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This memo was used to discuss the drainage approach. Final numbers would be found in the Stormwater report.

6/14/2019

Cindy Wellborn
City of Redmond
15670 NE 85th Street
Redmond, WA 98052

Re: Woodside Drainage Memo
CORE Project No. 18122

Dear Cindy Wellborn:

The purpose of this letter is to provide you with a narrative and supporting documents and information, including calculations, corresponding to the drainage discharge approach for the Woodside project. The following is a discussion addressing how the proposed design meets the requirements set forth by the City of Redmond and protects downstream properties using sound engineering methods and judgment.

Description of Discharge Strategy

This memo will provide data and information that supports this project's proposal to discharge stormwater runoff to the south towards the Woodbridge development. This is in addition to meeting the on-site flow control standard, which has been shown in the Storm Drainage Report for the project. The basis of the proposal to discharge stormwater runoff to the south is that the amount of stormwater in volume and peak flow rates will be less than the volume and peak flow rates that have been accounted for when designing the flow control facility for Woodbridge. The project proposes infiltration vaults that will infiltrate a large majority of the stormwater runoff, as calculated using multiple modeling programs. Data from the Woodbridge design was extracted from the Lakeside drainage report dated September 11, 2000 and is included herein.

The Woodside project proposes to construct two separate partial infiltration vaults for public and private areas onsite. The combined stormwater discharge that cannot be infiltrated within the vaults will be conveyed to the south and will not exceed the volume or flow rates that have been accounted for as part of the Woodbridge project.

The tables below show a summary of the data collected and documented within this memo. The data clearly shows using a single event model and a continuous runoff model, that the combined discharge from the proposed Woodside infiltration vaults will not exceed the flow rates or volume that was originally expected to come from the Woodside project site.

WWHM Model

	2-yr peak flow (cfs)	10-yr peak flow (cfs)	25-yr peak flow (cfs)	100-yr peak flow (cfs)	Volume (ac-ft)
0.89 acre Impervious Basin	0.395149	0.5744417	0.669012	0.816138	142.113
Discharge from Proposed Vaults	0.232587	0.458589	0.558082	0.692961	64.173

SBUH Model

	2-yr peak flow (cfs)	10-yr peak flow (cfs)	25-yr peak flow (cfs)	100-yr peak flow (cfs)	Volume (ac-ft) (25-yr storm event)
0.89 acre Impervious Basin	0.378	0.5963	0.6892	0.8059	0.2239
Discharge from Proposed Vaults	0.0151	0.0602	0.1241	0.1710	0.2296

Peak Flow Rates

The combined peak flow rates being discharged from the 2 infiltration vaults will not exceed the peak flow rates that were expected to come from the Woodside site. Stormwater runoff was originally expected to flow towards the Woodbridge project from the Woodside project site. Woodbridge was constructed as part of the Lakeside project. Design information was obtained for the Lakeside project which shows that a subbasin from the Woodside project site is included in the flow control calculations. Documents from the Lakeside drainage report are attached at the end of this memo. Referring to the exhibit titled Developed Drainage Basin Exhibit for Lakeside (Exhibit “B”), it is shown that 2.12 acres of off-site upstream area (Sub-basin SC5) is included in the developed condition hydrologic summary. This basin includes 1.23 acres of pervious area and 0.89 acres of impervious area. It is shown on the exhibit that the 0.89 acres of impervious area is assumed to come from the future extension of 192nd Avenue NE to the north. Furthermore, sub-basin SC5 is found in the calculations which show the developed flows from this basin were included in the flow control model.

Only area from the future extension of 192nd Avenue NE is part of the Woodside project. Therefore the flows are recreated to exclude the pervious area of the sub-basin that is not a part of the Woodside project site. Attached below is a screenshot from the Stormshed modeling program, which utilizes the SBUH method for determining flow rates. SBUH was the accepted methodology at the time the Lakeside project was designed.

Appended on: 09:12:18 Thursday, April 18, 2019

SC5 DEVELOPED BASIN Event Summary

Event	Peak Q (cfs)	Peak T (hrs)	Hyd Vol (acft)	Area (ac)	Method	Raintype
2 year	0.3780	8.00	0.1206	0.8900	SBUH	TYPE1A
other	0.4340	8.00	0.1390	0.8900	SBUH	TYPE1A
5 year	0.4875	8.00	0.1567	0.8900	SBUH	TYPE1A
10 year	0.5963	8.00	0.1928	0.8900	SBUH	TYPE1A
25 year	0.6892	8.00	0.2239	0.8900	SBUH	TYPE1A
100 year	0.8059	8.00	0.2630	0.8900	SBUH	TYPE1A

Record Id: SC5 DEVELOPED BASIN

Design Method	SBUH	**Rainfall type**	TYPE1A
Hyd Intv	15.00 min	**Peaking Factor**	484.00
		Abstraction Coeff	0.20
Pervious Area (AMC 2)	0.00 ac	**DCIA**	0.89 ac
Pervious CN	0.00	**DC CN**	98.00
Pervious TC	0.00 min	**DC TC**	5.00 min

Directly Connected CN Calc		
Description	**SubArea**	**Sub cn**
Impervious surfaces (pavements, roofs, etc)	0.89 ac	98.00
DC Composited CN (AMC 2)		98.00

Directly Connected TC Calc						
Type	**Description**	**Length**	**Slope**	**Coeff**	**Misc**	**TT**
Sheet	Smooth Surfaces.: 0.011	418.00 ft	2.00%	0.0110	1.85 in	5.00 min
Directly Connected TC						5.00min

The peak flow rates from 0.89 acres of impervious area are shown above. These areas are then compared to the combined discharge from the Woodside infiltration vaults. The flows were again calculated using Stormshed for a fair comparison.

Private Vault

HydID	Peak Q (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Cont Area (ac)
2 year out	0.1378	8.00	0.6651	9.4900
5 year out	0.1378	7.25	0.9805	9.4900
10 year out	0.1648	25.00	1.3138	9.4900
25 year out	0.2223	24.75	1.6092	9.4900
100 year out	0.2619	24.75	1.9910	9.4900
2 year-Infiltration-OutHyd	0.1378	8.00	0.6651	0.0000
5 year-Infiltration-OutHyd	0.1378	7.25	0.9805	0.0000
10 year-Infiltration-OutHyd	0.1378	6.50	1.3076	0.0000
25 year-Infiltration-OutHyd	0.1378	6.00	1.4887	0.0000
100 year-Infiltration-OutHyd	0.1378	5.50	1.6794	0.0000
2 year-Orifice-OutHyd	0.0000	0.00	0.0000	0.0000
5 year-Orifice-OutHyd	0.0000	0.00	0.0000	0.0000
10 year-Orifice-OutHyd	0.0270	25.00	0.0061	0.0000
25 year-Orifice-OutHyd	0.0846	24.75	0.1205	0.0000
100 year-Orifice-OutHyd	0.1242	24.75	0.3116	0.0000

Public Vault

HydID	Peak Q (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Cont Area (ac)
2 year out	0.0308	24.00	0.1138	1.5400
5 year out	0.0407	24.25	0.1561	1.5400
10 year out	0.0490	24.25	0.2015	1.5400
25 year out	0.0553	24.25	0.2424	1.5400
100 year out	0.0626	24.25	0.2961	1.5400
2 year-Infiltration-OutHyd	0.0157	4.00	0.0983	0.0000
5 year-Infiltration-OutHyd	0.0157	3.25	0.1111	0.0000
10 year-Infiltration-OutHyd	0.0157	2.75	0.1233	0.0000
25 year-Infiltration-OutHyd	0.0157	2.50	0.1333	0.0000
100 year-Infiltration-OutHyd	0.0157	2.25	0.1453	0.0000
2 year-Orifice-OutHyd	0.0151	24.00	0.0155	0.0000
5 year-Orifice-OutHyd	0.0250	24.25	0.0450	0.0000
10 year-Orifice-OutHyd	0.0332	24.25	0.0782	0.0000
25 year-Orifice-OutHyd	0.0395	24.25	0.1091	0.0000
100 year-Orifice-OutHyd	0.0468	24.25	0.1508	0.0000

As shown from the modeling file above, the combined peak flows (Peak Q) discharged from the vault are less than the peak flows from 0.89 acres of impervious area that is accounted for in the Woodbridge flow control calculations.

The above calculations were completed using the SBUH method, which is a single event model. In addition to the SBUH method, both of the conditions above were also modeled using the Western Washington Hydrology Model (WWHM) software which utilizes continuous runoff files. WWHM is currently an approved model by the 2012 Stormwater Management Manual for Western Washington as amended in 2014 and the City of Redmond Stormwater Technical Notebook.

The peak flow rates generated from 0.89 acres of impervious area and modeled using WWHM are included below.

Predeveloped Landuse Totals for POC #1
Total Pervious Area: 0
Total Impervious Area: 0.89

Flow Frequency Return Periods for Predeveloped. POC #1

Return Period	**Flow(cfs)**
2 year	0.395149
5 year	0.501719
10 year	0.574417
25 year	0.669012
50 year	0.741613
100 year	0.816138

These peak flows can then be compared to the combined peak flows from the two partial infiltration vaults. The flows discharged from each vault calculated using WWHM are included below.

Private Vault

Flow Frequency Return Periods for Mitigated. POC #2

Return Period	**Flow(cfs)**
2 year	0.201904
5 year	0.323394
10 year	0.393165
25 year	0.467651
50 year	0.513998
100 year	0.553557

Public Vault

Flow Frequency Return Periods for Mitigated. POC #1
Return Period Flow(cfs)
2 year 0.030683
5 year 0.049421
10 year 0.065424
25 year 0.090431
50 year 0.113011
100 year 0.139404

These flows are combined to show that the total amount of flow leaving the vaults is less than the flows calculated for the 0.89 acres of impervious area expected to be tributary to the Woodbridge detention system. The combined flow rates are shown below.

Combined Flows - Both Vaults

Flow Frequency Return Periods for Mitigated. POC #1
Return Period Flow(cfs)
2 year 0.232587
5 year 0.372815
10 year 0.458589
25 year 0.558082
50 year 0.627009
100 year 0.692961

Through both modeling methods, it can be clearly shown that the flow rates out of the proposed infiltration vaults will be less than the flow rates that were originally assumed to come from the Woodside project site.

Flow Volumes

In addition to the peak flow rates, the proposed discharge will not exceed the expected flow volumes from the Woodside property. The volumes from the basin including 0.89 acres of impervious area was calculated in the WWHM file below using the continuous runoff method.

Predeveloped Basin Volume
Total Volume Infiltrated (ac-ft): 142.113
Total Volume Through Riser (ac-ft): 0
Total Volume Through Facility (ac-ft): 142.113
Percent Infiltrated: 100

This volume is then compared to the combined volumes from the two infiltration vaults proposed for the Woodside project. Note that the volumes discharged through the risers of the vaults is much less than the volumes produced from a basin of 0.89 acres of impervious area.

Vault 1 (Private)
Width: 82 ft.
Length: 140 ft.
Depth: 11.5 ft.
Infiltration On
Infiltration rate: 1.8
Infiltration safety factor: 0.288
Total Volume Infiltrated (ac-ft): 1202.291
Total Volume Through Riser (ac-ft): 40.721
Total Volume Through Facility (ac-ft): 1243.012
Percent Infiltrated: 96.72

Vault 2 (Public)
Width: 82 ft.
Length: 16 ft.
Depth: 11 ft.
Infiltration On
Infiltration rate: 1.8
Infiltration safety factor: 0.288
Total Volume Infiltrated (ac-ft): 158.596
Total Volume Through Riser (ac-ft): 23.452
Total Volume Through Facility (ac-ft): 182.04
Percent Infiltrated: 87.12

The flow volumes have also been calculated using the SBUH method. The clip below is taken from the modeling file for the 0.89 acre basin that is included above.

Hyd Vol (acft)
0.1206
0.1390
0.1567
0.1928
0.2239
0.2630

The volumes discharged from each of the two infiltration vaults are shown below. The volumes are separated to show the amount lost to infiltration, as well as the amount that flows through the orifice in the riser structure of the vault. Note that these volumes are less than the volumes produced from 0.89 acres of impervious area that was included in the Lakeside flow control calculations.

Private Vault

HydID	Peak Q (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Cont Area (ac)
2 year out	0.1378	8.00	0.6651	9.4900
5 year out	0.1378	7.25	0.9805	9.4900
10 year out	0.1648	25.00	1.3138	9.4900
25 year out	0.2223	24.75	1.6092	9.4900
100 year out	0.2619	24.75	1.9910	9.4900
2 year-Infiltration-OutHyd	0.1378	8.00	0.6651	0.0000
5 year-Infiltration-OutHyd	0.1378	7.25	0.9805	0.0000
10 year-Infiltration-OutHyd	0.1378	6.50	1.3076	0.0000
25 year-Infiltration-OutHyd	0.1378	6.00	1.4887	0.0000
100 year-Infiltration-OutHyd	0.1378	5.50	1.6794	0.0000
2 year-Orifice-OutHyd	0.0000	0.00	0.0000	0.0000
5 year-Orifice-OutHyd	0.0000	0.00	0.0000	0.0000
10 year-Orifice-OutHyd	0.0270	25.00	0.0061	0.0000
25 year-Orifice-OutHyd	0.0846	24.75	0.1205	0.0000
100 year-Orifice-OutHyd	0.1242	24.75	0.3116	0.0000

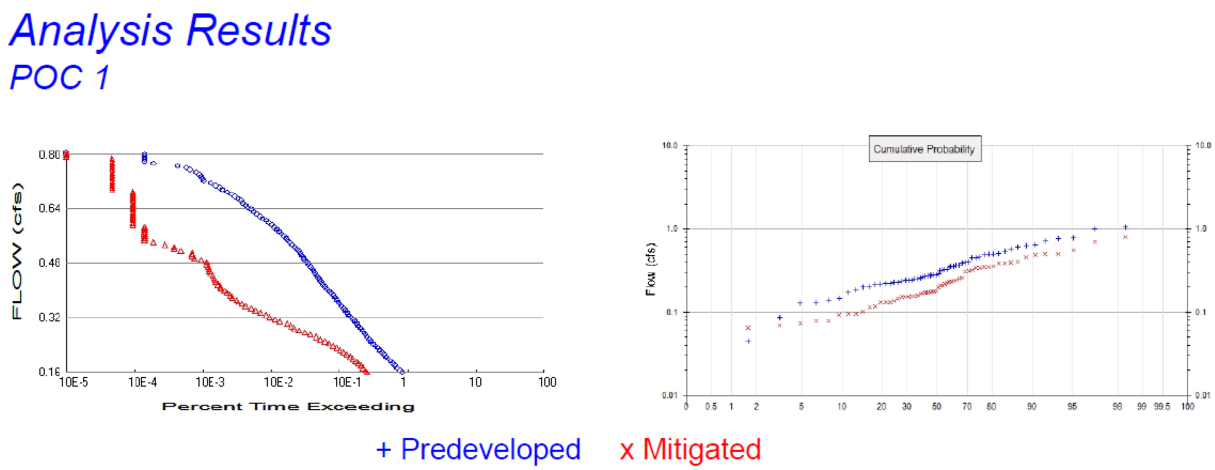
Public Vault

HydID	Peak Q (cfs)	Peak T (hrs)	Peak Vol (ac-ft)	Cont Area (ac)
2 year out	0.0308	24.00	0.1138	1.5400
5 year out	0.0407	24.25	0.1561	1.5400
10 year out	0.0490	24.25	0.2015	1.5400
25 year out	0.0553	24.25	0.2424	1.5400
100 year out	0.0626	24.25	0.2961	1.5400
2 year-Infiltration-OutHyd	0.0157	4.00	0.0983	0.0000
5 year-Infiltration-OutHyd	0.0157	3.25	0.1111	0.0000
10 year-Infiltration-OutHyd	0.0157	2.75	0.1233	0.0000
25 year-Infiltration-OutHyd	0.0157	2.50	0.1333	0.0000
100 year-Infiltration-OutHyd	0.0157	2.25	0.1453	0.0000
2 year-Orifice-OutHyd	0.0151	24.00	0.0155	0.0000
5 year-Orifice-OutHyd	0.0250	24.25	0.0450	0.0000
10 year-Orifice-OutHyd	0.0332	24.25	0.0782	0.0000
25 year-Orifice-OutHyd	0.0395	24.25	0.1091	0.0000
100 year-Orifice-OutHyd	0.0468	24.25	0.1508	0.0000

In summary, the existing development (Woodbridge) south of the Woodside project was designed to include 0.89 acres of impervious area from the Woodside project site. In this memo it has been shown that the stormwater discharge from the Woodside project will not exceed the flow rates or volumes that were originally expected to come from the site. This has been shown using a single event methodology (SBUH, the approved methodology at the time of design of the Woodbridge project), as well as a continuous runoff method (WWHM, current approved methodology by the 2014 Stormwater Management Manual for Western Washington).

Stream protection duration curves and flow frequency analysis for each vault is provided below, showing compliance with the on-site flow control requirement. This information is also provided in the Storm Drainage Report, Section 4.

Private Partial Infiltration Vault Analysis

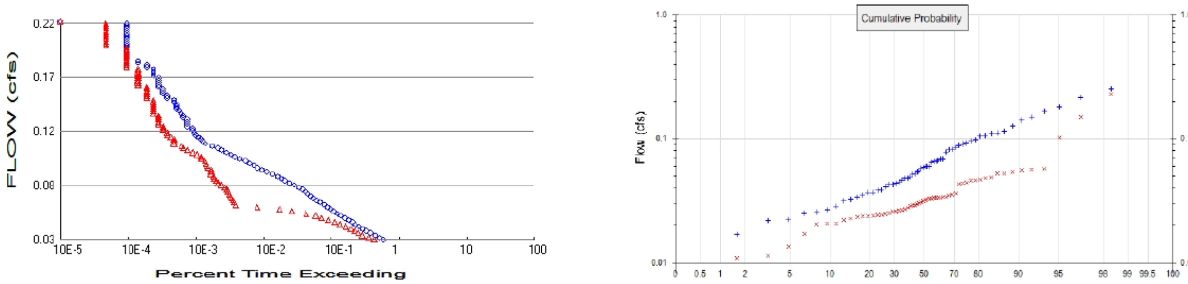


Flow Frequency Return Periods for Predeveloped. POC #1
Return Period Flow(cfs)
2 year 0.328702
5 year 0.516238
10 year 0.622519
25 year 0.735114
50 year 0.804788
100 year 0.864049

Flow Frequency Return Periods for Mitigated. POC #1
Return Period Flow(cfs)
2 year 0.199736
5 year 0.337239
10 year 0.446049
25 year 0.60369
50 year 0.735832
100 year 0.880685

Public Partial Infiltration Vault Analysis

Analysis Results
POC 1



+ Predeveloped x Mitigated

Flow Frequency Return Periods for Predeveloped. POC #1
Return Period Flow(cfs)
2 year 0.058823
5 year 0.100098
10 year 0.132163
25 year 0.177748
50 year 0.21525
100 year 0.255696

Flow Frequency Return Periods for Mitigated. POC #1
Return Period Flow(cfs)
2 year 0.030683
5 year 0.049421
10 year 0.065424
25 year 0.090431
50 year 0.113011
100 year 0.139404

The SC5 Developed Basin was also modeled in WWHM to compare the peak flow rates to the values provided in the Lakeside calculation package.

The peak flows shown in the Lakeside calculation package, calculated using SBUH, are shown below.

SC5	---	---	2.12 off-site	0.43 (2-yr) 0.78 (10-yr) 1.20 (100-yr)	Off-site upstream

The SC5 Developed basin was then recreated in WWHM. The input file and peak flow rates are shown below.

Mitigated Landuse Totals for POC #1
Total Pervious Area: 1.23
Total Impervious Area: 0.89

Flow Frequency Return Periods for Mitigated. POC #1
Return Period Flow(cfs)
2 year 0.423445
5 year 0.57508
10 year 0.684007
25 year 0.831631
50 year 0.949045
100 year 1.07299

Sincerely,

CORE DESIGN, INC.

Gary Sharnbroich, P.E.
Principal