ROOF DRAINAGE CONNECTION SEE ARCHITECTURAL FOR CONTINUATION

** SEE ARCHITECTURAL/PLUMBING FOR CONTINUATION AND FINAL LAYOUT

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CLIENT/OWNER

GREG NELSON

PROJECT NAME

NELSON 43

NAVIX PROJECT NUMBER: 50-609-001

PROJECT ADDRESS

4301 78TH ST SW
MUKILTEO, WA 98275

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REVISIONS

REV	ISSUED FOR:	DATE
	PERMIT SET	10.11.19

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SECTION, TOWNSHIP, RANGE:

SECTION 10, TOWNSHIP 28
NORTH, RANGE 4 EAST, W.M.

PROJECT TEAM

REVIEWED BY: S.HUMPHREY
DESIGNED BY: S.HUMPHREY
J.STEFANOFF

SHEET NAME

GRADING AND DRAINAGE PLAN

SHEET NUMBER

C-2.0

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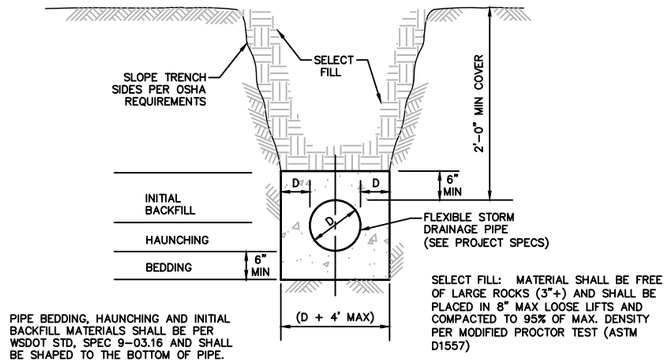
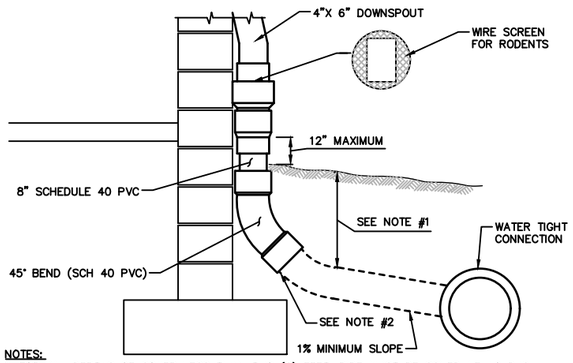
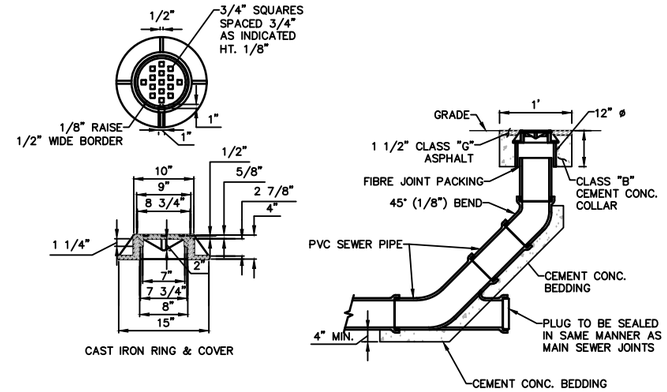


TYPICAL DRAINAGE TRENCH AND BEDDING
NTS
1

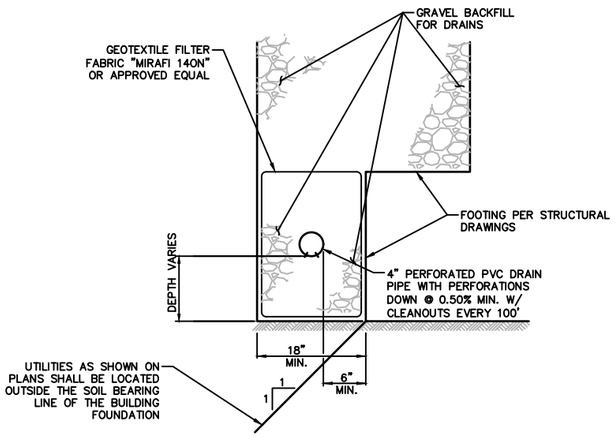


NOTES:
1. FOR ALL DEPTHS OF COVER LESS THAN TWO (2) FEET, PIPE MUST BE SCHEDULE 40 PVC. FOR DEPTHS OF COVER GREATER THAN TWO (2) FEET, FLEXIBLE PIPE MAY BE USED. REFER TO SPECIFICATIONS FOR ALLOWABLE PIPE TYPES.
2. A WATERTIGHT CONNECTION SHALL BE MAINTAINED WITH ANY TRANSITION FROM SCHEDULE 40 PVC PIPE TO ANY OTHER PIPE TYPE.
3. THE DOWNSPOUT COLLECTOR DRAIN SHALL BE INSTALLED BEFORE THE DOWNSPOUTS ARE INSTALLED ON THE BUILDING. SITEWORK CONTRACTOR SHALL BE RESPONSIBLE FOR ALL WORK TO AND INCLUDING THE RODENT SCREEN. BUILDING CONTRACTOR SHALL BE RESPONSIBLE FOR THE CONNECTION AT THE POINT OF THE RODENT SCREEN.

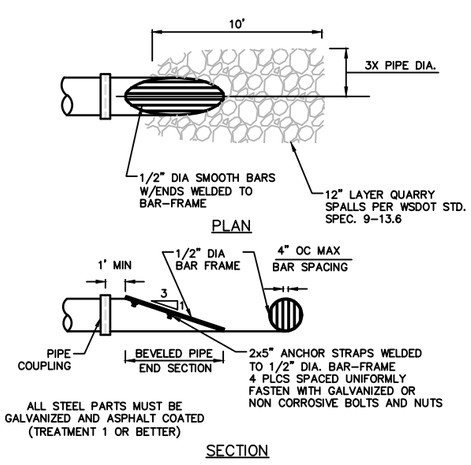
DOWNSPOUT COLLECTOR DETAIL
NTS
2



STORM DRAIN CLEANOUT
NTS
3



FOOTING DRAINAGE
NTS
4



OUTFALL PROTECTION
NTS
5

1 - 12"-30" PEDESTRIAN GRATES SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
2 - 12"-30" FRAMES SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05.
3 - DRAIN BASIN TO BE CUSTOM MANUFACTURED ACCORDING TO PLAN DETAILS. RISERS ARE NEEDED FOR BASINS OVER 84" DUE TO SHIPPING RESTRICTIONS, SEE DRAWING NO. 7001-110-005.
4 - DRAINAGE CONNECTION STUB JOINT TIGHTNESS SHALL CONFORM TO ASTM D3212 FOR CORRUGATED HDPE (ADS N-12/HANCOR DUAL WALL), N-12 HP, & PVC SEWER (4"-24").
5 - ADAPTERS CAN BE MOUNTED 0° TO 360°, TO DETERMINE MINIMUM ANGLE BETWEEN ADAPTERS SEE DRAWING NO. 7001-110-012.
6 - 12"-24" PEDESTRIAN GRATES SHALL MEET H-10 LOAD RATING, 30" PEDESTRIAN GRATE SHALL MEET H-20 LOAD RATING (SEE DRAWING NO. 7001-110-114 FOR H-20 TRAFFIC LOAD GUIDELINES).

DRAWN BY	EBC	MATERIAL	PVC
DATE	4-25-07		
REVISED BY	JJC	PROJECT NO./NAME	
DATE	4-25-13		
DWG SIZE	A	SCALE 1=40 SHEET 1 OF 1	

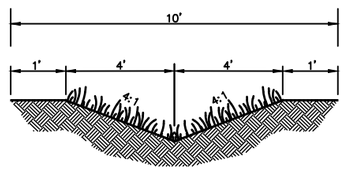
Nyloplast
3130 VERONA AVE
BUFORD, GA 30518
PHN (770) 932-2443
FAX (770) 932-2488
www.nyloplastus.com

TITLE: DRAIN BASIN WITH PEDESTRIAN GRATE QUICK SPEC INSTALLATION DETAIL

DWG NO. 7001-110-283 REV C

* OR APPROVED EQUAL

AREA DRAIN
NTS
6



GRASS LINED SWALE SECTION
NTS
7

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CLIENT/OWNER

GREG NELSON

PROJECT NAME

NELSON 43

NAVIX PROJECT NUMBER: 50-609-001

PROJECT ADDRESS

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SECTION, TOWNSHIP, RANGE:

SECTION 10, TOWNSHIP 28 NORTH, RANGE 4 EAST, W.M.

PROJECT TEAM

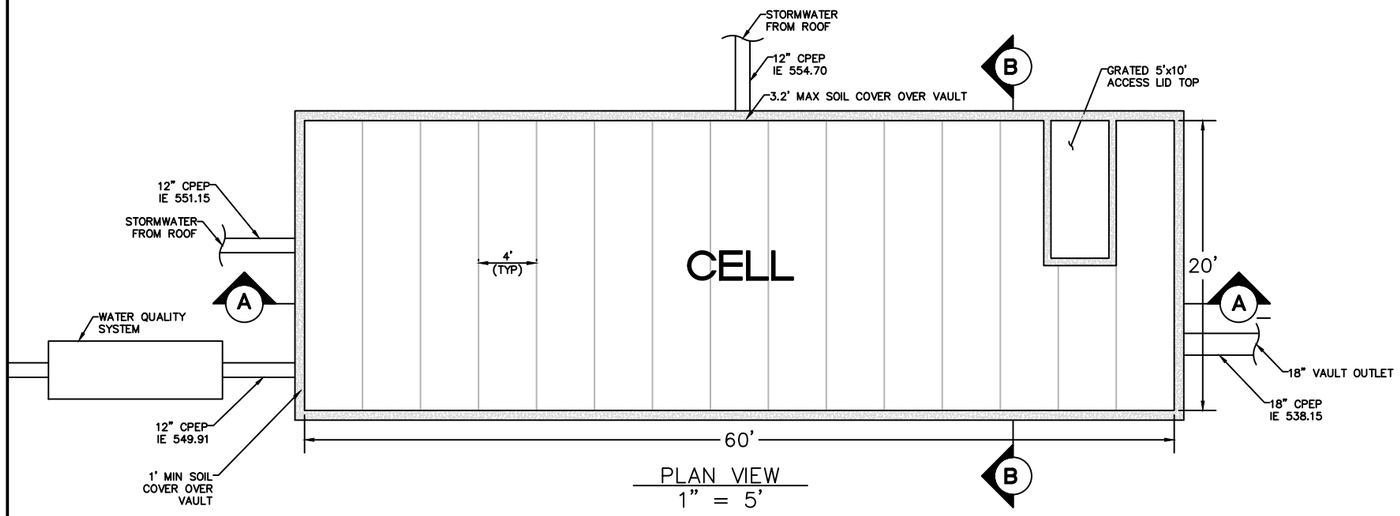
REVIEWED BY: S.HUMPHREY
DESIGNED BY: S.HUMPHREY
J.STEFANOFF

SHEET NAME

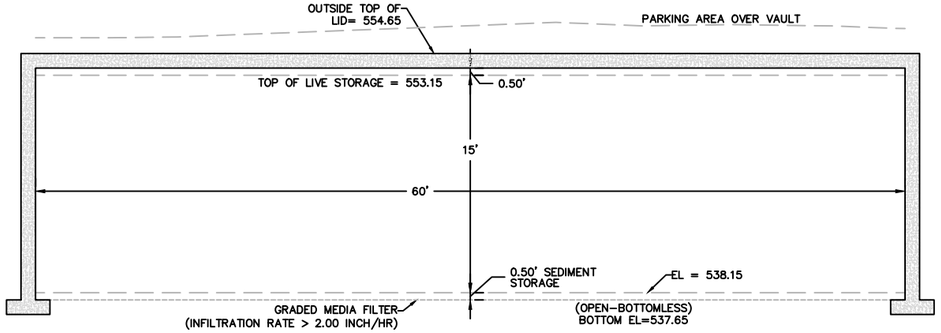
STORM DRAINAGE DETAILS

SHEET NUMBER

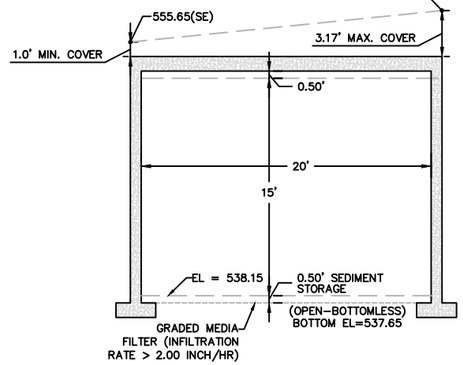
C-2.2



PLAN VIEW
1" = 5'



SECTION A
1" = 5'

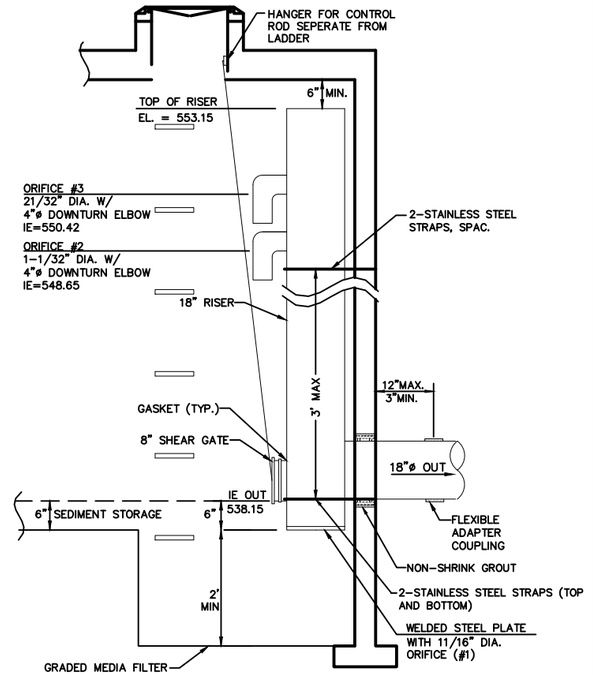


SECTION B
1" = 5'

NOTE

1. STRUCTURAL PLANS FOR VAULT TO BE INCLUDED WITH FUTURE SUBMITTAL.

STORMWATER VAULT DETAILS 1



VAULT CONTROL STRUCTURE 2

NTS

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CLIENT/OWNER

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SECTION, TOWNSHIP, RANGE:

SECTION 10, TOWNSHIP 28
NORTH, RANGE 4 EAST, W.M.

PROJECT TEAM

REVIEWED BY:	S.HUMPHREY
DESIGNED BY:	S.HUMPHREY
	J.STEFANOFF

SHEET NAME

STORM DRAINAGE DETAILS

SHEET NUMBER

C-2.3

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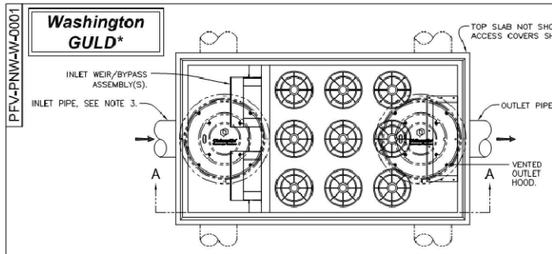
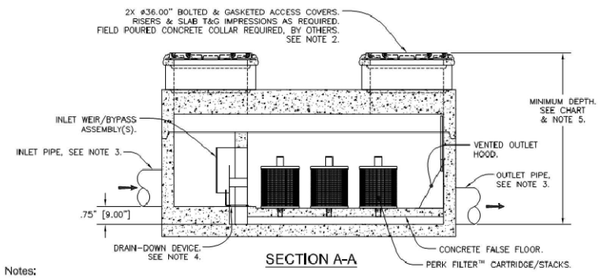
PFV-PNW-W-0001

Washington GULD*





SECTION A-A

Notes:

1. Precast concrete structure shall be manufactured in accordance with ASTM Designation C857 and C858.
2. Filter system shall be supplied with traffic rated (H20) bolted & gasketed Ø36" circular access covers with risers as required. Shallow applications may require configurations with (H20) bolted & gasketed square/rectangular access hatches. Field poured concrete collars required, by others.
3. Inlet & outlet pipe(s) may enter device on all three sides of the inlet & outlet chambers. See chart for maximum pipe size.
4. Inlet chamber shall be supplied with a drain-down device designed to remove standing water between storm events.
5. For depths less than specified minimums contact Oldcastle® Stormwater Solutions for engineering assistance.

* **Treatment Flow Rates shown conform to Washington State GULD Specifications**

Perk Filter™ Vault
Pacific Northwest Sizing
Washington State GULD
One to Twenty Nine Cartridges / Stacks

Media Filtration

Oldcastle® Stormwater Solutions
7921 Southpark Plaza, Suite 200 | Littleton, CO | 80120 | Ph: 800.579.5819 | oldcastlestormwater.com

DRAWING NO.	REV	ECO	DATE	
PFV-PNW-W-0001	NR	ECO-0138 NEW 11/16/15	JPR 11/16/15	SHEET 1 OF 2

PFV-PNW-W-0001

Washington GULD*

MINIMUM DEPTH
- RIM TO OUTLET INVERT -

CARTRIDGE STACK CONFIGURATION			
12"	18"	12" + 12"	12" + 18"
4.08' [49.00"]	4.83' [58.00"]	5.75' [69.00"]	6.50' [78.00"]

Treatment Flow Rates & Total Flow Capacities

VAULT SIZE ID (Nominal)	MAXIMUM PIPE SIZE	Cartridge / Stack Quantity	CARTRIDGE SIZE & STACK CONFIGURATION							
			12"		18"		12" + 12"		12" + 18"	
			TREATMENT FLOW RATE (GPM / CFS)	TOTAL FLOW CAPACITY (CFS)	TREATMENT FLOW RATE (GPM/CFS)	TOTAL FLOW CAPACITY (CFS)	TREATMENT FLOW RATE (GPM/CFS)	TOTAL FLOW CAPACITY (CFS)	TREATMENT FLOW RATE (GPM/CFS)	TOTAL FLOW CAPACITY (CFS)
4.0' X 6.5'	Ø18"	1	6.8 0.015	2.8	10.2 0.023	4.2	13.6 0.030	4.7	17.0 0.038	6.3
		2	13.6 0.030	2.8	20.4 0.045	4.2	27.2 0.061	4.7	34.0 0.076	6.3
		3	20.4 0.045	2.8	30.6 0.068	4.2	40.8 0.091	4.8	51.0 0.114	6.3
5.0' X 10.5'	Ø18"	4	27.2 0.061	2.9	40.8 0.091	4.2	54.4 0.121	4.8	68.0 0.152	6.4
		5	34.0 0.076	2.9	51.0 0.114	4.2	68.0 0.152	4.8	85.0 0.190	6.4
		6	40.8 0.091	2.9	61.2 0.136	4.3	81.6 0.182	4.9	102.0 0.227	6.4
		7	47.6 0.106	2.9	71.4 0.159	4.3	95.2 0.212	4.9	119.0 0.265	6.5
		8	54.4 0.121	2.9	81.6 0.182	4.3	108.8 0.243	4.9	136.0 0.303	6.5
6.0' X 12.0'	Ø24"	9	61.2 0.136	5.7	91.8 0.205	8.5	122.4 0.273	9.6	153.0 0.341	12.8
		10	68.0 0.152	5.8	102.0 0.227	8.5	136.0 0.303	9.6	170.0 0.379	12.8
		11	74.8 0.167	5.8	112.2 0.250	8.5	149.6 0.334	9.7	187.0 0.417	12.9
		12	81.6 0.182	5.8	122.4 0.273	8.5	163.2 0.364	9.7	204.0 0.455	12.9
8.0' X 16'	Ø24"	13	88.4 0.197	8.6	132.6 0.296	12.7	176.8 0.394	14.4	221.0 0.493	19.2
		14	95.2 0.212	8.6	142.8 0.318	12.7	190.4 0.425	14.4	238.0 0.531	19.2
		15	102.0 0.227	8.6	153.0 0.341	12.7	204.0 0.455	14.5	255.0 0.569	19.2
		16	108.8 0.243	8.6	163.2 0.364	12.8	217.6 0.485	14.5	272.0 0.607	19.3
		17	115.6 0.258	8.6	173.4 0.387	12.8	231.2 0.516	14.5	289.0 0.644	19.3
		18	122.4 0.273	8.7	183.6 0.409	12.8	244.8 0.546	14.6	306.0 0.682	19.3
		19	129.2 0.288	8.7	193.8 0.432	12.8	258.4 0.576	14.6	323.0 0.720	19.4
		20	136.0 0.303	8.7	204.0 0.455	12.8	272.0 0.607	14.6	340.0 0.758	19.4
		21	142.8 0.318	8.7	214.2 0.478	12.9	285.6 0.637	14.6	357.0 0.796	19.5
		22	149.6 0.334	8.7	224.4 0.500	12.9	299.2 0.667	14.7	374.0 0.834	19.5
		23	156.4 0.349	8.7	234.6 0.523	12.9	312.8 0.698	14.7	391.0 0.872	19.5
		24	163.2 0.364	8.8	244.8 0.546	12.9	326.4 0.728	14.7	408.0 0.910	19.6
		25	170.0 0.379	8.8	255.0 0.569	13.0	340.0 0.758	14.8	425.0 0.948	19.6
		26	176.8 0.394	8.8	265.2 0.591	13.0	353.6 0.789	14.8	442.0 0.986	19.6
		27	183.6 0.409	8.8	275.4 0.614	13.0	367.2 0.819	14.8	459.0 1.024	19.7
		28	190.4 0.425	8.8	285.6 0.637	13.0	380.8 0.849	14.9	476.0 1.061	19.7
		29	197.2 0.440	8.8	295.8 0.660	13.0	394.4 0.880	14.9	493.0 1.099	19.8
MAXIMUM HEAD LOSS			1.7 FEET		2.3 FEET		2.9 FEET		3.5 FEET	

* **Treatment Flow Rates shown conform to Washington State GULD Specifications**

Perk Filter™ Vault
Pacific Northwest Sizing
Washington State GULD
One to Twenty Nine Cartridges / Stacks

Media Filtration

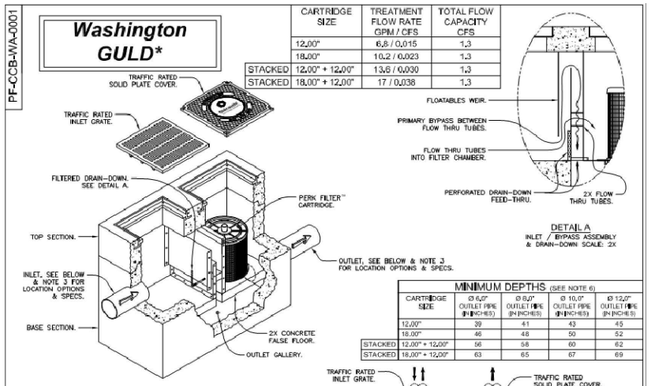
Oldcastle® Stormwater Solutions
7921 Southpark Plaza, Suite 200 | Littleton, CO | 80120 | Ph: 800.579.5819 | oldcastlestormwater.com

DRAWING NO.	REV	ECO	DATE	
PFV-PNW-W-0001	NR	ECO-0138 NEW 11/16/15	JPR 11/16/15	SHEET 2 OF 2

PF-CCB-WA-0001

Washington GULD*

CARTRIDGE SIZE		TREATMENT FLOW RATE GPM / CFS	TOTAL FLOW CAPACITY CFS
12,00"		6,8 / 0,015	1,3
18,00"		10,2 / 0,023	1,3
STACKED	12,00" + 12,00"	13,6 / 0,030	1,3
STACKED	18,00" + 12,00"	17 / 0,038	1,3



DETAIL A
INLET / BYPASS ASSEMBLY & DRAIN-DOWN SCALE: 2X

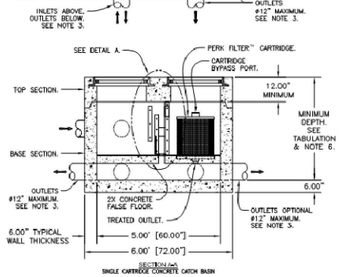
MINIMUM DEPTHS (SEE NOTE 6)

CARTRIDGE SIZE		Ø 6,0" OUTLET PIPE (IN INCHES)	Ø 8,0" OUTLET PIPE (IN INCHES)	Ø 10,0" OUTLET PIPE (IN INCHES)	Ø 12,0" OUTLET PIPE (IN INCHES)
12,00"		39	41	43	45
18,00"		46	48	50	52
STACKED	12,00" + 12,00"	56	58	60	62
STACKED	18,00" + 12,00"	63	65	67	69

Notes:

1. Precast concrete structure shall be manufactured in accordance with ASTM Designation C857 and C858.
2. Perk Filter™ Catch basin shall be supplied with traffic rated (H20) bicycle-proof grates and solid plate cover.
3. Inlet pipe(s) may enter device on three sides of the inlet chamber. Outlet pipe(s) may exit on all four sides. All pipe is Ø 12" maximum.
4. Inlet chamber shall be supplied with a drain-down device designed to remove standing water between storm events.
5. Perk Filter™ cartridge shall be maintained in accordance with manufacturer recommendations.
6. For depths less than the specified minimum contact Oldcastle® Stormwater Solutions for engineering assistance.

* **Treatment Flow Rates shown conform to Washington State GULD Specifications.**



SECTION A-A
SINGLE CARTRIDGE CONCRETE CATCH BASIN

Perk Filter™
Concrete Catch Basin
Washington State GULD
Single Cartridge

Media Filtration

Oldcastle® Stormwater Solutions
7921 Southpark Plaza, Suite 200 | Littleton, CO | 80120 | Ph: 800.579.5819 | oldcastlestormwater.com

DRAWING NO.	REV	ECO	DATE	
PF-CCB-WA-0001	E	ECO-0144 ZHD 8/26/16	JPR 3/2/11	SHEET 1 OF 1

NAVIX
SITE | CIVIL

11235 s.e. 6th street | suite 150
bellevue, wa 98004

t: 425.453.9501 | f: 425-453-8208
www.navixeng.com

CLIENT/OWNER

GREG NELSON

PROJECT NAME

NELSON 43

NAVIX PROJECT NUMBER: 50-609-001

PROJECT ADDRESS

4301 78TH ST SW
MUKILTEO, WA 98275

STAMP

REVISIONS

REV	ISSUED FOR:	DATE
	PERMIT SET	10.11.19

811

SECTION, TOWNSHIP, RANGE:

SECTION 10, TOWNSHIP 28
NORTH, RANGE 4 EAST, W.M.

PROJECT TEAM

REVIEWED BY: S.HUMPHREY
DESIGNED BY: S.HUMPHREY
J.STEFANOFF

SHEET NAME

STORM DRAINAGE DETAILS

SHEET NUMBER

C-2.4

B:\Washington\Mukilteo\Nelson 43\2Drawings\MUNE_1296.dwg Oct 11, 2019 - 9:34am

APPENDIX B

GEOTECHNICAL ENGINEERING INVESTIGATION REPORTS

Report 1 – Geotechnical Engineering Study–December 27, 2018
Report 2 – Infiltration Feasibility Report– May 8, 2019

Earth Solutions NW LLC

Geotechnical Engineering
Construction Observation/Testing
Environmental Services

GEOTECHNICAL ENGINEERING STUDY
PROPOSED COMMERCIAL WAREHOUSE
4301 - 78TH STREET SOUTHWEST
MUKILTEO, WASHINGTON

ES-6384

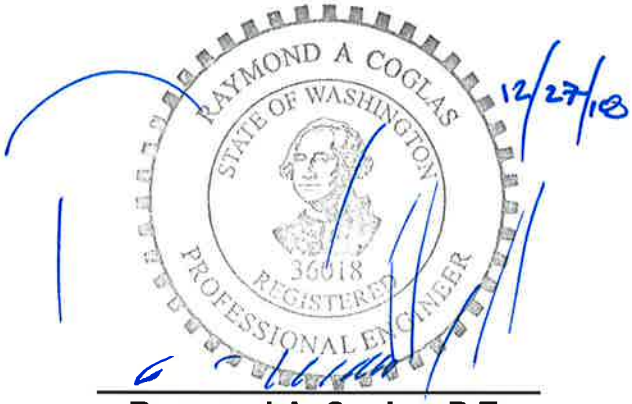
1805 - 136th Place N.E., Suite 201 Bellevue, WA 98005
(425) 449-4704 Fax (425) 449-4711
www.earthsolutionsnw.com

PREPARED FOR

UNDERWOOD NELSON DEVELOPMENT

December 27, 2018

Chase G. Halsen
Staff Geologist



Raymond A. Coglas, P.E.
Principal Engineer

GEOTECHNICAL ENGINEERING STUDY
PROPOSED COMMERCIAL WAREHOUSE
4301 – 78TH STREET SOUTHWEST
MUKILTEO, WASHINGTON

ES-6384

Earth Solutions NW, LLC
1805 – 136th Place Northeast, Suite 201
Bellevue, Washington 98005
Phone: 425-449-4704 | Fax: 425-449-4711
www.earthsolutionsnw.com

Important Information About Your

Geotechnical Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

The following information is provided to help you manage your risks.

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

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical engineering study conducted for a civil engineer may not fulfill the needs of a construction contractor or even another civil engineer. Because each geotechnical engineering study is unique, each geotechnical engineering report is unique, prepared *solely* for the client. No one except you should rely on your geotechnical engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply the report for any purpose or project except the one originally contemplated.

Read the Full Report

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

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

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

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

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

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light industrial plant to a refrigerated warehouse,
- elevation, configuration, location, orientation, or weight of the proposed structure,
- composition of the design team, or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

Subsurface Conditions Can Change

A geotechnical engineering report is based on conditions that existed at the time the study was performed. *Do not rely on a geotechnical engineering report* whose adequacy may have been affected by: the passage of time; by man-made events, such as construction on or adjacent to the site; or by natural events, such as floods, earthquakes, or groundwater fluctuations. *Always* contact the geotechnical engineer before applying the report to determine if it is still reliable. A minor amount of additional testing or analysis could prevent major problems.

Most Geotechnical Findings Are Professional Opinions

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

A Report's Recommendations Are *Not* Final

Do not overrely on the construction recommendations included in your report. *Those recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations only by observing actual

subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's recommendations if that engineer does not perform construction observation.*

A Geotechnical Engineering Report Is Subject to Misinterpretation

Other design team members' misinterpretation of geotechnical engineering reports has resulted in costly problems. Lower that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Contractors can also misinterpret a geotechnical engineering report. Reduce that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing construction observation.

Do Not Redraw the Engineer's Logs

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

Give Contractors a Complete Report and Guidance

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

Read Responsibility Provisions Closely

Some clients, design professionals, and contractors do not recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations" many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

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

Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, a number of mold prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; ***none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.***

Rely on Your ASFE-Member Geotechncial Engineer for Additional Assistance

Membership in ASFE/The Best People on Earth exposes geotechnical engineers to a wide array of risk management techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you ASFE-member geotechnical engineer for more information.

ASFE
The Best People on Earth

8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@asfe.org www.asfe.org

IIGER06045.0M

Earth Solutions NW LLC

Geotechnical Engineering, Construction
Observation/Testing and Environmental Services

December 27, 2018
ES-6384

Underwood Nelson Development
P.O. Box 1301
Seahurst, Washington 98062

Attention: Mr. Greg Nelson

Dear Mr. Nelson:

Earth Solutions NW, LLC (ESNW) is pleased to present this report titled "Geotechnical Engineering Study, Proposed Commercial Warehouse, 4301 – 78th Street Southwest, Mukilteo, Washington". Based on the results of our investigation, the proposal is feasible from a geotechnical standpoint. Our study indicates the site is underlain by glacial till deposits. Perched groundwater seepage was encountered at test pit location TP-1, at an emergence depth of about one-and-one-half feet below the existing ground surface elevation. Although seepage was not encountered elsewhere, it is our opinion the contractor be prepared to manage discrete zones of groundwater seepage encountered during construction.

The proposed commercial warehouse structure can be constructed on conventional continuous and spread footing foundation system bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. Competent native soil suitable for support of foundations will likely be encountered beginning at depths of about two-and-one-half to three feet below the existing ground surface elevation. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with suitable structural fill, will be necessary. It should be noted the recompacted native soils or new structural fill should be protected from water intrusion to help prevent saturation and softening of the subgrade proposed for foundation support.

We understand stormwater management will be provided by a stormwater vault located within the northeastern site corner. Given the presence of perched groundwater seepage and/or unweathered, cemented glacial till at relatively shallow depths, infiltration is considered infeasible for the subject project. In our opinion, the unweathered glacial till present at depth should be considered impermeable for practical design purposes.

Pertinent geotechnical recommendations are provided in this study. We appreciate the opportunity to be of service to you on this project. If you have questions regarding the content of this geotechnical engineering study, please call.

Sincerely,

EARTH SOLUTIONS NW, LLC

Chase G. Halsen
Staff Geologist

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ES-6384

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Cont'd

ES-6384

GEOTECHNICAL ENGINEERING STUDY
PROPOSED COMMERCIAL WAREHOUSE
4301 – 78TH STREET SOUTHWEST
MUKILTEO, WASHINGTON

ES-6384

INTRODUCTION

General

This geotechnical engineering study (study) was prepared for the proposed commercial warehouse to be constructed northeast of the 78th Street Southwest and 44th Avenue West intersection, in Mukilteo, Washington. The purpose of this study was to provide geotechnical recommendations for currently proposed development plans. Our scope of services for completing this study included the following:

- Test pits for the purpose of characterizing site soils;
- Laboratory testing of soil samples collected at the test pit locations;
- Engineering analyses, and;
- Preparation of this report.

The following documents and maps were reviewed as part of our study preparation:

- Site Plan Schematic, Client Provided, undated;
- Snohomish County Liquefaction Susceptibility, endorsed by the Washington State Department of Natural Resources, October 2009;
- Distribution and Description of Geologic Units in the Mukilteo Quadrangle, Washington, by James P. Minard, 1982, and;
- Online Web Soil Survey, provided by the United States Department of Agriculture, Natural Resources Conservation Service.

Project Description

Review of a preliminary site layout plan indicates the subject site will be developed with a commercial warehouse, a stormwater detention vault (vault), and associated infrastructure improvements. Ingress and egress will be provided via 78th Street Southwest. At the time of report submission, specific building load and grading plans were not available for review; however, we understand the proposed structure will be one story in height and constructed utilizing concrete tilt-up walls. We anticipate perimeter footing loads of 4 to 6 kips per lineal foot, column loads of about 120 kips, and slab-on-grade loading of approximately 350 pounds per square foot (psf). Site grading will likely involve cuts and fills utilizing a balanced approach. Site retaining walls will also likely be incorporated into the plans to facilitate grade transitions.

We understand stormwater will be managed by a vault located in the northeastern portion of the site; ESNW should provide specific construction and design recommendations when detention facility plans are available. We understand earthwork activities will primary consist of grade cuts up to five feet within the southern site area and fills up to about 10 to 15 feet within northern site area.

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

SITE CONDITIONS

Surface

The subject site is located northeast of the 78th Street Southwest and 44th Avenue West intersection, in Mukilteo, Washington. The approximate location of the property is illustrated on Plate 1 (Vicinity Map). The property is comprised of four adjoining tax parcels (Snohomish County Parcel Nos. 280410-003-001-00, -004-00, -005-00, and -006-00) totaling about 4.0 acres. The site is bordered to the north by undeveloped land, to the east by a church, to the south by 78th Street Southwest, and to the west by 44th Avenue West. The site is currently undeveloped and vegetated with mature forested growth with a dense underbrush. Site topography has a northeasterly declination with about 35 feet of elevation change occurring within the property bounds.

Subsurface

A representative of ESNW observed, logged, and sampled the excavation of eight test pits, at accessible locations of the site on December 5, 2018, using a mini trackhoe and operator retained by our firm. The explorations were completed for purposes of assessment and classification of site soils as well as characterization of groundwater conditions across the site. The approximate locations of the explorations are depicted on Plate 2 (Test Pit Location Plan). Please refer to the test pit logs provided in Appendix A for a more detailed description of subsurface conditions. Representative soil samples collected at the test pit locations were evaluated in general accordance with Unified Soil Classification System and United States Department of Agriculture (USDA) methods and procedures.

Topsoil and Fill

Topsoil was encountered in the upper 6 to 18 inches of existing grades at the test pit locations. The topsoil was characterized by dark brown color, the presence of fine organic material, and small root intrusions. Fill was not encountered at the test pit locations. Given the undeveloped nature of the site, we do not anticipate significant fill soils to be encountered during general earthwork activities. However, past (historic) clearing activities may have produced bury pits where stumps, logs, or other organic debris may have been locally buried.

Native Soil

Underlying topsoil, native deposits were observed primarily as silty sand and sandy silt with or without gravel (USCS: SM and ML, respectively). The upper approximate two to three feet of the deposit was characterized as loose to medium dense, thereafter becoming dense to very dense. The native soils were observed primarily in a moist condition, extending to the maximum exploration depth of about six-and-one-half feet below the existing ground surface elevation where refusal to mechanical excavation was observed.

Geologic Setting

The referenced geologic map resource identifies glacial till (Qvt) deposits as the native soil deposit underlying the subject site. The glacial till, locally referred to as Vashon till, consists of a nonsorted mixture of clay, silt, sand, pebbles, cobbles, and boulders. The referenced WSS resource identifies Alderwood-Urban land complex, 2 to 15 percent slopes (Map Unit Symbol: 5 and 6) as the primary soil unit underlying the subject site. Designations of Urban land complex indicates soils may have been previously modified through earthwork activities. Based on our field observations, site soils are consistent with local geologic mapping and soil survey designations.

Groundwater

During our subsurface exploration completed on December 5, 2018, groundwater seepage was encountered at TP-1, beginning at a depth of about one-and-one-half feet bgs. As such, it is our opinion the contractor should anticipate, and be prepared to respond and manage, zones of perched groundwater seepage during construction, especially within deeper site excavations. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches, sumps, and dewatering pumps. It should be noted that seepage rates and elevations fluctuate depending on many factors, including precipitation duration and intensity, the time of year, and soil conditions. In general, groundwater flow rates are higher during the winter, spring, and early summer months.

Geologically Hazardous Areas

Review of the available Snohomish County maintained GIS database does not indicate the presence of geologically hazardous areas. Additionally, no such indicators were observed during our fieldwork or within the test pit locations.

DISCUSSION AND RECOMMENDATIONS

General

Based on the results of our investigation, construction of the proposed commercial development is feasible from a geotechnical standpoint. The primary geotechnical considerations associated with the proposed development include foundation support, subgrade preparation, and the suitability of using native soils as structural fill.

The proposed commercial warehouse structure can be constructed on conventional continuous and spread footing foundation system bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. Competent native soil suitable for support of foundations will likely be encountered beginning at depths of about two-and-one-half to three feet below the existing ground surface elevation. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with suitable structural fill, will be necessary. It should be noted the recompacted native soils or new structural fill should be protected from water intrusion to help prevent saturation and softening of the subgrade proposed for foundation support.

We understand stormwater management will be provided by a vault located within the northeastern site corner. Given the presence of perched groundwater seepage and/or unweathered, cemented glacial till at relatively shallow depths, infiltration is considered infeasible for the subject project. In our opinion, the unweathered glacial till present at depth should be considered impermeable for practical design purposes.

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

Site Preparation and Earthwork

Initial site preparation activities will consist of installing temporary erosion control measures, establishing grading limits, and performing clearing and site stripping. Subsequent earthwork activities will involve mass site grading and related infrastructure improvements.

Temporary Erosion Control

The following temporary erosion control measures are offered:

- Temporary construction entrances and drive lanes, consisting of at least six inches of quarry spalls, should be considered to both minimize off-site soil tracking and provide a stable access entrance surface. Placing geotextile fabric underneath the quarry spalls will provide greater stability, if needed.
- Silt fencing should be placed around the site perimeter.
- When not in use, soil stockpiles should be covered or otherwise protected, especially during periods of wet weather to reduce the potential for soil erosion.
- Temporary measures for controlling surface water runoff, such as interceptor trenches, sumps, or interceptor swales, should be installed prior to beginning earthwork activities.
- Dry soils disturbed during construction should be wetted to minimize dust.
- When appropriate, permanent planting or hydroseeding will help to stabilize site soils.

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

Stripping

Topsoil was encountered within the upper approximately one to six inches of existing grades at the test pit locations. ESNW should be retained to provide site stripping recommendations at the time of construction. Topsoil and/or organic-rich soil is considered suitable for use neither in structural areas nor as structural fill. If desired, topsoil and/or organic-rich soil may be used in non-structural areas. Additionally, due to the undeveloped condition of the site, topsoil thicknesses may vary substantially across the property.

Excavations and Slopes

Excavation activities are likely to expose both medium dense soil (within the upper three to six feet bgs) and denser soils at depth. Based on the soil conditions observed at the test pit locations, the following allowable temporary slope inclinations, as a function of horizontal to vertical (H:V) inclination, may be used. The applicable Federal Occupation Safety and Health Administration (OSHA) and Washington Industrial Safety and Health Act (WISHA) soil classifications are also provided:

- Loose to medium dense soil — 1.5H:1V (Type C)
- Areas containing groundwater seepage — 1.5H:1V (Type C)
- Dense to very dense, undisturbed native soil — 0.75H:1V (Type A)

Steeper temporary slope inclinations within undisturbed, very dense glacial deposits may be feasible based on the soil and groundwater conditions exposed within the excavations. If pursued, ESNW can assist in evaluating the feasibility of utilizing steeper temporary slopes at the time of construction.

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

In-situ and Imported Soils

On-site soils are moisture sensitive, and successful use of on-site soils as structural fill will largely be dictated by the moisture content at the time of placement and compaction. Remedial measures, such as soil aeration and/or cement treatment (where approved by the local jurisdiction or utility district), may be necessary as part of site grading and earthwork activities. If the on-site soils cannot be successfully compacted, the use of an imported soil may be necessary. In our opinion, a contingency should be provided in the project budget for export of soil that cannot be successfully compacted as structural fill, particularly if grading activities take place during periods of extended rainfall activity. In general, soils with fines contents greater than 5 percent typically degrade rapidly when exposed to periods of rainfall.

Imported soil intended for use as structural fill should consist of a well-graded, granular soil with a moisture content that is at (or slightly above) the optimum level. During wet weather conditions, imported soil intended for use as structural fill should consist of a well-graded, granular soil with a fines content of 5 percent or less (where the fines content is defined as the percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction).

Subgrade Preparation

Foundation and slab subgrade surfaces should consist of competent undisturbed native soil (cut areas) or structural fill placed atop a competent native soil surface. ESNW should observe subgrade areas prior to placing formwork. Supplementary recommendations for subgrade improvement may be provided at the time of construction; such recommendations would likely include further mechanical compaction effort and/or overexcavation and replacement with suitable structural fill. It should be noted the recompacted native soils or new structural fill should be protected from water intrusion to help prevent saturation and softening of the subgrade proposed for foundation support.

Structural Fill

Structural fill is defined as compacted soil placed in foundation, slab-on-grade, roadway areas, permanent slope, retaining wall, and utility trench backfill areas. Soils placed in structural areas should be placed in loose lifts of 12 inches or less and compacted to a relative compaction of 95 percent, based on the laboratory maximum dry density as determined by the Modified Proctor Method (ASTM D1557). For soil placed in utility trenches underlying structural areas, compaction requirements are dictated by the local city, county, or utility district, and are typically specified to a relative compaction of at least 95 percent.

Foundations

The proposed commercial warehouse structure can be constructed on conventional continuous and spread footing foundations bearing on competent native soil, recompacted native soil, or new structural fill placed directly on competent native soil. Competent native soil suitable for support of foundations will likely be encountered beginning at depths of about two-and-one-half to three feet below the existing ground surface elevation. Where loose or unsuitable soil conditions are exposed at foundation subgrade elevations, compaction of soils to the specifications of structural fill, or overexcavation and replacement with suitable structural fill, will be necessary. It should be noted the recompacted native soils or new structural fill should be protected from water intrusion to help prevent saturation and softening of the subgrade proposed for foundation support.

Provided the foundations will be supported as prescribed, the following parameters may be used for design:

- Allowable soil bearing capacity — 2,500 psf
- Passive earth pressure — 350 pcf (equivalent fluid)
- Coefficient of friction — 0.40

A one-third increase in the allowable soil bearing capacity may be assumed for short-term wind and seismic loading conditions. The above passive pressure and friction values include a factor-of-safety of 1.5. With structural loading as expected, total settlement in the range of one inch and differential settlement of about one-half inch is anticipated across a typical column span. The majority of the settlements should occur during construction, as dead loads are applied. It should be noted, however, that structural fill must be placed and compacted as recommended in the *Structural Fill* section of this report. Saturation and softening of the subgrade must not be allowed to occur.

Seismic Design

The 2015 International Building Code recognizes the American Society of Civil Engineers (ASCE) for seismic site class definitions. In accordance with Table 20.3-1 of the ASCE Minimum Design Loads for Buildings and Other Structures manual, Site Class D should be used for design.

The referenced liquefaction susceptibility map indicates the subject site possesses very low liquefaction susceptibility. Liquefaction is a phenomenon where saturated and loose sandy soils suddenly lose internal strength and behave as a fluid. This behavior is in response to increased pore water pressures resulting from an earthquake or other intense ground shaking. In our opinion, site susceptibility to liquefaction may be considered negligible. The relatively high in-situ densities of the native soils and the absence of a uniformly established, shallow groundwater table were the primary bases for this consideration.

Slab-on-Grade Floors

Slab-on-grade floors for the proposed structure should be supported on competent and well-compacted, firm and unyielding subgrades. Unstable or yielding subgrade areas should be recompacted, or overexcavated and replaced with suitable structural fill, prior to slab construction. A capillary break consisting of at least four inches of free-draining crushed rock or gravel should be placed below each slab. The free-draining material should have a fines content of 5 percent or less (where the fines content is defined as the percent passing the Number 200 sieve, based on the minus three-quarter-inch fraction). In areas where slab moisture is undesirable, installation of a vapor barrier below the slab should be considered. If a vapor barrier is to be used, it should be a material specifically designed for use as a vapor barrier and should be installed in accordance with the specifications of the manufacturer.

Retaining Walls

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

• Active earth pressure (unrestrained condition)	35 pcf (equivalent fluid)
• At-rest earth pressure (restrained condition)	55 pcf
• Traffic surcharge (passenger vehicles)	70 psf (rectangular distribution)*
• Passive earth pressure	350 pcf (equivalent fluid)
• Coefficient of friction	0.40
• Seismic surcharge	6H psf**

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

A factor-of-safety of one and one half has been applied to the friction and passive resistance values. The above design parameters are based on a level backfill condition and level grade at the wall toe. Revised design values will be necessary if sloping grades are to be used above or below retaining walls. Additional surcharge loading from adjacent foundations, sloped backfill, or other loads should be included in the retaining wall design, where applicable.

Retaining walls should be backfilled with free-draining material or suitable sheet drainage that extends along the height of the wall and a distance of at least 18 inches behind the wall. The upper 12 inches of the wall backfill can consist of a less permeable soil, if desired. A perforated drainpipe should be placed along the base of the wall and connected to an approved discharge location. A typical retaining wall drainage detail is provided on Plate 3. If drainage is not provided, hydrostatic pressures should be included in the wall design.

Drainage

Zones of perched groundwater seepage should be anticipated in site excavations depending on the time of year grading operations take place, particularly within deeper excavations for utilities; seepage may be heavy if overexcavation of unsuitable soil conditions in building subgrade is pursued. Temporary measures to control surface water runoff and groundwater during construction would likely involve interceptor trenches and sumps. ESNW should be consulted during preliminary grading to identify areas of seepage and to provide recommendations to reduce the potential for instability related to seepage effects.

Finish grades must be designed to direct surface water away from the new structure for a distance of at least ten feet or as setbacks allow. Water must not be allowed to pond adjacent to the new structure. In our opinion, foundation drains should be installed along the building perimeter footings. A typical foundation drain detail is provided on Plate 4.

Infiltration Feasibility Evaluation

As indicated in the *Subsurface* section of this report, native soils encountered during our fieldwork were characterized primarily as glacial till. In accordance with USDA textural analyses, the native till is classified as slightly gravelly to gravelly loam and slight gravelly fine sandy loam. Disregarding gravel contents at the tested locations, fines contents within the native loam were about 51 to 54 percent, and fines contents within the native sandy loam were about 48 percent, per USDA testing procedures and methods.

Given the high fines contents of the tested soils, dense in-situ conditions, and shallow perched groundwater seepage encountered across the site, it is our opinion that infiltration be considered infeasible for the subject project, from a geotechnical standpoint. The encountered in-situ conditions would likely impede the long-term performance and intended function of any infiltration device.

Detention Vault Feasibility

Construction of a detention vault is feasible within the northeastern site area from a geotechnical standpoint. At the time of this report preparation, it is unclear whether or not the vault will be supported on competent native soils or structural fill placed during site earthwork activities. The final vault design must incorporate adequate buffer space from property boundaries such that temporary excavations to construct the vault structure may be successfully completed. Perimeter drains should be installed around the vault and conveyed to an approved discharge point. Perched groundwater seepage should be anticipated within the vault excavation; however, buoyancy is not expected to influence the vault structure.

Vault retaining walls should be backfilled with free-draining material or suitable sheet drainage that extends along the height of the walls. The upper one foot of the wall backfill may consist of a less permeable soil, if desired. A perforated drainpipe should be placed along the base of the wall and connected to an approved discharge location. If the elevation of the vault bottom is such that gravity flow to an outlet is not possible, the portions of the vault below the drain should be designed to include hydrostatic pressure. Soil design parameters can be provided as stormwater and grading plans develop. Improved allowable soil bearing values can be provided if the vault will be supported on the native soils.

ESNW should observe grading operations for the vault and subgrade conditions prior to concrete forming and pouring. If the soil conditions encountered during construction differ from those anticipated, supplementary recommendations may be provided. ESNW should be contacted to review the final vault design to confirm that appropriate geotechnical parameters have been incorporated.

Preliminary Pavement Sections

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

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

- Three inches of hot-mix asphalt (HMA) placed over six inches of crushed rock base (CRB), or;
- Three inches of HMA placed over four-and-one-half inches of asphalt-treated base (ATB).

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

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

Utility Support and Trench Backfill

Remedial measures may be necessary in some areas to provide support for utilities, such as overexcavation and replacement with structural fill and/or placement of geotextile fabric. Groundwater seepage may be encountered within utility excavations, and caving of trench walls may occur where groundwater is encountered. Depending on the time of year and conditions encountered, dewatering, as well as temporary trench shoring, may be necessary during utility excavation and installation.

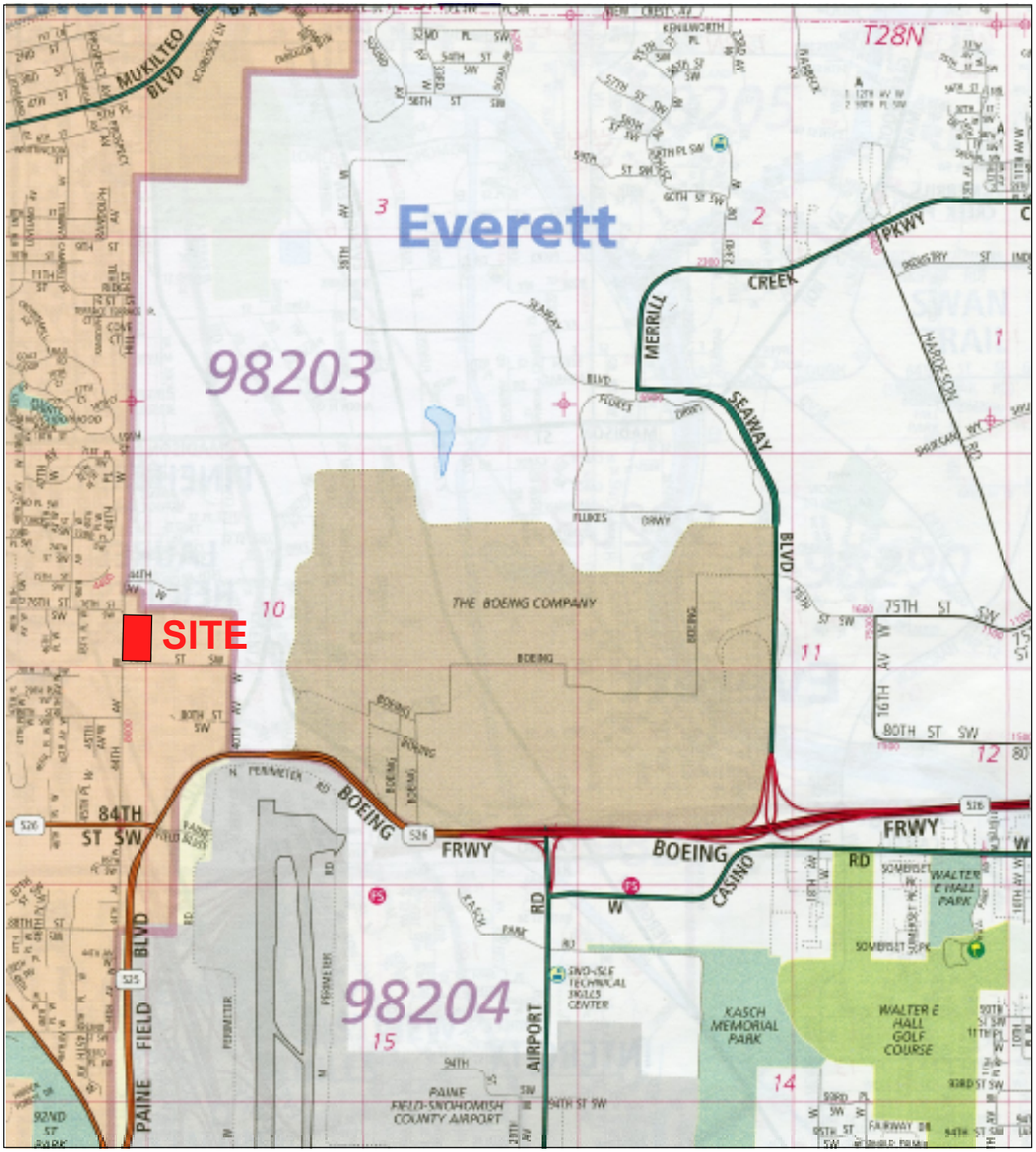
On-site soils may be suitable for use as structural backfill throughout utility trench excavations provided the soil is at (or slightly above) the optimum moisture content at the time of placement and compaction. Moisture conditioning of the soils may be necessary at some locations prior to use as structural fill. Each section of the utility lines must be adequately supported in the bedding material. Utility trench backfill should be placed and compacted to the specifications of structural fill as previously detailed in this report, or to the applicable specifications of responsible jurisdiction or agency.

LIMITATIONS

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

Additional Services

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



Reference:
Snohomish County, Washington
Map 415
By The Thomas Guide
Rand McNally
32nd Edition

NORTH

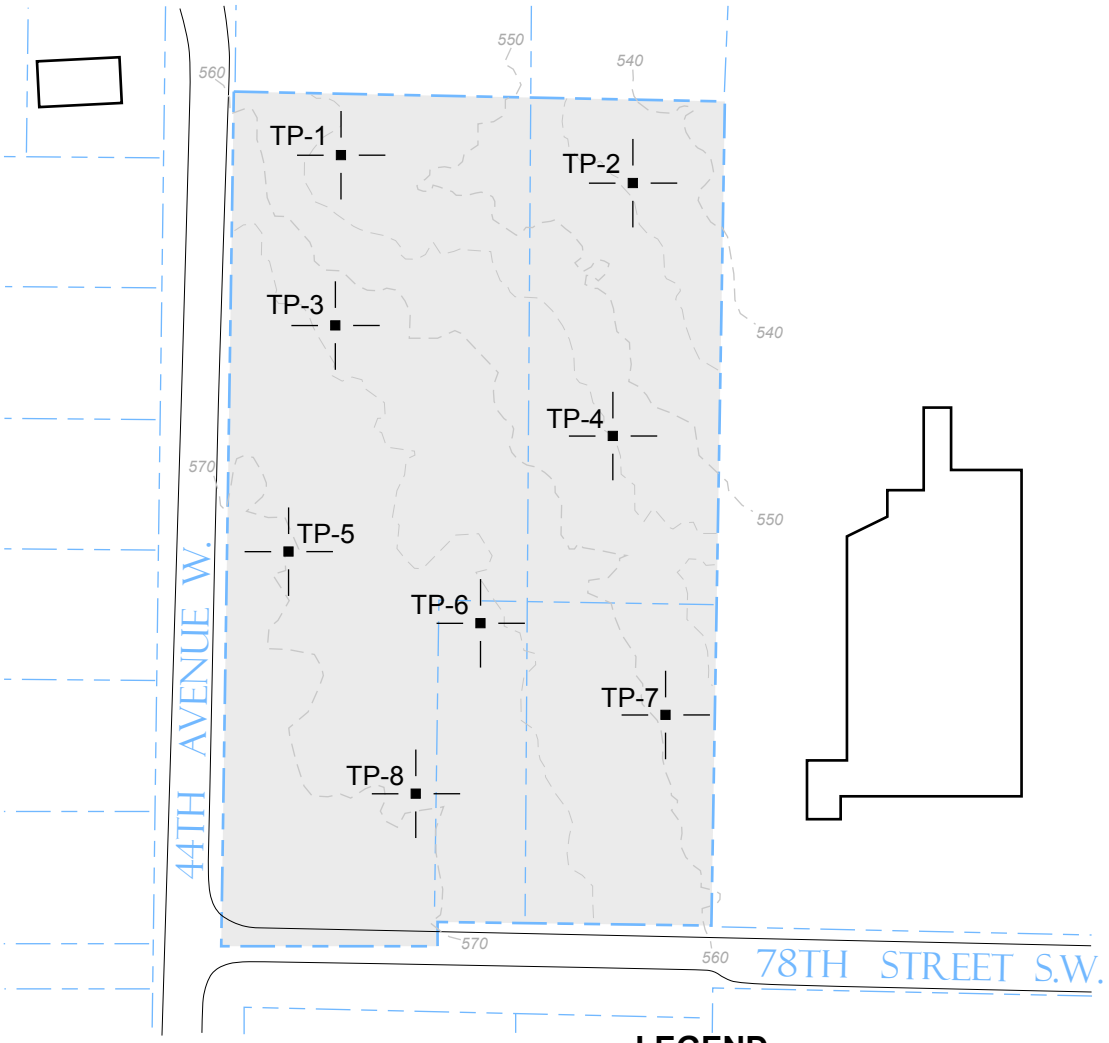
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Vicinity Map
4301 – 78th Street S.W.
Mukilteo, Washington

Drwn. MRS	Date 12/11/2018	Proj. No. 6384
Checked CGH	Date Dec. 2018	Plate 1



NORTH

NOT - TO - SCALE

LEGEND

TP-1 — Approximate Location of ESNW Test Pit, Proj. No. ES-6384, Dec. 2018

Subject Site

Existing Building

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

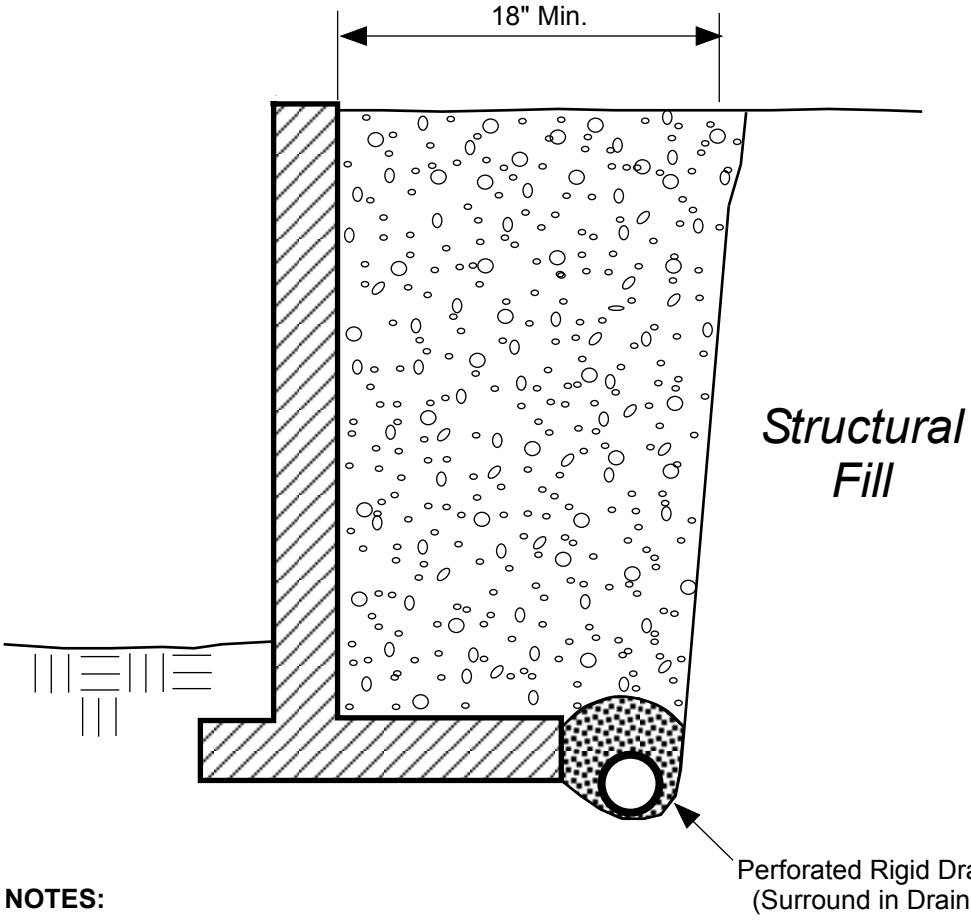
NOTE: This plate may contain areas of color. ESNW cannot be responsible for any subsequent misinterpretation of the information resulting from black & white reproductions of this plate.

Earth Solutions NW LLC

Geotechnical Engineering, Construction Observation/Testing and Environmental Services

Test Pit Location Plan
4301 – 78th Street S.W.
Mukilteo, Washington

Drwn. MRS	Date 12/11/2018	Proj. No. 6384
Checked CGH	Date Dec. 2018	Plate 2



NOTES:

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

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:

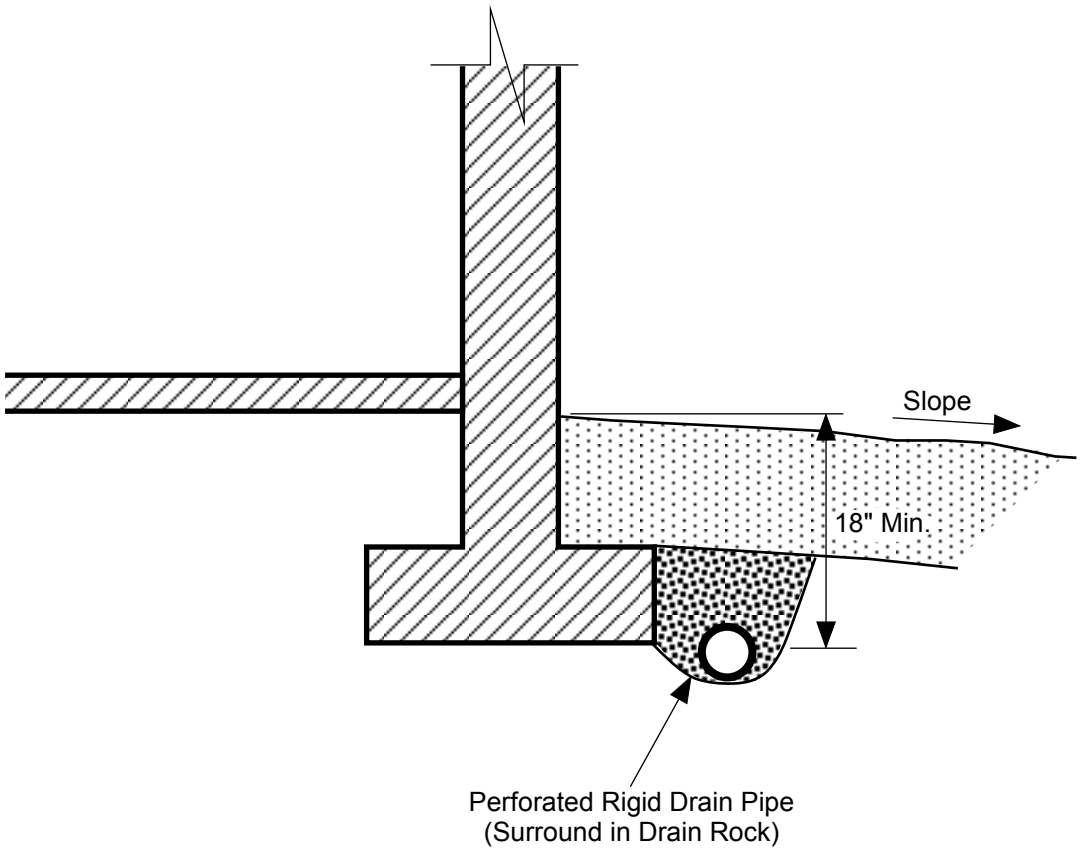
Free-draining Structural Backfill

1-inch Drain Rock

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

Retaining Wall Drainage Detail
4301 – 78th Street S.W.
Mukilteo, Washington

Drwn. MRS	Date 12/11/2018	Proj. No. 6384
Checked CGH	Date Dec. 2018	Plate 3



NOTES:

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

SCHEMATIC ONLY - NOT TO SCALE
NOT A CONSTRUCTION DRAWING

LEGEND:

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

1-inch Drain Rock

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

Footing Drain Detail
4301 – 78th Street S.W.
Mukilteo, Washington

Drwn. MRS	Date 12/11/2018	Proj. No. 6384
Checked CGH	Date Dec. 2018	Plate 4

Appendix A

Subsurface Exploration
Test Pit Logs

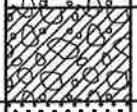
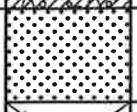
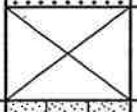
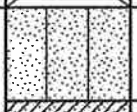
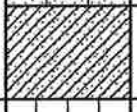
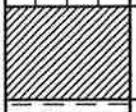
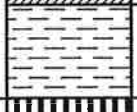
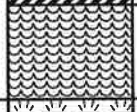
ES-6384

Subsurface conditions at the subject site were explored on December 5, 2018 by excavating eight test pits using a trackhoe and operator retained by ESNW. The approximate locations of the test pits are illustrated on Plate 2 of this study. The test pit logs are provided in this Appendix. The maximum exploration depth was approximately six-and-one-half feet bgs.

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

Earth Solutions NW LLC

SOIL CLASSIFICATION CHART

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

DUAL SYMBOLS are used to indicate borderline soil classifications.

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

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-1

PROJECT NUMBER 6384 **PROJECT NAME** 4301 – 78th Street Southwest

DATE STARTED 12/5/18 **COMPLETED** 12/5/18 **GROUND ELEVATION** _____ **TEST PIT SIZE** _____

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD _____ **AT TIME OF EXCAVATION** ---

LOGGED BY CGH **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 12": heavy brush **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, root intrusions to 3.5'
				1.0	Brown sandy SILT, loose, wet
					-heavy perched groundwater seepage to BOH
		MC = 38.80%			-becomes gray, very dense, moist
			ML		-becomes weakly cemented
5		MC = 14.00% Fines = 51.10%			[USDA Classification: slightly gravelly LOAM]
		MC = 13.30%		6.5	Test pit terminated at 6.5 feet below existing grade. Groundwater seepage encountered at 1.5 feet to BOH during excavation. No caving observed. Bottom of test pit at 6.5 feet.

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Bellevue, Washington 98005
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Fax: 425-449-4711

TEST PIT NUMBER TP-2

PROJECT NUMBER 6384 **PROJECT NAME** 4301 – 78th Street Southwest

DATE STARTED 12/5/18 **COMPLETED** 12/5/18 **GROUND ELEVATION** _____ **TEST PIT SIZE** _____

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD _____ **AT TIME OF EXCAVATION** ---

LOGGED BY CGH **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 6": heavy brush **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL	0.5	Dark brown TOPSOIL, root intrusions to 2'
			SM		Brown silty SAND with gravel, loose to medium dense, moist to wet
		MC = 19.90%			
		MC = 12.40%			-becomes gray, very dense, moist and moderately cemented
5		MC = 9.00% Fines = 39.50%		5.0	[USDA Classification: gravelly LOAM]
					Test pit terminated at 5.0 feet below existing grade due to refusal in very dense cemented till. No groundwater encountered during excavation. No caving observed. Bottom of test pit at 5.0 feet.

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-3

PROJECT NUMBER 6384 **PROJECT NAME** 4301 – 78th Street Southwest

DATE STARTED 12/5/18 **COMPLETED** 12/5/18 **GROUND ELEVATION** _____ **TEST PIT SIZE** _____

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD _____ **AT TIME OF EXCAVATION** ---

LOGGED BY CGH **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 6": heavy brush **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, root intrusions to 3'
				0.5	Brown to tan silty SAND with gravel, loose to medium dense, moist
		MC = 14.60%	SM		-becomes gray, dense, weakly cemented
5		MC = 9.60%		5.0	Test pit terminated at 5.0 feet below existing grade due to refusal in very dense cemented till. No groundwater encountered during excavation. No caving observed. Bottom of test pit at 5.0 feet.

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
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Fax: 425-449-4711

TEST PIT NUMBER TP-4

PROJECT NUMBER 6384 **PROJECT NAME** 4301 – 78th Street Southwest

DATE STARTED 12/5/18 **COMPLETED** 12/5/18 **GROUND ELEVATION** _____ **TEST PIT SIZE** _____

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD _____ **AT TIME OF EXCAVATION** ---

LOGGED BY CGH **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 12": heavy brush **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, root intrusions to 2'
					1.0
					Brown silty SAND, loose, moist
		MC = 13.70%	SM		-becomes gray, dense, weakly cemented
					-very light iron oxide staining
5					
		MC = 9.60%			6.5
					Test pit terminated at 6.5 feet below existing grade due to refusal in very dense cemented till. No groundwater encountered during excavation. No caving observed. Bottom of test pit at 6.5 feet.

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-5

PROJECT NUMBER 6384 **PROJECT NAME** 4301 – 78th Street Southwest

DATE STARTED 12/5/18 **COMPLETED** 12/5/18 **GROUND ELEVATION** _____ **TEST PIT SIZE** _____

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD _____ **AT TIME OF EXCAVATION** ---

LOGGED BY CGH **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 6": heavy brush **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, root intrusions to 2'
				0.5	Brown silty SAND, loose, moist to wet
		MC = 17.90% Fines = 40.60%	SM		[USDA Classification: slightly gravelly fine sandy LOAM] -becomes gray, medium dense, moist -moderate iron oxide staining -becomes dense to very dense, moderately cemented
5		MC = 13.20%		5.0	Test pit terminated at 5.0 feet below existing grade due to refusal in very dense cemented till. No groundwater encountered during excavation. No caving observed. Bottom of test pit at 5.0 feet.

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-6

PROJECT NUMBER 6384 **PROJECT NAME** 4301 – 78th Street Southwest

DATE STARTED 12/5/18 **COMPLETED** 12/5/18 **GROUND ELEVATION** _____ **TEST PIT SIZE** _____

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD _____ **AT TIME OF EXCAVATION** ---

LOGGED BY CGH **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Surface Conditions: heavy brush **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0					Brown to tan silty SAND, loose, wet
					-root intrusions to 2'
		MC = 29.80%			
			SM		-becomes gray, medium dense to dense, moist
		MC = 14.00%			-becomes dense to very dense, weakly cemented
5					
		MC = 12.30%			6.0
					Test pit terminated at 6.0 feet below existing grade due to refusal in very dense cemented till. No groundwater encountered during excavation. No caving observed. Bottom of test pit at 6.0 feet.

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-7

PROJECT NUMBER 6384 **PROJECT NAME** 4301 – 78th Street Southwest

DATE STARTED 12/5/18 **COMPLETED** 12/5/18 **GROUND ELEVATION** _____ **TEST PIT SIZE** _____

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD _____ **AT TIME OF EXCAVATION** ---

LOGGED BY CGH **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 8": ivy **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, root intrusions to 2'
				0.6	Brown silty SAND, loose, moist to wet
		MC = 18.90%			
			SM		-becomes gray, medium dense, moderate iron oxide staining
					-becomes very dense, cemented
5					
		MC = 10.60% Fines = 48.20%		6.0	[USDA Classification: slightly gravelly LOAM]
					Test pit terminated at 6.0 feet below existing grade due to refusal in very dense cemented till. No groundwater encountered during excavation. No caving observed. Bottom of test pit at 6.0 feet.

Earth Solutions NW
1805 - 136th Place N.E., Suite 201
Bellevue, Washington 98005
Telephone: 425-449-4704
Fax: 425-449-4711

TEST PIT NUMBER TP-8

PROJECT NUMBER 6384 **PROJECT NAME** 4301 – 78th Street Southwest

DATE STARTED 12/5/18 **COMPLETED** 12/5/18 **GROUND ELEVATION** _____ **TEST PIT SIZE** _____

EXCAVATION CONTRACTOR NW Excavating **GROUND WATER LEVELS:**

EXCAVATION METHOD _____ **AT TIME OF EXCAVATION** ---

LOGGED BY CGH **CHECKED BY** HTW **AT END OF EXCAVATION** ---

NOTES Depth of Topsoil & Sod 8": heavy brush **AFTER EXCAVATION** ---

DEPTH (ft)	SAMPLE TYPE NUMBER	TESTS	U.S.C.S.	GRAPHIC LOG	MATERIAL DESCRIPTION
0			TPSL		Dark brown TOPSOIL, root intrusions to 2'
				0.6	Brown silty SAND, loose, moist
		MC = 7.10%	SM		-becomes gray, medium dense
					-becomes dense, weakly cemented
					-light iron oxide staining
		MC = 8.30%		4.5	Test pit terminated at 4.5 feet below existing grade due to refusal in very dense cemented till. No groundwater encountered during excavation. No caving observed. Bottom of test pit at 4.5 feet.

Appendix B

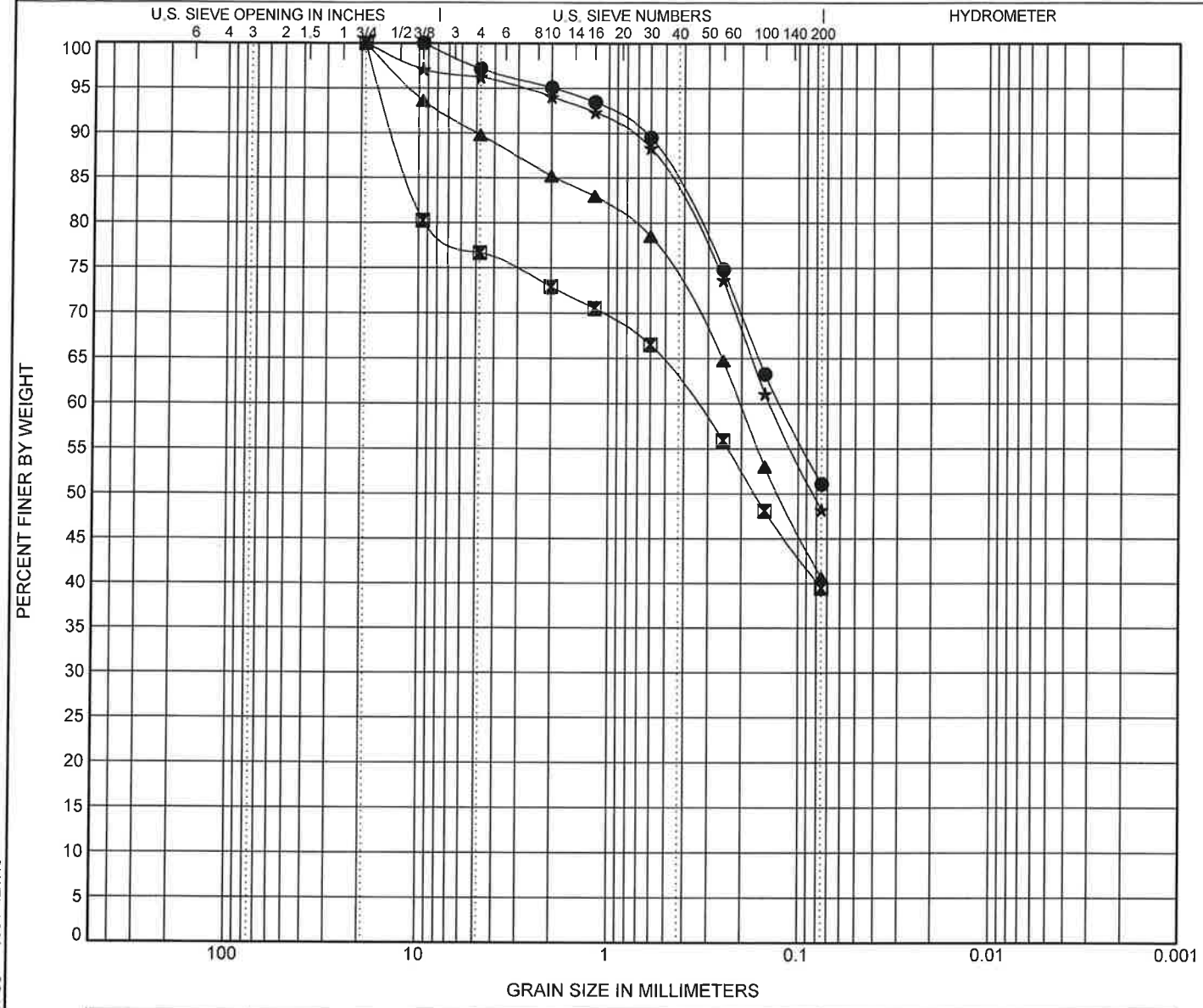
Laboratory Test Results

ES-6384

Earth Solutions NW, LLC
1805 - 136th PL N.E., Suite 201
Bellevue, WA 98005
Telephone: 425-449-4704
Fax: 425-449-4711

GRAIN SIZE DISTRIBUTION

PROJECT NUMBER ES-6384 **PROJECT NAME** 4301 - 78th Street Southwest



COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

Specimen Identification		Classification	Cc	Cu
● TP-01	4.50ft.	USDA: Gray Slightly Gravelly Loam. USCS: Sandy ML.		
⊠ TP-02	5.00ft.	USDA: Gray Gravelly Loam. USCS: SM with Gravel.		
▲ TP-05	2.50ft.	USDA: Gray Slightly Gravelly Fine Sandy Loam. USCS: SM.		
★ TP-07	6.00ft.	USDA: Gray Slightly Gravelly Loam. USCS: SM.		

Specimen Identification		D100	D60	D30	D10	LL	PL	PI	%Silt	%Clay
● TP-01	4.5ft.	9.5	0.125						51.1	
⊠ TP-02	5.0ft.	19	0.351						39.5	
▲ TP-05	2.5ft.	19	0.204						40.6	
★ TP-07	6.0ft.	19	0.142						48.2	

GRAIN SIZE USDA ES-6384 4301 - 78TH STREET SOUTHWEST.GPJ GINT US LAB.GDT 12/7/18

Report Distribution

ES-6384

EMAIL ONLY

Underwood Nelson Development
P.O. Box 1301
Seahurst, Washington 98062

Attention: Mr. Greg Nelson

APPENDIX C

WWHM2012 OUTPUT FOR VAULT SIZING

WWHM2012
PROJECT REPORT

Project Name: ND 43_3ORIF_20190717
Site Name: ND 43 Mukilteo
Site Address: 44th and 78th
City : Mukilteo
Report Date: 9/25/2019
Gage : Everett
Data Start : 1948/10/01
Data End : 2009/09/30
Precip Scale: 0.80
Version Date: 2018/10/10
Version : 4.2.16

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

High Flow Threshold for POC 1: 50 year

PREDEVELOPED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
C, Forest, Flat	.8699
C, Forest, Mod	1.6074
C, Forest, Steep	1.8055
Pervious Total	4.2828

Impervious Land Use	acre
Impervious Total	0
Basin Total	4.2828

Element Flows To:

Surface	Interflow	Groundwater

MITIGATED LAND USE

Name : Basin 1
Bypass: No

GroundWater: No

Pervious Land Use	acre
C, Forest, Mod	.0632
C, Forest, Steep	.0506
C, Lawn, Flat	.9134
Pervious Total	1.0272

Impervious Land Use	acre
ROADS FLAT	0.2332
ROOF TOPS FLAT	1.263
SIDEWALKS FLAT	0.0549
PARKING FLAT	1.257
PARKING MOD	0.407
PARKING STEEP	0.0405
Impervious Total	3.2556
Basin Total	4.2828

Element Flows To:

Surface	Interflow	Groundwater
Vault 1	Vault 1	Vault 1

Name : Vault 1
Width : 20 ft.
Length : 60 ft.
Depth: 16 ft.
Infiltration On
Infiltration rate: 2
Infiltration safety factor: 1
Total Volume Infiltrated (ac-ft.): 373.08
Total Volume Through Riser (ac-ft.): 89.157
Total Volume Through Facility (ac-ft.): 462.238
Percent Infiltrated: 80.71
Total Precip Applied to Facility: 0
Total Evap From Facility: 0
Discharge Structure
Riser Height: 15 ft.
Riser Diameter: 18 in.
Orifice 1 Diameter: 0.6875 in. **Elevation:** 0 ft.
Orifice 2 Diameter: 1.03125 in. **Elevation:** 10.5 ft.
Orifice 3 Diameter: 0.65625 in. **Elevation:** 12.2708333 ft.

Element Flows To:

Outlet 1	Outlet 2

Vault Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.027	0.000	0.000	0.000
0.1778	0.027	0.004	0.005	0.055
0.3556	0.027	0.009	0.007	0.055
0.5333	0.027	0.014	0.009	0.055
0.7111	0.027	0.019	0.010	0.055
0.8889	0.027	0.024	0.012	0.055
1.0667	0.027	0.029	0.013	0.055
1.2444	0.027	0.034	0.014	0.055
1.4222	0.027	0.039	0.015	0.055
1.6000	0.027	0.044	0.016	0.055
1.7778	0.027	0.049	0.017	0.055
1.9556	0.027	0.053	0.017	0.055
2.1333	0.027	0.058	0.018	0.055
2.3111	0.027	0.063	0.019	0.055
2.4889	0.027	0.068	0.020	0.055
2.6667	0.027	0.073	0.020	0.055
2.8444	0.027	0.078	0.021	0.055
3.0222	0.027	0.083	0.022	0.055
3.2000	0.027	0.088	0.022	0.055
3.3778	0.027	0.093	0.023	0.055
3.5556	0.027	0.097	0.024	0.055
3.7333	0.027	0.102	0.024	0.055
3.9111	0.027	0.107	0.025	0.055
4.0889	0.027	0.112	0.025	0.055
4.2667	0.027	0.117	0.026	0.055
4.4444	0.027	0.122	0.027	0.055
4.6222	0.027	0.127	0.027	0.055
4.8000	0.027	0.132	0.028	0.055
4.9778	0.027	0.137	0.028	0.055
5.1556	0.027	0.142	0.029	0.055
5.3333	0.027	0.146	0.029	0.055
5.5111	0.027	0.151	0.030	0.055
5.6889	0.027	0.156	0.030	0.055
5.8667	0.027	0.161	0.031	0.055
6.0444	0.027	0.166	0.031	0.055
6.2222	0.027	0.171	0.032	0.055
6.4000	0.027	0.176	0.032	0.055
6.5778	0.027	0.181	0.032	0.055
6.7556	0.027	0.186	0.033	0.055
6.9333	0.027	0.191	0.033	0.055
7.1111	0.027	0.195	0.034	0.055
7.2889	0.027	0.200	0.034	0.055
7.4667	0.027	0.205	0.035	0.055
7.6444	0.027	0.210	0.035	0.055
7.8222	0.027	0.215	0.035	0.055
8.0000	0.027	0.220	0.036	0.055
8.1778	0.027	0.225	0.036	0.055
8.3556	0.027	0.230	0.037	0.055
8.5333	0.027	0.235	0.037	0.055
8.7111	0.027	0.240	0.037	0.055
8.8889	0.027	0.244	0.038	0.055
9.0667	0.027	0.249	0.038	0.055
9.2444	0.027	0.254	0.039	0.055
9.4222	0.027	0.259	0.039	0.055
9.6000	0.027	0.264	0.039	0.055

9.7778	0.027	0.269	0.040	0.055
9.9556	0.027	0.274	0.040	0.055
10.133	0.027	0.279	0.040	0.055
10.311	0.027	0.284	0.041	0.055
10.489	0.027	0.289	0.041	0.055
10.667	0.027	0.293	0.053	0.055
10.844	0.027	0.298	0.059	0.055
11.022	0.027	0.303	0.063	0.055
11.200	0.027	0.308	0.067	0.055
11.378	0.027	0.313	0.070	0.055
11.556	0.027	0.318	0.073	0.055
11.733	0.027	0.323	0.076	0.055
11.911	0.027	0.328	0.078	0.055
12.089	0.027	0.333	0.081	0.055
12.267	0.027	0.337	0.083	0.055
12.444	0.027	0.342	0.090	0.055
12.622	0.027	0.347	0.094	0.055
12.800	0.027	0.352	0.098	0.055
12.978	0.027	0.357	0.101	0.055
13.156	0.027	0.362	0.104	0.055
13.333	0.027	0.367	0.107	0.055
13.511	0.027	0.372	0.110	0.055
13.689	0.027	0.377	0.112	0.055
13.867	0.027	0.382	0.115	0.055
14.044	0.027	0.386	0.118	0.055
14.222	0.027	0.391	0.120	0.055
14.400	0.027	0.396	0.122	0.055
14.578	0.027	0.401	0.125	0.055
14.756	0.027	0.406	0.127	0.055
14.933	0.027	0.411	0.129	0.055
15.111	0.027	0.416	0.719	0.055
15.289	0.027	0.421	2.508	0.055
15.467	0.027	0.426	4.461	0.055
15.644	0.027	0.431	5.787	0.055
15.822	0.027	0.435	6.565	0.055
16.000	0.027	0.440	7.228	0.055
16.178	0.027	0.445	7.834	0.055
16.356	0.000	0.000	8.396	0.221

ANALYSIS RESULTS

Stream Protection Duration

Predeveloped Landuse Totals for POC #1
Total Pervious Area:4.2828
Total Impervious Area:0

Mitigated Landuse Totals for POC #1
Total Pervious Area:1.0272
Total Impervious Area:3.2556

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.065502
5 year	0.100414
10 year	0.123106
25 year	0.150805
50 year	0.170621
100 year	0.189706

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.049723
5 year	0.10366
10 year	0.162309
25 year	0.275502
50 year	0.399056
100 year	0.567937

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

Year	Predeveloped	Mitigated
1949	0.019	0.037
1950	0.086	0.039
1951	0.058	0.037
1952	0.050	0.030
1953	0.042	0.029
1954	0.115	0.039
1955	0.111	0.063
1956	0.090	0.073
1957	0.103	0.100
1958	0.075	0.038
1959	0.073	0.040
1960	0.067	0.067
1961	0.071	0.065
1962	0.047	0.039
1963	0.064	0.038
1964	0.064	0.037
1965	0.062	0.037
1966	0.035	0.031
1967	0.094	0.039
1968	0.098	0.109
1969	0.048	0.037
1970	0.048	0.032
1971	0.077	0.040
1972	0.074	0.039
1973	0.043	0.033
1974	0.075	0.034
1975	0.052	0.033
1976	0.053	0.052
1977	0.028	0.037
1978	0.051	0.027
1979	0.090	0.082
1980	0.061	0.035
1981	0.052	0.036
1982	0.073	0.188

1983	0.070	0.037
1984	0.062	0.068
1985	0.093	0.082
1986	0.236	0.811
1987	0.081	0.122
1988	0.055	0.055
1989	0.044	0.027
1990	0.066	0.039
1991	0.071	0.057
1992	0.051	0.033
1993	0.037	0.035
1994	0.026	0.039
1995	0.064	0.074
1996	0.146	0.104
1997	0.251	1.304
1998	0.038	0.032
1999	0.065	0.039
2000	0.041	0.085
2001	0.008	0.028
2002	0.062	0.038
2003	0.041	0.035
2004	0.060	0.211
2005	0.055	0.040
2006	0.143	0.210
2007	0.108	0.038
2008	0.156	0.626
2009	0.052	0.038

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

Rank	Predeveloped	Mitigated
1	0.2506	1.3037
2	0.2360	0.8111
3	0.1563	0.6262
4	0.1457	0.2111
5	0.1434	0.2102
6	0.1149	0.1876
7	0.1110	0.1224
8	0.1080	0.1086
9	0.1025	0.1045
10	0.0984	0.1000
11	0.0943	0.0853
12	0.0929	0.0824
13	0.0902	0.0820
14	0.0896	0.0739
15	0.0858	0.0725
16	0.0807	0.0680
17	0.0768	0.0667
18	0.0755	0.0647
19	0.0750	0.0630
20	0.0741	0.0566
21	0.0733	0.0550
22	0.0728	0.0518
23	0.0714	0.0401
24	0.0709	0.0397
25	0.0695	0.0396

26	0.0666	0.0394
27	0.0664	0.0394
28	0.0648	0.0394
29	0.0644	0.0393
30	0.0640	0.0393
31	0.0637	0.0393
32	0.0624	0.0391
33	0.0622	0.0389
34	0.0616	0.0383
35	0.0606	0.0381
36	0.0600	0.0380
37	0.0580	0.0379
38	0.0551	0.0375
39	0.0547	0.0375
40	0.0528	0.0375
41	0.0525	0.0374
42	0.0518	0.0374
43	0.0516	0.0372
44	0.0508	0.0369
45	0.0507	0.0369
46	0.0499	0.0359
47	0.0484	0.0354
48	0.0480	0.0348
49	0.0475	0.0345
50	0.0439	0.0337
51	0.0427	0.0334
52	0.0423	0.0332
53	0.0412	0.0326
54	0.0405	0.0324
55	0.0383	0.0317
56	0.0365	0.0305
57	0.0348	0.0303
58	0.0276	0.0294
59	0.0265	0.0275
60	0.0191	0.0272
61	0.0080	0.0266

Stream Protection Duration
POC #1
The Facility PASSED

The Facility PASSED.

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0328	16784	11657	69	Pass
0.0341	15254	9037	59	Pass
0.0355	13907	6973	50	Pass
0.0369	12705	5390	42	Pass
0.0383	11599	4053	34	Pass
0.0397	10611	3001	28	Pass
0.0411	9700	2207	22	Pass
0.0425	8866	1957	22	Pass
0.0439	8130	1933	23	Pass
0.0453	7428	1903	25	Pass
0.0467	6797	1880	27	Pass
0.0481	6241	1857	29	Pass

0.0495	5719	1833	32	Pass
0.0509	5234	1804	34	Pass
0.0522	4819	1777	36	Pass
0.0536	4451	1735	38	Pass
0.0550	4070	1674	41	Pass
0.0564	3722	1621	43	Pass
0.0578	3420	1578	46	Pass
0.0592	3166	1535	48	Pass
0.0606	2905	1474	50	Pass
0.0620	2680	1407	52	Pass
0.0634	2496	1359	54	Pass
0.0648	2329	1312	56	Pass
0.0662	2190	1268	57	Pass
0.0676	2051	1217	59	Pass
0.0690	1898	1177	62	Pass
0.0704	1770	1130	63	Pass
0.0717	1651	1102	66	Pass
0.0731	1540	1046	67	Pass
0.0745	1450	1013	69	Pass
0.0759	1363	977	71	Pass
0.0773	1290	936	72	Pass
0.0787	1206	902	74	Pass
0.0801	1147	868	75	Pass
0.0815	1094	834	76	Pass
0.0829	1053	790	75	Pass
0.0843	1012	778	76	Pass
0.0857	969	766	79	Pass
0.0871	929	757	81	Pass
0.0885	866	749	86	Pass
0.0898	818	742	90	Pass
0.0912	773	731	94	Pass
0.0926	737	720	97	Pass
0.0940	708	708	100	Pass
0.0954	678	691	101	Pass
0.0968	651	676	103	Pass
0.0982	632	655	103	Pass
0.0996	614	624	101	Pass
0.1010	599	607	101	Pass
0.1024	584	584	100	Pass
0.1038	563	562	99	Pass
0.1052	552	534	96	Pass
0.1066	537	512	95	Pass
0.1080	527	490	92	Pass
0.1093	509	466	91	Pass
0.1107	496	448	90	Pass
0.1121	487	433	88	Pass
0.1135	475	421	88	Pass
0.1149	459	406	88	Pass
0.1163	448	392	87	Pass
0.1177	439	375	85	Pass
0.1191	431	360	83	Pass
0.1205	423	343	81	Pass
0.1219	408	323	79	Pass
0.1233	397	293	73	Pass
0.1247	382	273	71	Pass
0.1261	368	251	68	Pass
0.1274	357	232	64	Pass

0.1288	337	201	59	Pass
0.1302	328	187	57	Pass
0.1316	319	186	58	Pass
0.1330	310	186	60	Pass
0.1344	291	185	63	Pass
0.1358	282	182	64	Pass
0.1372	273	181	66	Pass
0.1386	265	181	68	Pass
0.1400	256	181	70	Pass
0.1414	250	181	72	Pass
0.1428	243	181	74	Pass
0.1442	238	180	75	Pass
0.1456	234	178	76	Pass
0.1469	227	178	78	Pass
0.1483	222	177	79	Pass
0.1497	219	176	80	Pass
0.1511	212	175	82	Pass
0.1525	208	175	84	Pass
0.1539	203	175	86	Pass
0.1553	198	174	87	Pass
0.1567	192	174	90	Pass
0.1581	190	173	91	Pass
0.1595	187	171	91	Pass
0.1609	184	171	92	Pass
0.1623	181	171	94	Pass
0.1637	176	170	96	Pass
0.1651	173	170	98	Pass
0.1664	171	170	99	Pass
0.1678	168	170	101	Pass
0.1692	167	168	100	Pass
0.1706	164	167	101	Pass

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

LID Report

LID Technique	Used for Water Quality Treatment?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft.)	Cumulative Infiltration Credit	Percent Volume Infiltrated	Water Quality Treated	Percent	Comment
Vault 1 POC	N	420.64			N	80.71			
Total Volume Infiltrated		420.64	0.00	0.00		80.71	0.00	0%	No Treat. Credit

Compliance with LID Standard 8
Duration Analysis Result = Failed

Perlnd and Implnd Changes

No changes have been made.

APPENDIX D

CONVEYANCE ANAYLSIS
(TO BE SUBMITTED LATER)

APPENDIX E

OPERATIONS AND MAINTENANCE CHECKLISTS

The owner or operator of the project shall be responsible for maintaining the stormwater facilities in accordance with local requirements. Proper maintenance is important for adequate functioning of the stormwater facilities. Operations and maintenance guidelines are provided below.

No. 2 – Infiltration

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

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

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

No. 4 – Control Structure/Flow Restrictor

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

No. 5 – Catch Basins

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

No. 5 – Catch Basins

Maintenance Component	Defect	Conditions When Maintenance is Needed	Results Expected When Maintenance is performed
	Contamination and Pollution	See "Detention Ponds" (No. 1).	No pollution present.
Catch Basin Cover	Cover Not in Place	Cover is missing or only partially in place. Any open catch basin requires maintenance.	Catch basin cover is closed
	Locking Mechanism Not Working	Mechanism cannot be opened by one maintenance person with proper tools. Bolts into frame have less than 1/2 inch of thread.	Mechanism opens with proper tools.
	Cover Difficult to Remove	One maintenance person cannot remove lid after applying normal lifting pressure. (Intent is keep cover from sealing off access to maintenance.)	Cover can be removed by one maintenance person.
Ladder	Ladder Rungs Unsafe	Ladder is unsafe due to missing rungs, not securely attached to basin wall, misalignment, rust, cracks, or sharp edges.	Ladder meets design standards and allows maintenance person safe access.
Metal Grates (If Applicable)	Grate opening Unsafe	Grate with opening wider than 7/8 inch.	Grate opening meets design standards.
	Trash and Debris	Trash and debris that is blocking more than 20% of grate surface inletting capacity.	Grate free of trash and debris.
	Damaged or Missing.	Grate missing or broken member(s) of the grate.	Grate is in place and meets design standards.

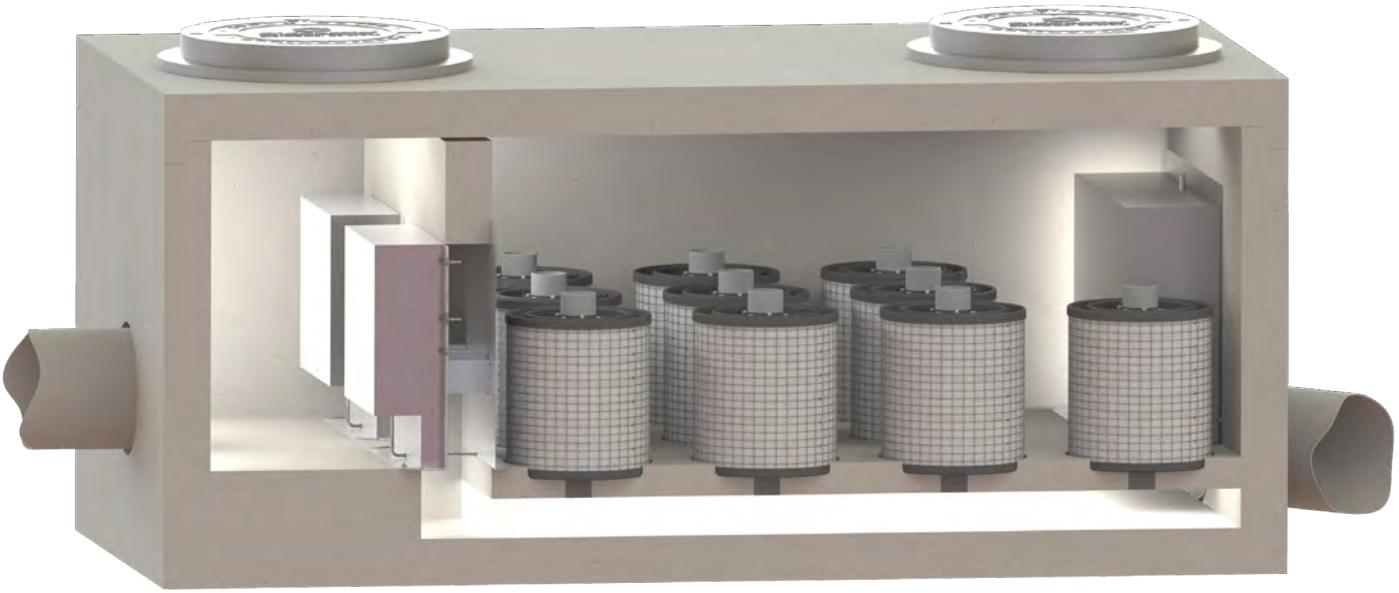
No. 6 – Debris Barriers (e.g., Trash Racks)

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

Oldcastle Infrastructure™
A CRH COMPANY

PERKFILTER®

Submittal Package



Water

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SECTION 6

Inspection & Maintenance

Oldcastle Infrastructure™
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PERKFILTER®

Inspection and Maintenance Guide

Water

PerkFilter Media Filtration System

Description

The PerkFilter is a stormwater treatment device used to remove pollutants from urban runoff. Impervious surfaces and other urban and suburban landscapes generate a variety of contaminants that can enter stormwater and pollute downstream receiving waters. The PerkFilter is a media-filled cartridge filtration device designed to capture and retain sediment, gross solids, metals, nutrients, hydrocarbons, and trash and debris. As with any stormwater treatment system, the PerkFilter requires periodic maintenance to sustain optimum system performance.

Function

The PerkFilter is a water quality treatment system consisting of three chambers: an inlet chamber, a filter cartridge treatment chamber, and an outlet chamber (Figure 1). Stormwater runoff enters the inlet chamber through an inlet pipe, curb opening, or grated inlet. Gross solids are settled out and floating trash and debris are trapped in the inlet chamber. Pretreated flow is then directed to the treatment chamber through an opening in the baffle wall between the inlet chamber and treatment chamber. The treatment chamber contains media-filled filter cartridges (Figure 2) that use physical and chemical processes to remove pollutants. During a storm event, runoff pools in the treatment chamber before passing radially through the cylindrical cartridges from the outside surface, through the media for treatment, and into the center of the cartridge. At the center of the cartridge is a center tube assembly designed to distribute the hydraulic load evenly across the surface of the filter cartridge and control the treatment flow rate. The center tube assembly discharges treated flow through the false floor and into the outlet chamber. A draindown feature built into each cartridge allows the treatment chamber to dewater between storm events.

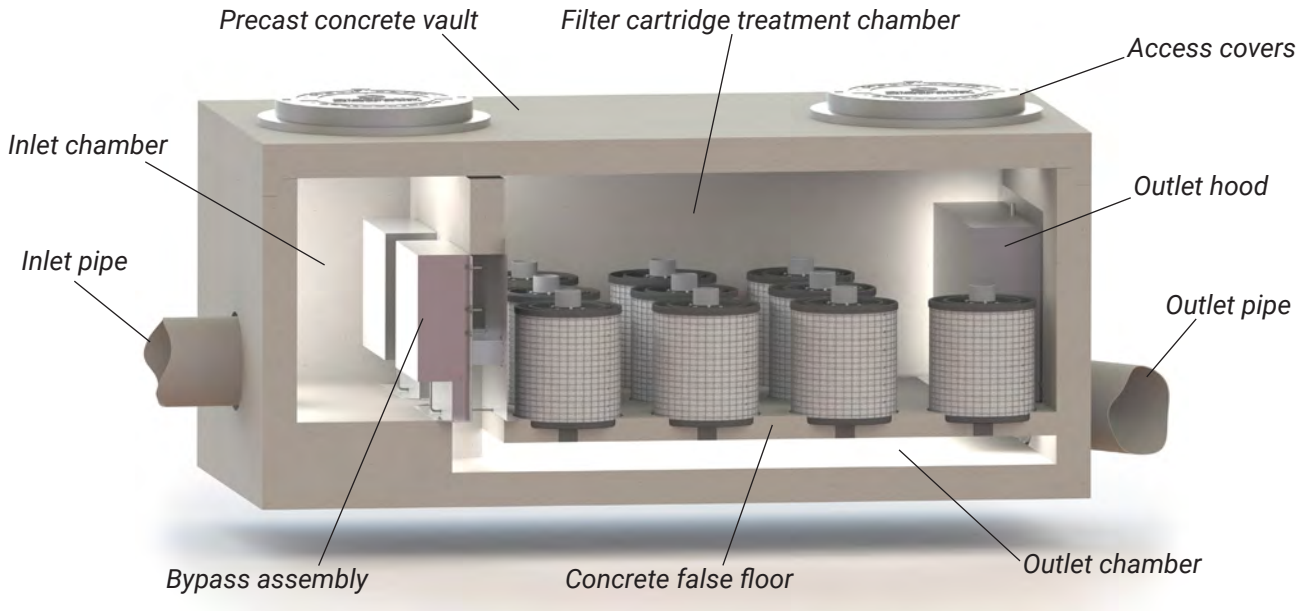
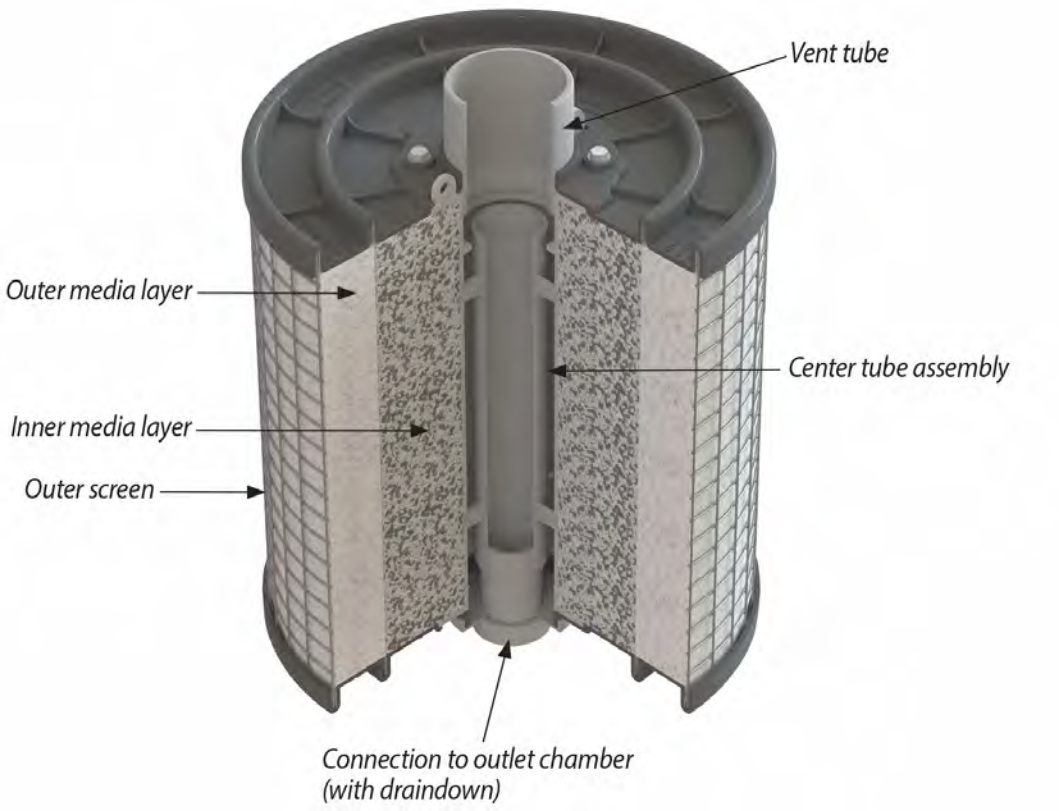


Figure 1. Schematic of the PerkFilter System.

All PerkFilter systems include a high flow bypass assembly to divert flow exceeding the treatment capacity of the filter cartridges around the treatment chamber. The bypass assembly routes peak flow from the inlet chamber directly to the outlet chamber, bypassing the treatment chamber to prevent sediment and other captured pollutants from being scoured and re-entrained by high flow. Treated flow and bypass flow merge in the outlet chamber for discharge by a single outlet pipe.



Configuration

The PerkFilter structure may consist of a vault, manhole, or catch basin configuration. Catch basin units may be fabricated from concrete or steel. Internal components including the PerkFilter cartridges are manufactured from durable plastic and stainless steel components and hardware. All cartridges are 18 inches in diameter and are available in two heights: 12-inch and 18-inch. Cartridges may be used alone or may be stacked (Figure 3) to provide 24-inch and 30-inch combinations. The capacity of each cartridge or cartridge combination is dictated by the allowable operating rate of the media and the outer surface area of the cartridge. Thus, taller cartridges have greater treatment capacity than shorter cartridges but they also require more hydraulic drop across the system. Cartridges may be filled with a wide variety of media but the standard mix is composed of zeolite, perlite and carbon (ZPC).

Access to an installed PerkFilter system is typically provided by ductile iron castings or hatch covers. The location and number of access appurtenances is dependent on the size and configuration of the system.

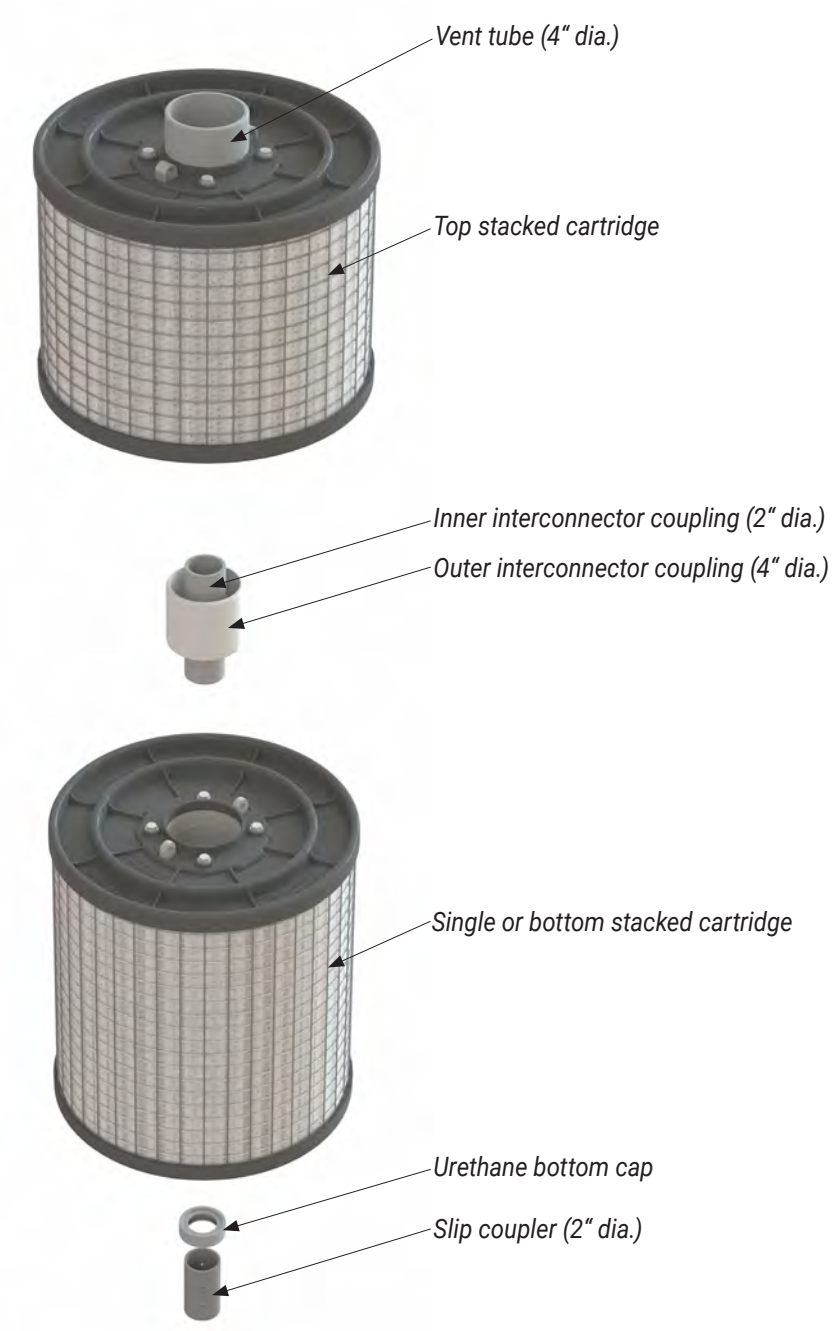


Figure 3. Schematic of stacked cartridges and connector components.

Maintenance Overview

State and local regulations require all stormwater management systems to be inspected on a periodic basis and maintained as necessary to ensure performance and protect downstream receiving waters. Maintenance prevents excessive pollutant buildup that can limit system performance by reducing the operating capacity and increasing the potential for scouring of pollutants during periods of high flow.

Inspection and Maintenance Frequency

The PerkFilter should be inspected on a periodic basis, typically twice per year, and maintained as required. Initially, inspections of a new system should be conducted more frequently to help establish an appropriate site-specific inspection frequency. The maintenance frequency will be driven by the amount of runoff and pollutant loading encountered by a given system. In most cases, the optimum maintenance interval will be one to three years. Inspection and maintenance activities should be performed only during dry weather periods.

Inspection Equipment

The following equipment is helpful when conducting PerkFilter inspections:

- Recording device (pen and paper form, voice recorder, iPad, etc.)
- Suitable clothing (appropriate footwear, gloves, hardhat, safety glasses, etc.)
- Traffic control equipment (cones, barricades, signage, flagging, etc.)
- Socket and wrench for bolt-down access covers
- Manhole hook or pry bar
- Flashlight
- Tape measure
- Measuring stick or sludge sampler
- Long-handled net (optional)

Inspection Procedures

PerkFilter inspections are visual and may be conducted from the ground surface without entering the unit. To complete an inspection, safety measures including traffic control should be deployed before the access covers are removed. Once the covers have been removed, the following items should be checked and recorded (see form provided at the end of this document) to determine whether maintenance is required:

- Inspect the internal components and note whether there are any broken or missing parts. In the unlikely event that internal parts are broken or missing, contact Oldcastle Infrastructure at (800) 579-8819 to determine appropriate corrective action.
- Note whether the inlet pipe is blocked or obstructed. The outlet pipe is covered by a removable outlet hood and cannot be observed without entering the unit.
- Observe, quantify and record the accumulation of floating trash and debris in the inlet chamber. The significance of accumulated floating trash and debris is a matter of judgment. A long-handled net may be used to retrieve the bulk of trash and debris at the time of inspection if full maintenance due to accumulation of floating oils or settled sediment is not yet warranted.

- Observe, quantify and record the accumulation of oils in the inlet chamber. The significance of accumulated floating oils is a matter of judgment. However, if there is evidence of an oil or fuel spill, immediate maintenance by appropriate certified personnel is warranted.
- Observe, quantify and record the average accumulation of sediment in the inlet chamber and treatment chamber. A calibrated dipstick, tape measure, or sludge sampler may be used to determine the amount of accumulated sediment in each chamber. The depth of sediment may be determined by calculating the difference between the measurement from the rim of the PerkFilter to the top of the accumulated sediment and the measurement from the rim of the PerkFilter to the bottom of the PerkFilter structure. Finding the top of the accumulated sediment below standing water takes some practice and a light touch, but increased resistance as the measuring device is lowered toward the bottom of the unit indicates the top of the accumulated sediment.
- Finally, observe, quantify and record the amount of standing water in the treatment chamber around the cartridges. If standing water is present, do not include the depth of sediment that may have settled out below the standing water in the measurement.

Maintenance Triggers

Maintenance should be scheduled if any of the following conditions are identified during the inspection:

- Internal components are broken or missing.
- Inlet piping is obstructed.
- The accumulation of floating trash and debris that cannot be retrieved with a net and/or oil in the inlet chamber is significant.
- There is more than 6” of accumulated sediment in the inlet chamber.
- There is more than 4” of accumulated sediment in the treatment chamber.
- There is more than 4” of standing water in the treatment chamber more than 24 hours after end of rain event.
- A hazardous material release (e.g. automotive fluids) is observed or reported.
- The system has not been maintained for 3 years (wet climates) to 5 years (dry climates).

Maintenance Equipment

The following equipment is helpful when conducting PerkFilter maintenance:

- Suitable clothing (appropriate footwear, gloves, hardhat, safety glasses, etc.)
- Traffic control equipment (cones, barricades, signage, flagging, etc.)
- Socket and wrench for bolt-down access covers
- Manhole hook or pry bar
- Confined space entry equipment, if needed
- Flashlight
- Tape measure
- 9/16” socket and wrench to remove hold-down struts and filter cartridge tops
- Replacement filter cartridges
- Vacuum truck with water supply and water jet

Contact Oldcastle Infrastructure at (800) 579-8819 for replacement Filter cartridges. A lead time of four weeks is recommended.

Maintenance Procedures

Maintenance should be conducted during dry weather when no flow is entering the system. Confined space entry is necessary to maintain vault and manhole PerkFilter configurations. Only personnel that are OSHA Confined Space Entry trained and certified may enter underground structures. Confined space entry is not required for catch basin PerkFilter configurations. Once safety measures such as traffic control are deployed, the access covers may be removed and the following activities may be conducted to complete maintenance:

- Remove FLoating trash, debris and oils from the water surface in the inlet chamber using the extension nozzle on the end of the boom hose of the vacuum truck. Continue using the vacuum truck to completely dewater the inlet chamber and evacuate all accumulated sediment from the inlet chamber. Some jetting may be required to fully remove sediment. The inlet chamber does not need to be reFIlled with water after maintenance is complete. The system will FIll with water when the next storm event occurs.
- Remove the hold-down strut from each row of FIlter cartridges and then remove the top of each cartridge (the top is held on by four 9/16” bolts) and use the vacuum truck to evacuate the spent media. When empty, the spent cartridges may be easily lifted off their slip couplers and removed from the vault. The couplers may be left inserted into couplings cast into the false FLoor to prevent sediment and debris from being washed into the outlet chamber during washdown.
- Once all the spent cartridges have been removed from the structure, the vacuum truck may be used to evacuate all accumulated sediment from the treatment chamber. Some jetting may be required to fully remove sediment. Take care not to wash sediment and debris through the openings in the false FLoor and into the outlet chamber. All material removed from the PerkFilter during maintenance including the spent media must be disposed of in accordance with local, state, and/or federal regulations. In most cases, the material may be handled in the same manner as disposal of material removed from sumped catch basins or manholes.
- Place a fresh cartridge in each cartridge position using the existing slip couplers and urethane bottom caps. If the vault is equipped with stacked cartridges, the existing outer and inner interconnector couplers must be used between the stacked cartridges to provide hydraulic connection. Transfer the existing vent tubes from the spent cartridges to the fresh cartridges. Finally, reFIt the struts to hold the fresh cartridges in place.
- Securely replace access covers, as appropriate.
- Make arrangements to return the empty spent cartridges to Oldcastle Infrastructure.

PerkFilter
Inspection and Maintenance Log

Location_____

Structure Configuration and Size:

Inspection Date_____

☐ Vault _____feet x _____feet
☐ Manhole _____feet diameter
☐ Catch Basin _____feet x _____feet

Number and Height of Cartridge Stacks:

Count_____each ☐12" ☐ 18" ☐ 24" ☐ 30"

Media Type:

☐ ZPC ☐ Perlite ☐ Other_____

Condition of Internal Components ☐ Good ☐ Damaged ☐ Missing	Notes:
Inlet or Outlet Blockage or Obstruction ☐ Yes ☐ No	Notes:
Floating Trash and Debris ☐ Significant ☐ Not Significant	Notes:
Floating Oils ☐ Significant ☐ Not Significant ☐ Spill	Notes:
Sediment Depth in Inlet Chamber ☐ Inches of Sediment:_____	Notes:
Sediment Depth in Treatment Chamber ☐ Inches of Sediment:_____	Notes:
Standing Water in Treatment Chamber ☐ Inches of Standing Water:_____	Notes:

Maintenance Required

☐ **Yes - Schedule Maintenance** ☐ **No - Inspect Again in _____ Months**

PERKFILTER®

OUR MARKETS

BUILDING STRUCTURES

COMMUNICATIONS

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TRANSPORTATION