USNR Stormwater Report

1981 Schurman Way
Woodland, WA 98674

Abbreviated Stormwater Report
May 24, 2021

Cushing Civil Engineers

cushing
Civil Engineers

909 N Beech Street, Ste D
Portland, OR 97227
Ph. 503-387-5331

"preserve and protect the general welfare of the public".

DONALD JOHN CUSHING
STATE OF WASHINGTON
31527
REGISTERED
PROFESSIONAL ENGINEER

RENEWAL DATE 10/31/21

Prepared by Winston Greene, PE
Rev. by Don Cushing, PE

Contents

Attachments:

Basin Map
Stormwater Calculations
Site Survey
Web Soil Survey Report

May, 2021

Project Description

The USNR site is located at 1981 Schurman Way, Woodland, WA 98674 on a 7.49-acre parcel zoned as light industrial (L-1). Design+Build is proposing an improvement to add a connecting parking lot between the existing lots on the south side of the building (approximately 3,778 sq. ft., with eleven additional spaces) and add a concrete patio area on the north side of the building (approximately 2,326 sq. ft.). The proposed development will add approximately 6,104 sq. ft. (0.14 ac) of new impervious surface to the site. Proposed grades will remain similar to existing to minimize cut and fill and retain existing drainage patterns.

Existing Site Conditions

On the north side of the USNR building, existing drainage flows north to a grassy field, which then slopes generally to the west. On the south and the west sides of the building, runoff flows south to a grassy ditch along the southern edge of the property, the ditch is roughly 1.2 ft. deep, 8 ft. wide, and 770 ft. long and flows to the west where it leaves the property at a ditch along Robinson Rd. There is an existing drywell on the east side of the property as well where the original parking lot stormwater appears to be routed (see survey).

A redevelopment to the site was made in 2014 by USNR and Mackenzie group (refer to previous stormwater evaluation dated 5/29/14) which added a new parking lot on the west side of the building and a new 8400 cu. ft. detention swale at the southwest corner of the property. The invert elevations of the inlet pipe (SDP 18 from survey) for the detention swale are at 13.2', the inlet pipe is currently located above the bottom of the drainage ditch and is not sloped, this condition will not allow water to flow into the detention swale. Therefore, we recommend making modifications to the drainage ditch to route stormwater water through the detention swale. See engineering plans and the proposed stormwater management section for more detail on proposed modifications.

Soils

See attached soil information obtained from the Web Soil Survey for on-site soil characteristics and properties. The soil is classified as moderately well drained with a moderately high transmit capacity of the dominant class C soil type: Maytown silt loam, 0 to 3 percent slopes (0.20 to 0.57 in/hr.). See attached NRCS soil report in Appendix for additional soil information.

Proposed Stormwater Management

Proposed stormwater management for the concrete patio area is to grade stormwater away from the building and use the large surrounding field for infiltration. The size and slope of the field will allow the stormwater runoff to naturally infiltrate into the ground.

Stormwater runoff for the new parking area will flow to the existing southern drainage ditch where it will flow toward the west end of the property through a low slope grass lined ditch. The ditch should be modified to prevent water from freely flowing to the public ditch without passing though the detention swale. We are proposing to add an armored soil dam in the ditch to route water through the detention swale, slowing the water down and promoting infiltration in the process. We also propose to replace the swale outflow pipe with a larger diameter 10" HDPE culvert pipe with 2% slope to prevent clogging.

Analysis

Stormwater was analyzed per the 1992 Stormwater Management Manual for the Puget Sound Basin. Rainfall data was obtained from USGS data from Longview (20 mile north) and Vancouver (20 miles south). Rainfall for 6-month, 2-year, 10-year, 25-year, and 100-year storms were also found. For the 6-month, 24-hour storm precipitation rainfall is (1.41+1.35)/2 = 1.38 inches. See appendix for rainfall data. CN numbers used are 85 for meadow/pasture and 98 for impervious surface (Table III-1.3 1992 SWMM). The CN numbers of the lot were averaged based on area per the 1992 SWMM.

A spreadsheet is attached which tabulates the existing, present, and proposed stormwater conditions and calculates stormwater outflow, volume, and flow rate. The calculations shows that with a detention volume of 8400 cu. ft. the development will maintain a peak flow rate at or below the pre-development condition per department of ecology standards (see stormwater tabulation sheet of appendix).

Conclusion

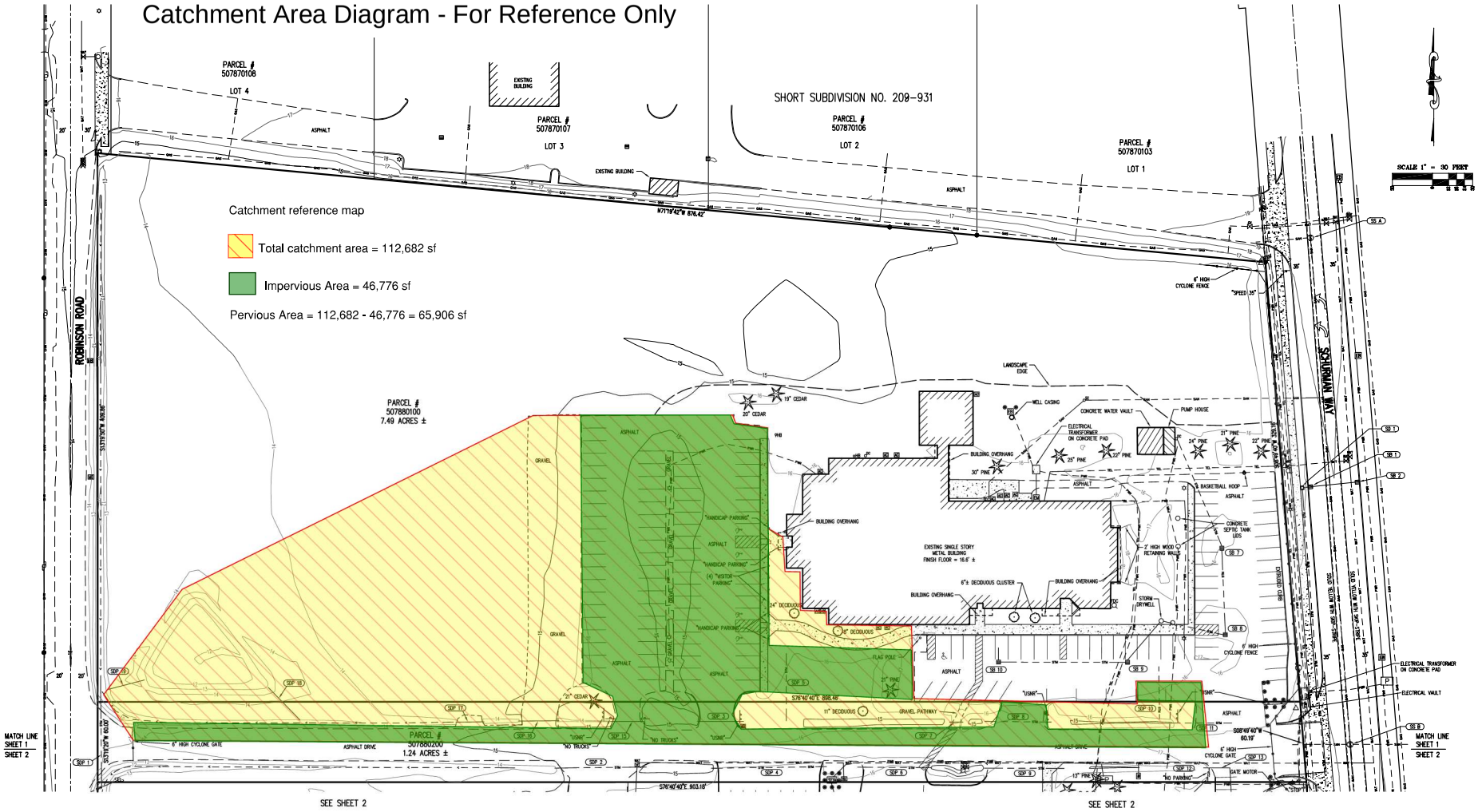
The additional areas proposed by USNR have been analyzed per the 1992 Puget Sound Stormwater Management Manual which shows the flow rate of stormwater discharged from the property is at or below pre-development rates with the detention pond. Cushing Civil Engineers would recommend the client review the existing detention swale and make modifications for it to receive water flowing from drainage ditch along the south side of the property, see plan for proposed design.

Sincerely,

Winston Greene, P.E.

Appendix

Catchment Area Diagram - For Reference Only



LEGEND

DECIDUOUS TREE	GAS METER	RIGHT-OF-WAY LINE	
CONIFEROUS TREE	GAS VALVE	BOUNDARY LINE	
FIRE HYDRANT	UTILITY POLE	PROPERTY LINE	
FIRE DEPARTMENT CONNECTION	POWER VAULT	CENTERLINE	
WATER HOSE BIB	ELECTRICAL METER	DITCH	
WATER METER	POWER JUNCTION BOX	CURB	
WATER VALVE	POWER RISER	EDGE OF PAVEMENT	
WATER VAULT	POWER TRANSFORMER	EASEMENT	
WATER MANHOLE	HVAC UNIT	FENCE LINE	
SANITARY SEWER CLEAN OUT	STREET LIGHT	GRAVEL EDGE	
SANITARY SEWER MANHOLE	TELEPHONE/TELEVISION VAULT	POWER LINE	
STORM SEWER CLEAN OUT	TELEPHONE MANHOLE	OVERHEAD WIRE	
STORM SEWER CATCH BASIN	TELEPHONE/TELEVISION JUNCTION BOX	TELEPHONE LINE	
STORM SEWER MANHOLE	TELEPHONE/TELEVISION RISER	GAS LINE	
MAILBOX	SIGN	STORM SEWER LINE	
	BOLLARD	SANITARY SEWER LINE	
	FOUND PROPERTY CORNER MONUMENT	WATER LINE	

STORM AND SANITARY SEWER INFORMATION

SS A SANITARY MANHOLE
RIM = 19.45'
12" E IN (S) = 6.0'
8" E IN (E) = 11.1'
12" E OUT (N) = 5.9'

SS B SANITARY MANHOLE
RIM = 18.35'
12" E IN (S) = 6.7'
8" E IN (E) = 10.7'
8" E IN (W) = 7.2'
12" E OUT (N) = 6.7'

SS C SANITARY MANHOLE
RIM = 17.85'
12" E IN (S) = 7.5'
8" E IN (E) = 10.7'
8" E IN (E) = 7.9'
12" E OUT (N) = 7.4'

SS D SANITARY MANHOLE
RIM = 17.39'
12" E IN (S) = 7.6'
8" E IN (E) = 8.0'
12" E OUT (N) = 7.6'

SD 1 STORM STRUCTURE
RIM = 19.04'
12" E IN (E) = 16.1'
12" E OUT (S) = 16.2'
SUMP = 15.1'

SB 1 STORM CATCH BASIN
RIM = 18.39'
12" E IN (E) = 16.2'
12" E OUT (W) = 16.2'
SUMP = 14.5'

SB 2 STORM CATCH BASIN
RIM = 18.51'
12" E OUT (W) = 16.2'
SUMP = 14.6'

SD 2 STORM STRUCTURE
RIM = 18.36'
12" E IN (N) = 15.5'
12" E IN (E) = 15.5'
12" E OUT (S) = 15.4'
SUMP = 14.5'

SB 3 STORM CATCH BASIN
RIM = 17.81'
12" E IN (E) = 15.3'
12" E OUT (W) = 15.4'
SUMP = 13.7'

SB 4 STORM CATCH BASIN
RIM = 17.79'
12" E OUT (W) = 15.3'
SUMP = 13.8'

SD 3 STORM STRUCTURE
RIM = 17.51'
12" E IN (N) = 14.8'
12" E IN (E) = 14.7'
15" E OUT (S) = 14.7'
SUMP = 13.6'

SB 5 STORM CATCH BASIN
RIM = 16.94'
12" E IN (E) = 14.8'
12" E OUT (W) = 14.7'
SUMP = 13.2'

SB 6 STORM CATCH BASIN
RIM = 16.90'
12" E OUT (W) = 14.8'
SUMP = 13.0'

SB 7 STORM CATCH BASIN
RIM = 15.70'
4" E IN (NW) = 13.9'
6" E OUT (S) = 13.9'
SUMP = 12.5'

SB 8 STORM CATCH BASIN
RIM = 15.70'
6" E IN (N) = 13.5'
6" E OUT (W) = 13.5'
SUMP = 12.4'

SB 9 STORM CATCH BASIN
RIM = 15.15'
6" E IN (W) = 13.0'
6" E OUT (NE) = 13.0'
SUMP = 12.1'

SB 10 STORM CATCH BASIN
RIM = 15.14'
6" E IN (N) = 13.5'
6" E OUT (E) = 13.4'
SUMP = 12.4'

SB 11 STORM CATCH BASIN
RIM = 16.63'
6" E OUT (W) = 15.5'
SUMP = 14.9'

SB 12 STORM CATCH BASIN
RIM = 16.50'
6" E OUT (S) = 15.3'
SUMP = 14.7'

SB 13 STORM CATCH BASIN
RIM = 14.86'
WATER LEVEL = 13.1'
PUMP INSIDE

SD 1 STORM DRAIN PIPE
12" CONCRETE
E IN (N) = 11.5'
E OUT (S) = 10.9'

SD 2 STORM DRAIN PIPE
12" HDPE
E IN (E) = 14.1'
E OUT (W) = 13.7'

SD 3 STORM DRAIN PIPE
12" CMP
E IN (E) = 14.3'
E OUT (W) = 14.2'

SD 4 STORM DRAIN PIPE
12" HDPE
E IN (E) = 14.6'
E OUT (W) = 14.7'

SD 5 STORM DRAIN PIPE
4" PVC
E OUT (S) = 14.5'
UNKNOWN INLET LOCATION

SD 6 STORM DRAIN PIPE
12" CONCRETE
E IN (E) = 14.3'
E OUT (W) = 14.2'

SD 7 STORM DRAIN PIPE
12" HDPE
E IN (E) = 14.4'
E OUT (W) = 14.2'

SD 8 STORM DRAIN PIPE
12" CONCRETE
E IN (E) = 14.6'
E OUT (W) = 14.2'

SD 9 STORM DRAIN PIPE
12" CONCRETE
E IN (E) = 14.5'
E OUT (W) = 14.1'

SD 10 STORM DRAIN PIPE
4" PVC
E OUT (S) = 15.2'
UNKNOWN INLET LOCATION

SD 11 STORM DRAIN PIPE
12" CONCRETE
E OUT (W) = 15.0'
UNKNOWN INLET LOCATION

SD 12 STORM DRAIN PIPE
4" PVC
E OUT (N) = 15.7'
UNKNOWN INLET LOCATION

SD 13 STORM DRAIN PIPE
12" CONCRETE
E OUT (W) = 15.4'

SD 14 STORM DRAIN PIPE
6" PVC
E OUT (S) = 13.6'
UNKNOWN INLET LOCATION

SD 15 STORM DRAIN PIPE
12" CONCRETE
E IN (E) = 14.2'
E OUT (W) = 14.0'

SD 16 STORM DRAIN PIPE
12" PLASTIC
E IN (E) = 13.9'
E OUT (W) = 13.7'

SD 17 STORM DRAIN PIPE
12" PLASTIC
E IN (E) = 13.6'
E OUT (W) = 13.5'

SD 18 STORM DRAIN PIPE
6" PLASTIC
E IN (NW) = 13.2'
E OUT (SE) = 13.2'

SD 19 STORM DRAIN PIPE
6" PLASTIC
E IN (NE) = 13.3'
E OUT (SW) = 13.1'

NOTES

1) THE FIELD SURVEY FOR THIS MAP WAS COMPLETED ON JULY 8, 2013. ON MAY 10, 2021 FIELD WORK WAS PERFORMED TO DEFINE THE EXPANDED PARKING LOT AND NEW DRAINAGE SWALE ON THE NORTH PARCEL. THE REMAINDER OF THE SITE WAS NOT CHECKED AND ADDITIONAL SITE MODIFICATIONS THAT HAVE OCCURRED SINCE 2013 ARE NOT REFLECTED HEREON.

2) ELEVATIONS AND CONTOURS ARE BASED ON WASHDOT MONUMENT ID #4082. THE BENCHMARK IS A STAINLESS STEEL ROD WITHOUT A SLEEVE AT THE NORTH END OF THE NORTHBOUND ON-RAMP OF EXIT 22 OFF INTERSTATE-5, AND HAS AN ELEVATION OF 39.947 FEET ON THE NAVD 88 DATUM.

3) ALL CURB ON THE SOUTH PROPERTY IS EXTRUDED. THERE IS EXTRUDED CURB ON THE NORTH PROPERTY WHERE NOTED.

4) THE UNDERGROUND UTILITIES ARE BASED ON THE MARKINGS PER LOCATE TICKET NUMBER 13166011 AND A PRIVATE UTILITY LOCATING COMPANY.

UTILITY STATEMENT

THE UNDERGROUND UTILITIES SHOWN HAVE BEEN LOCATED FROM FIELD SURVEY INFORMATION AND EXISTING DRAWINGS. THE SURVEYOR MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. THE SURVEYOR FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED ALTHOUGH HE DOES CERTIFY THAT THEY ARE LOCATED AS ACCURATELY AS POSSIBLE FROM INFORMATION AVAILABLE. THE SURVEYOR HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES.

NORTHWEST SURVEYING, Inc.
PO BOX 7177 BEAVERTON, OR 97007
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LOCATED IN THE SE 1/4 OF SECTION 11, SW 1/4 OF SECTION 12, NW 1/4 OF SECTION 13 AND NE 1/4 OF SECTION 14, TOWNSHIP 5 NORTH, RANGE 1 WEST, W.M., CITY OF WOODLAND, COWLITZ COUNTY, WASHINGTON

TOPOGRAPHIC SURVEY

WOODLAND, WASHINGTON

DRAWING NO.:	968 TOPO2
SCALE:	AS NOTED
DRAWING GENERATED BY:	LDS/BS
DRAWN BY:	CW
CHECKED BY:	SST

PREPARED FOR:
LDSW
1981 SCHURMAN WAY
WOODLAND, WA 98674
PHONE: (503) 226-1972

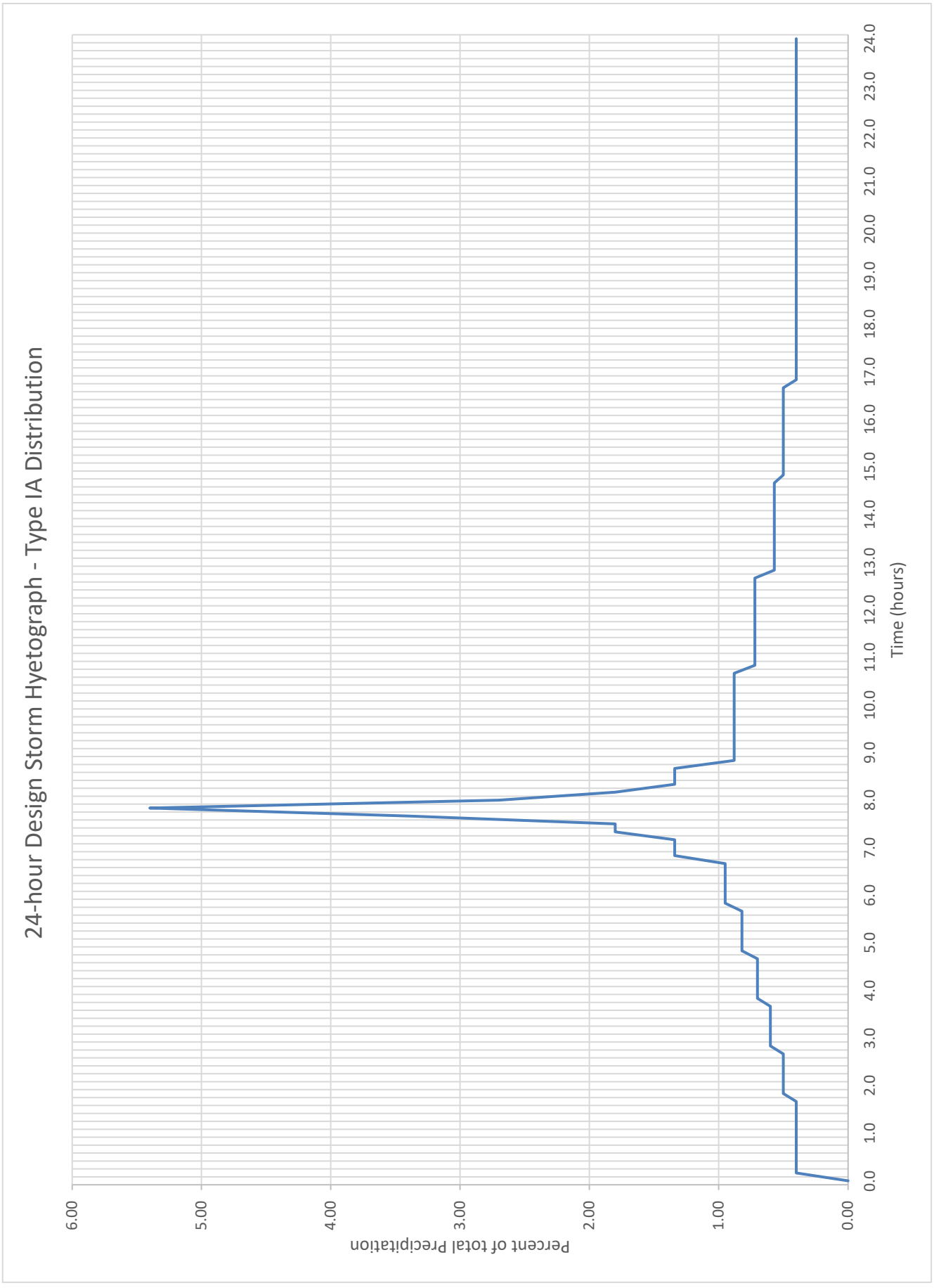
REVISIONS:
INITIAL RELEASE: JULY 17, 2013
UPDATED TOPO: MAY 13, 2021

JOB NUMBER
968

SHEET
1 OF 2

Table B.1 24-Hour Rainfall Amounts and Comparisons for Selected USGS Stations								
	Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Precip. Inches
1	Aberdeen	2.47	92.58%	3.43	72.0%	2.25	2.81	83.12
2	Anacortes	0.93	90.45%	1.37	67.9%	0.91	1.22	25.92
3	Appleton	1.39	89.04%	1.96	70.9%	1.45	1.80	32.71
4	Arlington	1.28	93.42%	1.74	73.6%	1.11	1.40	46.46
5	Bellingham	1.27	90.78%	1.79	70.9%	1.23	1.63	35.82
6	Bremerton	1.87	90.75%	2.61	71.6%	1.83	2.22	49.97
7	Cathlamet	2.13	92.52%	3.47	61.4%	1.89	2.59	78.97
8	Centralia	1.49	91.81%	2.09	71.3%	1.40	1.78	45.94
9	Chelan	0.62	84.50%	0.96	64.6%	0.76	1.00	10.44
10	Chimacum	1.20	89.63%	1.73	69.4%	1.22	1.52	29.45
11	Clearwater	3.46	92.88%	4.75	72.8%	3.04	3.94	125.25
12	CleElum	1.06	86.85%	1.66	63.9%	1.20	1.64	22.17
13	Colfax	0.80	90.52%	1.07	74.8%	0.80	0.99	19.78
14	Colville	0.71	90.46%	0.97	73.2%	0.69	0.86	18.31
15	Cushman Dam	3.31	91.26%	5.29	62.6%	3.18	4.25	100.82
16	Cushman PwrH	3.17	90.81%	4.42	71.7%	3.08	4.00	85.71
17	Darrington	2.90	91.19%	4.01	72.3%	2.73	3.42	82.90
18	Ellensburg	0.50	84.63%	0.79	63.3%	0.62	0.81	8.75
19	Elwha RS	2.14	90.49%	2.80	76.4%	2.11	2.53	55.87
20	Everett	1.10	93.14%	1.46	75.3%	1.00	1.22	36.80
21	Forks	3.47	92.50%	5.07	68.4%	3.13	4.00	117.83
22	Goldendale	0.84	86.92%	1.29	65.1%	0.98	1.25	17.57
23	Hartline	0.61	84.85%	0.96	63.5%	0.77	0.97	10.67
24	Kennewick	0.46	84.10%	0.71	64.8%	0.55	0.72	7.57
25	Lk. Wenatchee	2.20	85.87%	3.16	69.6%	2.58	3.16	42.72
26	Long Beach	2.32	93.09%	3.08	75.3%	2.04	2.55	80.89
27	Longview	1.41	92.02%	1.97	71.6%	1.29	1.67	45.62
28	Mc Millin	1.31	92.24%	1.82	72.0%	1.21	1.49	40.66
29	Monroe	1.38	92.90%	1.86	74.2%	1.26	1.53	48.16
30	Moses Lake	0.47	85.32%	0.70	67.1%	0.54	0.68	7.89
31	Oakville	1.81	92.86%	2.28	79.4%	1.62	1.98	57.35
32	Odessa	0.52	87.23%	0.76	68.4%	0.56	0.72	10.09
33	Olga	1.02	90.82%	1.52	67.1%	0.99	1.30	28.96
34	Olympia	1.74	91.13%	2.51	69.3%	1.65	2.19	50.68
35	Omak	0.66	85.89%	0.98	67.3%	0.79	0.98	11.97
36	Packwood	2.41	88.70%	3.52	68.5%	2.51	3.20	55.20

Table B.1 24-Hour Rainfall Amounts and Comparisons for Selected USGS Stations								
	Station Name	6 Month Storm Inches	6 Month % Rainfall Volume	2 Year Storm Inches	6 Month/ 2 year %	90% Rainfall Inches	95% Rainfall Inches	Mean Annual Precip. Inches
37	Pomeroy	0.75	89.29%	1.02	73.5%	0.78	0.98	16.04
38	Port Angeles	1.12	88.39%	1.66	67.5%	1.19	1.56	25.46
39	Port Townsend	0.77	90.56%	1.14	67.5%	0.76	0.95	19.13
40	Prosser	0.48	83.82%	0.74	64.9%	0.61	0.78	7.90
41	Quilcene	2.53	88.81%	3.40	74.4%	2.61	3.15	54.88
42	Quincy	0.53	82.12%	0.81	65.4%	0.68	0.90	8.07
43	Sea-Tac	1.32	91.13%	1.83	72.1%	1.27	1.63	38.10
44	Seattle JP	1.30	92.05%	1.74	74.7%	1.20	1.49	38.60
45	Sedro Woolley	1.50	92.07%	2.01	74.6%	1.41	1.80	46.97
46	Shelton	2.15	91.49%	3.13	68.7%	2.05	2.55	64.63
47	Smyrna	0.52	83.16%	0.76	68.4%	0.63	0.75	7.96
48	Spokane	0.68	89.54%	0.96	70.8%	0.70	0.88	16.04
49	Sunnyside	0.45	82.22%	0.73	61.6%	0.63	0.76	6.80
50	Tacoma	1.21	92.18%	1.61	75.2%	1.12	1.37	36.92
51	Toledo	1.36	92.73%	2.10	64.8%	1.25	1.68	50.18
52	Vancouver	1.35	91.32%	1.93	69.9%	1.28	1.62	38.87
53	Walla Walla	0.90	88.60%	1.23	73.2%	0.94	1.18	19.50
54	Waterville	0.67	84.43%	1.04	64.4%	0.81	1.05	11.47
55	Wauna	1.82	91.37%	2.50	72.8%	1.72	2.18	51.61
56	Wenatchee	0.58	81.97%	0.92	63.0%	0.80	1.04	8.93
57	Winthrop	0.75	85.36%	1.13	66.4%	0.94	1.13	14.28
58	Yakima	0.53	81.44%	0.85	62.4%	0.72	1.03	8.16


24-hour Design Storm Hyetograph - Type IA Distribution
Percent of total Precipitation
6.00
5.00
4.00
3.00
2.00
1.00
0.00
Time (hours)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
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16.0
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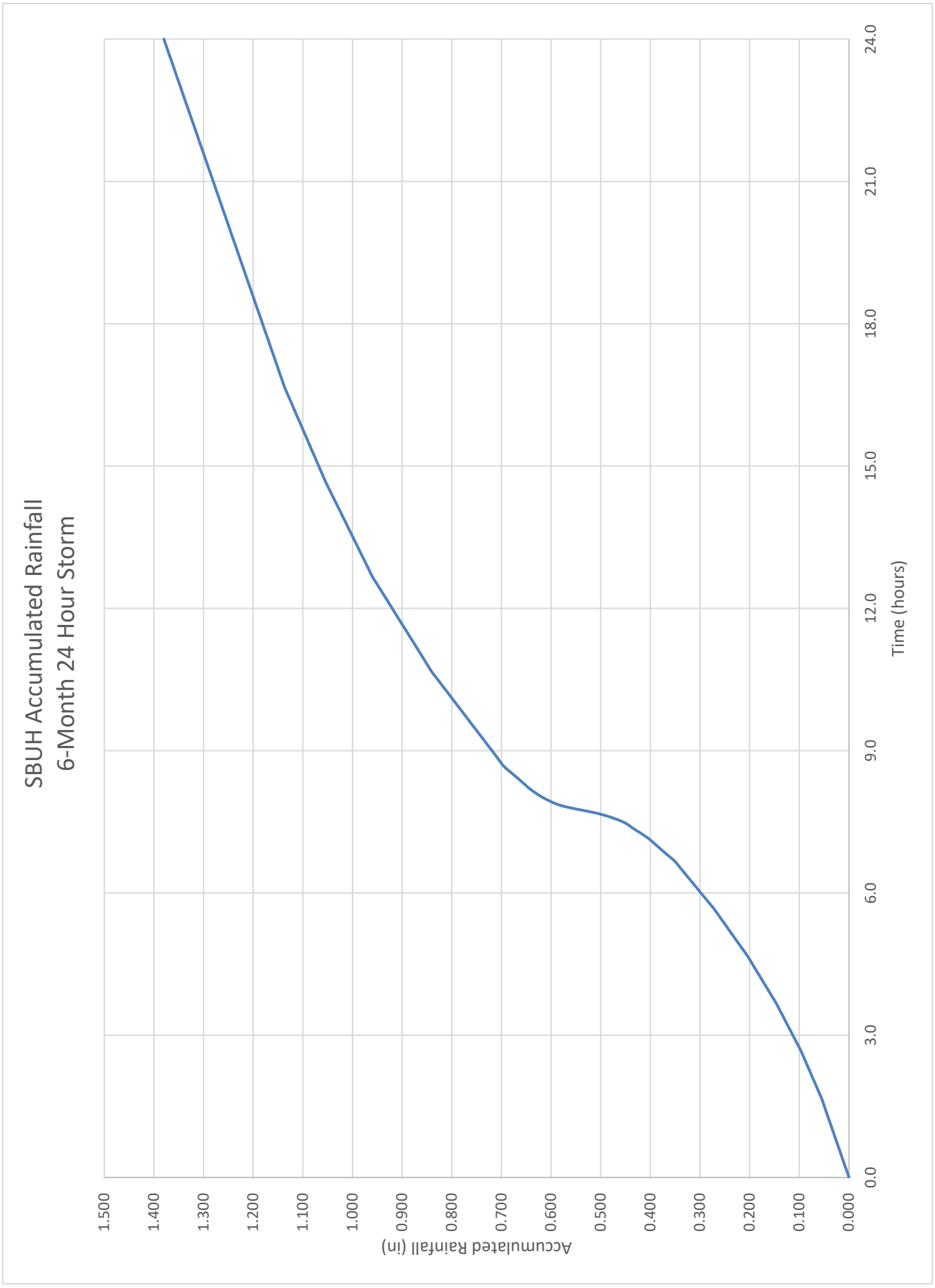
18.0
19.0
20.0
21.0
22.0
23.0
24.0


SBUH Accumulated Rainfall
6-Month 24 Hour Storm
Accumulated Rainfall (in)
0.000
0.100
0.200
0.300
0.400
0.500
0.600
0.700
0.800
0.900
1.000
1.100
1.200
1.300
1.400
1.500
Time (hours)
0.0
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0

Time of Concentration

Find precipitation from 24-hour 2-year storm by averaging values from Longview & Vancouver

Longview = 1.97"
Vancouver = 1.93"
Average = 1.95"

Sheet Flow travel time (1992 Puget Sound SWMM III-1-14)

$$T_{t1} = \frac{0.42(nL)^{0.8}}{(P_2)^{0.527}(S_o)^{0.4}} = \frac{0.42(0.11 \cdot 15')^{0.8}}{(1.95)^{0.527}(0.032)^{0.4}} = 1.74 \text{ min}$$

Grassed Waterway travel time (1992 SWMM III-1-14)

Assume water travels full length of drainage ditch (~650') w/ 2' drop. Ditch is grass lined.

$$V = K\sqrt{S_o} = 17\sqrt{\frac{2}{650}} = 0.94 \text{ ft/s}$$

$$T_{t2} = 650'/0.94 \text{ ft/s} = 691.5 \text{ seconds} = 11.52 \text{ min}$$

Time of Concentration

$$\boxed{T_c} = T_{t1} + T_{t2} = 1.74 \text{min} + 11.52 \text{min} = \boxed{13.26 \text{min}}$$

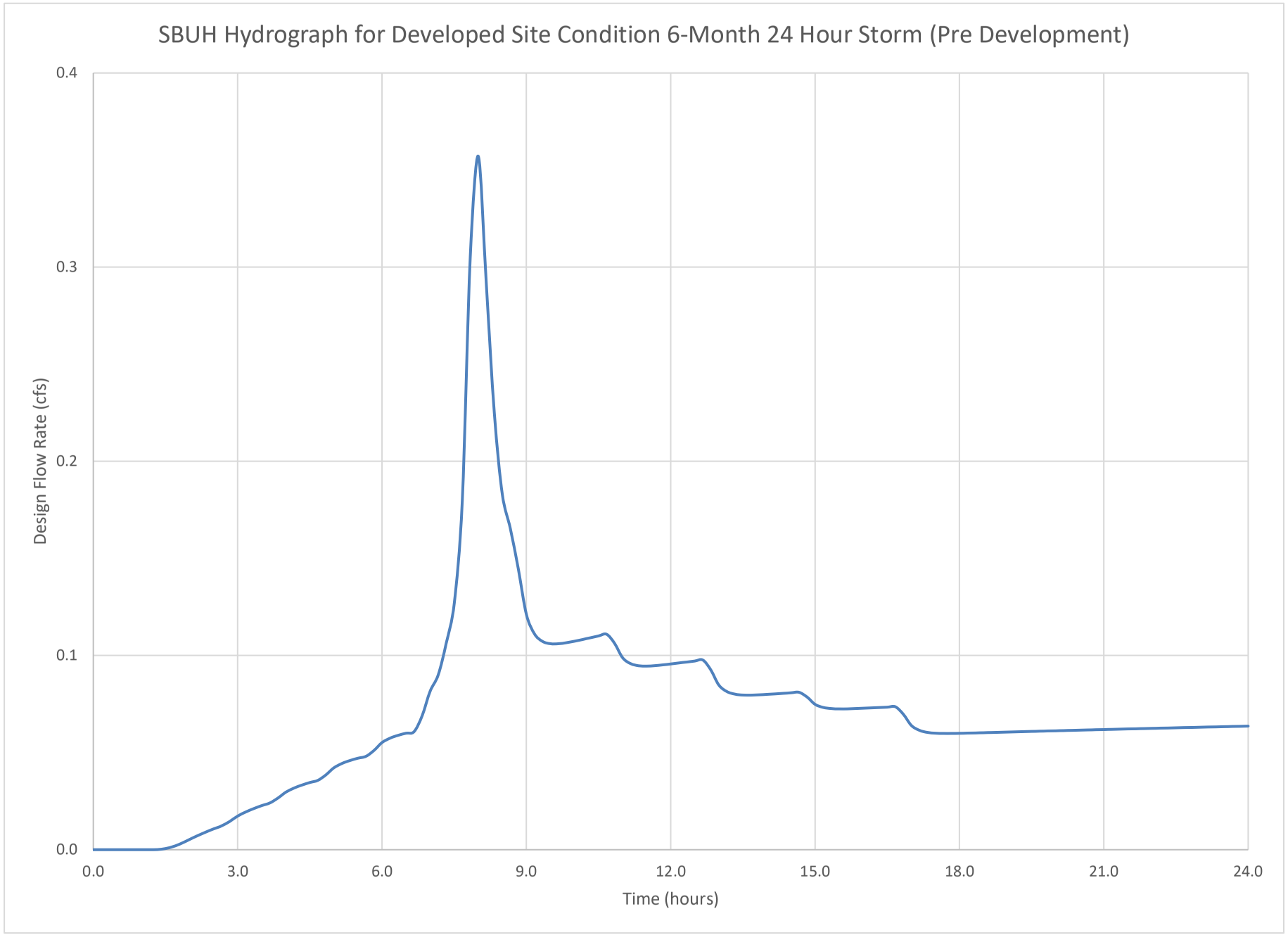
1992 Puget Sound SBUH hydrograph (Chapter III)- **6 -Month** 24-hour Storm (Pre-Development)

dt =	10	min	Tc =	13.26	min			w =	0.274	routing constant
Pt =	1.38	in								
CN perv	85		S =	1.76		0.2S =	0.353	A_{perv} =	1.66	ac
CN imperv	98		S =	0.20		0.2S =	0.041	A_{imperv} =	0.93	ac
								A_{total} =	2.59	ac

							Pervious Area		Impervious Area				
Time Increment	Time (min)	Time (hours)	Incremental Percent of Rainfall	Accum. Percent of Rainfall	Incremental Rainfall (inches)	Accum. Rainfall inches	Accum Runoff inches	Incr. Runoff Inches	Accum Runoff inches	Incr. Runoff Inches	Total Runoff inches	Instant Flow rate cfs	Design Flow rate cfs
1	0	0.0	0.00	0.0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
2	10	0.2	0.40	0.4	0.0055	0.006	0.000	0.000	0.000	0.000	0.000	0.0	0.0
3	20	0.3	0.40	0.8	0.0055	0.011	0.000	0.000	0.000	0.000	0.000	0.0	0.0
4	30	0.5	0.40	1.2	0.0055	0.017	0.000	0.000	0.000	0.000	0.000	0.0	0.0
5	40	0.7	0.40	1.6	0.0055	0.022	0.000	0.000	0.000	0.000	0.000	0.0	0.0
6	50	0.8	0.40	2.0	0.0055	0.028	0.000	0.000	0.000	0.000	0.000	0.0	0.0
7	60	1.0	0.40	2.4	0.0055	0.033	0.000	0.000	0.000	0.000	0.000	0.0	0.0
8	70	1.2	0.40	2.8	0.0055	0.039	0.000	0.000	0.000	0.000	0.000	0.0	0.0
9	80	1.3	0.40	3.2	0.0055	0.044	0.000	0.000	0.000	0.000	0.000	0.0	0.0
10	90	1.5	0.40	3.6	0.0055	0.050	0.000	0.000	0.000	0.000	0.000	0.0	0.0
11	100	1.7	0.40	4.0	0.0055	0.055	0.000	0.000	0.001	0.001	0.000	0.0	0.0
12	110	1.8	0.50	4.5	0.0069	0.062	0.000	0.000	0.002	0.001	0.000	0.0	0.0
13	120	2.0	0.50	5.0	0.0069	0.069	0.000	0.000	0.003	0.001	0.001	0.0	0.0
14	130	2.2	0.50	5.5	0.0069	0.076	0.000	0.000	0.005	0.002	0.001	0.0	0.0
15	140	2.3	0.50	6.0	0.0069	0.083	0.000	0.000	0.007	0.002	0.001	0.0	0.0
16	150	2.5	0.50	6.5	0.0069	0.090	0.000	0.000	0.009	0.002	0.001	0.0	0.0
17	160	2.7	0.50	7.0	0.0069	0.097	0.000	0.000	0.012	0.003	0.001	0.0	0.0
18	170	2.8	0.60	7.6	0.0083	0.105	0.000	0.000	0.015	0.003	0.001	0.0	0.0
19	180	3.0	0.60	8.2	0.0083	0.113	0.000	0.000	0.019	0.004	0.001	0.0	0.0
20	190	3.2	0.60	8.8	0.0083	0.121	0.000	0.000	0.023	0.004	0.001	0.0	0.0
21	200	3.3	0.60	9.4	0.0083	0.130	0.000	0.000	0.027	0.004	0.001	0.0	0.0
22	210	3.5	0.60	10.0	0.0083	0.138	0.000	0.000	0.031	0.004	0.002	0.0	0.0
23	220	3.7	0.60	10.6	0.0083	0.146	0.000	0.000	0.036	0.005	0.002	0.0	0.0
24	230	3.8	0.70	11.3	0.0097	0.156	0.000	0.000	0.042	0.006	0.002	0.0	0.0
25	240	4.0	0.70	12.0	0.0097	0.166	0.000	0.000	0.047	0.006	0.002	0.0	0.0
26	250	4.2	0.70	12.7	0.0097	0.175	0.000	0.000	0.053	0.006	0.002	0.0	0.0
27	260	4.3	0.70	13.4	0.0097	0.185	0.000	0.000	0.060	0.006	0.002	0.0	0.0
28	270	4.5	0.70	14.1	0.0097	0.195	0.000	0.000	0.066	0.006	0.002	0.0	0.0
29	280	4.7	0.70	14.8	0.0097	0.204	0.000	0.000	0.073	0.007	0.002	0.0	0.0
30	290	4.8	0.82	15.6	0.0113	0.216	0.000	0.000	0.081	0.008	0.003	0.0	0.0
31	300	5.0	0.82	16.4	0.0113	0.227	0.000	0.000	0.089	0.008	0.003	0.0	0.0
32	310	5.2	0.82	17.3	0.0113	0.238	0.000	0.000	0.097	0.008	0.003	0.0	0.0
33	320	5.3	0.82	18.1	0.0113	0.250	0.000	0.000	0.106	0.008	0.003	0.0	0.0
34	330	5.5	0.82	18.9	0.0113	0.261	0.000	0.000	0.114	0.009	0.003	0.0	0.0
35	340	5.7	0.82	19.7	0.0113	0.272	0.000	0.000	0.123	0.009	0.003	0.0	0.0
36	350	5.8	0.95	20.7	0.0131	0.285	0.000	0.000	0.133	0.010	0.004	0.1	0.1
37	360	6.0	0.95	21.6	0.0131	0.298	0.000	0.000	0.144	0.010	0.004	0.1	0.1
38	370	6.2	0.95	22.6	0.0131	0.311	0.000	0.000	0.154	0.011	0.004	0.1	0.1
39	380	6.3	0.95	23.5	0.0131	0.325	0.000	0.000	0.165	0.011	0.004	0.1	0.1
40	390	6.5	0.95	24.5	0.0131	0.338	0.000	0.000	0.176	0.011	0.004	0.1	0.1
41	400	6.7	0.95	25.4	0.0131	0.351	0.000	0.000	0.187	0.011	0.004	0.1	0.1
42	410	6.8	1.34	26.8	0.0185	0.369	0.000	0.000	0.203	0.016	0.006	0.1	0.1
43	420	7.0	1.34	28.1	0.0185	0.388	0.001	0.001	0.218	0.016	0.006	0.1	0.1
44	430	7.2	1.34	29.4	0.0185	0.406	0.002	0.001	0.235	0.016	0.006	0.1	0.1
45	440	7.3	1.80	31.2	0.0248	0.431	0.003	0.002	0.256	0.022	0.009	0.1	0.1
46	450	7.5	1.80	33.0	0.0248	0.456	0.006	0.002	0.278	0.022	0.009	0.1	0.1
47	460	7.7	3.40	36.4	0.0469	0.503	0.012	0.006	0.320	0.042	0.019	0.3	0.2
48	470	7.8	5.40	41.8	0.0745	0.577	0.025	0.014	0.389	0.068	0.033	0.5	0.3
49	480	8.0	2.70	44.5	0.0373	0.615	0.034	0.008	0.423	0.035	0.018	0.3	0.4
50	490	8.2	1.80	46.3	0.0248	0.639	0.040	0.006	0.446	0.023	0.012	0.2	0.3
51	500	8.3	1.34	47.7	0.0185	0.658	0.045	0.005	0.464	0.017	0.009	0.1	0.2
52	510	8.5	1.34	49.0	0.0185	0.676	0.050	0.005	0.481	0.017	0.010	0.1	0.2
53	520	8.7	1.34	50.4	0.0185	0.695	0.056	0.005	0.499	0.017	0.010	0.2	0.2
54	530	8.8	0.88	51.2	0.0121	0.707	0.059	0.004	0.510	0.011	0.006	0.1	0.1
55	540	9.0	0.88	52.1	0.0121	0.719	0.063	0.004	0.522	0.011	0.007	0.1	0.1
56	550	9.2	0.88	53.0	0.0121	0.731	0.067	0.004	0.533	0.012	0.007	0.1	0.1
57	560	9.3	0.88	53.9	0.0121	0.744	0.071	0.004	0.545	0.012	0.007	0.1	0.1

58	570	9.5	0.88	54.8	0.0121	0.756	0.075	0.004	0.556	0.012	0.007	0.1	0.1
59	580	9.7	0.88	55.6	0.0121	0.768	0.079	0.004	0.568	0.012	0.007	0.1	0.1
60	590	9.8	0.88	56.5	0.0121	0.780	0.083	0.004	0.579	0.012	0.007	0.1	0.1
61	600	10.0	0.88	57.4	0.0121	0.792	0.088	0.004	0.591	0.012	0.007	0.1	0.1
62	610	10.2	0.88	58.3	0.0121	0.804	0.092	0.004	0.602	0.012	0.007	0.1	0.1
63	620	10.3	0.88	59.2	0.0121	0.816	0.096	0.004	0.614	0.012	0.007	0.1	0.1
64	630	10.5	0.88	60.0	0.0121	0.829	0.101	0.005	0.626	0.012	0.007	0.1	0.1
65	640	10.7	0.88	60.9	0.0121	0.841	0.106	0.005	0.637	0.012	0.007	0.1	0.1
66	650	10.8	0.72	61.6	0.0099	0.851	0.109	0.004	0.647	0.010	0.006	0.1	0.1
67	660	11.0	0.72	62.4	0.0099	0.861	0.113	0.004	0.656	0.010	0.006	0.1	0.1
68	670	11.2	0.72	63.1	0.0099	0.871	0.117	0.004	0.666	0.010	0.006	0.1	0.1
69	680	11.3	0.72	63.8	0.0099	0.880	0.121	0.004	0.675	0.010	0.006	0.1	0.1
70	690	11.5	0.72	64.5	0.0099	0.890	0.125	0.004	0.685	0.010	0.006	0.1	0.1
71	700	11.7	0.72	65.2	0.0099	0.900	0.130	0.004	0.695	0.010	0.006	0.1	0.1
72	710	11.8	0.72	66.0	0.0099	0.910	0.134	0.004	0.704	0.010	0.006	0.1	0.1
73	720	12.0	0.72	66.7	0.0099	0.920	0.138	0.004	0.714	0.010	0.006	0.1	0.1
74	730	12.2	0.72	67.4	0.0099	0.930	0.142	0.004	0.723	0.010	0.006	0.1	0.1
75	740	12.3	0.72	68.1	0.0099	0.940	0.147	0.004	0.733	0.010	0.006	0.1	0.1
76	750	12.5	0.72	68.8	0.0099	0.950	0.151	0.004	0.743	0.010	0.006	0.1	0.1
77	760	12.7	0.72	69.6	0.0099	0.960	0.155	0.004	0.752	0.010	0.006	0.1	0.1
78	770	12.8	0.57	70.1	0.0079	0.968	0.159	0.004	0.760	0.008	0.005	0.1	0.1
79	780	13.0	0.57	70.7	0.0079	0.976	0.162	0.004	0.767	0.008	0.005	0.1	0.1
80	790	13.2	0.57	71.3	0.0079	0.984	0.166	0.004	0.775	0.008	0.005	0.1	0.1
81	800	13.3	0.57	71.8	0.0079	0.991	0.170	0.004	0.783	0.008	0.005	0.1	0.1
82	810	13.5	0.57	72.4	0.0079	0.999	0.173	0.004	0.790	0.008	0.005	0.1	0.1
83	820	13.7	0.57	73.0	0.0079	1.007	0.177	0.004	0.798	0.008	0.005	0.1	0.1
84	830	13.8	0.57	73.6	0.0079	1.015	0.181	0.004	0.805	0.008	0.005	0.1	0.1
85	840	14.0	0.57	74.1	0.0079	1.023	0.184	0.004	0.813	0.008	0.005	0.1	0.1
86	850	14.2	0.57	74.7	0.0079	1.031	0.188	0.004	0.821	0.008	0.005	0.1	0.1
87	860	14.3	0.57	75.3	0.0079	1.039	0.192	0.004	0.828	0.008	0.005	0.1	0.1
88	870	14.5	0.57	75.8	0.0079	1.046	0.196	0.004	0.836	0.008	0.005	0.1	0.1
89	880	14.7	0.57	76.4	0.0079	1.054	0.199	0.004	0.844	0.008	0.005	0.1	0.1
90	890	14.8	0.50	76.9	0.0069	1.061	0.203	0.003	0.850	0.007	0.005	0.1	0.1
91	900	15.0	0.50	77.4	0.0069	1.068	0.206	0.003	0.857	0.007	0.005	0.1	0.1
92	910	15.2	0.50	77.9	0.0069	1.075	0.210	0.003	0.864	0.007	0.005	0.1	0.1
93	920	15.3	0.50	78.4	0.0069	1.082	0.213	0.003	0.870	0.007	0.005	0.1	0.1
94	930	15.5	0.50	78.9	0.0069	1.089	0.217	0.003	0.877	0.007	0.005	0.1	0.1
95	940	15.7	0.50	79.4	0.0069	1.096	0.220	0.003	0.884	0.007	0.005	0.1	0.1
96	950	15.8	0.50	79.9	0.0069	1.103	0.224	0.003	0.891	0.007	0.005	0.1	0.1
97	960	16.0	0.50	80.4	0.0069	1.110	0.227	0.004	0.897	0.007	0.005	0.1	0.1
98	970	16.2	0.50	80.9	0.0069	1.116	0.231	0.004	0.904	0.007	0.005	0.1	0.1
99	980	16.3	0.50	81.4	0.0069	1.123	0.234	0.004	0.911	0.007	0.005	0.1	0.1
100	990	16.5	0.50	81.9	0.0069	1.130	0.238	0.004	0.918	0.007	0.005	0.1	0.1
101	1000	16.7	0.50	82.4	0.0069	1.137	0.241	0.004	0.924	0.007	0.005	0.1	0.1
102	1010	16.8	0.40	82.8	0.0055	1.143	0.244	0.003	0.930	0.005	0.004	0.1	0.1
103	1020	17.0	0.40	83.2	0.0055	1.148	0.247	0.003	0.935	0.005	0.004	0.1	0.1
104	1030	17.2	0.40	83.6	0.0055	1.154	0.250	0.003	0.940	0.005	0.004	0.1	0.1
105	1040	17.3	0.40	84.0	0.0055	1.159	0.253	0.003	0.946	0.005	0.004	0.1	0.1
106	1050	17.5	0.40	84.4	0.0055	1.165	0.256	0.003	0.951	0.005	0.004	0.1	0.1
107	1060	17.7	0.40	84.8	0.0055	1.170	0.259	0.003	0.957	0.005	0.004	0.1	0.1
108	1070	17.8	0.40	85.2	0.0055	1.176	0.262	0.003	0.962	0.005	0.004	0.1	0.1
109	1080	18.0	0.40	85.6	0.0055	1.181	0.265	0.003	0.967	0.005	0.004	0.1	0.1
110	1090	18.2	0.40	86.0	0.0055	1.187	0.268	0.003	0.973	0.005	0.004	0.1	0.1
111	1100	18.3	0.40	86.4	0.0055	1.192	0.271	0.003	0.978	0.005	0.004	0.1	0.1
112	1110	18.5	0.40	86.8	0.0055	1.198	0.274	0.003	0.984	0.005	0.004	0.1	0.1
113	1120	18.7	0.40	87.2	0.0055	1.203	0.277	0.003	0.989	0.005	0.004	0.1	0.1
114	1130	18.8	0.40	87.6	0.0055	1.209	0.280	0.003	0.994	0.005	0.004	0.1	0.1
115	1140	19.0	0.40	88.0	0.0055	1.214	0.283	0.003	1.000	0.005	0.004	0.1	0.1
116	1150	19.2	0.40	88.4	0.0055	1.220	0.286	0.003	1.005	0.005	0.004	0.1	0.1
117	1160	19.3	0.40	88.8	0.0055	1.225	0.289	0.003	1.011	0.005	0.004	0.1	0.1
118	1170	19.5	0.40	89.2	0.0055	1.231	0.292	0.003	1.016	0.005	0.004	0.1	0.1
119	1180	19.7	0.40	89.6	0.0055	1.236	0.295	0.003	1.021	0.005	0.004	0.1	0.1
120	1190	19.8	0.40	90.0	0.0055	1.242	0.298	0.003	1.027	0.005	0.004	0.1	0.1
121	1200	20.0	0.40	90.4	0.0055	1.248	0.301	0.003	1.032	0.005	0.004	0.1	0.1
122	1210	20.2	0.40	90.8	0.0055	1.253	0.304	0.003	1.038	0.005	0.004	0.1	0.1
123	1220	20.3	0.40	91.2	0.0055	1.259	0.307	0.003	1.043	0.005	0.004	0.1	0.1
124	1230	20.5	0.40	91.6	0.0055	1.264	0.310	0.003	1.048	0.005	0.004	0.1	0.1
125	1240	20.7	0.40	92.0	0.0055	1.270	0.313	0.003	1.054	0.005	0.004	0.1	0.1
126	1250	20.8	0.40	92.4	0.0055	1.275	0.317	0.003	1.059	0.005	0.004	0.1	0.1

127	1260	21.0	0.40	92.8	0.0055	1.281	0.320	0.003	1.065	0.005	0.004	0.1	0.1
128	1270	21.2	0.40	93.2	0.0055	1.286	0.323	0.003	1.070	0.005	0.004	0.1	0.1
129	1280	21.3	0.40	93.6	0.0055	1.292	0.326	0.003	1.075	0.005	0.004	0.1	0.1
130	1290	21.5	0.40	94.0	0.0055	1.297	0.329	0.003	1.081	0.005	0.004	0.1	0.1
131	1300	21.7	0.40	94.4	0.0055	1.303	0.332	0.003	1.086	0.005	0.004	0.1	0.1
132	1310	21.8	0.40	94.8	0.0055	1.308	0.336	0.003	1.092	0.005	0.004	0.1	0.1
133	1320	22.0	0.40	95.2	0.0055	1.314	0.339	0.003	1.097	0.005	0.004	0.1	0.1
134	1330	22.2	0.40	95.6	0.0055	1.319	0.342	0.003	1.102	0.005	0.004	0.1	0.1
135	1340	22.3	0.40	96.0	0.0055	1.325	0.345	0.003	1.108	0.005	0.004	0.1	0.1
136	1350	22.5	0.40	96.4	0.0055	1.330	0.348	0.003	1.113	0.005	0.004	0.1	0.1
137	1360	22.7	0.40	96.8	0.0055	1.336	0.352	0.003	1.119	0.005	0.004	0.1	0.1
138	1370	22.8	0.40	97.2	0.0055	1.341	0.355	0.003	1.124	0.005	0.004	0.1	0.1
139	1380	23.0	0.40	97.6	0.0055	1.347	0.358	0.003	1.130	0.005	0.004	0.1	0.1
140	1390	23.2	0.40	98.0	0.0055	1.352	0.361	0.003	1.135	0.005	0.004	0.1	0.1
141	1400	23.3	0.40	98.4	0.0055	1.358	0.365	0.003	1.140	0.005	0.004	0.1	0.1
142	1410	23.5	0.40	98.8	0.0055	1.363	0.368	0.003	1.146	0.005	0.004	0.1	0.1
143	1420	23.7	0.40	99.2	0.0055	1.369	0.371	0.003	1.151	0.005	0.004	0.1	0.1
144	1430	23.8	0.40	99.6	0.0055	1.374	0.375	0.003	1.157	0.005	0.004	0.1	0.1
145	1440	24.0	0.40	100.0	0.0055	1.380	0.378	0.003	1.162	0.005	0.004	0.1	0.1


SBUH Hydrograph for Developed Site Condition 6-Month 24 Hour Storm (Pre Development)
Design Flow Rate (cfs)
0.4
0.3
0.2
0.1
0.0
0.0
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0
Time (hours)

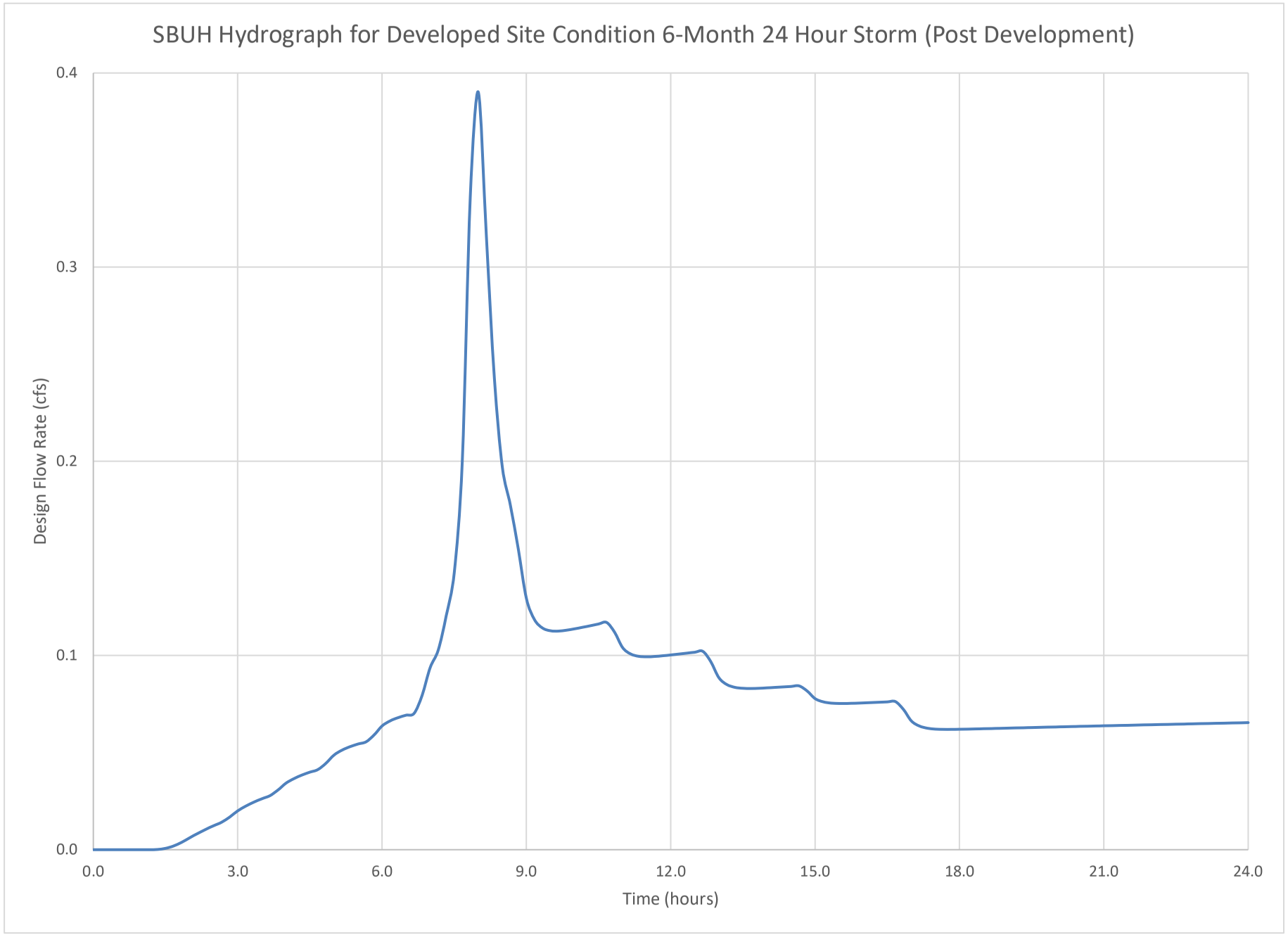
1992 Puget Sound SBUH hydrograph (Chapter III)- **6 -Month** 24-hour Storm (Post-Development)

dt =	10	min	Tc =	13.26	min			w =	0.274	routing constant
Pt =	1.38	in								
CN perv	85		S =	1.76		0.2S =	0.353	A_{perv} =	1.51	ac
CN imperv	98		S =	0.20		0.2S =	0.041	A_{imperv} =	1.07	ac
								A_{total} =	2.59	ac

							Pervious Area		Impervious Area				
Time Increment	Time (min)	Time (hours)	Incremental Percent of Rainfall	Accum. Percent of Rainfall	Incremental Rainfall (inches)	Accum. Rainfall inches	Accum Runoff inches	Incr. Runoff Inches	Accum Runoff inches	Incr. Runoff Inches	Total Runoff inches	Instant Flow rate cfs	Design Flow rate cfs
1	0	0.0	0.00	0.0	0.0000	0.000	0.000	0.000	0.000	0.000	0.000	0.0	0.0
2	10	0.2	0.40	0.4	0.0055	0.006	0.000	0.000	0.000	0.000	0.000	0.0	0.0
3	20	0.3	0.40	0.8	0.0055	0.011	0.000	0.000	0.000	0.000	0.000	0.0	0.0
4	30	0.5	0.40	1.2	0.0055	0.017	0.000	0.000	0.000	0.000	0.000	0.0	0.0
5	40	0.7	0.40	1.6	0.0055	0.022	0.000	0.000	0.000	0.000	0.000	0.0	0.0
6	50	0.8	0.40	2.0	0.0055	0.028	0.000	0.000	0.000	0.000	0.000	0.0	0.0
7	60	1.0	0.40	2.4	0.0055	0.033	0.000	0.000	0.000	0.000	0.000	0.0	0.0
8	70	1.2	0.40	2.8	0.0055	0.039	0.000	0.000	0.000	0.000	0.000	0.0	0.0
9	80	1.3	0.40	3.2	0.0055	0.044	0.000	0.000	0.000	0.000	0.000	0.0	0.0
10	90	1.5	0.40	3.6	0.0055	0.050	0.000	0.000	0.000	0.000	0.000	0.0	0.0
11	100	1.7	0.40	4.0	0.0055	0.055	0.000	0.000	0.001	0.001	0.000	0.0	0.0
12	110	1.8	0.50	4.5	0.0069	0.062	0.000	0.000	0.002	0.001	0.000	0.0	0.0
13	120	2.0	0.50	5.0	0.0069	0.069	0.000	0.000	0.003	0.001	0.001	0.0	0.0
14	130	2.2	0.50	5.5	0.0069	0.076	0.000	0.000	0.005	0.002	0.001	0.0	0.0
15	140	2.3	0.50	6.0	0.0069	0.083	0.000	0.000	0.007	0.002	0.001	0.0	0.0
16	150	2.5	0.50	6.5	0.0069	0.090	0.000	0.000	0.009	0.002	0.001	0.0	0.0
17	160	2.7	0.50	7.0	0.0069	0.097	0.000	0.000	0.012	0.003	0.001	0.0	0.0
18	170	2.8	0.60	7.6	0.0083	0.105	0.000	0.000	0.015	0.003	0.001	0.0	0.0
19	180	3.0	0.60	8.2	0.0083	0.113	0.000	0.000	0.019	0.004	0.002	0.0	0.0
20	190	3.2	0.60	8.8	0.0083	0.121	0.000	0.000	0.023	0.004	0.002	0.0	0.0
21	200	3.3	0.60	9.4	0.0083	0.130	0.000	0.000	0.027	0.004	0.002	0.0	0.0
22	210	3.5	0.60	10.0	0.0083	0.138	0.000	0.000	0.031	0.004	0.002	0.0	0.0
23	220	3.7	0.60	10.6	0.0083	0.146	0.000	0.000	0.036	0.005	0.002	0.0	0.0
24	230	3.8	0.70	11.3	0.0097	0.156	0.000	0.000	0.042	0.006	0.002	0.0	0.0
25	240	4.0	0.70	12.0	0.0097	0.166	0.000	0.000	0.047	0.006	0.002	0.0	0.0
26	250	4.2	0.70	12.7	0.0097	0.175	0.000	0.000	0.053	0.006	0.003	0.0	0.0
27	260	4.3	0.70	13.4	0.0097	0.185	0.000	0.000	0.060	0.006	0.003	0.0	0.0
28	270	4.5	0.70	14.1	0.0097	0.195	0.000	0.000	0.066	0.006	0.003	0.0	0.0
29	280	4.7	0.70	14.8	0.0097	0.204	0.000	0.000	0.073	0.007	0.003	0.0	0.0
30	290	4.8	0.82	15.6	0.0113	0.216	0.000	0.000	0.081	0.008	0.003	0.1	0.0
31	300	5.0	0.82	16.4	0.0113	0.227	0.000	0.000	0.089	0.008	0.003	0.1	0.0
32	310	5.2	0.82	17.3	0.0113	0.238	0.000	0.000	0.097	0.008	0.003	0.1	0.1
33	320	5.3	0.82	18.1	0.0113	0.250	0.000	0.000	0.106	0.008	0.004	0.1	0.1
34	330	5.5	0.82	18.9	0.0113	0.261	0.000	0.000	0.114	0.009	0.004	0.1	0.1
35	340	5.7	0.82	19.7	0.0113	0.272	0.000	0.000	0.123	0.009	0.004	0.1	0.1
36	350	5.8	0.95	20.7	0.0131	0.285	0.000	0.000	0.133	0.010	0.004	0.1	0.1
37	360	6.0	0.95	21.6	0.0131	0.298	0.000	0.000	0.144	0.010	0.004	0.1	0.1
38	370	6.2	0.95	22.6	0.0131	0.311	0.000	0.000	0.154	0.011	0.004	0.1	0.1
39	380	6.3	0.95	23.5	0.0131	0.325	0.000	0.000	0.165	0.011	0.004	0.1	0.1
40	390	6.5	0.95	24.5	0.0131	0.338	0.000	0.000	0.176	0.011	0.005	0.1	0.1
41	400	6.7	0.95	25.4	0.0131	0.351	0.000	0.000	0.187	0.011	0.005	0.1	0.1
42	410	6.8	1.34	26.8	0.0185	0.369	0.000	0.000	0.203	0.016	0.007	0.1	0.1
43	420	7.0	1.34	28.1	0.0185	0.388	0.001	0.001	0.218	0.016	0.007	0.1	0.1
44	430	7.2	1.34	29.4	0.0185	0.406	0.002	0.001	0.235	0.016	0.007	0.1	0.1
45	440	7.3	1.80	31.2	0.0248	0.431	0.003	0.002	0.256	0.022	0.010	0.2	0.1
46	450	7.5	1.80	33.0	0.0248	0.456	0.006	0.002	0.278	0.022	0.011	0.2	0.1
47	460	7.7	3.40	36.4	0.0469	0.503	0.012	0.006	0.320	0.042	0.021	0.3	0.2
48	470	7.8	5.40	41.8	0.0745	0.577	0.025	0.014	0.389	0.068	0.036	0.6	0.3
49	480	8.0	2.70	44.5	0.0373	0.615	0.034	0.008	0.423	0.035	0.019	0.3	0.4
50	490	8.2	1.80	46.3	0.0248	0.639	0.040	0.006	0.446	0.023	0.013	0.2	0.3
51	500	8.3	1.34	47.7	0.0185	0.658	0.045	0.005	0.464	0.017	0.010	0.2	0.2
52	510	8.5	1.34	49.0	0.0185	0.676	0.050	0.005	0.481	0.017	0.010	0.2	0.2
53	520	8.7	1.34	50.4	0.0185	0.695	0.056	0.005	0.499	0.017	0.010	0.2	0.2
54	530	8.8	0.88	51.2	0.0121	0.707	0.059	0.004	0.510	0.011	0.007	0.1	0.2
55	540	9.0	0.88	52.1	0.0121	0.719	0.063	0.004	0.522	0.011	0.007	0.1	0.1
56	550	9.2	0.88	53.0	0.0121	0.731	0.067	0.004	0.533	0.012	0.007	0.1	0.1
57	560	9.3	0.88	53.9	0.0121	0.744	0.071	0.004	0.545	0.012	0.007	0.1	0.1

58	570	9.5	0.88	54.8	0.0121	0.756	0.075	0.004	0.556	0.012	0.007	0.1	0.1
59	580	9.7	0.88	55.6	0.0121	0.768	0.079	0.004	0.568	0.012	0.007	0.1	0.1
60	590	9.8	0.88	56.5	0.0121	0.780	0.083	0.004	0.579	0.012	0.007	0.1	0.1
61	600	10.0	0.88	57.4	0.0121	0.792	0.088	0.004	0.591	0.012	0.007	0.1	0.1
62	610	10.2	0.88	58.3	0.0121	0.804	0.092	0.004	0.602	0.012	0.007	0.1	0.1
63	620	10.3	0.88	59.2	0.0121	0.816	0.096	0.004	0.614	0.012	0.007	0.1	0.1
64	630	10.5	0.88	60.0	0.0121	0.829	0.101	0.005	0.626	0.012	0.007	0.1	0.1
65	640	10.7	0.88	60.9	0.0121	0.841	0.106	0.005	0.637	0.012	0.008	0.1	0.1
66	650	10.8	0.72	61.6	0.0099	0.851	0.109	0.004	0.647	0.010	0.006	0.1	0.1
67	660	11.0	0.72	62.4	0.0099	0.861	0.113	0.004	0.656	0.010	0.006	0.1	0.1
68	670	11.2	0.72	63.1	0.0099	0.871	0.117	0.004	0.666	0.010	0.006	0.1	0.1
69	680	11.3	0.72	63.8	0.0099	0.880	0.121	0.004	0.675	0.010	0.006	0.1	0.1
70	690	11.5	0.72	64.5	0.0099	0.890	0.125	0.004	0.685	0.010	0.006	0.1	0.1
71	700	11.7	0.72	65.2	0.0099	0.900	0.130	0.004	0.695	0.010	0.006	0.1	0.1
72	710	11.8	0.72	66.0	0.0099	0.910	0.134	0.004	0.704	0.010	0.006	0.1	0.1
73	720	12.0	0.72	66.7	0.0099	0.920	0.138	0.004	0.714	0.010	0.006	0.1	0.1
74	730	12.2	0.72	67.4	0.0099	0.930	0.142	0.004	0.723	0.010	0.006	0.1	0.1
75	740	12.3	0.72	68.1	0.0099	0.940	0.147	0.004	0.733	0.010	0.007	0.1	0.1
76	750	12.5	0.72	68.8	0.0099	0.950	0.151	0.004	0.743	0.010	0.007	0.1	0.1
77	760	12.7	0.72	69.6	0.0099	0.960	0.155	0.004	0.752	0.010	0.007	0.1	0.1
78	770	12.8	0.57	70.1	0.0079	0.968	0.159	0.004	0.760	0.008	0.005	0.1	0.1
79	780	13.0	0.57	70.7	0.0079	0.976	0.162	0.004	0.767	0.008	0.005	0.1	0.1
80	790	13.2	0.57	71.3	0.0079	0.984	0.166	0.004	0.775	0.008	0.005	0.1	0.1
81	800	13.3	0.57	71.8	0.0079	0.991	0.170	0.004	0.783	0.008	0.005	0.1	0.1
82	810	13.5	0.57	72.4	0.0079	0.999	0.173	0.004	0.790	0.008	0.005	0.1	0.1
83	820	13.7	0.57	73.0	0.0079	1.007	0.177	0.004	0.798	0.008	0.005	0.1	0.1
84	830	13.8	0.57	73.6	0.0079	1.015	0.181	0.004	0.805	0.008	0.005	0.1	0.1
85	840	14.0	0.57	74.1	0.0079	1.023	0.184	0.004	0.813	0.008	0.005	0.1	0.1
86	850	14.2	0.57	74.7	0.0079	1.031	0.188	0.004	0.821	0.008	0.005	0.1	0.1
87	860	14.3	0.57	75.3	0.0079	1.039	0.192	0.004	0.828	0.008	0.005	0.1	0.1
88	870	14.5	0.57	75.8	0.0079	1.046	0.196	0.004	0.836	0.008	0.005	0.1	0.1
89	880	14.7	0.57	76.4	0.0079	1.054	0.199	0.004	0.844	0.008	0.005	0.1	0.1
90	890	14.8	0.50	76.9	0.0069	1.061	0.203	0.003	0.850	0.007	0.005	0.1	0.1
91	900	15.0	0.50	77.4	0.0069	1.068	0.206	0.003	0.857	0.007	0.005	0.1	0.1
92	910	15.2	0.50	77.9	0.0069	1.075	0.210	0.003	0.864	0.007	0.005	0.1	0.1
93	920	15.3	0.50	78.4	0.0069	1.082	0.213	0.003	0.870	0.007	0.005	0.1	0.1
94	930	15.5	0.50	78.9	0.0069	1.089	0.217	0.003	0.877	0.007	0.005	0.1	0.1
95	940	15.7	0.50	79.4	0.0069	1.096	0.220	0.003	0.884	0.007	0.005	0.1	0.1
96	950	15.8	0.50	79.9	0.0069	1.103	0.224	0.003	0.891	0.007	0.005	0.1	0.1
97	960	16.0	0.50	80.4	0.0069	1.110	0.227	0.004	0.897	0.007	0.005	0.1	0.1
98	970	16.2	0.50	80.9	0.0069	1.116	0.231	0.004	0.904	0.007	0.005	0.1	0.1
99	980	16.3	0.50	81.4	0.0069	1.123	0.234	0.004	0.911	0.007	0.005	0.1	0.1
100	990	16.5	0.50	81.9	0.0069	1.130	0.238	0.004	0.918	0.007	0.005	0.1	0.1
101	1000	16.7	0.50	82.4	0.0069	1.137	0.241	0.004	0.924	0.007	0.005	0.1	0.1
102	1010	16.8	0.40	82.8	0.0055	1.143	0.244	0.003	0.930	0.005	0.004	0.1	0.1
103	1020	17.0	0.40	83.2	0.0055	1.148	0.247	0.003	0.935	0.005	0.004	0.1	0.1
104	1030	17.2	0.40	83.6	0.0055	1.154	0.250	0.003	0.940	0.005	0.004	0.1	0.1
105	1040	17.3	0.40	84.0	0.0055	1.159	0.253	0.003	0.946	0.005	0.004	0.1	0.1
106	1050	17.5	0.40	84.4	0.0055	1.165	0.256	0.003	0.951	0.005	0.004	0.1	0.1
107	1060	17.7	0.40	84.8	0.0055	1.170	0.259	0.003	0.957	0.005	0.004	0.1	0.1
108	1070	17.8	0.40	85.2	0.0055	1.176	0.262	0.003	0.962	0.005	0.004	0.1	0.1
109	1080	18.0	0.40	85.6	0.0055	1.181	0.265	0.003	0.967	0.005	0.004	0.1	0.1
110	1090	18.2	0.40	86.0	0.0055	1.187	0.268	0.003	0.973	0.005	0.004	0.1	0.1
111	1100	18.3	0.40	86.4	0.0055	1.192	0.271	0.003	0.978	0.005	0.004	0.1	0.1
112	1110	18.5	0.40	86.8	0.0055	1.198	0.274	0.003	0.984	0.005	0.004	0.1	0.1
113	1120	18.7	0.40	87.2	0.0055	1.203	0.277	0.003	0.989	0.005	0.004	0.1	0.1
114	1130	18.8	0.40	87.6	0.0055	1.209	0.280	0.003	0.994	0.005	0.004	0.1	0.1
115	1140	19.0	0.40	88.0	0.0055	1.214	0.283	0.003	1.000	0.005	0.004	0.1	0.1
116	1150	19.2	0.40	88.4	0.0055	1.220	0.286	0.003	1.005	0.005	0.004	0.1	0.1
117	1160	19.3	0.40	88.8	0.0055	1.225	0.289	0.003	1.011	0.005	0.004	0.1	0.1
118	1170	19.5	0.40	89.2	0.0055	1.231	0.292	0.003	1.016	0.005	0.004	0.1	0.1
119	1180	19.7	0.40	89.6	0.0055	1.236	0.295	0.003	1.021	0.005	0.004	0.1	0.1
120	1190	19.8	0.40	90.0	0.0055	1.242	0.298	0.003	1.027	0.005	0.004	0.1	0.1
121	1200	20.0	0.40	90.4	0.0055	1.248	0.301	0.003	1.032	0.005	0.004	0.1	0.1
122	1210	20.2	0.40	90.8	0.0055	1.253	0.304	0.003	1.038	0.005	0.004	0.1	0.1
123	1220	20.3	0.40	91.2	0.0055	1.259	0.307	0.003	1.043	0.005	0.004	0.1	0.1
124	1230	20.5	0.40	91.6	0.0055	1.264	0.310	0.003	1.048	0.005	0.004	0.1	0.1
125	1240	20.7	0.40	92.0	0.0055	1.270	0.313	0.003	1.054	0.005	0.004	0.1	0.1
126	1250	20.8	0.40	92.4	0.0055	1.275	0.317	0.003	1.059	0.005	0.004	0.1	0.1

127	1260	21.0	0.40	92.8	0.0055	1.281	0.320	0.003	1.065	0.005	0.004	0.1	0.1
128	1270	21.2	0.40	93.2	0.0055	1.286	0.323	0.003	1.070	0.005	0.004	0.1	0.1
129	1280	21.3	0.40	93.6	0.0055	1.292	0.326	0.003	1.075	0.005	0.004	0.1	0.1
130	1290	21.5	0.40	94.0	0.0055	1.297	0.329	0.003	1.081	0.005	0.004	0.1	0.1
131	1300	21.7	0.40	94.4	0.0055	1.303	0.332	0.003	1.086	0.005	0.004	0.1	0.1
132	1310	21.8	0.40	94.8	0.0055	1.308	0.336	0.003	1.092	0.005	0.004	0.1	0.1
133	1320	22.0	0.40	95.2	0.0055	1.314	0.339	0.003	1.097	0.005	0.004	0.1	0.1
134	1330	22.2	0.40	95.6	0.0055	1.319	0.342	0.003	1.102	0.005	0.004	0.1	0.1
135	1340	22.3	0.40	96.0	0.0055	1.325	0.345	0.003	1.108	0.005	0.004	0.1	0.1
136	1350	22.5	0.40	96.4	0.0055	1.330	0.348	0.003	1.113	0.005	0.004	0.1	0.1
137	1360	22.7	0.40	96.8	0.0055	1.336	0.352	0.003	1.119	0.005	0.004	0.1	0.1
138	1370	22.8	0.40	97.2	0.0055	1.341	0.355	0.003	1.124	0.005	0.004	0.1	0.1
139	1380	23.0	0.40	97.6	0.0055	1.347	0.358	0.003	1.130	0.005	0.004	0.1	0.1
140	1390	23.2	0.40	98.0	0.0055	1.352	0.361	0.003	1.135	0.005	0.004	0.1	0.1
141	1400	23.3	0.40	98.4	0.0055	1.358	0.365	0.003	1.140	0.005	0.004	0.1	0.1
142	1410	23.5	0.40	98.8	0.0055	1.363	0.368	0.003	1.146	0.005	0.004	0.1	0.1
143	1420	23.7	0.40	99.2	0.0055	1.369	0.371	0.003	1.151	0.005	0.004	0.1	0.1
144	1430	23.8	0.40	99.6	0.0055	1.374	0.375	0.003	1.157	0.005	0.004	0.1	0.1
145	1440	24.0	0.40	100.0	0.0055	1.380	0.378	0.003	1.162	0.005	0.004	0.1	0.1


SBUH Hydrograph for Developed Site Condition 6-Month 24 Hour Storm (Post Development)
Design Flow Rate (cfs)
0.4
0.3
0.2
0.1
0.0
0.0
3.0
6.0
9.0
12.0
15.0
18.0
21.0
24.0
Time (hours)

Stormwater Tabulation

Pre-Dev	Acres Total	Developed Acres	$CN_{pervious}$	Undeveloped Acres	$CN_{impervious}$	CN,ave	Rainfall, P_R [in]	S	0.2S	Qd-Depth [in]	V_r Volume	$Q_{release}$
6 Month	2.59	0	98	2.59	85	85.0	1.38	1.76	0.35	0.38	3552.4	0.041
2 Year	2.59	0	98	2.59	85	85.0	2.2	1.76	0.35	0.94	8880.7	0.103
10 Year	2.59	0	98	2.59	85	85.0	3.2	1.76	0.35	1.76	16524.6	0.191
25 Year	2.59	0	98	2.59	85	85.0	4	1.76	0.35	2.46	23107.5	0.267
100 Year	2.59	0	98	2.59	85	85.0	4.5	1.76	0.35	2.91	27350.8	0.317

Present	Acres Total	Developed Acres	$CN_{pervious}$	Undeveloped Acres	$CN_{impervious}$	CN,ave	Rainfall, P_R [in]	S	0.2S	Qd-Depth [in]	V_r	$Q_{release}$	$Q_{release}$ w/ det.
6 Month	2.59	0.93	98	1.66	85	89.7	1.38	1.15	0.23	0.57	5397.5	0.06	-0.035
2 Year	2.59	0.93	98	1.66	85	89.7	2.2	1.15	0.23	1.24	11682.5	0.14	0.038
10 Year	2.59	0.93	98	1.66	85	89.7	3.2	1.15	0.23	2.14	20114.1	0.23	0.136
25 Year	2.59	0.93	98	1.66	85	89.7	4	1.15	0.23	2.89	27143.2	0.31	0.217
100 Year	2.59	0.93	98	1.66	85	89.7	4.5	1.15	0.23	3.36	31610.1	0.37	0.269

Proposed	Acres Total	Developed Acres	$CN_{pervious}$	Undeveloped Acres	$CN_{impervious}$	CN,ave	Rainfall, P_R [in]	S	0.2S	Qd-Depth [in]	V_r	$Q_{release}$	$Q_{release}$ w/ det.
6 Month	2.59	1.07	98	1.52	85	90.4	1.38	1.07	0.21	0.61	5734.4	0.07	-0.031
2 Year	2.59	1.07	98	1.52	85	90.4	2.2	1.07	0.21	1.29	12159.3	0.14	0.044
10 Year	2.59	1.07	98	1.52	85	90.4	3.2	1.07	0.21	2.20	20698.1	0.24	0.142
25 Year	2.59	1.07	98	1.52	85	90.4	4	1.07	0.21	2.96	27785.2	0.32	0.224
100 Year	2.59	1.07	98	1.52	85	90.4	4.5	1.07	0.21	3.43	32280.5	0.37	0.276

Equations and CN values per 1992 Puget Sound SWMM

S = (1000/CN)-10 "Potential Max Detention"

Q_d = (Rainfall - 0.2S)^2 / (Rainfall + 0.8S) "Runoff Depth"

V_r = (3630 x Qd x Dev Acres)

$Q_{release}$ = (Vr / 24) / 3600

$Q_{release\ w/\ detention}$ = ((Vr - 8400) / 24) / 3600

Note: $Q_{release}$ with detention is less than the original $Q_{release}$

Therefore flow rate is at or below the pre-development rate.

Job: USNR
Date: 5/24/2021
By: WKG

Pipe Calculation - Manning's Equation for Partially Full Pipe

Design Flow Rate

Design Flow Rate, **Q** =	0.400	[ft^3/s]	

Constants

Pipe Diameter, **D** =	0.833	[ft]	
Pipe Radius, **r** =	0.417	[ft]	
Roughness, **n** =	0.013		
Slope, **S** =	0.02		10" Corrugated HDPE pipe
Conversion Constant, **k** =	1.49		

$$\frac{Qn}{1.49 * \sqrt{S}} = \frac{A^{\frac{5}{3}}}{P^{\frac{2}{3}}}$$ Manning's Eq.

$$\frac{Qn}{1.49 * \sqrt{S}} =$$ 0.0247 Solve Constants

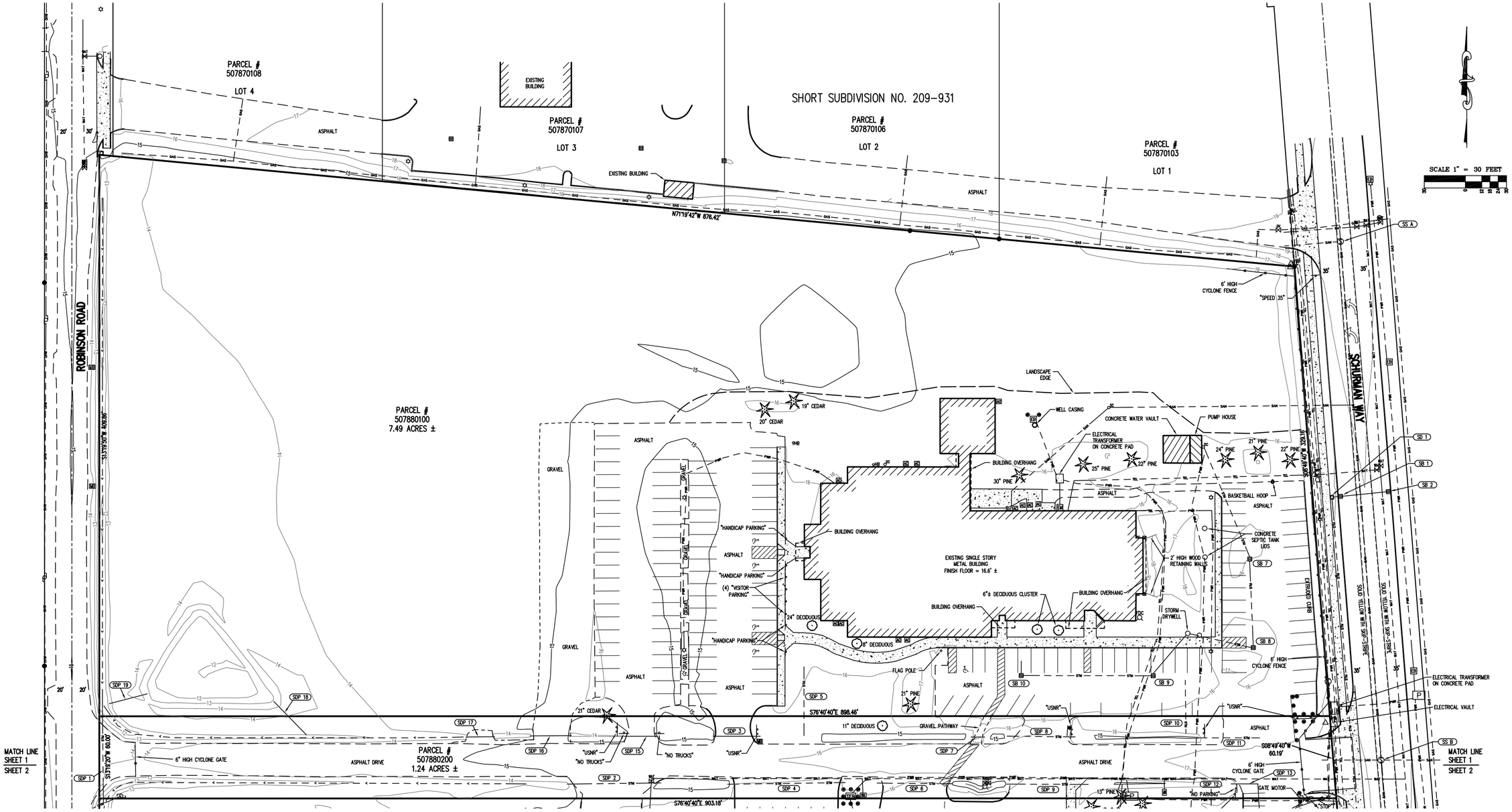
Geometric equations for partially full pipe

$$A = \frac{1}{8}[\theta - \sin(\theta)]D^2$$ Area

$$\mathrm{P} = \frac{1}{2}\theta D$$ Wetted perimeter

Manning's Calculation

Central Angle, **θ** =	2.060	[rad]	Solve for theta with goal seek
Area, **A** =	0.10	[ft^2]	
Wetted Perimeter, **P** =	0.86	[ft]	
Hydraulic Radius, **R** =	0.12	[ft]	
Top Width, **T** =	0.71	[ft]	
Calculated Flow Rate, **Q** =	0.401	[ft^3/s]	Calculated flow matches design flow
Normal Depth, **d** =	0.202	[ft]	
Froude Number, **F$_r$** =	1.82		
(d/D) =	0.243		
Flow Velocity, **V** =	3.923	[ft/s]	V>2ft/s - self cleaning



LEGEND

DECIDUOUS TREE	GAS METER	RIGHT-OF-WAY LINE	
CONIFEROUS TREE	GAS VALVE	BOUNDARY LINE	
FIRE HYDRANT	UTILITY POLE	PROPERTY LINE	
FIRE DEPARTMENT CONNECTION	POWER VAULT	CENTERLINE	
WATER HOSE BIB	ELECTRICAL METER	DITCH	
WATER METER	POWER JUNCTION BOX	CURB	
WATER VALVE	POWER RISER	EDGE OF PAVEMENT	
WATER VAULT	POWER TRANSFORMER	EASEMENT	
WATER MANHOLE	HVAC UNIT	FENCE LINE	
SANITARY SEWER CLEAN OUT	STREET LIGHT	GRAVEL EDGE	
SANITARY SEWER MANHOLE	TELEPHONE/TELEVISION VAULT	POWER LINE	PWR
STORM SEWER CLEAN OUT	TELEPHONE MANHOLE	OVERHEAD WIRE	OHW
STORM SEWER CATCH BASIN	TELEPHONE/TELEVISION JUNCTION BOX	TELEPHONE LINE	TEL
STORM SEWER MANHOLE	TELEPHONE/TELEVISION RISER	GAS LINE	GAS
MAILBOX	SIGN	STORM SEWER LINE	STM
	BOLLARD	SANITARY SEWER LINE	SAN
	FOUND PROPERTY CORNER MONUMENT	WATER LINE	WAT

STORM AND SANITARY SEWER INFORMATION

SS A SANITARY MANHOLE
RIM = 19.41'
12" IE IN (S) = 6.0'
8" IE IN (E) = 11.1'
12" IE OUT (N) = 5.9'

SS B SANITARY MANHOLE
RIM = 15.35'
12" IE IN (S) = 6.7'
8" IE IN (E) = 10.7'
8" IE IN (W) = 7.2'
12" IE OUT (N) = 6.7'

SS C SANITARY MANHOLE
RIM = 17.66'
12" IE IN (S) = 7.5'
8" IE IN (E) = 10.7'
8" IE IN (E) = 7.9'
12" IE OUT (N) = 7.4'

SS D SANITARY MANHOLE
RIM = 17.39'
12" IE IN (S) = 7.6'
8" IE IN (W) = 8.0'
12" IE OUT (N) = 7.6'

SD 1 STORM STRUCTURE
RIM = 19.04'
12" IE IN (E) = 16.1'
12" IE OUT (S) = 16.2'
SUMP = 15.1'

SB 1 STORM CATCH BASIN
RIM = 18.38'
12" IE IN (E) = 16.2'
12" IE OUT (W) = 16.2'
SUMP = 14.5'

SB 2 STORM CATCH BASIN
RIM = 18.51'
12" IE OUT (W) = 16.2'
SUMP = 14.6'

SD 2 STORM STRUCTURE
RIM = 18.36'
12" IE IN (N) = 15.5'
12" IE IN (E) = 15.5'
12" IE OUT (S) = 15.4'
SUMP = 14.5'

SB 3 STORM CATCH BASIN
RIM = 17.61'
12" IE IN (E) = 15.3'
12" IE OUT (W) = 15.4'
SUMP = 13.7'

SB 4 STORM CATCH BASIN
RIM = 17.79'
12" IE OUT (W) = 15.3'
SUMP = 13.8'

SD 3 STORM STRUCTURE
RIM = 17.51'
12" IE IN (N) = 14.8'
12" IE IN (E) = 14.7'
15" IE OUT (S) = 14.7'
SUMP = 13.6'

SB 5 STORM CATCH BASIN
RIM = 16.84'
12" IE IN (E) = 14.8'
12" IE OUT (W) = 14.7'
SUMP = 13.2'

SB 6 STORM CATCH BASIN
RIM = 16.90'
12" IE OUT (W) = 14.8'
SUMP = 13.0'

SB 7 STORM CATCH BASIN
RIM = 15.70'
4" IE IN (NW) = 13.9'
6" IE OUT (S) = 13.9'
SUMP = 12.5'

SB 8 STORM CATCH BASIN
RIM = 15.70'
6" IE IN (N) = 13.5'
6" IE OUT (W) = 13.5'
SUMP = 12.4'

SB 9 STORM CATCH BASIN
RIM = 15.13'
6" IE IN (W) = 13.0'
6" IE OUT (NE) = 13.0'
SUMP = 12.1'

SB 10 STORM CATCH BASIN
RIM = 15.14'
6" IE IN (N) = 13.5'
6" IE OUT (E) = 13.4'
SUMP = 12.4'

SB 11 STORM CATCH BASIN
RIM = 16.63'
6" IE OUT (N) = 15.5'
SUMP = 14.9'

SB 12 STORM CATCH BASIN
RIM = 16.55'
6" IE OUT (S) = 15.3'
SUMP = 14.7'

SB 13 STORM CATCH BASIN
RIM = 14.86'
WATER LEVEL = 13.1'
PUMP INSIDE

SDP 1 STORM DRAIN PIPE
12" CONCRETE
IE IN (N) = 11.3'
IE OUT (S) = 10.9'

SDP 2 STORM DRAIN PIPE
12" HDPE
IE IN (E) = 14.1'
IE OUT (W) = 13.7'

SDP 3 STORM DRAIN PIPE
12" CMP
IE IN (E) = 14.3'
IE OUT (W) = 14.2'

SDP 4 STORM DRAIN PIPE
12" HDPE
IE IN (E) = 14.9'
IE OUT (W) = 14.7'

SDP 5 STORM DRAIN PIPE
4" PVC
IE OUT (S) = 14.5'
UNKNOWN INLET LOCATION

SDP 6 STORM DRAIN PIPE
12" CONCRETE
IE IN (E) = 14.3'
IE OUT (W) = 14.2'

SDP 7 STORM DRAIN PIPE
12" HDPE
IE IN (E) = 14.4'
IE OUT (W) = 14.2'

SDP 8 STORM DRAIN PIPE
12" CONCRETE
IE IN (E) = 14.6'
IE OUT (W) = 14.2'

SDP 9 STORM DRAIN PIPE
12" CONCRETE
IE IN (E) = 14.5'
IE OUT (W) = 14.1'

SDP 10 STORM DRAIN PIPE
4" PVC
IE OUT (S) = 15.2'
UNKNOWN INLET LOCATION

SDP 11 STORM DRAIN PIPE
12" CONCRETE
IE OUT (W) = 15.0'
UNKNOWN INLET LOCATION

SDP 12 STORM DRAIN PIPE
4" PVC
IE OUT (N) = 15.7'
UNKNOWN INLET LOCATION

SDP 13 STORM DRAIN PIPE
12" CONCRETE
IE OUT (W) = 15.4'

SDP 14 STORM DRAIN PIPE
8" PVC
IE OUT (S) = 13.6'
UNKNOWN INLET LOCATION

SDP 15 STORM DRAIN PIPE
12" CONCRETE
IE IN (E) = 14.2'
IE OUT (W) = 14.0'

SDP 16 STORM DRAIN PIPE
12" PLASTIC
IE IN (E) = 13.9'
IE OUT (W) = 13.7'

SDP 17 STORM DRAIN PIPE
12" PLASTIC
IE IN (E) = 13.6'
IE OUT (W) = 13.5'

SDP 18 STORM DRAIN PIPE
6" PLASTIC
IE IN (NW) = 13.2'
IE OUT (SE) = 13.2'

SDP 19 STORM DRAIN PIPE
6" PLASTIC
IE IN (NE) = 13.3'
IE OUT (SW) = 13.1'

NOTES

1) THE FIELD SURVEY FOR THIS MAP WAS COMPLETED ON JULY 8, 2013. ON MAY 10, 2021 FIELD WORK WAS PERFORMED TO DEFINE THE EXPANDED PARKING LOT AND NEW DRAINAGE SWALE ON THE NORTH PARCEL. THE REMAINDER OF THE SITE WAS NOT CHECKED AND ADDITIONAL SITE MODIFICATIONS THAT HAVE OCCURRED SINCE 2013 ARE NOT REFLECTED HEREON.

2) ELEVATIONS AND CONTOURS ARE BASED ON WASHDOT MONUMENT ID #4082. THE BENCHMARK IS A STAINLESS STEEL ROD WITHOUT A SLEEVE AT THE NORTH END OF THE NORTHBOUND ON-RAMP OF EXIT 22 OFF INTERSTATE-5, AND HAS AN ELEVATION OF 39.947 FEET ON THE NAVD 88 DATUM.

3) ALL CURB ON THE SOUTH PROPERTY IS EXTRUDED. THERE IS EXTRUDED CURB ON THE NORTH PROPERTY WHERE NOTED.

4) THE UNDERGROUND UTILITIES ARE BASED ON THE MARKINGS PER LOCATE TICKET NUMBER 13166011 AND A PRIVATE UTILITY LOCATING COMPANY.

UTILITY STATEMENT

THE UNDERGROUND UTILITIES SHOWN HAVE BEEN LOCATED FROM FIELD SURVEY INFORMATION AND EXISTING DRAWINGS. THE SURVEYOR MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. THE SURVEYOR FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED ALTHOUGH HE DOES CERTIFY THAT THEY ARE LOCATED AS ACCURATELY AS POSSIBLE FROM INFORMATION AVAILABLE. THE SURVEYOR HAS NOT PHYSICALLY LOCATED THE UNDERGROUND UTILITIES.

NORTHWEST SURVEYING, Inc.
PO BOX 1177 BEVERTON, OR 97007
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EMAIL: nwsurveying@nwsurvy.com

TOPOGRAPHIC SURVEY

LOCATED IN THE SE 1/4 OF SECTION 11, SW 1/4 OF SECTION 12, NW 1/4 OF SECTION 13 AND NE 1/4 OF SECTION 14, TOWNSHIP 5 NORTH, RANGE 1 WEST, W.M., CITY OF WOODLAND, COWLITZ COUNTY, WASHINGTON

WOODLAND, WASHINGTON

DRAWING NO.: 968 TOPO2
SCALE: AS NOTED
DRAWING GENERATED BY LD2004
DRAWN BY: CW
CHECKED BY: SFF

PREPARED FOR:
USNR
1981 SCHURMAN WAY
WOODLAND, WA 98674
PHONE: (503) 226-1972

REVISIONS:
INITIAL RELEASE: JULY 17, 2013
UPDATED TOPO: MAY 13, 2021

JOB NUMBER **968**

SHEET **1 OF 2**

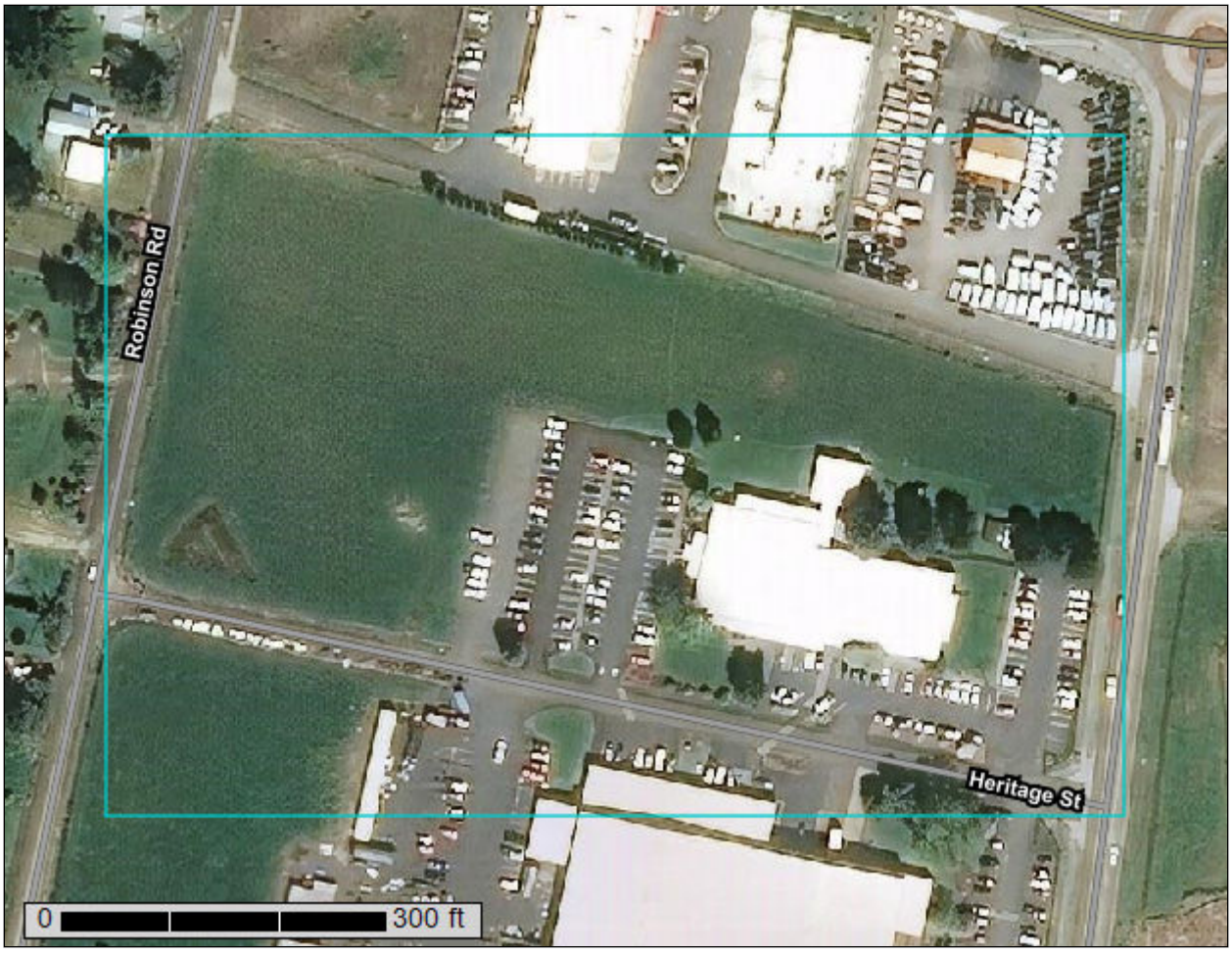
United States Department of Agriculture

NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Cowlitz County, Washington



Preface

Soil surveys contain information that affects land use planning in survey areas. They highlight soil limitations that affect various land uses and provide information about the properties of the soils in the survey areas. Soil surveys are designed for many different users, including farmers, ranchers, foresters, agronomists, urban planners, community officials, engineers, developers, builders, and home buyers. Also, conservationists, teachers, students, and specialists in recreation, waste disposal, and pollution control can use the surveys to help them understand, protect, or enhance the environment.

Various land use regulations of Federal, State, and local governments may impose special restrictions on land use or land treatment. Soil surveys identify soil properties that are used in making various land use or land treatment decisions. The information is intended to help the land users identify and reduce the effects of soil limitations on various land uses. The landowner or user is responsible for identifying and complying with existing laws and regulations.

Although soil survey information can be used for general farm, local, and wider area planning, onsite investigation is needed to supplement this information in some cases. Examples include soil quality assessments (http://www.nrcs.usda.gov/wps/portal/nrcs/main/soils/health/) and certain conservation and engineering applications. For more detailed information, contact your local USDA Service Center (https://offices.sc.egov.usda.gov/locator/app?agency=nrcs) or your NRCS State Soil Scientist (http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/contactus/?cid=nrcs142p2_053951).

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

The National Cooperative Soil Survey is a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local agencies. The Natural Resources Conservation Service (NRCS) has leadership for the Federal part of the National Cooperative Soil Survey.

Information about soils is updated periodically. Updated information is available through the NRCS Web Soil Survey, the site for official soil survey information.

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Contents

How Soil Surveys Are Made

Soil surveys are made to provide information about the soils and miscellaneous areas in a specific area. They include a description of the soils and miscellaneous areas and their location on the landscape and tables that show soil properties and limitations affecting various uses. Soil scientists observed the steepness, length, and shape of the slopes; the general pattern of drainage; the kinds of crops and native plants; and the kinds of bedrock. They observed and described many soil profiles. A soil profile is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed or from the surface down to bedrock. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biological activity.

Currently, soils are mapped according to the boundaries of major land resource areas (MLRAs). MLRAs are geographically associated land resource units that share common characteristics related to physiography, geology, climate, water resources, soils, biological resources, and land uses (USDA, 2006). Soil survey areas typically consist of parts of one or more MLRA.

The soils and miscellaneous areas in a survey area occur in an orderly pattern that is related to the geology, landforms, relief, climate, and natural vegetation of the area. Each kind of soil and miscellaneous area is associated with a particular kind of landform or with a segment of the landform. By observing the soils and miscellaneous areas in the survey area and relating their position to specific segments of the landform, a soil scientist develops a concept, or model, of how they were formed. Thus, during mapping, this model enables the soil scientist to predict with a considerable degree of accuracy the kind of soil or miscellaneous area at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-vegetation-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, reaction, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. Soil taxonomy, the system of taxonomic classification used in the United States, is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil

scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

The objective of soil mapping is not to delineate pure map unit components; the objective is to separate the landscape into landforms or landform segments that have similar use and management requirements. Each map unit is defined by a unique combination of soil components and/or miscellaneous areas in predictable proportions. Some components may be highly contrasting to the other components of the map unit. The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The delineation of such landforms and landform segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, onsite investigation is needed to define and locate the soils and miscellaneous areas.

Soil scientists make many field observations in the process of producing a soil map. The frequency of observation is dependent upon several factors, including scale of mapping, intensity of mapping, design of map units, complexity of the landscape, and experience of the soil scientist. Observations are made to test and refine the soil-landscape model and predictions and to verify the classification of the soils at specific locations. Once the soil-landscape model is refined, a significantly smaller number of measurements of individual soil properties are made and recorded. These measurements may include field measurements, such as those for color, depth to bedrock, and texture, and laboratory measurements, such as those for content of sand, silt, clay, salt, and other components. Properties of each soil typically vary from one point to another across the landscape.

Observations for map unit components are aggregated to develop ranges of characteristics for the components. The aggregated values are presented. Direct measurements do not exist for every property presented for every map unit component. Values for some properties are estimated from combinations of other properties.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpret the data from these analyses and tests as well as the field-observed characteristics and the soil properties to determine the expected behavior of the soils under different uses. Interpretations for all of the soils are field tested through observation of the soils in different uses and under different levels of management. Some interpretations are modified to fit local conditions, and some new interpretations are developed to meet local needs. Data are assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management are assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree of accuracy that a given soil will have a high water table within certain depths in most years, but they cannot predict that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and

identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

The soil map section includes the soil map for the defined area of interest, a list of soil map units on the map and extent of each map unit, and cartographic symbols displayed on the map. Also presented are various metadata about data used to produce the map, and a description of each soil map unit.

Map Scale: 1:1,610 if printed on A landscape (11" x 8.5") sheet.

N

Meters
0 20 40 80 120

Feet
0 50 100 200 300

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

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Cowlitz County, Washington
Survey Area Data: Version 21, Jun 4, 2020

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

Date(s) aerial images were photographed: Apr 26, 2019—Jun 11, 2019

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
127	Maytown silt loam, 0 to 3 percent slopes	10.7	79.4%
141	Newberg fine sandy loam, 0 to 3 percent slopes	2.8	20.6%
Totals for Area of Interest		**13.5**	**100.0%**

Map Unit Descriptions

The map units delineated on the detailed soil maps in a soil survey represent the soils or miscellaneous areas in the survey area. The map unit descriptions, along with the maps, can be used to determine the composition and properties of a unit.

A map unit delineation on a soil map represents an area dominated by one or more major kinds of soil or miscellaneous areas. A map unit is identified and named according to the taxonomic classification of the dominant soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural phenomena, and they have the characteristic variability of all natural phenomena. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of other taxonomic classes. Consequently, every map unit is made up of the soils or miscellaneous areas for which it is named and some minor components that belong to taxonomic classes other than those of the major soils.

Most minor soils have properties similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting, or similar, components. They may or may not be mentioned in a particular map unit description. Other minor components, however, have properties and behavioral characteristics divergent enough to affect use or to require different management. These are called contrasting, or dissimilar, components. They generally are in small areas and could not be mapped separately because of the scale used. Some small areas of strongly contrasting soils or miscellaneous areas are identified by a special symbol on the maps. If included in the database for a given area, the contrasting minor components are identified in the map unit descriptions along with some characteristics of each. A few areas of minor components may not have been observed, and consequently they are not mentioned in the descriptions, especially where the pattern was so complex that it was impractical to make enough observations to identify all the soils and miscellaneous areas on the landscape.

The presence of minor components in a map unit in no way diminishes the usefulness or accuracy of the data. The objective of mapping is not to delineate pure taxonomic classes but rather to separate the landscape into landforms or landform segments that have similar use and management requirements. The delineation of such segments on the map provides sufficient information for the development of resource plans. If intensive use of small areas is planned, however,

onsite investigation is needed to define and locate the soils and miscellaneous areas.

An identifying symbol precedes the map unit name in the map unit descriptions. Each description includes general facts about the unit and gives important soil properties and qualities.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer, slope, stoniness, salinity, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Alpha silt loam, 0 to 2 percent slopes, is a phase of the Alpha series.

Some map units are made up of two or more major soils or miscellaneous areas. These map units are complexes, associations, or undifferentiated groups.

A *complex* consists of two or more soils or miscellaneous areas in such an intricate pattern or in such small areas that they cannot be shown separately on the maps. The pattern and proportion of the soils or miscellaneous areas are somewhat similar in all areas. Alpha-Beta complex, 0 to 6 percent slopes, is an example.

An *association* is made up of two or more geographically associated soils or miscellaneous areas that are shown as one unit on the maps. Because of present or anticipated uses of the map units in the survey area, it was not considered practical or necessary to map the soils or miscellaneous areas separately. The pattern and relative proportion of the soils or miscellaneous areas are somewhat similar. Alpha-Beta association, 0 to 2 percent slopes, is an example.

An *undifferentiated group* is made up of two or more soils or miscellaneous areas that could be mapped individually but are mapped as one unit because similar interpretations can be made for use and management. The pattern and proportion of the soils or miscellaneous areas in a mapped area are not uniform. An area can be made up of only one of the major soils or miscellaneous areas, or it can be made up of all of them. Alpha and Beta soils, 0 to 2 percent slopes, is an example.

Some surveys include *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Rock outcrop is an example.

Cowlitz County, Washington

127—Maytown silt loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2f2r
Elevation: 50 to 500 feet
Mean annual precipitation: 45 to 70 inches
Mean annual air temperature: 50 to 52 degrees F
Frost-free period: 165 to 195 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Maytown and similar soils: 80 percent
Minor components: 10 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Maytown

Setting

Landform: Flood plains
Parent material: Alluvium

Typical profile

H1 - 0 to 18 inches: silt loam
H2 - 18 to 36 inches: silt loam, silty clay loam
H2 - 18 to 36 inches: silty clay loam, silt loam
H3 - 36 to 60 inches:
H3 - 36 to 60 inches:

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Moderately well drained
Capacity of the most limiting layer to transmit water (Ksat): Moderately high (0.20 to 0.57 in/hr)
Depth to water table: About 30 to 42 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Available water capacity: Very high (about 19.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: C
Forage suitability group: Soils with Few Limitations (G002XV502WA)
Other vegetative classification: Soils with Few Limitations (G002XV502WA)
Hydric soil rating: No

Minor Components

Godfrey

Percent of map unit: 10 percent
Hydric soil rating: Yes

141—Newberg fine sandy loam, 0 to 3 percent slopes

Map Unit Setting

National map unit symbol: 2f3d
Elevation: 10 to 1,500 feet
Mean annual precipitation: 18 to 60 inches
Mean annual air temperature: 50 to 54 degrees F
Frost-free period: 165 to 210 days
Farmland classification: Prime farmland if protected from flooding or not frequently flooded during the growing season

Map Unit Composition

Newberg and similar soils: 85 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Newberg

Setting

Landform: Flood plains
Parent material: Alluvium

Typical profile

H1 - 0 to 10 inches: fine sandy loam
H2 - 10 to 28 inches: very fine sandy loam, sandy loam, fine sandy loam
H2 - 10 to 28 inches: fine sandy loam, loamy fine sand, loamy very fine sand
H2 - 10 to 28 inches:
H3 - 28 to 60 inches:
H3 - 28 to 60 inches:
H3 - 28 to 60 inches:

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Well drained
Capacity of the most limiting layer to transmit water (Ksat): High (1.98 to 5.95 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: NoneOccasional
Frequency of ponding: None
Available water capacity: Very high (about 20.1 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 3w
Hydrologic Soil Group: A
Forage suitability group: Soils with Few Limitations (G002XV502WA)
Other vegetative classification: Soils with Few Limitations (G002XV502WA)
Hydric soil rating: No

Minor Components

Chehalis

Percent of map unit: 5 percent
Hydric soil rating: No

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