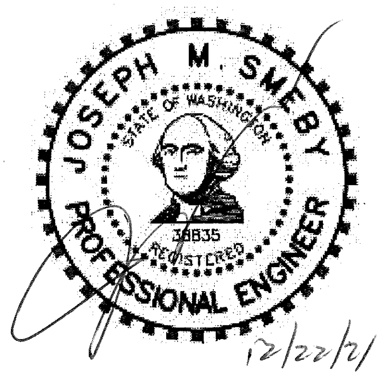
Drainage Report
Cowles SP

for

Owner
Dean Cowles
13710 42nd Ave SE
Mill Creek, WA 98012

Applicant
Brooks Homes, LLC
Attn: Edward Brooks
Edwardbrooks51@yahoo.com
425.750.4312

Property Address
13710 42nd Ave SE
Mill Creek, WA
TPN: 28053300202200



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I. PROJECT OVERVIEW

The Cowles Short Plat Development project is located at 13710 42nd Ave SE, Mill Creek, Washington 98012 (see the attached vicinity map). This project will consist of 4 new lots for future SFRs, private driveway, on-site parking, and associated storm drainage and other utility construction to serve the future project. Preliminary plans are being submitted, at this time with the other associated documents/designs for this project. The developable area on this site totals approximately 1.03 acres that are to be developed for residential uses. Currently, the site drains to the west toward 41st Ave SE. The site is bordered to the south and north by residential lots, to the west by the public road of 41st Ave SE, and to the east by the private road of 42nd Ave SE. The developed site will include impervious surface areas of approximately 0.48 acres, or 44% impervious.

This project has been designed with a modular detention system that will detain and release site runoff to the existing stormwater conveyance system within 41st Ave SE to the west. The system has been designed to meet the flow control and water quality standards.

The 2012 WSDOE Manual (2014 Revision), Volume I, lists 9 Minimum Requirements for New Development. Each of the items was addressed as follows:

1. **<u>Preparation of Stormwater Site Plans</u>** - A grading and storm drainage plan has been submitted with this report along with detailed information for the layout and construction of the stormwater facilities. The storm drainage plan accurately shows how the drainage basin for this project will be collected, conveyed, and discharged. The storm drainage plan corresponds with the basin maps and the narrative in this report. A final construction plan will be prepared prior to permit issuance for this project.

2. **<u>Construction Stormwater Pollution Prevention (SWPP)</u>** – A SWPP plan has been prepared for this project and is shown on sheet 2 of the engineering plan set. The plan has been designed to protect the downstream system during the construction of the frontage and on-site improvements. This section is a summary of the proposed measures to reduce the impacts to the downstream system. A complete SWPPP Report using the DOE template will be provided at a later date.

Element 1: Marking Clearing Limits

The proposed clearing limits are shown on the SWPPP/ESC Plan contained in the Construction plan set submitted with this report. In addition, staking of the clearing limits along with approval of the limits by the City is required before any construction activities may begin.

Contractor's Note: Plastic, metal or stake wire fence may be used to mark the clearing limits, any material must first be approved by the City of Mill Creek.

Element 2: Establish Construction Entrance

The proposed construction entrance location is shown on the SWPPP/ESC Plan contained in the Construction plan set submitted with this report. There is one entrance location shown. In addition to the construction entrance, the standard City of Mill Creek Note, included on sheet 2 requires the cleaning of the City Streets once per day or as directed by the City, and flushing of the streets will not be allowed.

Element 3: Control Flow Rates

The site as it exists is currently forest with an existing residence on the east side and some cleared areas with grasses and brush.

Since the existing soils are essentially impermeable, this site design will not implement any on-site stormwater BMPs, and all runoff will drain to a conventional system for detention and treatment to protect the downstream system. The detention system will be one of the first features constructed so the control structure will be in-place throughout the construction process to meter the release of runoff to the downstream system. In addition, the detention system can be used as a sediment pond to remove the larger particulate in the construction runoff.

Element 4: Install Sediment Controls

This site is already partially cleared/improved. In addition, the proposed development will be 49% impervious. Therefore, areas around all the improvements will be available to retain topsoil. The detention system will be one of the first features constructed for this project so it will be available to act as a sediment pond during construction.

In addition, silt fence will be installed on the downhill side of disturbed areas to protect neighboring properties for excessive sedimentation.

Element 5: Stabilize Soils

The construction sequence along with the City of Mill Creek General Notes requires the contractor to cover or stabilize all unworked soils. The time exposed soils can be left exposed without protect is different depending upon the season and is specified in both the General Notes and Construction Sequence. In addition, the Construction Sequence lists some methods the contractor may use to protect these soils from erosion.

Element 6: Protect Slopes

The grading of this site was designed to minimize the existence of cut or fill slopes. However, along the south and east sides of the project cut and fill slopes will be necessary. The slopes have been designed as 3:1 or flatter to limit the potential for erosion. These slopes will be vegetated immediately after final grading to protect the exposed soil from erosion. In addition, runoff during construction will be directed toward the vault rather than allowed to flow over the slopes to the south or west.

Element 7: Protect Drain Inlets

All new storm drain inlets along with the existing CBs in 41st Ave SE adjacent to the access to this site will be protected with silt socks. Prior to the end of construction once the site has been stabilized the entire collection/conveyance system shall be cleaned and flushed.

Element 8: Stabilize Channels and Outlets

The proposed on-site conveyance will be in the form of yard drains, catch basins and pipes. No new or existing channels will be created or impacted by this project.

Element 9: Control Pollutants

The contractor shall be responsible for handling all pollutants used or produced on-site and dispose of the materials in a manner that does not cause contamination of stormwater. Hazardous materials should also be stored in a safe and secure location.

Element 10: Control De-Watering

Dewatering may be required for this project based on the geotechnical findings, depending on time of year that construction work is being conducted. We recommend some vegetated areas around the site are maintained to provide areas to pump de-watering runoff to clean the water prior to collection by the conveyance system

Element 11: Maintain BMPs

The contractor shall maintain and repair on-site BMPs as necessary to ensure proper performance. BMPs may need to be relocated during construction as the site changes. Sediment control BMPs shall be inspected weekly or after a run-off producing event during the dry season and daily during the wet season. Sediment control BMPs shall be removed within 30-days of final site stabilization.

Element 12: Manage the Project

The contractor shall work with the City and this engineer to ensure that Seasonal Work Limitations are being met and that the BMPs are working as designed. In addition, the City may require additional BMPs if the existing measures are not adequately protecting the downstream system.

Element 13: Protect LID BMPs

No LID BMPs will be used for this project.

3. **Source Control of Pollution** – Residential projects do not require any additional Source control BMPs per Volume IV of the DOE manual.

4. **<u>Preservation of Natural Drainage Systems and Outfalls</u>** – This site drains to the west and eventually into an offsite open vault. The proposed detention system will discharge to the existing stormwater conveyance system within 41st Ave SE that drains to the same open vault. Therefore, this project will maintain the flows to the existing downstream system within ¼ mile of this project.

5. **<u>On-site Stormwater Management</u>** – Runoff from the new pervious and impervious surfaces constructed for this project will be collected in roof drains, yard drains and catch basins and directed to the detention system for flow attenuation. Based on the geotechnical findings, the use of permeable pavement for future sidewalks and driveways is feasible and may be included later in the design process to shrink the required size of detention. All roof downspouts will be connected to a perforated stubout connection prior to connection to the drainage system. Finally, all permeable/landscaped surfaces will receive amended soils to meet BMP T5.13.

6. **<u>Runoff Treatment</u>** – On-site water quality treatment will be provided upstream of the detention system via a stormwater filter catch basin. We will work with Contech Stormwater Solutions to provide the correct number of filters in the structure.

7. **<u>Flow Control</u>** - On-site flow control will be accomplished via an underground modular detention system located along the southwestern edges of the property. The system has been sized using the WWHM2012 software based on the existing condition assumption of forested and the proposed improvements for the developed condition. Note, all proposed sidewalks and driveways were not

modeled as permeable at this stage of the design, resulting in a potentially conservative detention size.

8. **Wetlands Protection** – This project site does not drain directly to a wetland.

9. **Operation and Maintenance Manual** - A complete operation and maintenance manual specific to the final design will be included as part of the construction submittal.

II. EXISTING CONDITIONS SUMMARY

This site contains some significant trees in the western portion of the site. Site soils on this site have been reviewed and classified by Cobalt Geosciences and were also analyzed for infiltration potential. They found 6 to 12 inches of fill underlain by weathered glacial till over glacial till and identified some shallow infiltration potential for this site with an unfactored rate of 0.77"/hr be used for potential permeable pavements and rain gardens this project. In addition, the depth to *perched* groundwater in February of 2020 was observed to be approximately 2.5-feet below grade around the site.

III. OFF-SITE ANALYSIS

A. UPSTREAM TRIBUTARY AREA

Due to the topography and development of the surrounding areas there is no upstream area tributary to this site.

B. DOWNSTREAM ANALYSIS

Drainage from the developed portion of the existing site naturally drains to the west and onto 41st Ave SE, where runoff sheets in a southwestern direction and is collected by multiple catch basins along the western curb/gutter of 41st Ave SE. In this main stormwater conveyance system, runoff flows north in a 12-inch main approximately 300 feet under 41st Ave SE where it turns 90 degrees in a manhole to flow west under an asphalt driveway located in what appears to be a detention tract for this neighborhood to the north. The runoff continues west in this main approximately 250 feet where it flows into an open detention vault. The exact location of the outlet from this detention vault could not be found in the field, but it can be assumed based on Snohomish County LIDAR topography that the detention vault discharges to the west and into the large wetland complex in the local low area to the west.

Runoff appears to flow very gradually in a generally southern direction in this wetland approximately ½ mile, where it eventually flows into Thomas Lake.

IV. DEVELOPED CONDITIONS SUMMARY – BASIN OVERVIEW

This site will create a single drainage facility to manage runoff from the site improvements. This will consist of CBs, yard drains, pipes, and detention system. Runoff from the proposed on-site impervious and vegetated areas will be collected and managed on-site.

V. DEVELOPED CONDITIONS SUMMARY

A. HYDROLOGIC ANALYSIS

1. Developed Basin

The hydrologic analysis for the developed area of the site was conducted using WWHM2012 which is based on a continuous runoff model calibrated for western Washington. The site soils for this project has been identified as weather glacial till over glacial till, refer to appendix B for the detailed Geotechnical study. In addition, the depth to perched groundwater was found to be approximately 2.5-feet in February of 2020, which would require the bottom of any infiltration system to be no deeper than approximately 1.5-feet below existing grade.

The area for potential future LID BMP facilities will be based on additional analysis by the project Geotech and may include permeable sidewalks and driveways. For the sake of being conservative, the detention system at this time has been sized assuming no on-site LID BMPs will be used for this project. Modeled as a vault to determine required volume, the results of the WWHM2012 indicate the required total volume is approximately 9,130 cubic feet at riser head. The model printout results of the WWHM were sent to an Advanced Drainage Systems staff member for preliminary sizing of a StormTech detention system.

They concluded that 51 total MC-3500 chambers, with 6 endcaps, 9 inches of stone below the chambers and 12 inches of stone above the chambers would provide more than enough detention volume (10,640 cubic feet at riser head). They also provided a stage storage spreadsheet that will be used during construction design to ensure that this unique system of varying porosity meets the flow control standard for the site. We may choose to modify the design as the project progresses to incorporate permeable pavement and reduce the size of the detention system.

B. DETENTION ROUTING CALCULATION

The detention routing calculation, a continuation of the hydrologic analysis, uses the WWHM2012 software to size the detention system, and control structure to mitigate the effects of the proposed development. The printouts from the WWHM 2012 modeling software are included in Appendix 'A'.

C. WATER QUALITY CALCULATION

Since this project will treat the runoff in a proposed stormfilter catch basin before it flows into the catch basin, it will be sized for the design water quality flow rate of 0.033 cfs determined by the WWHM 2012 (see Appendix 'A' for model printout). This is based on the DOE requirements and the GULD approval this system has received, and the design requirements contained in that document. When a final design is proposed for construction, we will work with Contech Stormfilter staff to determine how many ZPG media cartridges are required for this project to provide basic treatment upstream of the detention system.

D. WATER QUALITY TREATMENT

A stormfilter as noted above will be located upstream of the detention system which will provide the required basic treatment level for this project as noted above.

E. CONVEYANCE CALCULATIONS

For this project, the site conveyance will be analyzed using Manning's Equation at the time of construction review.

SPECIAL REPORTS AND STUDIES (Refer to Additional Documents Previously Submitted)

A. **CRITICAL AREA STUDY**
   N/A

B. **GEOTECHNICAL ENGINEERING STUDIES**
   By: Cobalt Geosciences (Refer to Appendix B)

IX. OTHER PERMITS

Other permits that may be necessary for this project in the future are:

Construction Permit (These documents are intended to support this permit application)

Building Permit

NPDES Permit (To be provided to the City once received from the WADOE)

X. OPERATION AND MAINTENANCE MANUAL

The Property Owner will be responsible for maintaining the stormwater and landscaping facilities within this development. Operation and Maintenance checklists will be provided at the time of construction review.

APPENDIX A

WWHM CALCULATIONS

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	WQ Flow Rate
Site Name:	
Site Address:	
City:	
Report Date:	12/10/2021
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	0.000 (adjusted)
Version Date:	2019/09/13
Version:	4.2.17

POC Thresholds

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

Landuse Basin Data
Predeveloped Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	1.1
Pervious Total	1.1
Impervious Land Use	acre
Impervious Total	0
Basin Total	1.1

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.62
Pervious Total	0.62
Impervious Land Use	acre
ROADS FLAT	0.04
DRIVEWAYS MOD	0.13
SIDEWALKS FLAT	0.03
Impervious Total	0.2
Basin Total	0.82

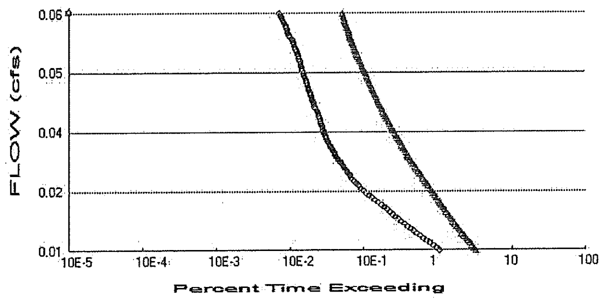
Element Flows To:

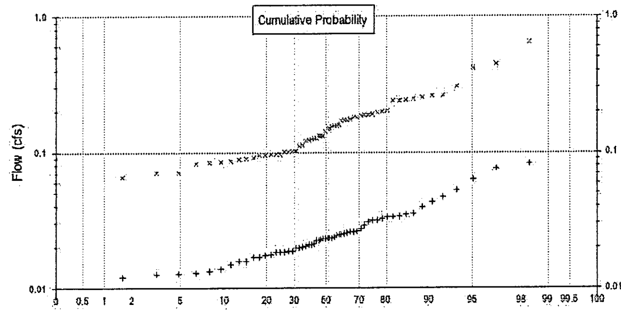
Surface	Interflow	Groundwater

Routing Elements
Predeveloped Routing

Mitigated Routing

Analysis Results
POC 1





+ Predeveloped x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 1.1
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.62
Total Impervious Area: 0.2

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	Flow(cfs)
2 year	0.02358
5 year	0.034901
10 year	0.042653
25 year	0.05265
50 year	0.060213
100 year	0.067858

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	Flow(cfs)
2 year	0.139225
5 year	0.213448
10 year	0.273197
25 year	0.362009
50 year	0.438662
100 year	0.525027

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	Predeveloped	Mitigated
1949	0.013	0.187
1950	0.026	0.196
1951	0.021	0.125
1952	0.017	0.131
1953	0.014	0.156
1954	0.052	0.303
1955	0.035	0.186
1956	0.031	0.083
1957	0.035	0.174
1958	0.023	0.418

1959	0.025	0.127
1960	0.022	0.155
1961	0.023	0.643
1962	0.020	0.126
1963	0.025	0.240
1964	0.021	0.113
1965	0.023	0.085
1966	0.013	0.089
1967	0.029	0.188
1968	0.034	0.131
1969	0.025	0.446
1970	0.018	0.100
1971	0.026	0.173
1972	0.023	0.245
1973	0.018	0.171
1974	0.032	0.202
1975	0.019	0.180
1976	0.018	0.102
1977	0.015	0.086
1978	0.018	0.071
1979	0.033	0.243
1980	0.021	0.124
1981	0.017	0.096
1982	0.022	0.088
1983	0.032	0.176
1984	0.023	0.133
1985	0.031	0.148
1986	0.075	0.240
1987	0.034	0.159
1988	0.019	0.121
1989	0.016	0.156
1990	0.024	0.097
1991	0.026	0.100
1992	0.020	0.142
1993	0.013	0.095
1994	0.012	0.083
1995	0.025	0.097
1996	0.043	0.150
1997	0.082	0.259
1998	0.016	0.190
1999	0.023	0.070
2000	0.012	0.260
2001	0.004	0.066
2002	0.024	0.065
2003	0.017	0.091
2004	0.027	0.252
2005	0.020	0.096
2006	0.047	0.198
2007	0.040	0.179
2008	0.063	0.111
2009	0.020	0.102

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	Predeveloped	Mitigated
1	0.0824	0.6432
2	0.0754	0.4458
3	0.0631	0.4179

4	0.0522	0.3032
5	0.0466	0.2599
6	0.0432	0.2590
7	0.0397	0.2525
8	0.0354	0.2448
9	0.0347	0.2435
10	0.0337	0.2400
11	0.0335	0.2400
12	0.0332	0.2016
13	0.0323	0.1980
14	0.0315	0.1960
15	0.0313	0.1903
16	0.0306	0.1876
17	0.0288	0.1873
18	0.0273	0.1864
19	0.0261	0.1800
20	0.0260	0.1792
21	0.0259	0.1763
22	0.0253	0.1738
23	0.0252	0.1727
24	0.0249	0.1705
25	0.0246	0.1591
26	0.0244	0.1564
27	0.0238	0.1558
28	0.0235	0.1552
29	0.0234	0.1498
30	0.0233	0.1483
31	0.0232	0.1416
32	0.0230	0.1328
33	0.0227	0.1313
34	0.0224	0.1313
35	0.0223	0.1266
36	0.0211	0.1263
37	0.0208	0.1247
38	0.0208	0.1237
39	0.0204	0.1213
40	0.0201	0.1130
41	0.0198	0.1114
42	0.0198	0.1025
43	0.0186	0.1021
44	0.0185	0.1003
45	0.0184	0.1002
46	0.0184	0.0967
47	0.0184	0.0966
48	0.0177	0.0963
49	0.0173	0.0959
50	0.0170	0.0948
51	0.0168	0.0907
52	0.0157	0.0893
53	0.0156	0.0882
54	0.0148	0.0858
55	0.0138	0.0853
56	0.0133	0.0832
57	0.0129	0.0827
58	0.0127	0.0711
59	0.0125	0.0704
60	0.0121	0.0662
61	0.0041	0.0655

Duration Flows

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0118	22629	70369	310	Fail
0.0123	20565	65984	320	Fail
0.0128	18617	61942	332	Fail
0.0133	16818	58242	346	Fail
0.0137	15163	54926	362	Fail
0.0142	13719	51611	376	Fail
0.0147	12461	48702	390	Fail
0.0152	11300	45900	406	Fail
0.0157	10243	43270	422	Fail
0.0162	9306	40810	438	Fail
0.0167	8451	38607	456	Fail
0.0172	7676	36511	475	Fail
0.0177	6953	34586	497	Fail
0.0181	6318	32789	518	Fail
0.0186	5779	31057	537	Fail
0.0191	5285	29388	556	Fail
0.0196	4855	27912	574	Fail
0.0201	4442	26479	596	Fail
0.0206	4094	25110	613	Fail
0.0211	3700	23827	643	Fail
0.0216	3375	22651	671	Fail
0.0221	3050	21539	706	Fail
0.0226	2748	20475	745	Fail
0.0230	2507	19475	776	Fail
0.0235	2306	18499	802	Fail
0.0240	2108	17554	832	Fail
0.0245	1951	16713	856	Fail
0.0250	1823	15924	873	Fail
0.0255	1698	15130	891	Fail
0.0260	1581	14352	907	Fail
0.0265	1481	13631	920	Fail
0.0270	1398	12979	928	Fail
0.0274	1329	12331	927	Fail
0.0279	1260	11680	926	Fail
0.0284	1197	11084	925	Fail
0.0289	1138	10553	927	Fail
0.0294	1082	10029	926	Fail
0.0299	1025	9563	932	Fail
0.0304	956	9154	957	Fail
0.0309	915	8737	954	Fail
0.0314	879	8372	952	Fail
0.0318	845	8031	950	Fail
0.0323	808	7679	950	Fail
0.0328	767	7313	953	Fail
0.0333	731	7001	957	Fail
0.0338	700	6680	954	Fail
0.0343	676	6402	947	Fail
0.0348	655	6143	937	Fail
0.0353	639	5880	920	Fail
0.0358	620	5608	904	Fail
0.0362	604	5366	888	Fail
0.0367	588	5146	875	Fail
0.0372	573	4937	861	Fail
0.0377	560	4755	849	Fail

0.0382	551	4562	827	Fail
0.0387	539	4372	811	Fail
0.0392	523	4207	804	Fail
0.0397	511	4047	791	Fail
0.0402	496	3910	788	Fail
0.0406	473	3767	796	Fail
0.0411	458	3608	787	Fail
0.0416	448	3482	777	Fail
0.0421	438	3367	768	Fail
0.0426	426	3247	762	Fail
0.0431	417	3127	749	Fail
0.0436	402	3009	748	Fail
0.0441	396	2922	737	Fail
0.0446	385	2830	735	Fail
0.0451	374	2736	731	Fail
0.0455	362	2644	730	Fail
0.0460	355	2556	720	Fail
0.0465	349	2470	707	Fail
0.0470	338	2396	708	Fail
0.0475	329	2323	706	Fail
0.0480	320	2242	700	Fail
0.0485	310	2162	697	Fail
0.0490	306	2081	680	Fail
0.0495	300	2021	673	Fail
0.0499	296	1955	660	Fail
0.0504	288	1884	654	Fail
0.0509	283	1825	644	Fail
0.0514	276	1778	644	Fail
0.0519	270	1724	638	Fail
0.0524	260	1663	639	Fail
0.0529	252	1613	640	Fail
0.0534	245	1569	640	Fail
0.0539	239	1525	638	Fail
0.0543	234	1469	627	Fail
0.0548	227	1437	633	Fail
0.0553	214	1404	656	Fail
0.0558	205	1365	665	Fail
0.0563	200	1338	669	Fail
0.0568	194	1298	669	Fail
0.0573	188	1262	671	Fail
0.0578	184	1231	669	Fail
0.0583	176	1199	681	Fail
0.0587	170	1162	683	Fail
0.0592	165	1145	693	Fail
0.0597	158	1119	708	Fail
0.0602	152	1089	716	Fail

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

Water Quality

Water Quality BMP Flow and Volume for POC #1

On-line facility volume:	0.0376 acre-feet
On-line facility target flow:	0.0333 cfs.
Adjusted for 15 min:	0.0333 cfs.
Off-line facility target flow:	0.0186 cfs.
Adjusted for 15 min:	0.0186 cfs.

WWHM2012

PROJECT REPORT

General Model Information

Project Name:	DETENTION - ~~5~~ 5.5 FT
Site Name:	
Site Address:	
City:	
Report Date:	12/10/2021
Gage:	Everett
Data Start:	1948/10/01
Data End:	2009/09/30
Timestep:	15 Minute
Precip Scale:	0.000 (adjusted)
Version Date:	2019/09/13
Version:	4.2.17

POC Thresholds

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

Landuse Basin Data
Predeveloped Land Use

Basin 1	
Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Forest, Flat	1.1
Pervious Total	1.1
Impervious Land Use	acre
Impervious Total	0
Basin Total	1.1

Element Flows To:

Surface	Interflow	Groundwater

Mitigated Land Use

Basin 1

Bypass:	No
GroundWater:	No
Pervious Land Use	acre
C, Lawn, Flat	0.62
Pervious Total	0.62
Impervious Land Use	acre
ROADS FLAT	0.04
ROOF TOPS FLAT	0.28
DRIVEWAYS MOD	0.13
SIDEWALKS FLAT	0.03
Impervious Total	0.48
Basin Total	1.1

Element Flows To:

Surface	Interflow	Groundwater
Vault 1	Vault 1	

Routing Elements
Predeveloped Routing

Mitigated Routing

Vault 1

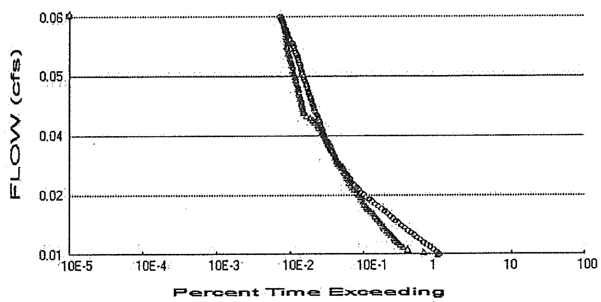
Width:	12.8791010171654 ft.
Length:	128.791010171655 ft.
Depth:	6.5 ft.
Discharge Structure	
Riser Height:	5.5 ft.
Riser Diameter:	18 in.
Notch Type:	Rectangular
Notch Width:	0.013 ft.
Notch Height:	0.843 ft.
Orifice 1 Diameter:	0.465 in. Elevation:0 ft.
Element Flows To:	
Outlet 1	Outlet 2

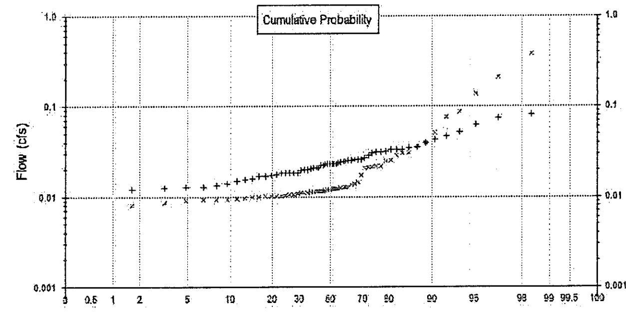
Vault Hydraulic Table

Stage(feet)	Area(ac.)	Volume(ac-ft.)	Discharge(cfs)	Infilt(cfs)
0.0000	0.038	0.000	0.000	0.000
0.0722	0.038	0.002	0.001	0.000
0.1444	0.038	0.005	0.002	0.000
0.2167	0.038	0.008	0.002	0.000
0.2889	0.038	0.011	0.003	0.000
0.3611	0.038	0.013	0.003	0.000
0.4333	0.038	0.016	0.003	0.000
0.5056	0.038	0.019	0.004	0.000
0.5778	0.038	0.022	0.004	0.000
0.6500	0.038	0.024	0.004	0.000
0.7222	0.038	0.027	0.005	0.000
0.7944	0.038	0.030	0.005	0.000
0.8667	0.038	0.033	0.005	0.000
0.9389	0.038	0.035	0.005	0.000
1.0111	0.038	0.038	0.005	0.000
1.0833	0.038	0.041	0.006	0.000
1.1556	0.038	0.044	0.006	0.000
1.2278	0.038	0.046	0.006	0.000
1.3000	0.038	0.049	0.006	0.000
1.3722	0.038	0.052	0.006	0.000
1.4444	0.038	0.055	0.007	0.000
1.5167	0.038	0.057	0.007	0.000
1.5889	0.038	0.060	0.007	0.000
1.6611	0.038	0.063	0.007	0.000
1.7333	0.038	0.066	0.007	0.000
1.8056	0.038	0.068	0.007	0.000
1.8778	0.038	0.071	0.008	0.000
1.9500	0.038	0.074	0.008	0.000
2.0222	0.038	0.077	0.008	0.000
2.0944	0.038	0.079	0.008	0.000
2.1667	0.038	0.082	0.008	0.000
2.2389	0.038	0.085	0.008	0.000
2.3111	0.038	0.088	0.008	0.000
2.3833	0.038	0.090	0.009	0.000
2.4556	0.038	0.093	0.009	0.000
2.5278	0.038	0.096	0.009	0.000
2.6000	0.038	0.099	0.009	0.000

2.6722	0.038	0.101	0.009	0.000
2.7444	0.038	0.104	0.009	0.000
2.8167	0.038	0.107	0.009	0.000
2.8889	0.038	0.110	0.010	0.000
2.9611	0.038	0.112	0.010	0.000
3.0333	0.038	0.115	0.010	0.000
3.1056	0.038	0.118	0.010	0.000
3.1778	0.038	0.121	0.010	0.000
3.2500	0.038	0.123	0.010	0.000
3.3222	0.038	0.126	0.010	0.000
3.3944	0.038	0.129	0.010	0.000
3.4667	0.038	0.132	0.010	0.000
3.5389	0.038	0.134	0.011	0.000
3.6111	0.038	0.137	0.011	0.000
3.6833	0.038	0.140	0.011	0.000
3.7556	0.038	0.143	0.011	0.000
3.8278	0.038	0.145	0.011	0.000
3.9000	0.038	0.148	0.011	0.000
3.9722	0.038	0.151	0.011	0.000
4.0444	0.038	0.154	0.011	0.000
4.1167	0.038	0.156	0.011	0.000
4.1889	0.038	0.159	0.012	0.000
4.2611	0.038	0.162	0.012	0.000
4.3333	0.038	0.165	0.012	0.000
4.4056	0.038	0.167	0.012	0.000
4.4778	0.038	0.170	0.012	0.000
4.5500	0.038	0.173	0.012	0.000
4.6222	0.038	0.176	0.012	0.000
4.6944	0.038	0.178	0.013	0.000
4.7667	0.038	0.181	0.014	0.000
4.8389	0.038	0.184	0.016	0.000
4.9111	0.038	0.187	0.018	0.000
4.9833	0.038	0.189	0.020	0.000
5.0556	0.038	0.192	0.022	0.000
5.1278	0.038	0.195	0.025	0.000
5.2000	0.038	0.198	0.028	0.000
5.2722	0.038	0.200	0.031	0.000
5.3444	0.038	0.203	0.034	0.000
5.4167	0.038	0.206	0.037	0.000
5.4889	0.038	0.209	0.040	0.000
5.5611	0.038	0.211	0.281	0.000
5.6333	0.038	0.214	0.812	0.000
5.7056	0.038	0.217	1.502	0.000
5.7778	0.038	0.220	2.290	0.000
5.8500	0.038	0.222	3.113	0.000
5.9222	0.038	0.225	3.913	0.000
5.9944	0.038	0.228	4.630	0.000
6.0667	0.038	0.231	5.220	0.000
6.1389	0.038	0.233	5.662	0.000
6.2111	0.038	0.236	5.976	0.000
6.2833	0.038	0.239	6.313	0.000
6.3556	0.038	0.242	6.596	0.000
6.4278	0.038	0.244	6.867	0.000
6.5000	0.038	0.247	7.128	0.000
6.5722	0.038	0.250	7.380	0.000
6.6444	0.000	0.000	7.623	0.000

Analysis Results
POC 1





+ Predeveloped   x Mitigated

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 1.1
Total Impervious Area: 0

Mitigated Landuse Totals for POC #1
Total Pervious Area: 0.62
Total Impervious Area: 0.48

Flow Frequency Method: Log Pearson Type III 17B

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.02358
5 year	0.034901
10 year	0.042653
25 year	0.05265
50 year	0.060213
100 year	0.067858

Flow Frequency Return Periods for Mitigated. POC #1

Return Period	**Flow(cfs)**
2 year	0.014935
5 year	0.031052
10 year	0.048541
25 year	0.082232
50 year	0.118947
100 year	0.169065

Annual Peaks

Annual Peaks for Predeveloped and Mitigated. POC #1

Year	**Predeveloped**	**Mitigated**
1949	0.013	0.010
1950	0.026	0.013
1951	0.021	0.010
1952	0.017	0.010
1953	0.014	0.010
1954	0.052	0.011
1955	0.035	0.036
1956	0.031	0.040
1957	0.035	0.017
1958	0.023	0.012

1959	0.025	0.012
1960	0.022	0.012
1961	0.023	0.031
1962	0.020	0.009
1963	0.025	0.011
1964	0.021	0.009
1965	0.023	0.012
1966	0.013	0.010
1967	0.029	0.011
1968	0.034	0.012
1969	0.025	0.011
1970	0.018	0.011
1971	0.026	0.051
1972	0.023	0.011
1973	0.018	0.014
1974	0.032	0.012
1975	0.019	0.009
1976	0.018	0.012
1977	0.015	0.010
1978	0.018	0.010
1979	0.033	0.010
1980	0.021	0.010
1981	0.017	0.009
1982	0.022	0.022
1983	0.032	0.011
1984	0.023	0.077
1985	0.031	0.030
1986	0.075	0.211
1987	0.034	0.087
1988	0.019	0.014
1989	0.016	0.009
1990	0.024	0.014
1991	0.026	0.012
1992	0.020	0.013
1993	0.013	0.008
1994	0.012	0.013
1995	0.025	0.025
1996	0.043	0.022
1997	0.082	0.382
1998	0.016	0.011
1999	0.023	0.012
2000	0.012	0.025
2001	0.004	0.007
2002	0.024	0.021
2003	0.017	0.011
2004	0.027	0.021
2005	0.020	0.011
2006	0.047	0.029
2007	0.040	0.022
2008	0.063	0.138
2009	0.020	0.012

Ranked Annual Peaks

Ranked Annual Peaks for Predeveloped and Mitigated. POC #1

Rank	**Predeveloped**	**Mitigated**
1	0.0824	0.3820
2	0.0754	0.2114
3	0.0631	0.1381

4	0.0522	0.0870
5	0.0466	0.0770
6	0.0432	0.0515
7	0.0397	0.0397
8	0.0354	0.0363
9	0.0347	0.0309
10	0.0337	0.0304
11	0.0335	0.0291
12	0.0332	0.0255
13	0.0323	0.0249
14	0.0315	0.0220
15	0.0313	0.0220
16	0.0306	0.0215
17	0.0288	0.0212
18	0.0273	0.0210
19	0.0261	0.0171
20	0.0260	0.0144
21	0.0259	0.0140
22	0.0253	0.0136
23	0.0252	0.0129
24	0.0249	0.0127
25	0.0246	0.0126
26	0.0244	0.0124
27	0.0238	0.0123
28	0.0235	0.0122
29	0.0234	0.0122
30	0.0233	0.0122
31	0.0232	0.0121
32	0.0230	0.0120
33	0.0227	0.0119
34	0.0224	0.0115
35	0.0223	0.0115
36	0.0211	0.0115
37	0.0208	0.0114
38	0.0208	0.0113
39	0.0204	0.0113
40	0.0201	0.0111
41	0.0198	0.0110
42	0.0198	0.0109
43	0.0186	0.0108
44	0.0185	0.0107
45	0.0184	0.0106
46	0.0184	0.0104
47	0.0184	0.0102
48	0.0177	0.0102
49	0.0173	0.0102
50	0.0170	0.0102
51	0.0168	0.0100
52	0.0157	0.0099
53	0.0156	0.0097
54	0.0148	0.0096
55	0.0138	0.0094
56	0.0133	0.0093
57	0.0129	0.0093
58	0.0127	0.0092
59	0.0125	0.0085
60	0.0121	0.0080
61	0.0041	0.0070

Duration Flows
The Facility PASSED

Flow(cfs)	Predev	Mit	Percentage	Pass/Fail
0.0118	22629	21032	92	Pass
0.0123	20565	13744	66	Pass
0.0128	18617	8393	45	Pass
0.0133	16818	7217	42	Pass
0.0137	15163	6714	44	Pass
0.0142	13719	6171	44	Pass
0.0147	12461	5784	46	Pass
0.0152	11300	5422	47	Pass
0.0157	10243	5037	49	Pass
0.0162	9306	4654	50	Pass
0.0167	8451	4361	51	Pass
0.0172	7676	4092	53	Pass
0.0177	6953	3841	55	Pass
0.0181	6318	3610	57	Pass
0.0186	5779	3420	59	Pass
0.0191	5285	3228	61	Pass
0.0196	4855	3033	62	Pass
0.0201	4442	2840	63	Pass
0.0206	4094	2631	64	Pass
0.0211	3700	2428	65	Pass
0.0216	3375	2289	67	Pass
0.0221	3050	2175	71	Pass
0.0226	2748	2079	75	Pass
0.0230	2507	1971	78	Pass
0.0235	2306	1885	81	Pass
0.0240	2108	1794	85	Pass
0.0245	1951	1687	86	Pass
0.0250	1823	1571	86	Pass
0.0255	1698	1476	86	Pass
0.0260	1581	1414	89	Pass
0.0265	1481	1351	91	Pass
0.0270	1398	1297	92	Pass
0.0274	1329	1248	93	Pass
0.0279	1260	1203	95	Pass
0.0284	1197	1153	96	Pass
0.0289	1138	1104	97	Pass
0.0294	1082	1057	97	Pass
0.0299	1025	1008	98	Pass
0.0304	956	953	99	Pass
0.0309	915	916	100	Pass
0.0314	879	897	102	Pass
0.0318	845	871	103	Pass
0.0323	808	842	104	Pass
0.0328	767	822	107	Pass
0.0333	731	791	108	Pass
0.0338	700	767	109	Pass
0.0343	676	742	109	Pass
0.0348	655	702	107	Pass
0.0353	639	665	104	Pass
0.0358	620	637	102	Pass
0.0362	604	607	100	Pass
0.0367	588	585	99	Pass
0.0372	573	558	97	Pass

0.0377	560	529	94	Pass
0.0382	551	500	90	Pass
0.0387	539	464	86	Pass
0.0392	523	431	82	Pass
0.0397	511	396	77	Pass
0.0402	496	354	71	Pass
0.0406	473	327	69	Pass
0.0411	458	318	69	Pass
0.0416	448	314	70	Pass
0.0421	438	310	70	Pass
0.0426	426	305	71	Pass
0.0431	417	302	72	Pass
0.0436	402	295	73	Pass
0.0441	396	291	73	Pass
0.0446	385	283	73	Pass
0.0451	374	279	74	Pass
0.0455	362	274	75	Pass
0.0460	355	271	76	Pass
0.0465	349	268	76	Pass
0.0470	338	259	76	Pass
0.0475	329	254	77	Pass
0.0480	320	247	77	Pass
0.0485	310	242	78	Pass
0.0490	306	236	77	Pass
0.0495	300	230	76	Pass
0.0499	296	228	77	Pass
0.0504	288	223	77	Pass
0.0509	283	222	78	Pass
0.0514	276	219	79	Pass
0.0519	270	211	78	Pass
0.0524	260	208	80	Pass
0.0529	252	203	80	Pass
0.0534	245	199	81	Pass
0.0539	239	197	82	Pass
0.0543	234	193	82	Pass
0.0548	227	192	84	Pass
0.0553	214	192	89	Pass
0.0558	205	191	93	Pass
0.0563	200	186	93	Pass
0.0568	194	185	95	Pass
0.0573	188	184	97	Pass
0.0578	184	181	98	Pass
0.0583	176	179	101	Pass
0.0587	170	176	103	Pass
0.0592	165	171	103	Pass
0.0597	158	169	106	Pass
0.0602	152	166	109	Pass

Water Quality

Water Quality BMP Flow and Volume for POC #1

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

LID Report

LID Technique	Used for Treatment ?	Total Volume Needs Treatment (ac-ft)	Volume Through Facility (ac-ft)	Infiltration Volume (ac-ft)	Cumulative Volume Infiltration Credit	Percent Volume Infiltrated	Water Quality	Percent Water Quality Treated	Comment
Vault 1 POC	☐	111.09			☐	0.00			
Total Volume Infiltrated		111.09	0.00	0.00		0.00	0.00	0%	No Treat. Credit
Compliance with LID Standard 8% of 2-yr to 50% of 2-yr									Duration Analysis Result = Failed

Model Default Modifications

Total of 0 changes have been made.

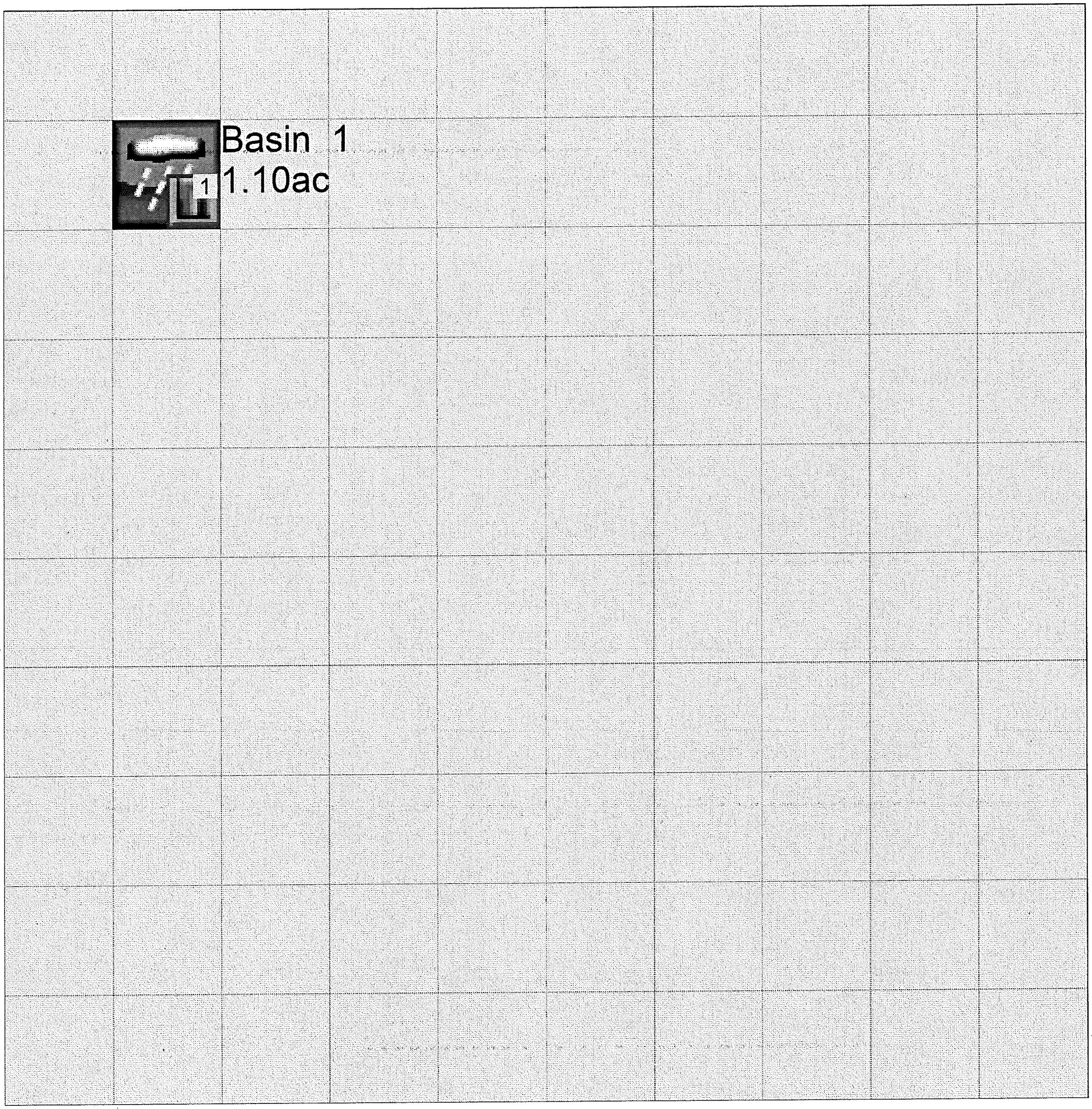
PERLND Changes

No PERLND changes have been made.

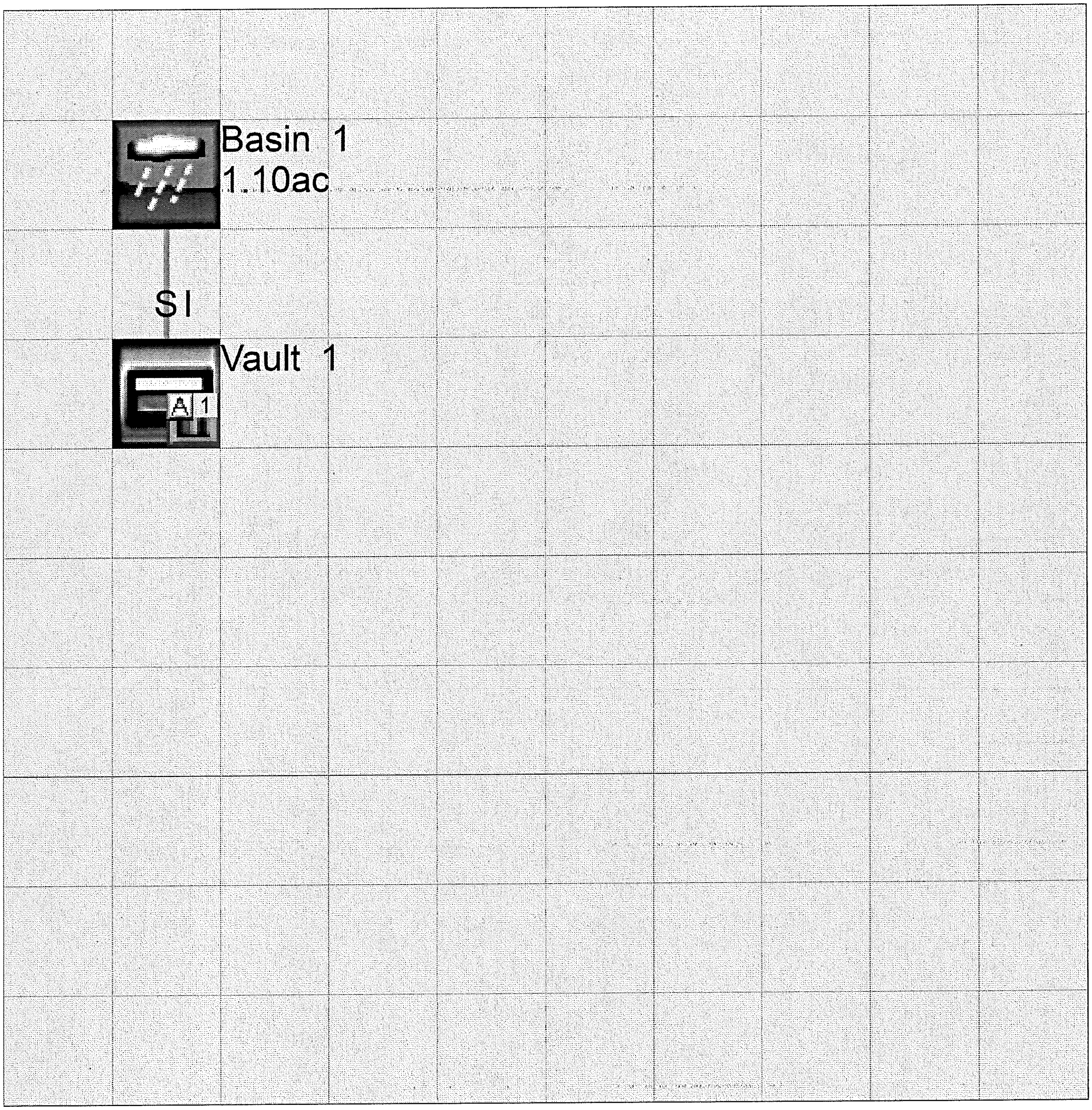
IMPLND Changes

No IMPLND changes have been made.

Appendix
Predeveloped Schematic



Mitigated Schematic



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Project: REV0 - COWLES - OPTION 2 - S2587-22

StormTech
A division of ADS

Chamber Model -	MC-3500	
Units -	Imperial	Click Here for Metric
Number of Chambers -	51	
Number of End Caps -	6	
Voids in the stone (porosity) -	40	%
Base of Stone Elevation -	0.00	ft
Amount of Stone Above Chambers -	12	in
Amount of Stone Below Chambers -	9	in
Amount of Stone Between Chambers -	6	in
Area of system -	3283	sf Min. Area - 2626 sf min. area

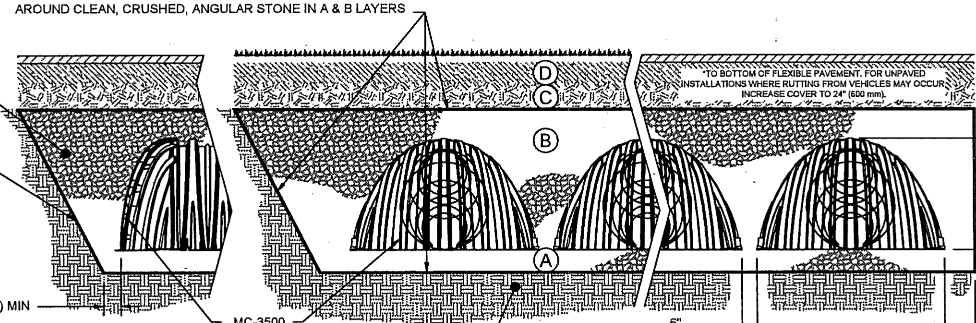
☑ Include Perimeter Stone in Calculations

Height of System (inches)	Incremental Single Chamber (cubic feet)	Incremental Single End Cap (cubic feet)	Incremental Chambers (cubic feet)	Incremental End Cap (cubic feet)	Incremental Stone (cubic feet)	Incremental Ch, EC and Stone (cubic feet)	Cumulative System (cubic feet)	Elevation (feet)
66	0.00	0.00	0.00	0.00	109.43	109.43	10640.83	5.50
65	0.00	0.00	0.00	0.00	109.43	109.43	10531.39	5.42
64	0.00	0.00	0.00	0.00	109.43	109.43	10421.96	5.33
63	0.00	0.00	0.00	0.00	109.43	109.43	10312.53	5.25
62	0.00	0.00	0.00	0.00	109.43	109.43	10203.09	5.17
61	0.00	0.00	0.00	0.00	109.43	109.43	10093.66	5.08
60	0.00	0.00	0.00	0.00	109.43	109.43	9984.23	5.00
59	0.00	0.00	0.00	0.00	109.43	109.43	9874.79	4.92
58	0.00	0.00	0.00	0.00	109.43	109.43	9765.36	4.83
57	0.00	0.00	0.00	0.00	109.43	109.43	9655.93	4.75
56	0.00	0.00	0.00	0.00	109.43	109.43	9546.49	4.67
55	0.00	0.00	0.00	0.00	109.43	109.43	9437.06	4.58
54	0.06	0.00	2.96	0.00	108.25	111.21	9327.63	4.50
53	0.19	0.02	9.90	0.14	105.42	115.46	9216.41	4.42
52	0.29	0.04	14.99	0.23	103.35	118.56	9100.96	4.33
51	0.40	0.05	20.59	0.31	101.08	121.97	8982.39	4.25
50	0.69	0.07	35.05	0.41	95.25	130.70	8860.42	4.17
49	1.03	0.09	52.44	0.53	88.24	141.22	8729.72	4.08
48	1.25	0.11	63.73	0.64	83.69	148.05	8588.50	4.00
47	1.42	0.13	72.53	0.76	80.12	153.41	8440.45	3.92
46	1.57	0.14	80.23	0.87	76.99	158.09	8287.04	3.83
45	1.71	0.16	87.06	0.98	74.22	162.26	8128.95	3.75
44	1.83	0.18	93.25	1.09	71.70	166.04	7966.69	3.67
43	1.94	0.20	98.83	1.20	69.42	169.45	7800.65	3.58
42	2.04	0.22	104.08	1.31	67.28	172.67	7631.20	3.50
41	2.13	0.23	108.87	1.41	65.32	175.60	7458.53	3.42
40	2.22	0.25	113.44	1.50	63.46	178.40	7282.93	3.33
39	2.31	0.27	117.65	1.59	61.74	180.98	7104.53	3.25
38	2.38	0.28	121.62	1.68	60.11	183.42	6923.55	3.17
37	2.46	0.29	125.41	1.76	58.56	185.74	6740.14	3.08
36	2.53	0.31	128.94	1.85	57.12	187.90	6554.40	3.00
35	2.59	0.32	132.28	1.93	55.75	189.96	6366.50	2.92
34	2.66	0.33	135.46	2.01	54.45	191.91	6176.54	2.83
33	2.72	0.35	138.47	2.08	53.21	193.76	5984.63	2.75
32	2.77	0.36	141.34	2.16	52.04	195.53	5790.86	2.67
31	2.82	0.37	144.06	2.23	50.92	197.21	5595.33	2.58
30	2.88	0.38	146.65	2.31	49.85	198.81	5398.12	2.50
29	2.92	0.40	149.13	2.38	48.83	200.34	5199.32	2.42
28	2.97	0.41	151.46	2.45	47.87	201.78	4998.98	2.33
27	3.01	0.42	153.63	2.51	46.97	203.12	4797.20	2.25
26	3.05	0.43	155.72	2.58	46.12	204.41	4594.08	2.17
25	3.09	0.44	157.81	2.64	45.25	205.70	4389.67	2.08
24	3.13	0.45	159.66	2.70	44.49	206.85	4183.96	2.00
23	3.17	0.46	161.45	2.77	43.75	207.96	3977.11	1.92
22	3.20	0.47	163.17	2.82	43.03	209.03	3769.15	1.83
21	3.23	0.48	164.79	2.88	42.37	210.03	3560.12	1.75
20	3.26	0.49	166.33	2.94	41.73	210.99	3350.09	1.67
19	3.29	0.50	167.80	2.99	41.12	211.91	3139.09	1.58
18	3.32	0.51	169.22	3.04	40.53	212.79	2927.18	1.50
17	3.34	0.51	170.55	3.09	39.98	213.62	2714.40	1.42
16	3.37	0.52	171.80	3.13	39.46	214.39	2500.78	1.33
15	3.39	0.53	173.02	3.18	38.96	215.15	2286.39	1.25
14	3.41	0.54	174.14	3.22	38.49	215.85	2071.24	1.17
13	3.44	0.54	175.29	3.26	38.01	216.56	1855.39	1.08
12	3.46	0.55	176.34	3.30	37.58	217.22	1638.83	1.00
11	3.48	0.56	177.41	3.33	37.14	217.88	1421.61	0.92
10	3.51	0.59	178.76	3.57	36.50	218.83	1203.73	0.83
9	0.00	0.00	0.00	0.00	109.43	109.43	984.90	0.75
8	0.00	0.00	0.00	0.00	109.43	109.43	875.47	0.67
7	0.00	0.00	0.00	0.00	109.43	109.43	766.03	0.58
6	0.00	0.00	0.00	0.00	109.43	109.43	656.60	0.50
5	0.00	0.00	0.00	0.00	109.43	109.43	547.17	0.42
4	0.00	0.00	0.00	0.00	109.43	109.43	437.73	0.33
3	0.00	0.00	0.00	0.00	109.43	109.43	328.30	0.25
2	0.00	0.00	0.00	0.00	109.43	109.43	218.87	0.17
1	0.00	0.00	0.00	0.00	109.43	109.43	109.43	0.08

ACCEPTABLE FILL MATERIALS: STORMTECH MC-3500 CHAMBER SYSTEMS

	MATERIAL LOCATION	DESCRIPTION	AASHTO MATERIAL CLASSIFICATIONS	COMPACTION / DENSITY REQUIREMENT
D	**FINAL FILL:** FILL MATERIAL FOR LAYER 'D' STARTS FROM THE TOP OF THE 'C' LAYER TO THE BOTTOM OF FLEXIBLE PAVEMENT OR UNPAVED FINISHED GRADE ABOVE. NOTE THAT PAVEMENT SUBBASE MAY BE PART OF THE 'D' LAYER	ANY SOIL/ROCK MATERIALS, NATIVE SOILS, OR PER ENGINEER'S PLANS. CHECK PLANS FOR PAVEMENT SUBGRADE REQUIREMENTS.	N/A	PREPARE PER SITE DESIGN ENGINEER'S PLANS. PAVED INSTALLATIONS MAY HAVE STRINGENT MATERIAL AND PREPARATION REQUIREMENTS.
C	**INITIAL FILL:** FILL MATERIAL FOR LAYER 'C' STARTS FROM THE TOP OF THE EMBEDMENT STONE ('B' LAYER) TO 24" (600 mm) ABOVE THE TOP OF THE CHAMBER. NOTE THAT PAVEMENT SUBBASE MAY BE A PART OF THE 'C' LAYER.	GRANULAR WELL-GRADED SOIL/AGGREGATE MIXTURES, <35% FINES OR PROCESSED AGGREGATE. MOST PAVEMENT SUBBASE MATERIALS CAN BE USED IN LIEU OF THIS LAYER.	AASHTO M145[1] A-1, A-2-4, A-3 OR AASHTO M43[1] 3, 357, 4, 467, 5, 56, 57, 6, 67, 68, 7, 78, 8, 89, 9, 10	BEGIN COMPACTIONS AFTER 24" (600 mm) OF MATERIAL OVER THE CHAMBERS IS REACHED. COMPACT ADDITIONAL LAYERS IN 12" (300 mm) MAX LIFTS TO A MIN. 95% PROCTOR DENSITY FOR WELL GRADED MATERIAL AND 95% RELATIVE DENSITY FOR PROCESSED AGGREGATE MATERIALS.
B	**EMBEDMENT STONE:** FILL SURROUNDING THE CHAMBERS FROM THE FOUNDATION STONE ('A' LAYER) TO THE 'C' LAYER ABOVE.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 4	NO COMPACTION REQUIRED.
A	**FOUNDATION STONE:** FILL BELOW CHAMBERS FROM THE SUBGRADE UP TO THE FOOT (BOTTOM) OF THE CHAMBER.	CLEAN, CRUSHED, ANGULAR STONE	AASHTO M43[1] 3, 4	PLATE COMPACT OR ROLL TO ACHIEVE A FLAT SURFACE.[2,3]

PLEASE NOTE:
1. THE LISTED AASHTO DESIGNATIONS ARE FOR GRADATIONS ONLY. THE STONE MUST ALSO BE CLEAN, CRUSHED, ANGULAR. FOR EXAMPLE, A SPECIFICATION FOR #4 STONE WOULD STATE: "CLEAN, CRUSHED, ANGULAR NO. 4 (AASHTO M43) STONE".
2. STORMTECH COMPACTION REQUIREMENTS ARE MET FOR 'A' LOCATION MATERIALS WHEN PLACED AND COMPACTED IN 9" (230 mm) (MAX) LIFTS USING TWO FULL COVERAGES WITH A VIBRATORY COMPACTOR.
3. WHERE INFILTRATION SURFACES MAY BE COMPROMISED BY COMPACTION, FOR STANDARD DESIGN LOAD CONDITIONS, A FLAT SURFACE MAY BE ACHIEVED BY RAKING OR DRAGGING WITHOUT COMPACTION EQUIPMENT. FOR SPECIAL LOAD DESIGNS, CONTACT STORMTECH FOR COMPACTION REQUIREMENTS.
4. ONCE LAYER 'C' IS PLACED, ANY SOIL/MATERIAL CAN BE PLACED IN LAYER 'D' UP TO THE FINISHED GRADE. MOST PAVEMENT SUBBASE SOILS CAN BE USED TO REPLACE THE MATERIAL REQUIREMENTS OF LAYER 'C' OR 'D' AT THE SITE DESIGN ENGINEER'S DISCRETION.



**THIS CROSS SECTION DETAIL REPRESENTS MINIMUM REQUIREMENTS FOR INSTALLATION. PLEASE SEE THE LAYOUT SHEET(S) FOR PROJECT SPECIFIC REQUIREMENTS.

NOTES:

1. CHAMBERS SHALL MEET THE REQUIREMENTS OF ASTM F2418, "STANDARD SPECIFICATION FOR POLYPROPYLENE (PP) CORRUGATED WALL STORMWATER COLLECTION CHAMBERS" CHAMBER CLASSIFICATION 45x76 DESIGNATION SS.
2. MC-3500 CHAMBERS SHALL BE DESIGNED IN ACCORDANCE WITH ASTM F2787 "STANDARD PRACTICE FOR STRUCTURAL DESIGN OF THERMOPLASTIC CORRUGATED WALL STORMWATER COLLECTION CHAMBERS".
3. THE SITE DESIGN ENGINEER IS RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE (ALLOWABLE BEARING CAPACITY) OF THE SUBGRADE SOILS AND THE DEPTH OF FOUNDATION STONE WITH CONSIDERATION FOR THE RANGE OF EXPECTED SOIL MOISTURE CONDITIONS.
4. PERIMETER STONE MUST BE EXTENDED HORIZONTALLY TO THE EXCAVATION WALL FOR BOTH VERTICAL AND SLOPED EXCAVATION WALLS.
5. REQUIREMENTS FOR HANDLING AND INSTALLATION:
   - TO MAINTAIN THE WIDTH OF CHAMBERS DURING SHIPPING AND HANDLING, CHAMBERS SHALL HAVE INTEGRAL, INTERLOCKING STACKING LUGS.
   - TO ENSURE A SECURE JOINT DURING INSTALLATION AND BACKFILL, THE HEIGHT OF THE CHAMBER JOINT SHALL NOT BE LESS THAN 3".
   - TO ENSURE THE INTEGRITY OF THE ARCH SHAPE DURING INSTALLATION, a) THE ARCH STIFFNESS CONSTANT AS DEFINED IN SECTION 6.2.8 OF ASTM F2418 SHALL BE GREATER THAN OR EQUAL TO 500 LBS/IN/IN. AND b) TO RESIST CHAMBER DEFORMATION DURING INSTALLATION AT ELEVATED TEMPERATURES (ABOVE 73° F / 23° C), CHAMBERS SHALL BE PRODUCED FROM REFLECTIVE GOLD OR YELLOW COLORS.

COWLES SHORT PLAT
MILL CREEK, WA

DATE: 09-18-21 | DRAWN: TSG
PROJECT #: S258722 | CHECKED: CTS

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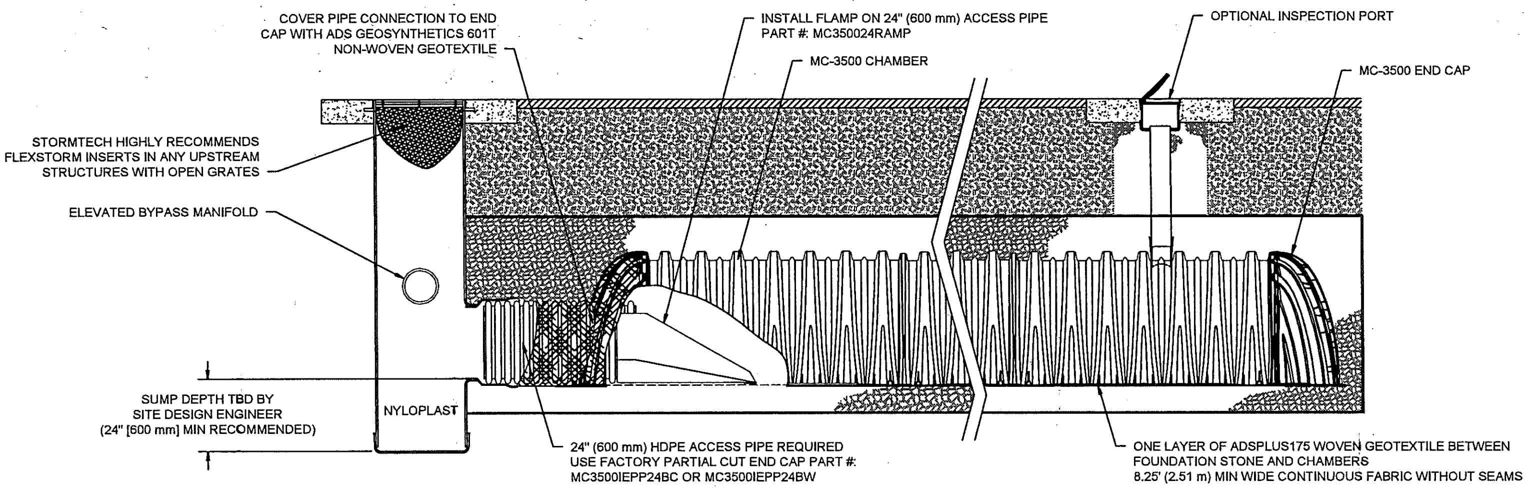


MC-3500 ISOLATOR ROW PLUS DETAIL
NTS

INSPECTION & MAINTENANCE

STEP 1) INSPECT ISOLATOR ROW PLUS FOR SEDIMENT
- A. INSPECTION PORTS (IF PRESENT)
  - A.1. REMOVE/OPEN LID ON NYLOPLAST INLINE DRAIN
  - A.2. REMOVE AND CLEAN FLEXSTORM FILTER IF INSTALLED
  - A.3. USING A FLASHLIGHT AND STADIA ROD, MEASURE DEPTH OF SEDIMENT AND RECORD ON MAINTENANCE LOG
  - A.4. LOWER A CAMERA INTO ISOLATOR ROW PLUS FOR VISUAL INSPECTION OF SEDIMENT LEVELS (OPTIONAL)
  - A.5. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.
- B. ALL ISOLATOR PLUS ROWS
  - B.1. REMOVE COVER FROM STRUCTURE AT UPSTREAM END OF ISOLATOR ROW PLUS
  - B.2. USING A FLASHLIGHT, INSPECT DOWN THE ISOLATOR ROW PLUS THROUGH OUTLET PIPE
    - i) MIRRORS ON POLES OR CAMERAS MAY BE USED TO AVOID A CONFINED SPACE ENTRY
    - ii) FOLLOW OSHA REGULATIONS FOR CONFINED SPACE ENTRY IF ENTERING MANHOLE
  - B.3. IF SEDIMENT IS AT, OR ABOVE, 3" (80 mm) PROCEED TO STEP 2. IF NOT, PROCEED TO STEP 3.

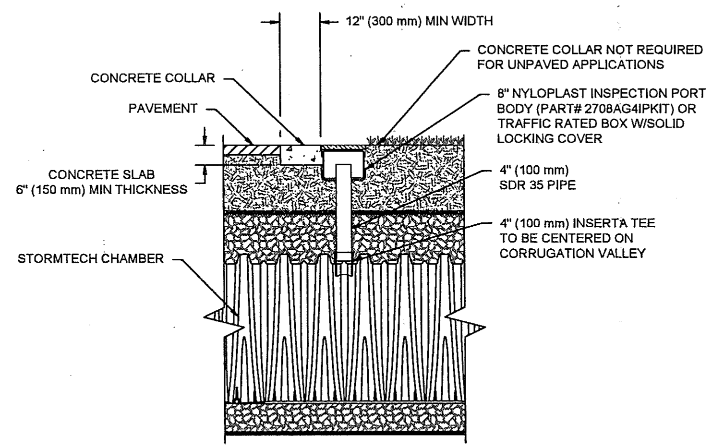
STEP 2) CLEAN OUT ISOLATOR ROW PLUS USING THE JETVAC PROCESS
- A. A FIXED CULVERT CLEANING NOZZLE WITH REAR FACING SPREAD OF 45" (1.1 m) OR MORE IS PREFERRED
- B. APPLY MULTIPLE PASSES OF JETVAC UNTIL BACKFLUSH WATER IS CLEAN
- C. VACUUM STRUCTURE SUMP AS REQUIRED

STEP 3) REPLACE ALL COVERS, GRATES, FILTERS, AND LIDS; RECORD OBSERVATIONS AND ACTIONS.

STEP 4) INSPECT AND CLEAN BASINS AND MANHOLES UPSTREAM OF THE STORMTECH SYSTEM.

NOTES

1. INSPECT EVERY 6 MONTHS DURING THE FIRST YEAR OF OPERATION. ADJUST THE INSPECTION INTERVAL BASED ON PREVIOUS OBSERVATIONS OF SEDIMENT ACCUMULATION AND HIGH WATER ELEVATIONS.
2. CONDUCT JETTING AND VACTORING ANNUALLY OR WHEN INSPECTION SHOWS THAT MAINTENANCE IS NECESSARY.



NOTE:
INSPECTION PORTS MAY BE CONNECTED THROUGH ANY CHAMBER CORRUGATION VALLEY.

4" PVC INSPECTION PORT DETAIL (MC SERIES CHAMBER)
NTS

COWLES SHORT PLAT
MILL CREEK, WA

DATE: 09-18-21	DRAWN: TSG
PROJECT #: S258722	CHECKED: CTS

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UNDERDRAIN DETAIL
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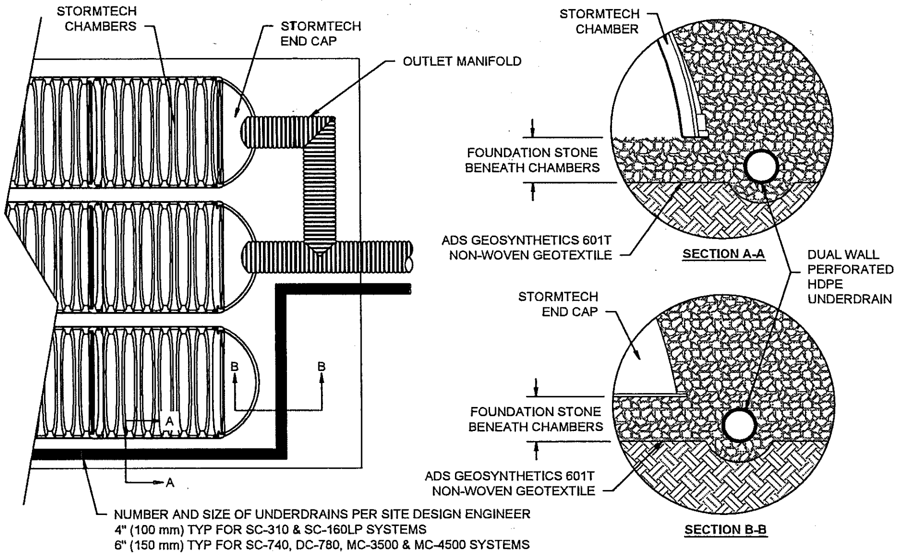
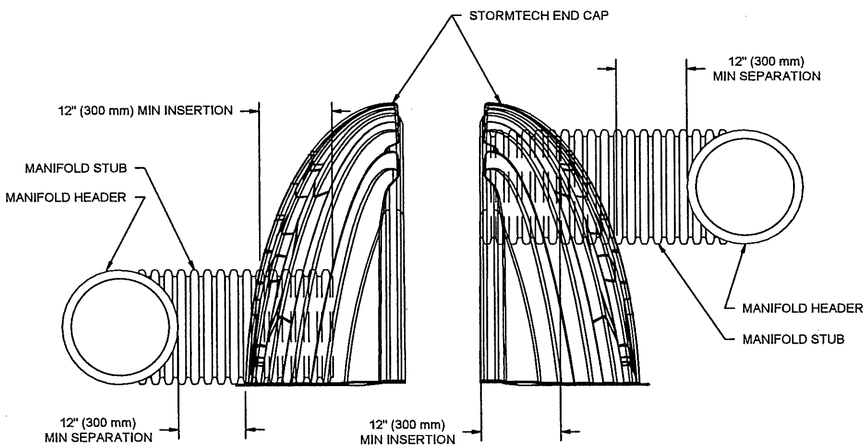


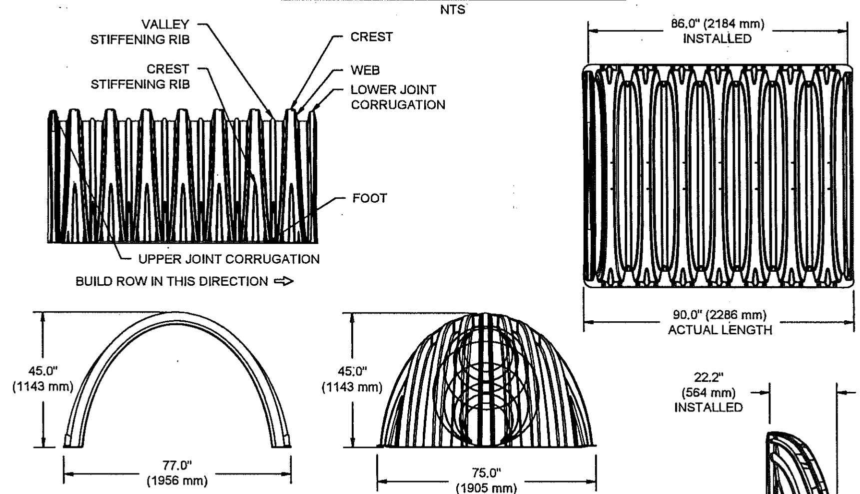
NUMBER AND SIZE OF UNDERDRAINS PER SITE DESIGN ENGINEER
4" (100 mm) TYP FOR SC-310 & SC-160LP SYSTEMS
6" (150 mm) TYP FOR SC-740, DC-780, MC-3500 & MC-4500 SYSTEMS

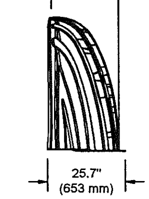
MC-SERIES END CAP INSERTION DETAIL
NTS



NOTE: MANIFOLD STUB MUST BE LAID HORIZONTAL FOR A PROPER FIT IN END CAP OPENING.

MC-3500 TECHNICAL SPECIFICATION
NTS





NOMINAL CHAMBER SPECIFICATIONS

SIZE (W X H X INSTALLED LENGTH)	77.0" X 45.0" X 86.0"	(1956 mm X 1143 mm X 2184 mm)
CHAMBER STORAGE	109.9 CUBIC FEET	(3.11 m³)
MINIMUM INSTALLED STORAGE*	175.0 CUBIC FEET	(4.96 m³)
WEIGHT	134 lbs.	(60.8 kg)

NOMINAL END CAP SPECIFICATIONS

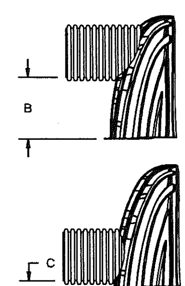
SIZE (W X H X INSTALLED LENGTH)	75.0" X 45.0" X 22.2"	(1905 mm X 1143 mm X 564 mm)
END CAP STORAGE	14.9 CUBIC FEET	(0.42 m³)
MINIMUM INSTALLED STORAGE*	45.1 CUBIC FEET	(1.28 m³)
WEIGHT	49 lbs.	(22.2 kg)

*ASSUMES 12" (305 mm) STONE ABOVE, 9" (229 mm) STONE FOUNDATION, 6" (152 mm) STONE BETWEEN CHAMBERS, 6" (152 mm) STONE PERIMETER IN FRONT OF END CAPS AND 40% STONE POROSITY.

PARTIAL CUT HOLES AT BOTTOM OF END CAP FOR PART NUMBERS ENDING WITH "B"
PARTIAL CUT HOLES AT TOP OF END CAP FOR PART NUMBERS ENDING WITH "T"
END CAPS WITH A PREFABRICATED WELDED STUB END WITH "W"
END CAPS WITH A WELDED CROWN PLATE END WITH "C"

PART #	STUB	B	C
MC3500IEPP06T	6" (150 mm)	33.21" (844 mm)	—
MC3500IEPP06B		—	0.66" (17 mm)
MC3500IEPP08T	8" (200 mm)	31.16" (791 mm)	—
MC3500IEPP08B		—	0.81" (21 mm)
MC3500IEPP10T	10" (250 mm)	29.04" (738 mm)	—
MC3500IEPP10B		—	0.93" (24 mm)
MC3500IEPP12T	12" (300 mm)	26.36" (670 mm)	—
MC3500IEPP12B		—	1.35" (34 mm)
MC3500IEPP15T	15" (375 mm)	23.39" (594 mm)	—
MC3500IEPP15B		—	1.50" (38 mm)
MC3500IEPP18TC	18" (450 mm)	20.03" (509 mm)	—
MC3500IEPP18TW			
MC3500IEPP18BC		—	1.77" (45 mm)
MC3500IEPP18BW			
MC3500IEPP24TC	24" (600 mm)	14.48" (368 mm)	—
MC3500IEPP24TW			
MC3500IEPP24BC		—	2.06" (52 mm)
MC3500IEPP24BW			
MC3500IEPP30BC	30" (750 mm)	—	2.75" (70 mm)

NOTE: ALL DIMENSIONS ARE NOMINAL



CUSTOM PARTIAL CUT INVERTS ARE AVAILABLE UPON REQUEST. INVENTORIED MANIFOLDS INCLUDE 12-24" (300-600 mm) SIZE ON SIZE AND 15-48" (375-1200 mm) ECCENTRIC MANIFOLDS. CUSTOM INVERT LOCATIONS ON THE MC-3500 END CAP CUT IN THE FIELD ARE NOT RECOMMENDED FOR PIPE SIZES GREATER THAN 10" (250 mm). THE INVERT LOCATION IN COLUMN 'B' ARE THE HIGHEST POSSIBLE FOR THE PIPE SIZE.

COWLES SHORT PLAT
MILL CREEK, WA

DATE: 09-18-21	DRAWN: TSG	PROJECT #: S258722	CHECKED: CTS

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NYLOPLAST DRAIN BASIN

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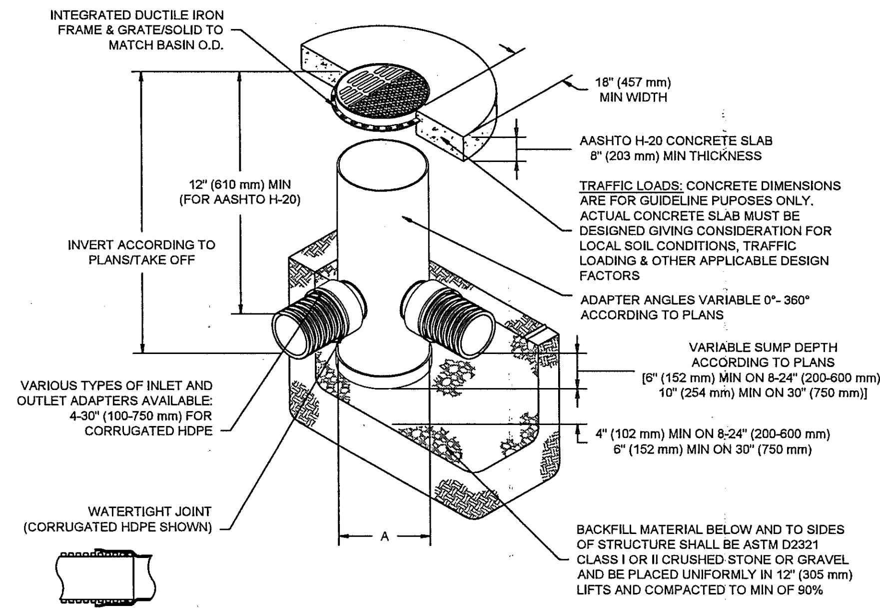

NOTES

1. 8-30" (200-750 mm) GRATES/SOLID COVERS SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05
2. 12-30" (300-750 mm) FRAMES SHALL BE DUCTILE IRON PER ASTM A536 GRADE 70-50-05
3. DRAIN BASIN TO BE CUSTOM MANUFACTURED ACCORDING TO PLAN DETAILS
4. DRAINAGE CONNECTION STUB JOINT TIGHTNESS SHALL CONFORM TO ASTM D3212 FOR CORRUGATED HDPE (ADS & HANCOR DUAL WALL) & SDR 35 PVC
5. FOR COMPLETE DESIGN AND PRODUCT INFORMATION: **WWW.NYLOPLAST-US.COM**
6. TO ORDER CALL: **800-821-6710**

A	PART #	GRATE/SOLID COVER OPTIONS		
8" (200 mm)	2808AG	PEDESTRIAN LIGHT DUTY	STANDARD LIGHT DUTY	SOLID LIGHT DUTY
10" (250 mm)	2810AG	PEDESTRIAN LIGHT DUTY	STANDARD LIGHT DUTY	SOLID LIGHT DUTY
12" (300 mm)	2812AG	PEDESTRIAN AASHTO H-10	STANDARD AASHTO H-20	SOLID AASHTO H-20
15" (375 mm)	2815AG	PEDESTRIAN AASHTO H-10	STANDARD AASHTO H-20	SOLID AASHTO H-20
18" (450 mm)	2818AG	PEDESTRIAN AASHTO H-10	STANDARD AASHTO H-20	SOLID AASHTO H-20
24" (600 mm)	2824AG	PEDESTRIAN AASHTO H-10	STANDARD AASHTO H-20	SOLID AASHTO H-20
30" (750 mm)	2830AG	PEDESTRIAN AASHTO H-20	STANDARD AASHTO H-20	SOLID AASHTO H-20

COWLES SHORT PLAT
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APPENDIX B

GEOTECHNICAL REPORT

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

June 4, 2021

Chris Brooks
Chrisjbrooks610@gmail.com

RE: Geotechnical Evaluation
Proposed Residential Development
13710 42nd Avenue SE
Mill Creek, Washington

In accordance with your authorization, Cobalt Geosciences, LLC has prepared this letter to discuss the results of our geotechnical evaluation at the referenced site.

The purpose of our evaluation was to provide recommendations for foundation design, grading, stormwater management, and earthwork.

Site Description

The site is located at 13710 42nd Avenue SE in Mill Creek, Washington. The site consists of one rectangular shaped parcel (No. 28053300202200) with a total area of about 1 acre.

The northeast central portion of the property is developed with a single-family residence and driveway. The remainder of the property is undeveloped and vegetated with grasses, blackberry vines, ivy, ferns, bushes, and variable diameter trees.

The site slopes gently downward from east to west at magnitudes of 5 to 10 percent and relief of about 12 feet.

The property is bordered to the north, west, and south by residential properties and to the east by 42nd Avenue SE.

The project includes construction of up to four new residences, access roadway, driveways and stormwater facilities. Stormwater management may include dispersion, detention, or infiltration facilities depending on feasibility.

Area Geology

The Geologic Map of Washington – Northwest Quadrant indicates that the site is underlain by Vashon Glacial Till.

Vashon Glacial Till consists of nearly impermeable mixtures of silt, sand, gravel, and clay. These materials are typically dense to very dense. Vashon Recessional Outwash often overlies the till. Recessional outwash has not been consolidated by glacial activity and can be permeable.

Soil & Groundwater Conditions

As part of our evaluation, we excavated two test pits within the property to determine the shallow soil and groundwater conditions, where accessible. Several years ago, we excavated two test pits at this site with a subcontracted excavator. We have included these test pit logs for reference.

All of the test pits encountered about 6 to 12 inches of topsoil and grass underlain by 2 to 3 feet of loose to medium dense, silty-fine to medium grained sand with gravel (Weathered Glacial Till). This layer was underlain by dense to very dense, silty-fine to medium grained sand with gravel (Glacial Till), which continued to the termination depths of the test pits.

Groundwater was not encountered during the two test pits excavations on April 28, 2021. Groundwater was encountered in the previous test pits excavated on February 6, 2020. Groundwater was observed in TP-1 at 2.25 feet below grade and in TP-2 at 2.5 feet below grade. Groundwater appears to be perched within weathered native soils.

Erosion Hazard

The Natural Resources Conservation Services (NRCS) maps for Snohomish County indicate that the site is underlain by Alderwood gravelly sandy loam (0 to 8 percent slopes). These soils would have a slight to moderate erosion potential in a disturbed state depending on the slope magnitude.

It is our opinion that soil erosion potential at this project site can be reduced through landscaping and surface water runoff control. Typically, erosion of exposed soils will be most noticeable during periods of rainfall and may be controlled by the use of normal temporary erosion control measures, such as silt fences, hay bales, mulching, control ditches and diversion trenches. The typical wet weather season, with regard to site grading, is from October 31st to April 1st. Erosion control measures should be in place before the onset of wet weather.

Seismic Hazard

The overall subsurface profile corresponds to a Site Class *D* as defined by Table 1613.5.2 of the International Building Code (IBC). A Site Class *D* applies to an overall profile consisting of stiff/medium dense soils within the upper 100 feet.

We referenced the U.S. Geological Survey (USGS) Earthquake Hazards Program Website to obtain values for S_S, S_1, F_a, and F_v. The USGS website includes the most updated published data on seismic conditions. The following tables provide seismic parameters from the USGS web site with referenced parameters from ASCE 7-10 and 7-16.

Seismic Design Parameters (ASCE 7-10)

Site Class	Spectral Acceleration at 0.2 sec. (g)	Spectral Acceleration at 1.0 sec. (g)	Site Coefficients		Design Spectral Response Parameters		Design PGA
			F_a	F_v	S_{DS}	S_{D1}	
D	1.384	0.535	1.0	1.5	0.923	0.535	0.583

Seismic Design Parameters (ASCE 7-16)

Site Class	Spectral Acceleration at 0.2 sec. (g)	Spectral Acceleration at 1.0 sec. (g)	Site Coefficients		Design Spectral Response Parameters		Design PGA
			F_a	F_v	S_{DS}	S_{D1}	
D	1.348	0.478	1.0	Null	1.079	Null	0.582

Additional seismic considerations include liquefaction potential and amplification of ground motions by soft/loose soil deposits. The liquefaction potential is highest for loose sand with a high groundwater table. The site has a low likelihood of liquefaction. For items listed as "Null" see Section 11.4.8 of the ASCE.

Conclusions and Recommendations

General

The site is underlain by weathered and unweathered glacial till. The proposed residences may be supported on shallow foundation systems bearing on medium dense or firmer native soils or on structural fill placed on the native soils. Local overexcavation or recompaction of loose weathered native soils may be necessary depending on the proposed elevations and locations of the new footings.

Widespread infiltration is not feasible due to the shallow soil and groundwater conditions. In general, dispersion trenches, rock pads, rain gardens, detention systems, and permeable pavements are feasible depending on their location and elevation. Permeable pavements and rain gardens typically require at least 12 inches of clearance above groundwater and restrictive layers. If minimal cuts are proposed, these systems should be feasible. We can provide additional recommendations once civil plans are prepared.

Site Preparation

Trees, shrubs and other vegetation should be removed prior to stripping of surficial organic-rich soil and fill. Based on observations from the site investigation program, it is anticipated that the stripping depth will be 6 to 12 inches. Deeper excavations will be necessary in areas of existing foundation systems, below large trees, and in any areas underlain by undocumented fill.

The native soils consist of silty-sand with gravel. Most of the native soils may be used as structural fill provided they achieve compaction requirements and are within 3 percent of the optimum moisture. Some of these soils may only be suitable for use as fill during the summer months, as they will be above the optimum moisture levels in their current state. These soils are variably moisture sensitive and may degrade during periods of wet weather and under equipment traffic.

Imported structural fill should consist of a sand and gravel mixture with a maximum grain size of 3 inches and less than 5 percent fines (material passing the U.S. Standard No. 200 Sieve). Structural fill should be placed in maximum lift thicknesses of 12 inches and should be compacted to a minimum of 95 percent of the modified proctor maximum dry density, as determined by the ASTM D 1557 test method.

Temporary Excavations

Based on our understanding of the project, we anticipate that the grading could include local cuts on the order of approximately 4 feet or less for foundation and utility placement. Any deeper excavations should be sloped no steeper than 1.5H:1V (Horizontal:Vertical) in loose native soils and fill, 1H:1V in medium dense native soils and 3/4H:1V in dense to very dense soils. If an excavation is subject to heavy vibration or surcharge loads, we recommend that the excavations be sloped no steeper than 2H:1V, where room permits.

Temporary cuts should be in accordance with the Washington Administrative Code (WAC) Part N, Excavation, Trenching, and Shoring. Temporary slopes should be visually inspected daily by a qualified person during construction activities and the inspections should be documented in daily reports. The contractor is responsible for maintaining the stability of the temporary cut slopes and reducing slope erosion during construction.

Temporary cut slopes should be covered with visqueen to help reduce erosion during wet weather, and the slopes should be closely monitored until the permanent retaining systems or slope configurations are complete. Materials should not be stored or equipment operated within 10 feet of the top of any temporary cut slope.

Soil conditions may not be completely known from the geotechnical investigation. In the case of temporary cuts, the existing soil conditions may not be completely revealed until the excavation work exposes the soil. Typically, as excavation work progresses the maximum inclination of temporary slopes will need to be re-evaluated by the geotechnical engineer so that supplemental recommendations can be made. Soil and groundwater conditions can be highly variable. Scheduling for soil work will need to be adjustable, to deal with unanticipated conditions, so that the project can proceed and required deadlines can be met.

If any variations or undesirable conditions are encountered during construction, we should be notified so that supplemental recommendations can be made. If room constraints or groundwater conditions do not permit temporary slopes to be cut to the maximum angles allowed by the WAC, temporary shoring systems may be required. The contractor should be responsible for developing temporary shoring systems, if needed. We recommend that Cobalt Geosciences and the project structural engineer review temporary shoring designs prior to installation, to verify the suitability of the proposed systems.

Foundation Design

The proposed residential structures may be supported on shallow spread footing foundation systems bearing on undisturbed dense or firmer native soils or on properly compacted structural fill placed on the suitable native soils. Any undocumented fill and/or loose native soils should be removed and replaced with structural fill below foundation elements. Structural fill below footings should consist of clean angular rock 5/8 to 4 inches in size. It may be feasible to recompact loose outwash soils in lieu of overexcavation and replacement. We should verify soil conditions during foundation excavation work.

For shallow foundation support, we recommend widths of at least 16 and 24 inches, respectively, for continuous wall and isolated column footings supporting the proposed structure. Provided that the footings are supported as recommended above, a net allowable bearing pressure of 2,000 pounds per square foot (psf) may be used for design. If detention vaults are utilized, a bearing pressure of 5,000 psf may be used for systems set at least 5 feet below grade.

A 1/3 increase in the above value may be used for short duration loads, such as those imposed by wind and seismic events. Structural fill placed on bearing, native subgrade should be compacted to at least 95 percent of the maximum dry density based on ASTM Test Method D1557. Footing excavations should be inspected to verify that the foundations will bear on suitable material.

Exterior footings should have a minimum depth of 18 inches below pad subgrade (soil grade) or adjacent exterior grade, whichever is lower. Interior footings should have a minimum depth of 12 inches below pad subgrade (soil grade) or adjacent exterior grade, whichever is lower.

If constructed as recommended, the total foundation settlement is not expected to exceed 1 inch. Differential settlement, along a 25-foot exterior wall footing, or between adjoining column footings, should be less than ½ inch. This translates to an angular distortion of 0.002. Most settlement is expected to occur during construction, as the loads are applied. However, additional post-construction settlement may occur if the foundation soils are flooded or saturated. All footing excavations should be observed by a qualified geotechnical consultant.

Resistance to lateral footing displacement can be determined using an allowable friction factor of 0.40 acting between the base of foundations and the supporting subgrades. Lateral resistance for footings can also be developed using an allowable equivalent fluid passive pressure of 225 pounds per cubic foot (pcf) acting against the appropriate vertical footing faces (neglect the upper 12 inches below grade in exterior areas). The frictional and passive resistance of the soil may be combined without reduction in determining the total lateral resistance.

Care should be taken to prevent wetting or drying of the bearing materials during construction. Any extremely wet or dry materials, or any loose or disturbed materials at the bottom of the footing excavations, should be removed prior to placing concrete. The potential for wetting or drying of the bearing materials can be reduced by pouring concrete as soon as possible after completing the footing excavation and evaluating the bearing surface by the geotechnical engineer or his representative.

Concrete Retaining Walls

The following table, titled **Wall Design Criteria**, presents the recommended soil related design parameters for retaining walls with a level backslope. Contact Cobalt if an alternate retaining wall system is used. This has been included for new cast in place walls.

Wall Design Criteria	
"At-rest" Conditions (Lateral Earth Pressure – EFD$^+$)	55 pcf (Equivalent Fluid Density)
"Active" Conditions (Lateral Earth Pressure – EFD$^+$)	35 pcf (Equivalent Fluid Density)
Seismic Increase for "At-rest" Conditions (Lateral Earth Pressure)	21H* (Uniform Distribution) 1 in 2,500 year event
Seismic Increase for "At-rest" Conditions (Lateral Earth Pressure)	14H* (Uniform Distribution) 1 in 500 year event

Seismic Increase for "Active" Conditions (Lateral Earth Pressure)	7H* (Uniform Distribution)
Passive Earth Pressure on Low Side of Wall (Allowable, includes F.S. = 1.5)	Neglect upper 2 feet, then 300 pcf EFD+
Soil-Footing Coefficient of Sliding Friction (Allowable; includes F.S. = 1.5)	0.40

*H is the height of the wall; Increase based on one in 500 year seismic event (10 percent probability of being exceeded in 50 years),
+EFD – Equivalent Fluid Density

The stated lateral earth pressures do not include the effects of hydrostatic pressure generated by water accumulation behind the retaining walls. Uniform horizontal lateral active and at-rest pressures on the retaining walls from vertical surcharges behind the wall may be calculated using active and at-rest lateral earth pressure coefficients of 0.3 and 0.5, respectively. A soil unit weight of 125 pcf may be used to calculate vertical earth surcharges.

To reduce the potential for the buildup of water pressure against the walls, continuous footing drains (with cleanouts) should be provided at the bases of the walls. The footing drains should consist of a minimum 4-inch diameter perforated pipe, sloped to drain, with perforations placed down and enveloped by a minimum 6 inches of pea gravel in all directions.

The backfill adjacent to and extending a lateral distance behind the walls at least 2 feet should consist of free-draining granular material. All free draining backfill should contain less than 3 percent fines (passing the U.S. Standard No. 200 Sieve) based upon the fraction passing the U.S. Standard No. 4 Sieve with at least 30 percent of the material being retained on the U.S. Standard No. 4 Sieve. The primary purpose of the free-draining material is the reduction of hydrostatic pressure. Some potential for the moisture to contact the back face of the wall may exist, even with treatment, which may require that more extensive waterproofing be specified for walls, which require interior moisture sensitive finishes.

We recommend that the backfill be compacted to at least 90 percent of the maximum dry density based on ASTM Test Method D1557. In place density tests should be performed to verify adequate compaction. Soil compactors place transient surcharges on the backfill. Consequently, only light hand operated equipment is recommended within 3 feet of walls so that excessive stress is not imposed on the walls.

Stormwater Management Feasibility

The site is underlain by weathered to unweathered glacial till. These materials are not conducive for infiltration of runoff. The unweathered glacial till acts as a restrictive layer which prevent vertical infiltration of runoff.

Widespread infiltration is not feasible due to the shallow soil and groundwater conditions. While groundwater was not present in April 2021; groundwater was observed in shallow test pits conducted in February 2020. There is inadequate clearance above groundwater and a restrictive layer for widespread infiltration.

In general, dispersion trenches, rock pads, rain gardens, detention systems, and permeable pavements are feasible depending on their location and elevation. Permeable pavements and rain gardens typically require at least 12 inches of clearance above groundwater and restrictive layers. If minimal cuts are proposed, these systems should be feasible.

In February 2020, we conducted a shallow infiltration test in the upper weathered till in case rain gardens or permeable pavements were to be utilized. The upper weathered glacial till soils have a permeability/infiltration rate of 0.31 inches per hour. This rate includes correction factors for site variability (0.9), influent control (0.9), and testing (0.5). The unfactored rate was 0.77 inches per hour just below the topsoil and vegetation, approximately 18 inches below grade. This rate can be used for permeable pavements and rain gardens only, with a bottom elevation at least 12 inches above groundwater or restrictive layers. The weathered soils are consistent with Loamy Sand if the USDA soil type is utilized.

We generally recommend that permeable pavements be supported on at least 8 inches of 5/8 inch clean angular rock. The pavements should be at least 4.5 inches thick and used in light duty traffic or parking areas only. The underlying subgrade should be verified to be firm by the geotechnical engineer but NOT compacted or recompacted using equipment.

We can provide additional recommendations once civil plans are prepared. We should be provided with final plans for review to determine if the intent of our recommendations has been incorporated or if additional modifications are needed.

Slab-on-Grade

We recommend that the upper 18 inches of the existing fill and/or native soils within slab areas be re-compacted to at least 95 percent of the modified proctor (ASTM D1557 Test Method).

Often, a vapor barrier is considered below concrete slab areas. However, the usage of a vapor barrier could result in curling of the concrete slab at joints. Floor covers sensitive to moisture typically requires the usage of a vapor barrier. A materials or structural engineer should be consulted regarding the detailing of the vapor barrier below concrete slabs. Exterior slabs typically do not utilize vapor barriers.

The American Concrete Institutes ACI 360R-06 Design of Slabs on Grade and ACI 302.1R-04 Guide for Concrete Floor and Slab Construction are recommended references for vapor barrier selection and floor slab detailing.

Slabs on grade may be designed using a coefficient of subgrade reaction of 210 pounds per cubic inch (pci) assuming the slab-on-grade base course is underlain by structural fill placed and compacted as outlined in Section 8.1. A 4- to 6-inch-thick capillary break layer should be placed over the prepared subgrade. This material should consist of pea gravel or 5/8 inch clean angular rock.

A perimeter drainage system is recommended unless interior slab areas are elevated a minimum of 12 inches above adjacent exterior grades. If installed, a perimeter drainage system should consist of a 4-inch diameter perforated drain pipe surrounded by a minimum 6 inches of drain rock wrapped in a non-woven geosynthetic filter fabric to reduce migration of soil particles into the drainage system. The perimeter drainage system should discharge by gravity flow to a suitable stormwater system.

Exterior grades surrounding buildings should be sloped at a minimum of one percent to facilitate surface water flow away from the building and preferably with a relatively impermeable surface cover immediately adjacent to the building.

Erosion and Sediment Control

Erosion and sediment control (ESC) is used to reduce the transportation of eroded sediment to wetlands, streams, lakes, drainage systems, and adjacent properties. Erosion and sediment control measures should be implemented, and these measures should be in general accordance with local regulations. At a minimum, the following basic recommendations should be incorporated into the design of the erosion and sediment control features for the site:

- Schedule the soil, foundation, utility, and other work requiring excavation or the disturbance of the site soils, to take place during the dry season (generally May through September). However, provided precautions are taken using Best Management Practices (BMP's), grading activities can be completed during the wet season (generally October through April).
- All site work should be completed and stabilized as quickly as possible.
- Additional perimeter erosion and sediment control features may be required to reduce the possibility of sediment entering the surface water. This may include additional silt fences, silt fences with a higher Apparent Opening Size (AOS), construction of a berm, or other filtration systems.
- Any runoff generated by dewatering discharge should be treated through construction of a sediment trap if there is sufficient space. If space is limited other filtration methods will need to be incorporated.

Groundwater Influence on Construction

If groundwater is encountered, we anticipate that sump excavations and small diameter pumps systems will adequately de-water short-term excavations, if required. Any system should be designed by the contractor. We can provide additional recommendations upon request.

Utilities

Utility trenches should be excavated according to accepted engineering practices following OSHA (Occupational Safety and Health Administration) standards, by a contractor experienced in such work. The contractor is responsible for the safety of open trenches. Traffic and vibration adjacent to trench walls should be reduced; cyclic wetting and drying of excavation side slopes should be avoided. Depending upon the location and depth of some utility trenches, groundwater flow into open excavations could be experienced, especially during or shortly following periods of precipitation.

In general, silty soils were encountered at shallow depths in the explorations at this site. These soils have low cohesion and density and will have a tendency to cave or slough in excavations. Shoring or sloping back trench sidewalls is required within these soils in excavations greater than 4 feet deep.

All utility trench backfill should consist of imported structural fill or suitable on site soils. Utility trench backfill placed in or adjacent to buildings and exterior slabs should be compacted to at least 95 percent of the maximum dry density based on ASTM Test Method D1557. The upper 5 feet of utility trench backfill placed in pavement areas should be compacted to at least 95 percent of the maximum dry density based on ASTM Test Method D1557. Below 5 feet, utility trench backfill in pavement areas should be compacted to at least 90 percent of the maximum dry density based on ASTM Test Method D1557. Pipe bedding should be in accordance with the pipe manufacturer's recommendations.

The contractor is responsible for removing all water-sensitive soils from the trenches regardless of the backfill location and compaction requirements. Depending on the depth and location of the proposed utilities, we anticipate the need to re-compact existing fill soils below the utility structures and pipes. The contractor should use appropriate equipment and methods to avoid damage to the utilities and/or structures during fill placement and compaction procedures.

Pavements

The near surface subgrade soils generally consist of silty sand with gravel. These soils are rated as good for pavement subgrade material (depending on silt content and moisture conditions). We estimate that the subgrade will have a California Bearing Ratio (CBR) value of 10 and a modulus of subgrade reaction value of k = 200 pci, provided the subgrade is prepared in general accordance with our recommendations.

We recommend that at a minimum, 12 inches of the existing subgrade material be moisture conditioned (as necessary) and re-compacted to prepare for the construction of pavement sections. Deeper levels of recompaction or overexcavation and replacement may be necessary in areas where fill and/or very poor (soft/loose) soils are present.

The subgrade should be compacted to at least 95 percent of the maximum dry density as determined by ASTM Test Method D1557. In place density tests should be performed to verify proper moisture content and adequate compaction.

The recommended flexible and rigid pavement sections are based on design CBR and modulus of subgrade reaction (k) values that are achieved, only following proper subgrade preparation. It should be noted that subgrade soils that have relatively high silt contents will likely be highly sensitive to moisture conditions. The subgrade strength and performance characteristics of a silty subgrade material may be dramatically reduced if this material becomes wet.

Based on our knowledge of the proposed project, we expect the traffic to range from light duty (passenger automobiles) to heavy duty (delivery trucks). The following tables show the recommended pavement sections for light duty and heavy duty use.

ASPHALTIC CONCRETE (FLEXIBLE) PAVEMENT

LIGHT DUTY

Asphaltic Concrete	Aggregate Base*	Compacted Subgrade* **
2.5 in.	6.0 in.	12.0 in.

HEAVY DUTY

Asphaltic Concrete	Aggregate Base*	Compacted Subgrade* **
3.5 in.	6.0 in.	12.0 in.

PORTLAND CEMENT CONCRETE (RIGID) PAVEMENT

Min. PCC Depth	Aggregate Base*	Compacted Subgrade* **
6.0 in.	6.0 in.	12.0 in.

** 95% compaction based on ASTM Test Method D1557*

*** A proof roll may be performed in lieu of in place density tests*

The asphaltic concrete depth in the flexible pavement tables should be a surface course type asphalt, such as Washington Department of Transportation (WSDOT) ½ inch HMA. The rigid pavement design is based on a Portland Cement Concrete (PCC) mix that has a 28 day compressive strength of 4,000 pounds per square inch (psi). The design is also based on a concrete flexural strength or modulus of rupture of 550 psi.

CONSTRUCTION FIELD REVIEWS

Cobalt Geosciences should be retained to provide part time field review during construction in order to verify that the soil conditions encountered are consistent with our design assumptions and that the intent of our recommendations is being met. This will require field and engineering review to:

- Monitor and test structural fill placement and soil compaction
- Observe bearing capacity at foundation locations
- Observe slab-on-grade preparation
- Monitor subgrade preparation of roadways
- Observe excavation stability

Geotechnical design services should also be anticipated during the subsequent final design phase to support the structural design and address specific issues arising during this phase. Field and engineering review services will also be required during the construction phase in order to provide a Final Letter for the project.

CLOSURE

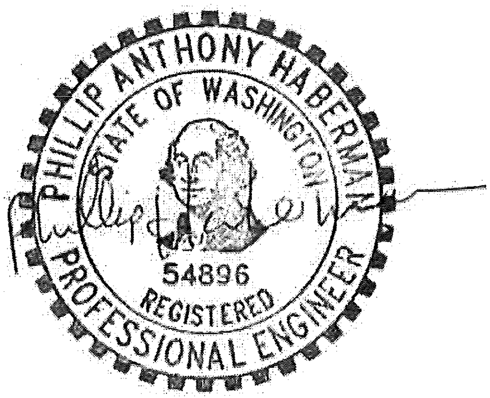
This report was prepared for the exclusive use of Chris Brooks and his appointed consultants. Any use of this report or the material contained herein by third parties, or for other than the intended purpose, should first be approved in writing by Cobalt Geosciences, LLC.

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

Use of this report is subject to the Statement of General Conditions provided in Appendix A. It is the responsibility of Chris Brooks who is identified as "the Client" within the Statement of General Conditions, and its agents to review the conditions and to notify Cobalt Geosciences should any of these not be satisfied.

Sincerely,

Cobalt Geosciences, LLC



6/4/2021
Phil Haberman, PE, LG, LEG
Principal

Statement of General Conditions

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Cobalt Geosciences and the Client. Any use which a third party makes of this report is the responsibility of such third party.

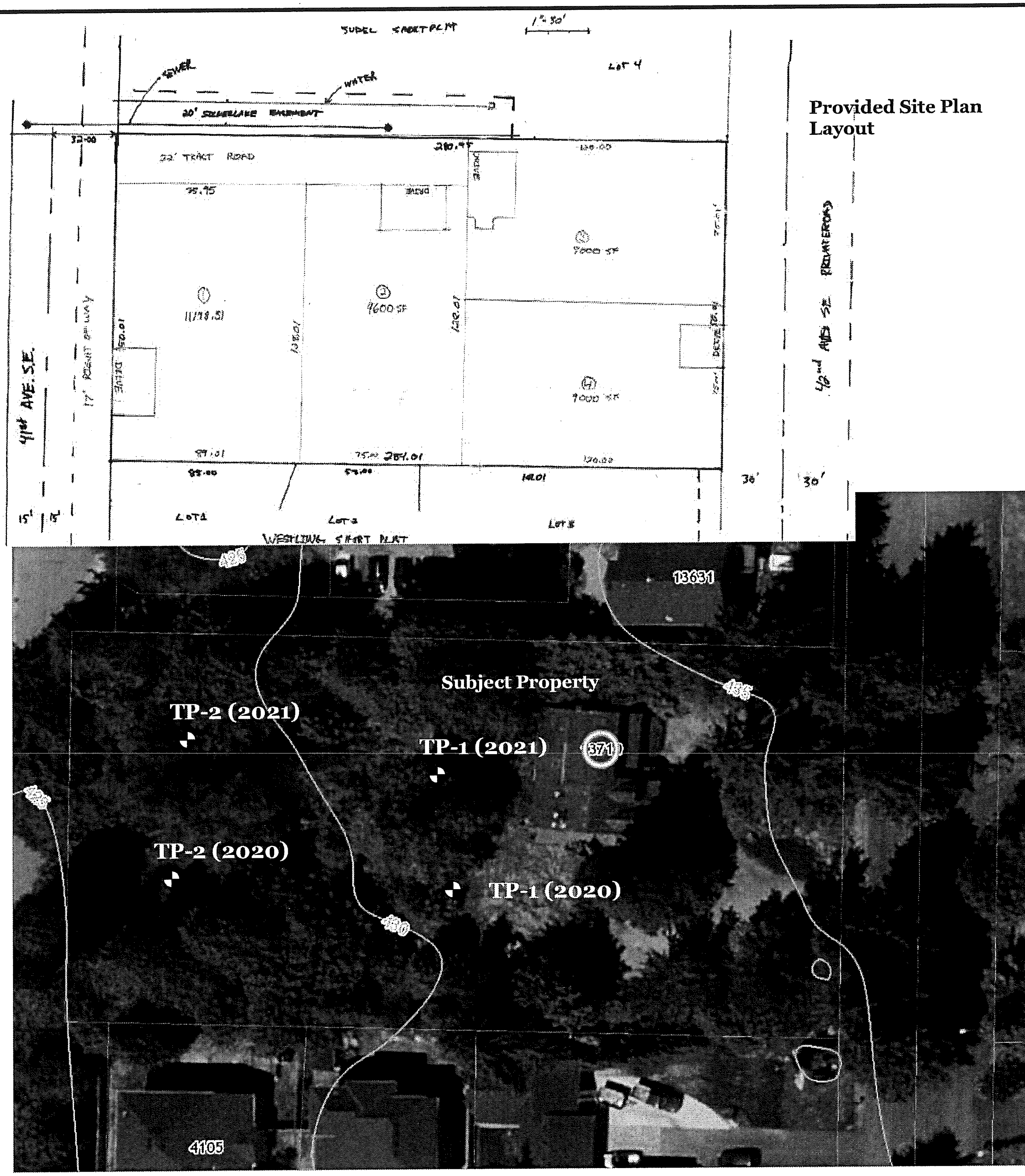
BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Cobalt Geosciences present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Cobalt Geosciences is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state of execution for the specific professional service provided to the Client. No other warranty is made.

INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Cobalt Geosciences at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Cobalt Geosciences must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Cobalt Geosciences will not be responsible to any party for damages incurred as a result of failing to notify Cobalt Geosciences that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Cobalt Geosciences, sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Cobalt Geosciences cannot be responsible for site work carried out without being present.



Aerial Photo from Snohomish County Website/GIS

TP-1 ⌖ Approximate Test Pit Location

N

Not to Scale

COBALT GEOSCIENCES	Proposed Residential Development 13710 42nd Avenue SE Mill Creek, Washington	SITE PLAN FIGURE 1	Cobalt Geosciences, LLC P.O. Box 82243 Kenmore, WA 98028 (206) 331-1097 www.cobaltgeo.com cobaltgeo@gmail.com

Unified Soil Classification System (USCS)

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

Classification of Soil Constituents

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

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

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

Relative Density (Coarse Grained Soils)

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

Consistency (Fine Grained Soils)

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

Grain Size Definitions

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

Moisture Content Definitions

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

COBALT GEOSCIENCES

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Soil Classification Chart

Figure C1

Test Pit TP-1

Date: April 28, 2021	Depth: 5'	Groundwater: None
Contractor: Client provided	Elevation: N/A	Logged By: PH Checked By: SC

Depth (Feet)	Interval	Graphic Log	USCS Symbol	Material Description	Groundwater	Moisture Content (%) (Plastic Limit – Liquid Limit); DCP Equivalent N-Value (0 10 20 30 40 50)
0				Topsoil/Grass		
1–3	■ (2)		SM	Loose to medium dense, silty-fine to medium grained sand with gravel, mottled reddish brown to yellowish brown, moist to wet. (Weathered Glacial Till)		
4–5	■ (4)		SM	Dense to very dense, silty-fine to medium grained sand with gravel, grayish brown, moist. (Glacial Till)		
5–10				End of Test Pit 5'		

Test Pit TP-2

Date: April 28, 2021	Depth: 4'	Groundwater: None
Contractor: Client provided	Elevation: N/A	Logged By: PH Checked By: SC

Depth (Feet)	Interval	Graphic Log	USCS Symbol	Material Description	Groundwater	Moisture Content (%) (Plastic Limit – Liquid Limit); DCP Equivalent N-Value (0 10 20 30 40 50)
0				Topsoil/Grass		
1–2	■ (1)		SM	Loose to medium dense, silty-fine to medium grained sand with gravel, mottled reddish brown to yellowish brown, moist. (Weathered Glacial Till)		
3–4	■ (4)		SM	Dense to very dense, silty-fine to medium grained sand with gravel, grayish brown, moist. (Glacial Till)		
4–10				End of Test Pit 4'		

COBALT GEOSCIENCES

Proposed Short Plat
13710 42nd Avenue SE
Mill Creek, Washington

Test Pit Logs

Cobalt Geosciences, LLC
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Kenmore, WA 98028
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Test Pit TP-1

Date: February 6, 2020	Depth: 5.5'	Groundwater: 2.25'
Contractor: Jim	Elevation: N/A	Logged By: PH Checked By: SC

Depth (Feet)	Interval	Graphic Log	USCS Symbol	Material Description	Groundwater	Moisture Content (%) / DCP Equivalent N-Value (0–50)
0–1				Topsoil/Grass		
1–3	■ (at ~2)		SM	Loose to medium dense, silty-fine to medium grained sand with gravel, mottled reddish brown to yellowish brown, moist to wet. (Weathered Glacial Till)	∇ (at 2.25)	
3–5.5	■ (at ~4)		SM	Dense to very dense, silty-fine to medium grained sand with gravel, grayish brown, moist. (Glacial Till)		
5.5–10				End of Test Pit 5.5'		

Test Pit TP-2

Date: February 6, 2020	Depth: 7'	Groundwater: 2.5'
Contractor: Jim	Elevation: N/A	Logged By: PH Checked By: SC

Depth (Feet)	Interval	Graphic Log	USCS Symbol	Material Description	Groundwater	Moisture Content (%) / DCP Equivalent N-Value (0–50)
0–0.5				Topsoil/Grass		
0.5–3.5	■ (at ~1.5)		SM	Loose to medium dense, silty-fine to medium grained sand with gravel mottled reddish brown to yellowish brown, moist to wet. (Weathered Glacial Till)	∇ (at 2.5)	
3.5–7	■ (at ~4)		SM	Dense to very dense, silty-fine to medium grained sand with gravel, grayish brown, moist. (Glacial Till)		
7–10				End of Test Pit 7'		