Exhibit I: Preliminary Stormwater Report

Autumn Sunrise Subdivision
Tualatin, Oregon

Preliminary Stormwater Report

Date:	July 2021
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AKS Job Number:	7454

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Preliminary Stormwater Report

AUTUMN SUNRISE SUBDIVISION
TUALATIN, OREGON

1.0 Purpose of Report

This report analyzes the effects of the proposed development with respect to the existing and proposed stormwater conveyance system. Evaluation of the stormwater system includes documentation of regulatory criteria, methodology, and informational sources used to design/evaluate the stormwater system. The results of the preliminary hydraulic analysis are presented.

2.0 Project Location/Description

The proposed residential subdivision will be located southeast of the SW Norwood Road and SW Lower Boones Ferry Road intersection in Tualatin, Oregon. The project site is approximately 61.7 acres in size and consists of various tax lots (Washington County Tax Lots 100, 400, 401, 500, 501, 600, 800, and 900 – Tax Map 2S 1 35D). A portion of the subject site, approximately 3.9 acres, is reserved for future development as commercial.

The Autumn Sunrise subdivision will include the creation of a 400-lot residential subdivision for single-family attached and detached homes. The project will include frontage street improvements to SW Lower Boones Ferry Road and SW Norwood Road along with construction of new interior local streets and all applicable utilities. Two onsite stormwater facilities, located in the southwest corner of property and the middle of the northern portion of the site, will be constructed releasing flows into the Lower Boones Ferry drainage located to the west and ODOT right of way located to the east. The stormwater facilities will manage proposed developed site stormwater runoff. For purposes of this report, the site stormwater facilities drainage locations will be referred to as western and eastern basins.

3.0 Regulatory Design Criteria

3.1 STORMWATER QUANTITY

Per *Clean Water Services (CWS) Design and Construction Standards Manual for Sanitary Sewer and Surface Water Management (R&O 19-05), Section 4.02, Quantity Control Requirements for Conveyance Capacity;* on-site detention for conveyance capacity (25-year storm event) is required when any of the following conditions exist:

1. *There is an identified downstream deficiency and the District or City determines that detention rather than conveyance system enlargement is the more effective solution.*
2. *There is an identified regional detention site within the boundary of the development.*
3. *Water quantity facilities are required by District-adopted watershed management plans or adopted subbasin master plans.*

Per City standards, the stormwater facilities must be designed to detain the subject site's post-developed 25-year storm event peak flow to the site pre-developed 25-year storm event peak flow.

Per ODOT hydraulic manual standards, the eastern stormwater facility must provide site post-developed 50-year storm event peak flow to the site pre-developed 50-year storm event peak flow.

3.2 STORMWATER HYDROMODIFICATION

Per *CWS R&O 19-05, Section 4.03, Hydromodification Approach Requirements;* stormwater hydromodification is required unless the project meets any of the following criteria:

1. *The project results in the addition and/or modification of less than 12,000 square feet of impervious surface.*

2. *The project is located in an area with a District approved subbasin strategy with an identified regional stormwater management approach for hydromodification.*

Per listed criteria in the Hydromodification Approach Project Category Table 4-2, the subject project is identified as Category 3. Therefore, the subject project will meet CWS hydromodification requirements by providing peak-flow matching detention, using the design criteria established within CWS Section 4.08.6.

3.3 STORMWATER QUALITY

The proposed project must meet CWS and ODOT stormwater quality standards, providing stormwater treatment to all impervious surface's runoff. Comparing the two jurisdictional standards, it has been determined CWS has the stricter design and construction policy. Therefore, the proposed project will be designed per CWS standards. Stormwater quality management for this project will be provided by extended dry detention basins. The stormwater facilities have been designed per CWS standards as established in section 4.04.

4.0 Design Methodology

The Santa Barbara Urban Hydrograph (SBUH) Method was used to analyze stormwater runoff from the site. This method utilizes the SCS Type 1A 24-hour design storm. HydroCAD 10.0 computer software aided in the analysis. Representative CN numbers were obtained from the USDA-NCRS Technical Release 55 (TR-55) and are included in Appendix E.

5.0 Design Parameters

5.1 DESIGN STORMS

Per CWS and ODOT requirements, the following rainfall intensities and durations were used in analyzing the existing and proposed hydrologic site conditions:

Table 5-1: Rainfall Intensities

Recurrence Interval (Years)	Storm Period (hours)	Total Precipitation Depth (Inches)
WQ	4	0.36
2	24	2.50
5	24	3.10
10	24	3.45
25	24	3.90
50	24	4.40

5.2 PRE-DEVELOPED SITE CONDITIONS

5.2.1 Site Topography

Existing on-site grades vary from ±1% to ±30%, with a high point of ±355 feet along the northern and western property line and a low point of ±309 feet near the northeast property corner. The northern portion of the site slopes from west to east and the southern portion slopes from north to south.

5.2.2 Existing Land Use

The existing sites consists of commercial and residential zones with native forest and two single-family detached homes with associated buildings and vacant land, partially used for agricultural purposes.

5.3 SOIL TYPE

The soils beneath the project site and the associated drainage basins consist of silty clay residual soils with abundant rock fragments underlain by weathered basalt bedrock. Per the site geotechnical observations and report the soils underlying the site classify as Hydrologic Soil Group C. Further information regarding site geology can be found in Appendix D of this report.

5.4 POST-DEVELOPED SITE CONDITIONS

5.4.1 Site Topography

The onsite slopes will be modified with cuts and fills to accommodate the construction of the streets and residential lots. The proposed site grading will change the existing site topography within the southeast portion of the site.

5.4.2 Proposed Land Use

The site land-use will consist of single-family residential with the construction of a new 400-lot subdivision, two commercial lots, streets, and utilities.

5.4.3 Post-Developed Input Parameters

Appendices A and B provide the HydroCAD reports and input parameters that were generated for the analyzed storm events with respect to the drainage basins contributing to the subdivision. These reports include all the parameters (e.g., impervious/pervious areas, time of concentration, etc.) used to model the site hydrology.

5.4.4 Description of Off-Site Contributing Basins

Adjacent to the subject site is Horizon School, Interstate 5, and Washington County owned streets. A portion of the existing streets, City owned reservoir property, and adjacent property frontage will be routed and managed through the proposed development.

6.0 Stormwater Analyses

6.1 PROPOSED STORMWATER CONDUIT SIZING AND INLET SPACING

The proposed on-site curb inlets will be spaced per City and CWS requirements to properly convey stormwater runoff. The proposed storm pipes will be sized to meet City and CWS sizing requirements using Manning's equation to convey the peak flows from the 25-year storm event.

6.2 PROPOSED STORMWATER QUALITY MANAGEMENT

Stormwater quality for the proposed project will be provided via two extended dry basins, designed per CWS Design and Construction Standards. The extended dry basins have been sized to treat impervious area runoff created by the proposed project and future commercial lot development. For design purposes, the commercial lots were assumed to be 85 percent impervious.

The water quality volume will be routed through the proposed extended dry basins which will provide water quality treatment per CWS standards. Detailed calculations and checks against CWS criteria are included in the Appendices.

6.3 STORMWATER HYDROMODIFICATION MANAGEMENT

The proposed project will generate approximately 41.3 acres of impervious area, thus classifying as a Large Project. Per CWS Hydromod Planning Tool, the subject site is located within an expansion area and drains into a high-risk level exiting stream. Based on these parameters and CWS Table 4-2, the subject project is within Category 3 Hydromodification Approach.

Per CWS Category 3, the subject site will provide peak-flow matching detention, using design criteria in CWS Section 4.08.6. Specifically, the subject site post-developed 2-year storm event runoff flows will not exceed the site pre-developed 50% of 2-year storm event runoff flows and will match the 5-year and 10-year flows.

Table 6-1: Total Pre and Post Developed Flows

Recurrence Interval (Years)	Peak Pre-Development Flows (cfs)	Peak Post-Development Flows (cfs)	Peak Flow Increase or (Decrease) – (cfs)
2	*5.03	4.86	(0.17)
5	14.27	8.15	(6.12)
10	17.69	11.41	(6.28)

*Peak pre-developed flow for 2-year storm event is calculated by subtracting 50% of the subject site (Basins 10S, 20S, 30S, 40S, 50S, 60S, 70S, and 110S) peak flow from the total pre-developed peak flow.

6.4 STORMWATER QUANTITY CONTROL FACILITY DESIGN

The proposed project provides stormwater quantity management by utilizing extended dry basins designed per CWS, City, and ODOT standards (ODOT standards only applicable to east facility). The following tables outline the results of the extended dry basin outflow which limits the post-development peak flows to less than the allowable pre-development peak flows for each storm event, as outlined within CWS and ODOT stormwater detention management requirements. The peak flows were computed by analyzing flows at the western and eastern release points (i.e. western and eastern basins).

Table 6-2: West Facility Pre and Post Developed Flows

Recurrence Interval (Years)	Peak Pre-Development Flows (cfs)	Peak Post-Development Flows (cfs)	Peak Flow Increase or (Decrease) – (cfs)
2	6.45	3.65	(2.80)
10	11.77	9.42	(2.35)
25	14.45	14.17	(0.28)

The extended dry basin has been designed per CWS requirements with at least 1-foot of freeboard, during the 25-year storm event, and a permanent pool storage depth of 0.2 feet.

Table 6-3: East Facility Pre and Post Developed Flows			
Recurrence Interval (Years)	Peak Pre-Development Flows (cfs)	Peak Post-Development Flows (cfs)	Peak Flow Increase or (Decrease) – (cfs)
2	2.51	1.91	(0.60)
10	5.94	4.59	(1.35)
25	7.89	6.87	(1.02)
50	10.23	10.18	(0.05)

The extended dry basin has been designed per CWS and ODOT requirements with at least 1-foot of freeboard, during the 50-year storm event, and a permanent pool storage depth of 0.2 feet.

The proposed extended dry basins have sufficient capacity to detain the required post-developed site flows to less than or equal to the allowable pre-developed site flows, for each respective basin, and meets the requirements established by Clean Water Service's *Design and Construction for Sanitary Sewer and Surface Water Management Manual* (R&O 19-05) and ODOT Hydraulics Manual.

6.5 DOWNSTREAM ANALYSIS

6.5.1 Western Basin

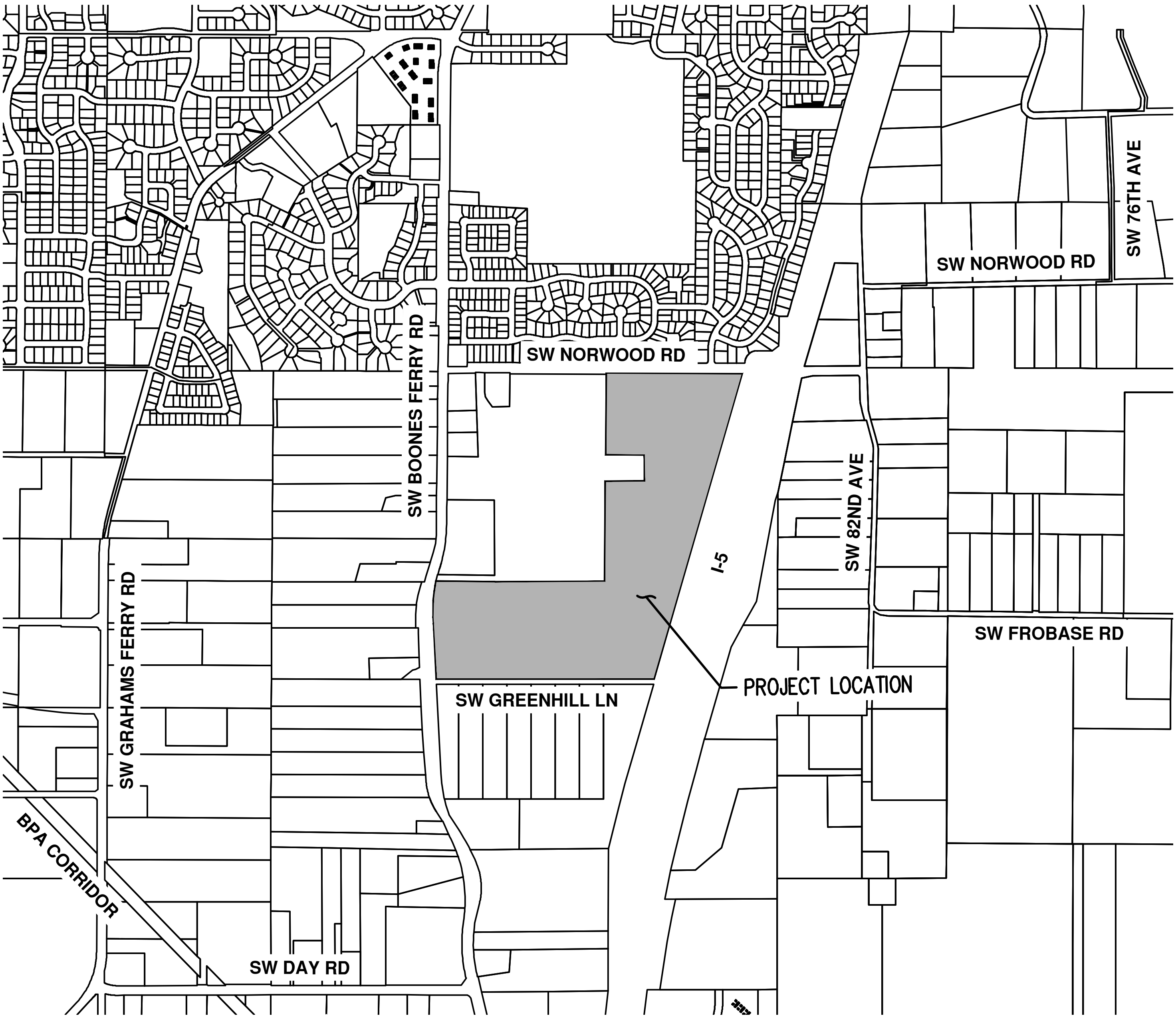
Stormwater runoff from the project site will be conveyed and directed into the existing Lower Boones Ferry Road stormwater system. The proposed western stormwater facility will release flows into an existing 24" pipe, located within Boones Ferry Road in the southwest corner of subject site. From there, runoff is directed westerly into an existing drainage way, flowing towards the south.

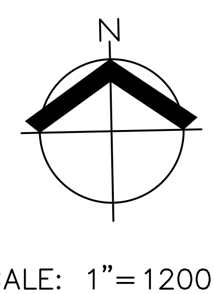
A quarter mile downstream visual investigation of the storm system was performed, and no obstructions were found.

6.5.2 Eastern Basin

Stormwater runoff from the project site will be conveyed and directed into the existing Interstate 5 drainage channel. The proposed eastern stormwater facility will release flows into a proposed 24" pipe, discharging into an existing ODOT I-5 channel. From there, runoff is conveyed to the south along I-5 roadway.

A quarter mile downstream visual investigation of the storm system was performed, and no obstructions were found.





SCALE: 1"=1200 FEET

1200 0 300 600 1200

ORIGINAL PAGE SIZE: 11" x 8.5"

DATE: 07/01/2021

SITE VICINITY MAP AUTUMN SUNRISE	FIGURE 1
AKS ENGINEERING & FORESTRY, LLC 12965 SW HERMAN RD, STE 100 TUALATIN, OR 97062 503.563.6151 WWW.AKS-ENG.COM	DRWN: JSM CHKD: DS AKS JOB: 7454

DWG: VICINITY MAP | LAYOUT1

DATE: 07/01/2021

PRE-DEVELOPED BASIN DELINEATION

AUTUMN SUNRISE SUBDIVISION

AKS ENGINEERING & FORESTRY, LLC
12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
503.563.6151 WWW.AKS-ENG.COM

FIGURE 2

DRWN: JSM
CHKD: DS
AKS JOB: 7454

DWG: PRE-DEVELOPED | LAYOUT1

SCALE: 1"=250 FEET

250 0 50 125 250

DATE: 07/01/2021

POST-DEVELOPED BASIN DELINEATION	FIGURE 3
AUTUMN SUNRISE SUBDIVISION	
AKS ENGINEERING & FORESTRY, LLC 12965 SW HERMAN RD, STE 100 TUALATIN, OR 97062 503.563.6151 WWW.AKS-ENG.COM	DRWN: JSM CHKD: DS AKS JOB: 7454

DWG: POST-DEVELOPED | LAYOUT1

POST-DEVELOPED IMPERVIOUS AREA TABLE	
PROPOSED IMPERVIOUS AREA RECEIVING TREATMENT	1,643,470 SF
PROPOSED COMMERCIAL (LOTS 251 AND 252) IMPERVIOUS AREA RECEIVING TREATMENT	74,761
PROPOSED UNTREATABLE IMPERVIOUS AREA	8,091 SF
EXISTING UNTREATED IMPERVIOUS AREA RECEIVING TREATMENT WITHIN PROPOSED FACILIES	70,669 SF
REQUIRED IMPERVIOUS AREA TO TREAT	1,726,322 SF
IMPERVIOUS AREA TREATMENT PROVIDED	1,788,900 SF
NET TOTAL	+62,578 SF

— INDICATES PROPOSED IMPERVIOUS AREA RECEIVING TREATMENT
2,640 SQ. FT. ASSUMED FOR ALL LOTS
74,761 SQ. FT. (85% OF NET) ASSUMED FOR FUTURE LOTS 251 AND 252 - COMMERCIAL AREAS

— INDICATES PROPOSED IMPERVIOUS AREA UNABLE TO BE TREATED

— INDICATES EXISTING UNTREATED IMPERVIOUS AREA TO BE TREATED WITHIN THE PROPOSED FACILITY

SCALE: 1"= 250 FEET

250 0 50 125 250

N

DATE: 07/01/2021

WATER QUALITY TREATMENT MAP

FIGURE 4

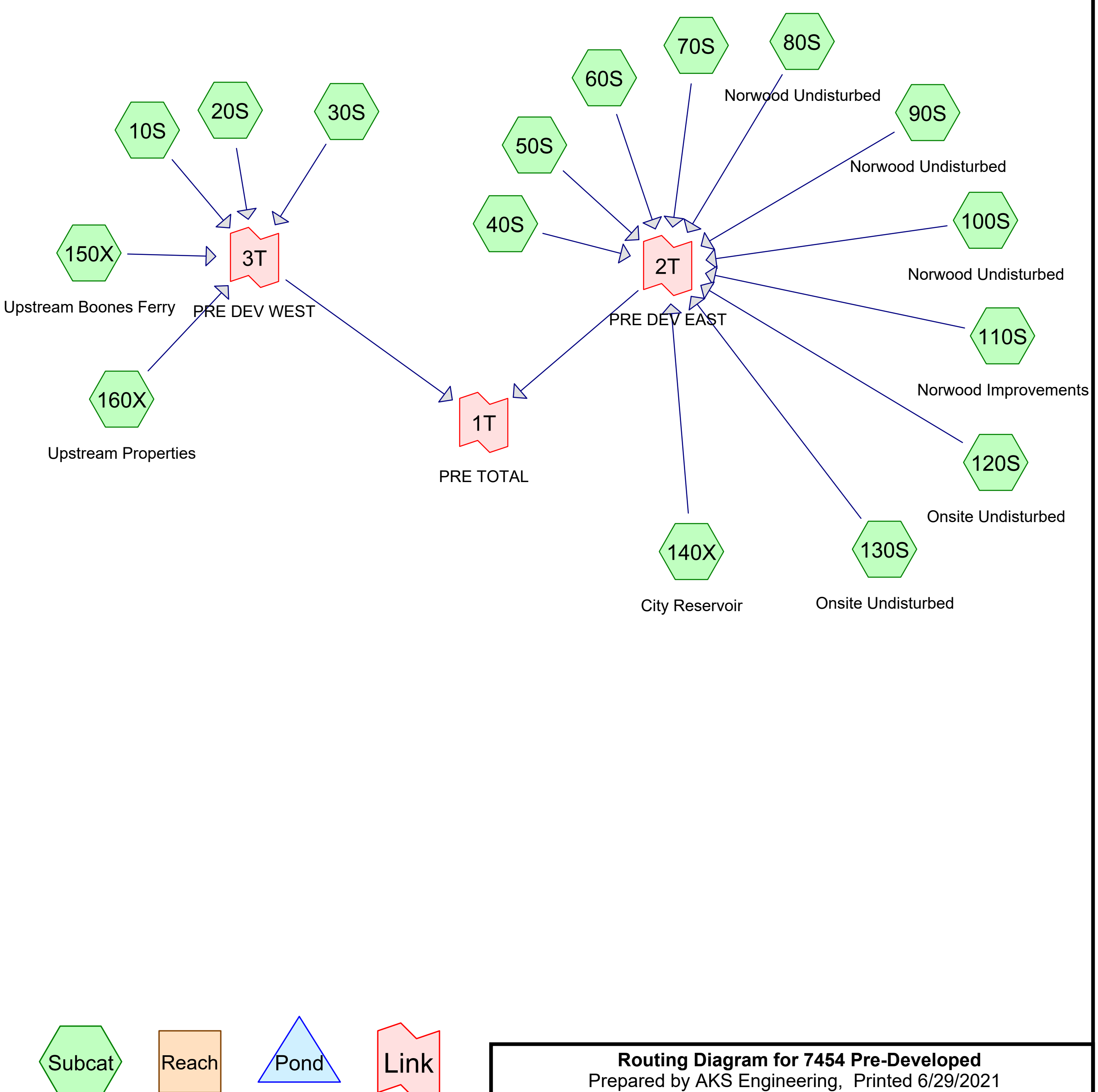
AUTUMN SUNRISE SUBDIVISION

AKS ENGINEERING & FORESTRY, LLC
12965 SW HERMAN RD, STE 100
TUALATIN, OR 97062
503.563.6151 WWW.AKS-ENG.COM

DRWN: JSM
CHKD: DS
AKS JOB: 7454

DWG: TREATMENT MAP | SP-00

Appendix A: HydroCAD Reports for Pre-Developed Condition Storm Events (25-Year Storm Event Analysis) (50-Year Storm Event Summary) (10-Year Storm Event Summary) (5-Year Storm Event Summary) (2-Year Storm Event Summary)



Routing Diagram for 7454 Pre-Developed
Prepared by AKS Engineering, Printed 6/29/2021
HydroCAD® 10.00-22 s/n 05095 © 2018 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
199,375	79	50-75% Grass cover, Fair, HSG C (80S, 90S, 100S, 110S, 160X)
46,914	86	<50% Grass cover, Poor, HSG C (140X)
8,685	74	>75% Grass cover, Good, HSG C (150X)
168,971	87	Dirt roads, HSG C (10S, 20S, 30S)
123,564	82	Farmsteads, HSG C (10S)
2,000	89	Gravel roads, HSG C (30S)
18,835	96	Gravel surface, HSG C (10S, 160X)
81,956	98	Impervious Area (80S, 90S, 100S, 110S, 150X, 160X)
1,920	98	Paved parking, HSG C (20S, 30S)
14,216	98	Paved roads w/curbs & sewers, HSG C (140X)
1,044,944	85	Row crops, straight row, Good, HSG C (10S, 20S, 30S, 40S)
7,483	98	Unconnected roofs, HSG C (10S, 30S)
123,094	73	Woods, Fair, HSG C (50S)
1,042,216	70	Woods, Good, HSG C (60S, 70S, 120S, 130S)
171,927	82	Woods/grass comb., Poor, HSG C (50S)
3,056,100	**79**	**TOTAL AREA**

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment10S: Runoff Area=407,524 sf 1.28% Impervious Runoff Depth>2.28"
Flow Length=650' Tc=17.2 min CN=84/98 Runoff=4.45 cfs 77,497 cf

Subcatchment20S: Runoff Area=166,164 sf 0.80% Impervious Runoff Depth>2.44"
Flow Length=465' Tc=23.3 min CN=86/98 Runoff=1.82 cfs 33,774 cf

Subcatchment30S: Runoff Area=643,684 sf 0.45% Impervious Runoff Depth>2.34"
Flow Length=624' Tc=26.9 min CN=85/98 Runoff=6.36 cfs 125,741 cf

Subcatchment40S: Runoff Area=137,415 sf 0.00% Impervious Runoff Depth>2.36"
Flow Length=280' Tc=11.5 min CN=85/0 Runoff=1.72 cfs 26,979 cf

Subcatchment50S: Runoff Area=295,021 sf 0.00% Impervious Runoff Depth>1.78"
Flow Length=1,575' Tc=29.0 min CN=78/0 Runoff=1.90 cfs 43,727 cf

Subcatchment60S: Runoff Area=250,731 sf 0.00% Impervious Runoff Depth>1.22"
Flow Length=1,650' Tc=46.2 min CN=70/0 Runoff=0.71 cfs 25,581 cf

Subcatchment70S: Runoff Area=754,638 sf 0.00% Impervious Runoff Depth>1.22"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=2.05 cfs 76,724 cf

Subcatchment80S: Norwood Undisturbed Runoff Area=7,546 sf 15.66% Impervious Runoff Depth>2.16"
Tc=5.0 min CN=79/98 Runoff=0.09 cfs 1,356 cf

Subcatchment90S: Norwood Undisturbed Runoff Area=26,839 sf 13.26% Impervious Runoff Depth>2.11"
Tc=5.0 min CN=79/98 Runoff=0.31 cfs 4,728 cf

Subcatchment100S: Norwood Runoff Area=18,245 sf 17.23% Impervious Runoff Depth>2.18"
Tc=5.0 min CN=79/98 Runoff=0.22 cfs 3,321 cf

Subcatchment110S: Norwood Runoff Area=73,346 sf 56.47% Impervious Runoff Depth>2.83"
Tc=51.0 min CN=79/98 Runoff=0.69 cfs 17,289 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth>1.22"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.09 cfs 3,253 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth>1.22"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.01 cfs 494 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth>2.66"
Flow Length=2,860' Tc=59.4 min CN=86/98 Runoff=0.51 cfs 13,576 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth>2.62"
Tc=5.0 min CN=74/98 Runoff=0.26 cfs 3,931 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth>2.26"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=1.60 cfs 29,881 cf

Link 1T: PRE TOTAL
Inflow=22.33 cfs 487,850 cf
Primary=22.33 cfs 487,850 cf

Link 2T: PRE DEV EAST
Inflow=7.89 cfs 217,026 cf
Primary=7.89 cfs 217,026 cf

Link 3T: PRE DEV WEST
Inflow=14.45 cfs 270,824 cf
Primary=14.45 cfs 270,824 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 487,850 cf Average Runoff Depth = 1.92"
96.55% Pervious = 2,950,525 sf 3.45% Impervious = 105,575 sf

Summary for Subcatchment 10S:

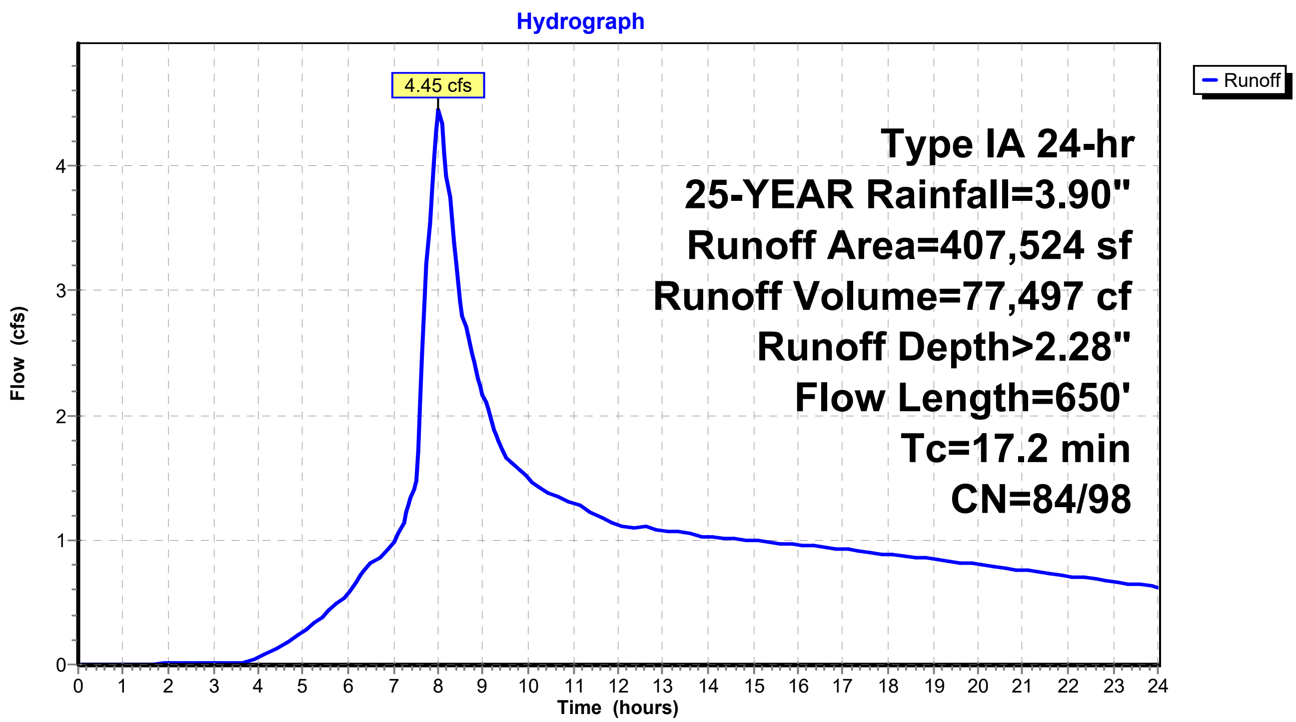
Runoff = 4.45 cfs @ 8.02 hrs, Volume= 77,497 cf, Depth> 2.28"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
123,564	82	Farmsteads, HSG C
256,474	85	Row crops, straight row, Good, HSG C
5,905	96	Gravel surface, HSG C
5,200	98	Unconnected roofs, HSG C
16,381	87	Dirt roads, HSG C
407,524	84	Weighted Average
402,324	84	98.72% Pervious Area
5,200	98	1.28% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.4	200	0.0500	0.25		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.50"
3.7	450	0.0400	2.00		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
17.2	650	Total			

Subcatchment 10S:



Summary for Subcatchment 20S:

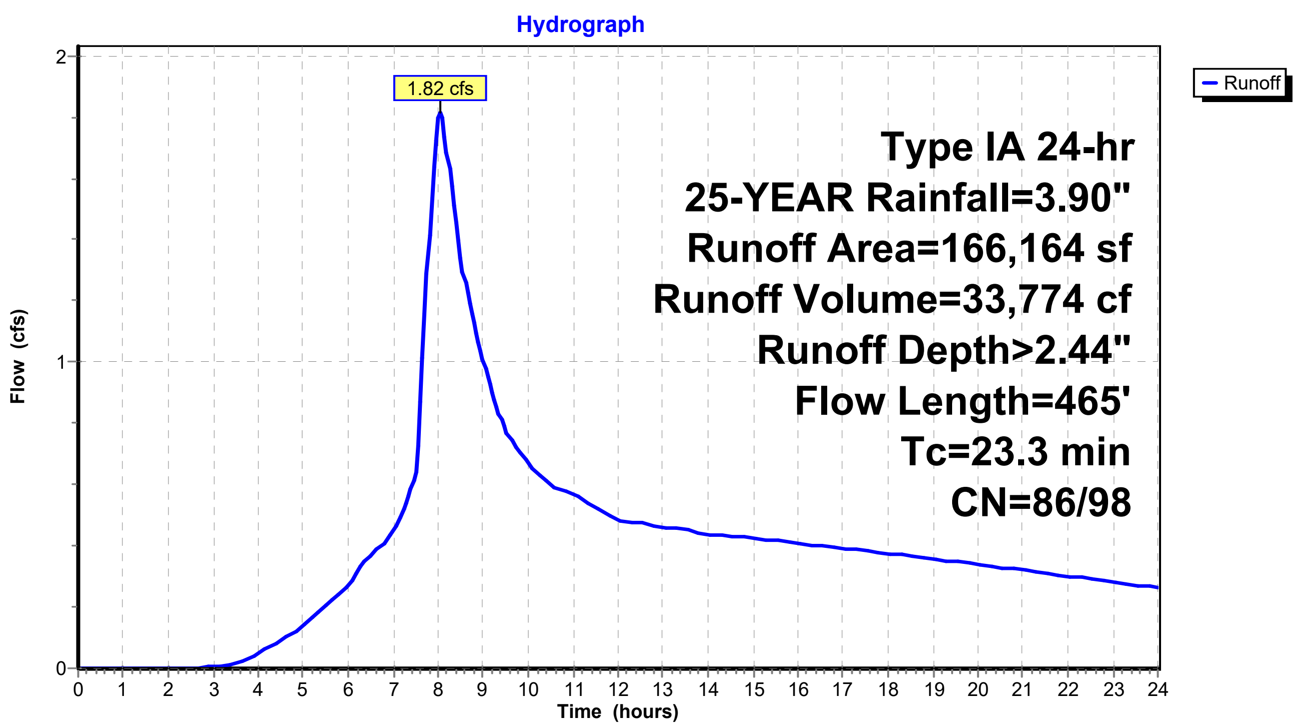
Runoff = 1.82 cfs @ 8.04 hrs, Volume= 33,774 cf, Depth> 2.44"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
93,934	87	Dirt roads, HSG C
70,900	85	Row crops, straight row, Good, HSG C
1,330	98	Paved parking, HSG C
166,164	86	Weighted Average
164,834	86	99.20% Pervious Area
1,330	98	0.80% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
19.4	230	0.0260	0.20		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.50"
3.9	235	0.0100	1.00		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
23.3	465	Total			

Subcatchment 20S:



Summary for Subcatchment 30S:

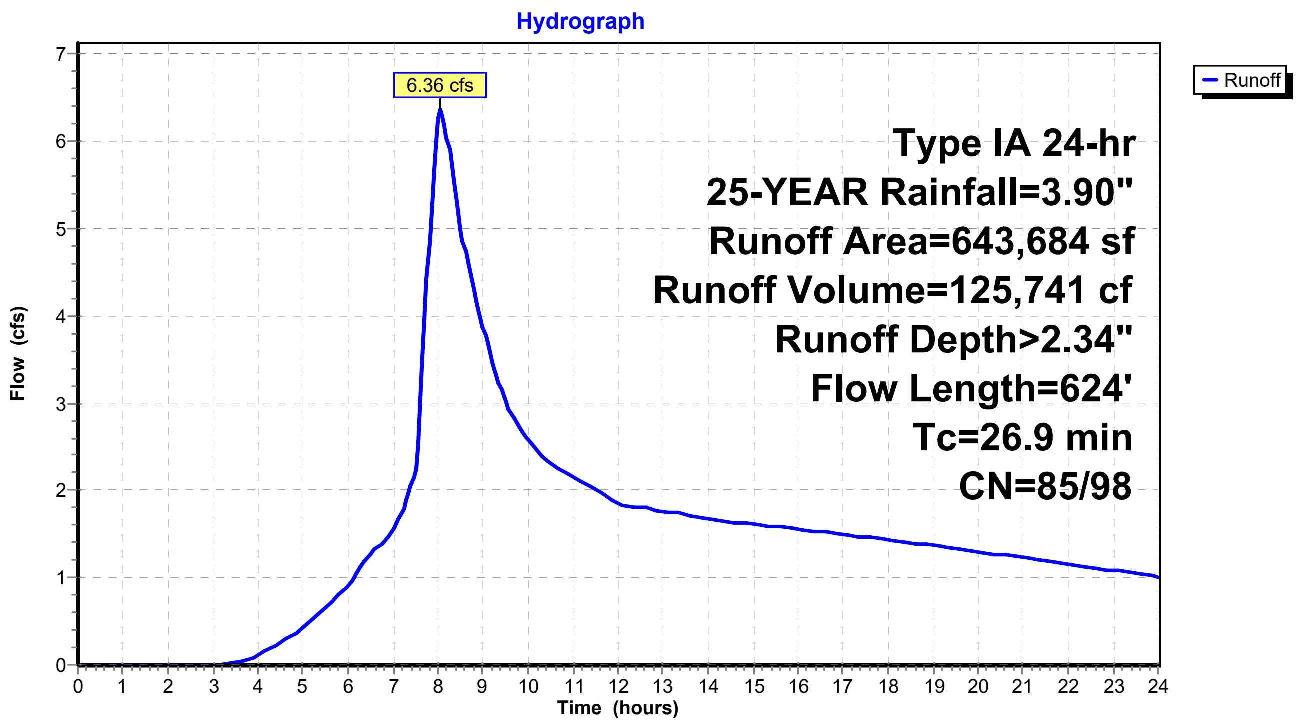
Runoff = 6.36 cfs @ 8.05 hrs, Volume= 125,741 cf, Depth> 2.34"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
58,656	87	Dirt roads, HSG C
2,000	89	Gravel roads, HSG C
2,283	98	Unconnected roofs, HSG C
590	98	Paved parking, HSG C
580,155	85	Row crops, straight row, Good, HSG C
643,684	85	Weighted Average
640,811	85	99.55% Pervious Area
2,873	98	0.45% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.0	300	0.0260	0.21		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.50"
2.9	324	0.0350	1.87		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
26.9	624	Total			

Subcatchment 30S:



Summary for Subcatchment 40S:

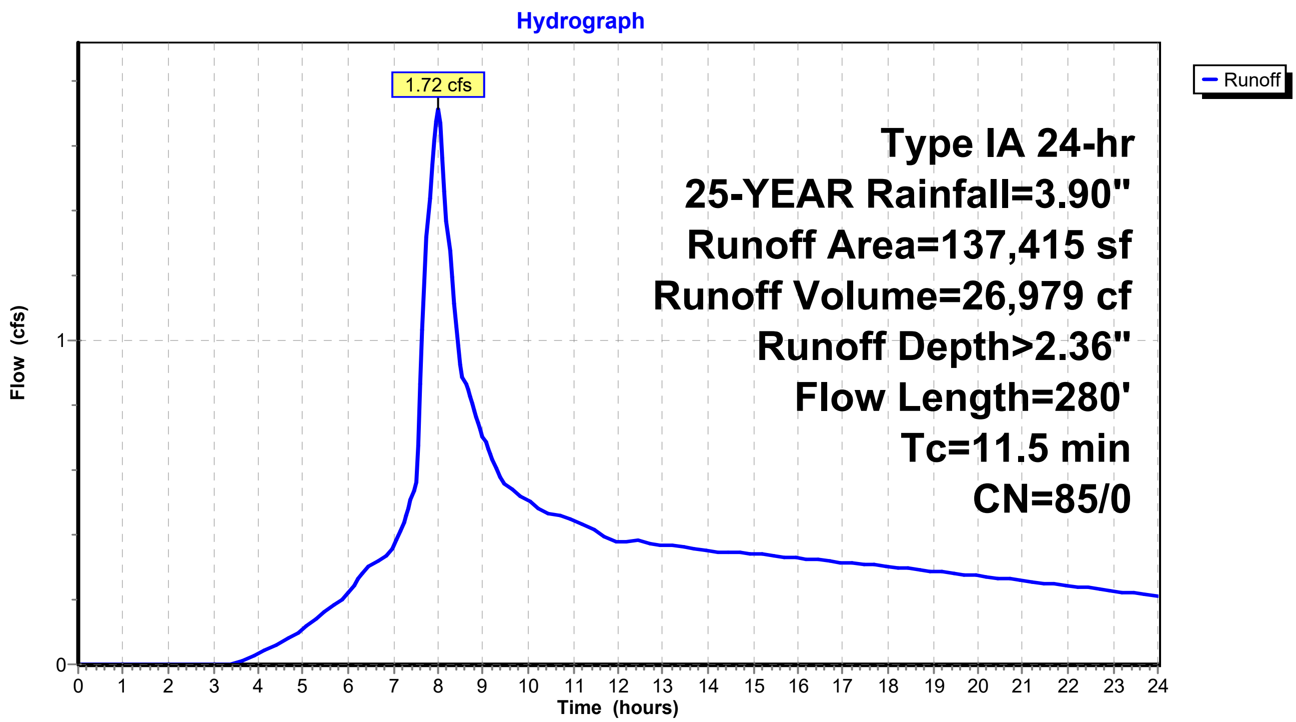
Runoff = 1.72 cfs @ 8.00 hrs, Volume= 26,979 cf, Depth> 2.36"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
137,415	85	Row crops, straight row, Good, HSG C
137,415	85	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.2	150	0.0420	0.25		**Sheet Flow,** Range n= 0.130 P2= 2.50"
1.3	130	0.0300	1.73		**Shallow Concentrated Flow,** Nearly Bare & Untilled Kv= 10.0 fps
11.5	280	Total			

Subcatchment 40S:



Summary for Subcatchment 50S:

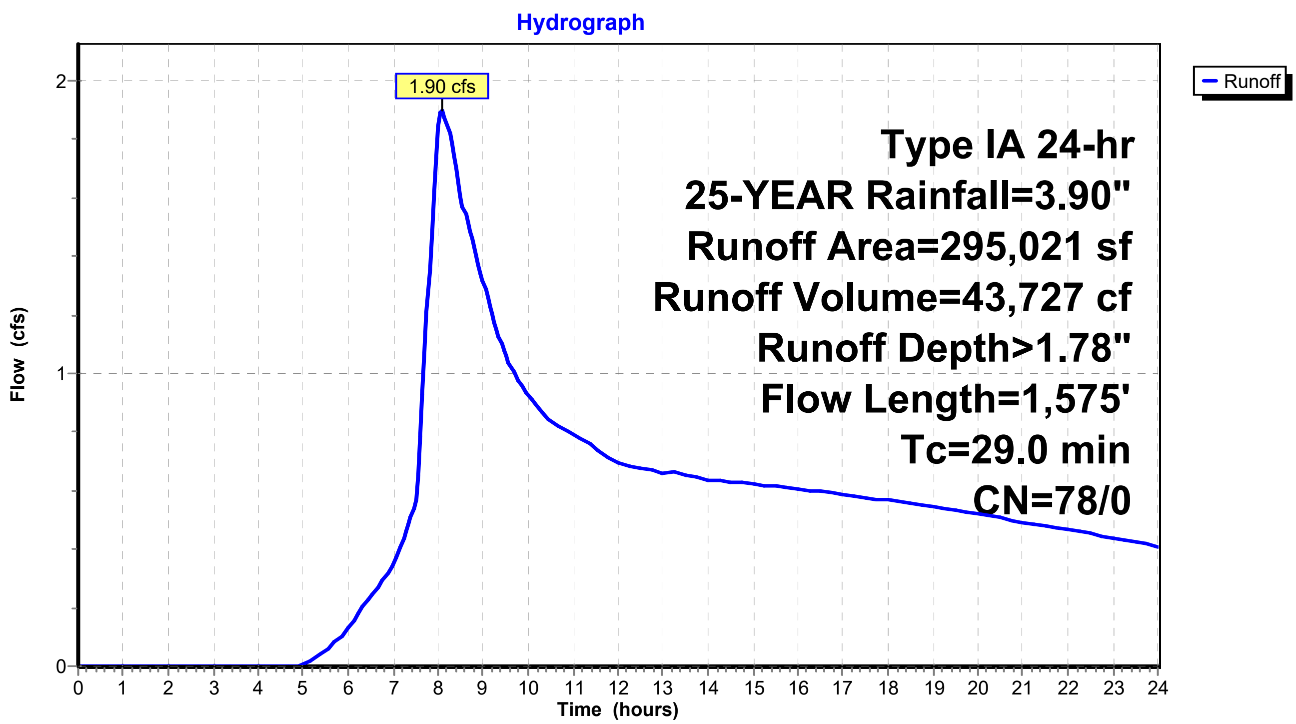
Runoff = 1.90 cfs @ 8.07 hrs, Volume= 43,727 cf, Depth> 1.78"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
171,927	82	Woods/grass comb., Poor, HSG C
123,094	73	Woods, Fair, HSG C
295,021	78	Weighted Average
295,021	78	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
15.2	100	0.0650	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.50"
8.4	535	0.0450	1.06		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
5.4	940	0.0100	2.93	11.71	**Channel Flow,** Area= 4.0 sf Perim= 8.8' r= 0.45' n= 0.030 Earth, grassed & winding
29.0	1,575	Total			

Subcatchment 50S:



Summary for Subcatchment 60S:

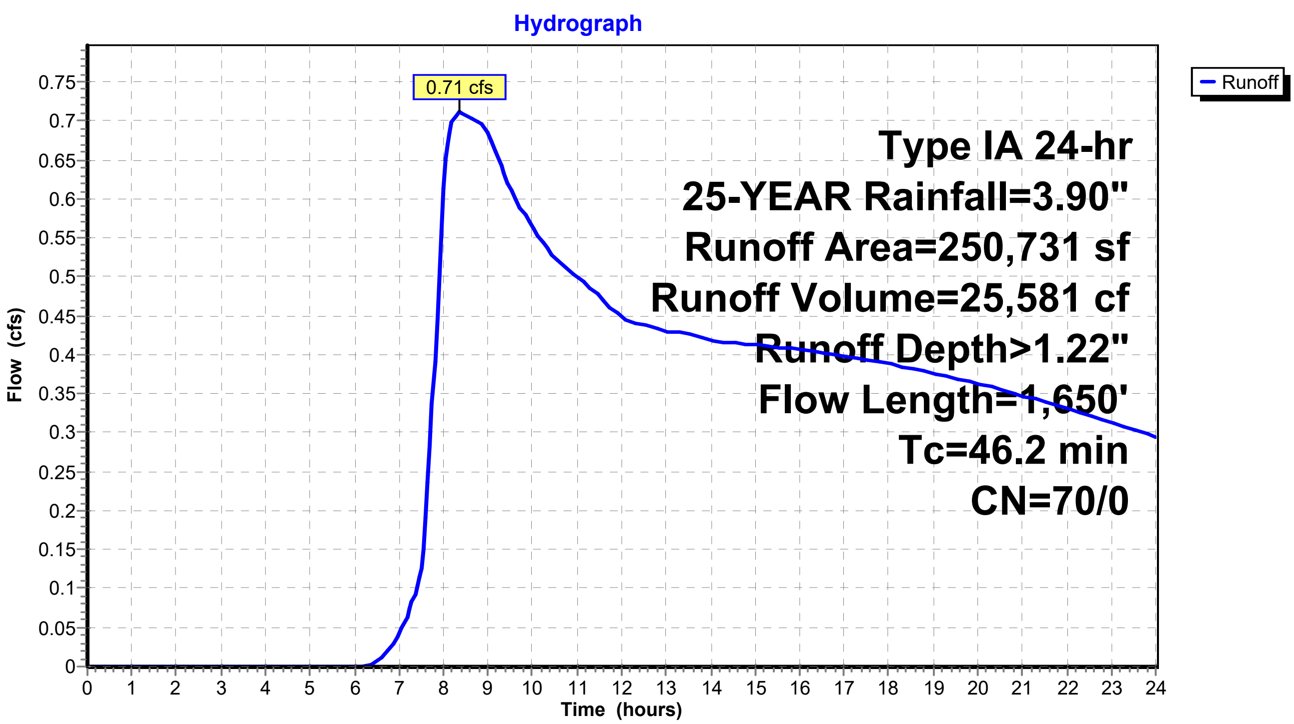
Runoff = 0.71 cfs @ 8.36 hrs, Volume= 25,581 cf, Depth> 1.22"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
250,731	70	Woods, Good, HSG C
250,731	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
37.7	150	0.0150	0.07		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.50"
8.5	1,500	0.0100	2.93	11.71	**Channel Flow,** Area= 4.0 sf Perim= 8.8' r= 0.45' n= 0.030 Earth, grassed & winding
46.2	1,650	Total			

Subcatchment 60S:



Summary for Subcatchment 70S:

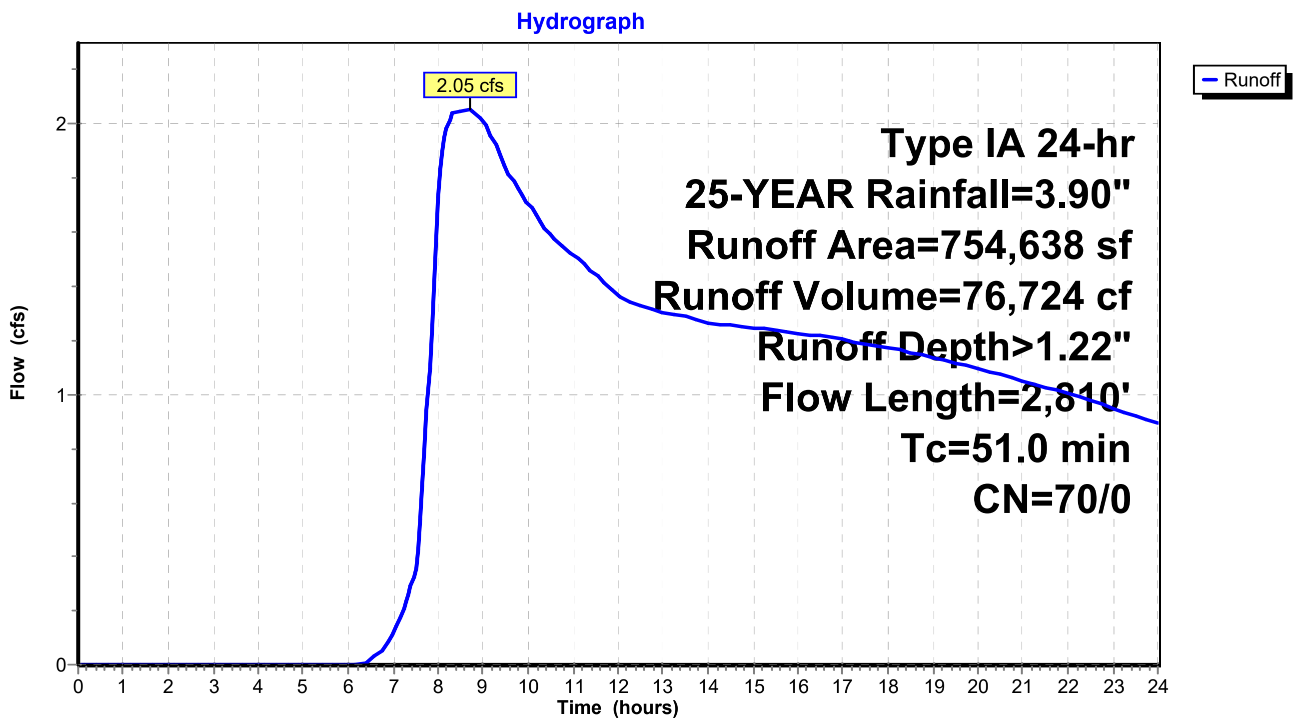
Runoff = 2.05 cfs @ 8.70 hrs, Volume= 76,724 cf, Depth> 1.22"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
754,638	70	Woods, Good, HSG C
754,638	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.9	200	0.0440	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.50"
8.1	500	0.0420	1.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
12.0	2,110	0.0100	2.93	11.71	**Channel Flow,** Area= 4.0 sf Perim= 8.8' r= 0.45' n= 0.030 Earth, grassed & winding
51.0	2,810	Total			

Subcatchment 70S:



Summary for Subcatchment 80S: Norwood Undisturbed

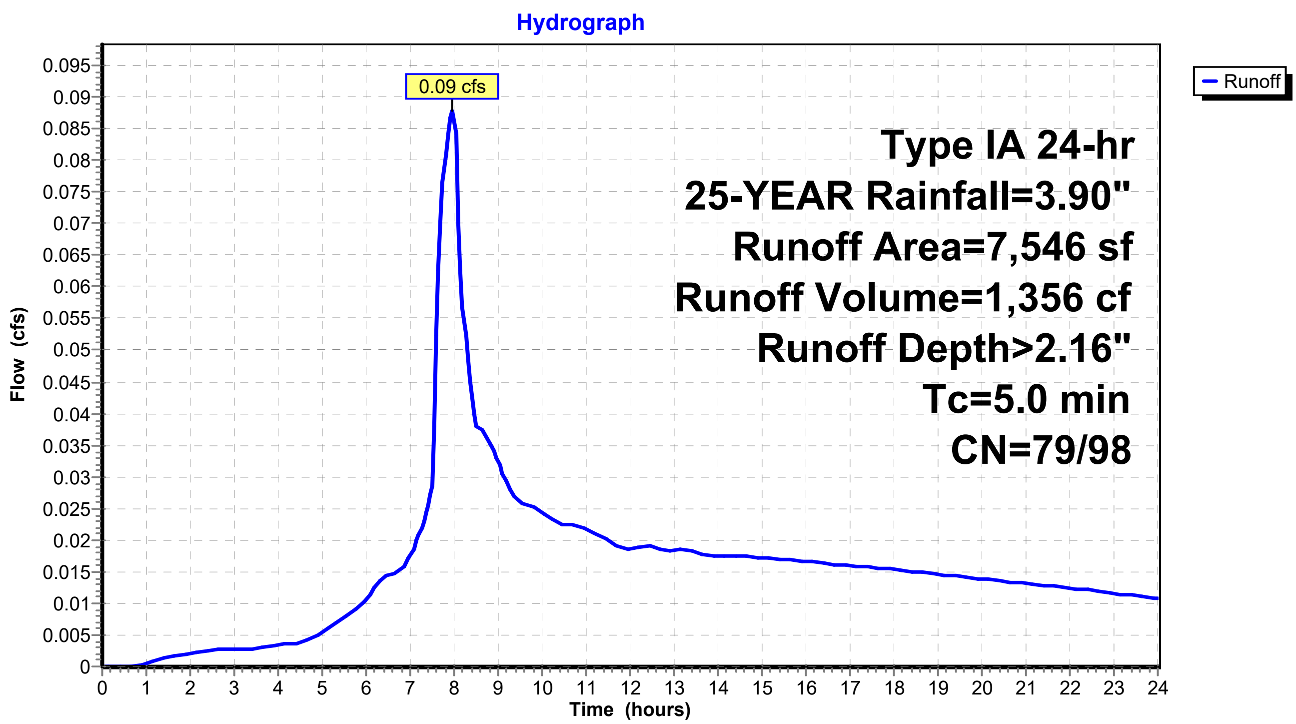
Runoff = 0.09 cfs @ 7.97 hrs, Volume= 1,356 cf, Depth> 2.16"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	1,182	98	Impervious Area
	6,364	79	50-75% Grass cover, Fair, HSG C
	7,546	82	Weighted Average
	6,364	79	84.34% Pervious Area
	1,182	98	15.66% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 80S: Norwood Undisturbed



Summary for Subcatchment 90S: Norwood Undisturbed

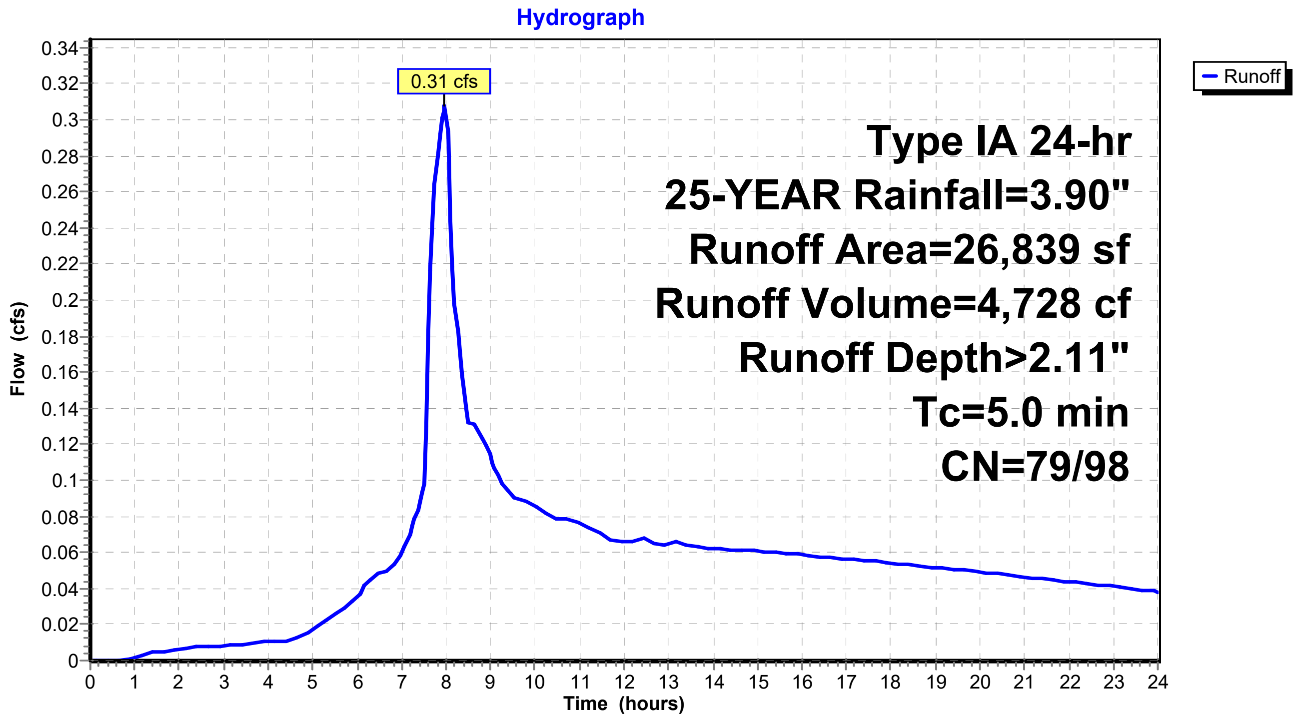
Runoff = 0.31 cfs @ 7.98 hrs, Volume= 4,728 cf, Depth> 2.11"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	3,558	98	Impervious Area
	23,281	79	50-75% Grass cover, Fair, HSG C
	26,839	82	Weighted Average
	23,281	79	86.74% Pervious Area
	3,558	98	13.26% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 90S: Norwood Undisturbed



Summary for Subcatchment 100S: Norwood Undisturbed

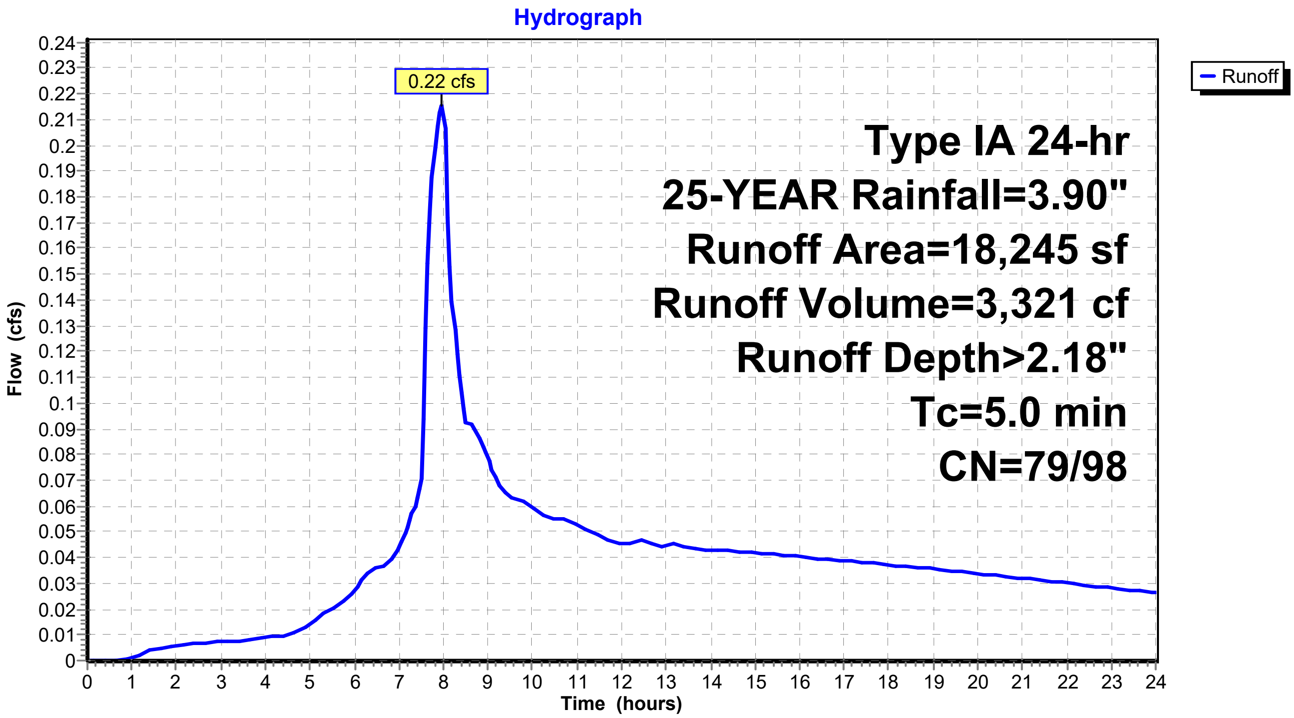
Runoff = 0.22 cfs @ 7.97 hrs, Volume= 3,321 cf, Depth> 2.18"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	3,143	98	Impervious Area
	15,102	79	50-75% Grass cover, Fair, HSG C
	18,245	82	Weighted Average
	15,102	79	82.77% Pervious Area
	3,143	98	17.23% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 100S: Norwood Undisturbed



Summary for Subcatchment 110S: Norwood Improvements

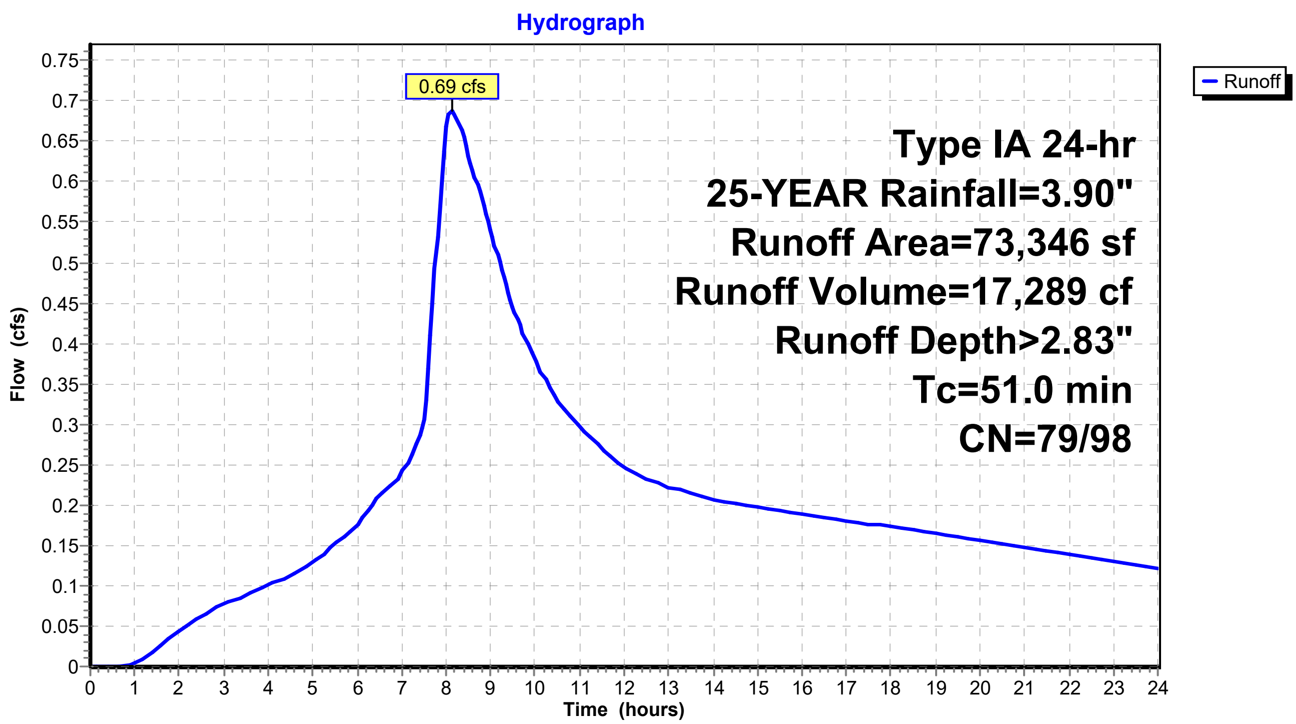
Runoff = 0.69 cfs @ 8.13 hrs, Volume= 17,289 cf, Depth> 2.83"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	41,417	98	Impervious Area
	31,929	79	50-75% Grass cover, Fair, HSG C
	73,346	90	Weighted Average
	31,929	79	43.53% Pervious Area
	41,417	98	56.47% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
51.0					**Direct Entry, Tc through Site (Basin 70S)**

Subcatchment 110S: Norwood Improvements



Summary for Subcatchment 120S: Onsite Undisturbed

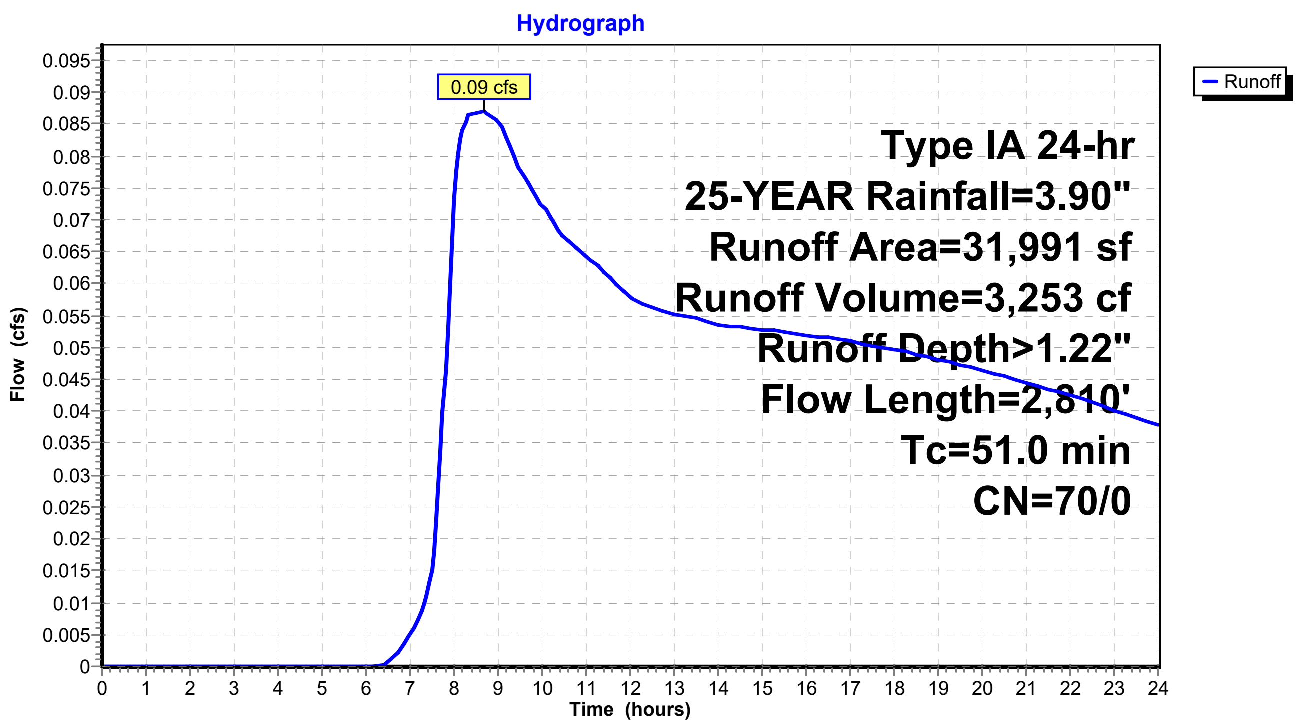
Runoff = 0.09 cfs @ 8.70 hrs, Volume= 3,253 cf, Depth> 1.22"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
31,991	70	Woods, Good, HSG C
31,991	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.9	200	0.0440	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.50"
8.1	500	0.0420	1.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
12.0	2,110	0.0100	2.93	11.71	**Channel Flow,** Area= 4.0 sf Perim= 8.8' r= 0.45' n= 0.030 Earth, grassed & winding
51.0	2,810	Total			

Subcatchment 120S: Onsite Undisturbed



Summary for Subcatchment 130S: Onsite Undisturbed

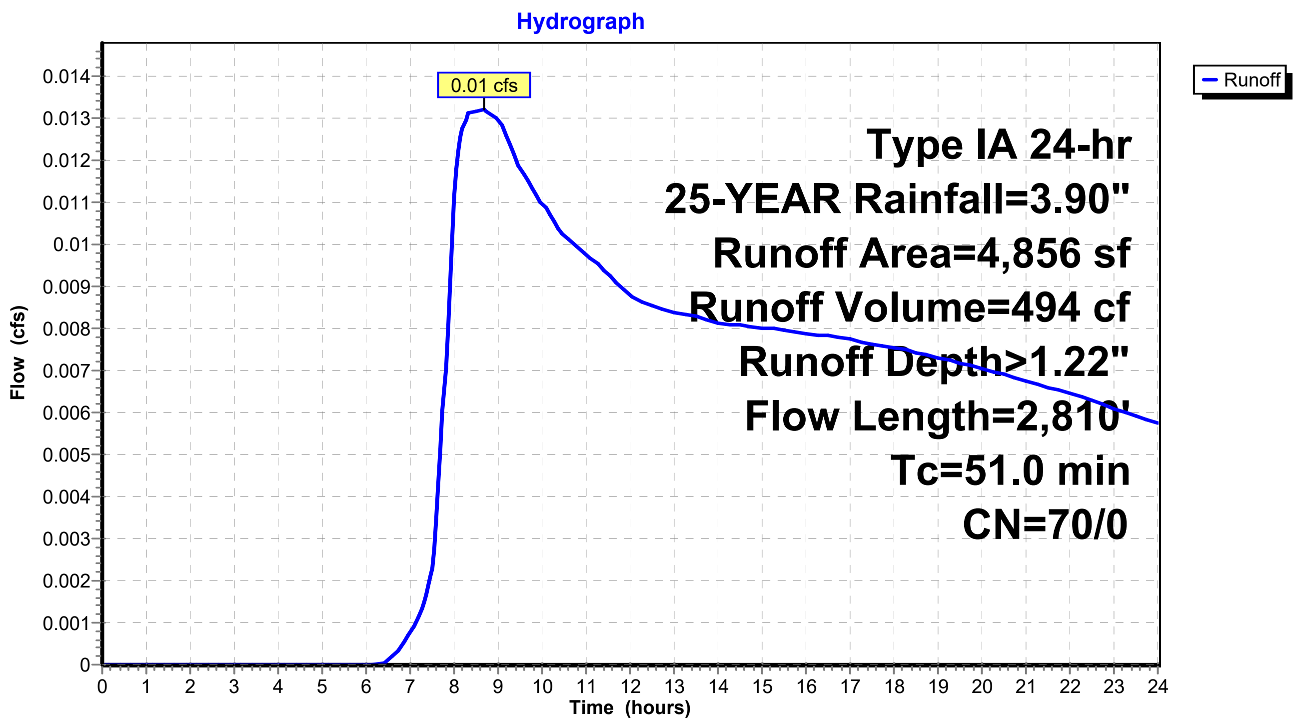
Runoff = 0.01 cfs @ 8.70 hrs, Volume= 494 cf, Depth> 1.22"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
4,856	70	Woods, Good, HSG C
4,856	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
30.9	200	0.0440	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.50"
8.1	500	0.0420	1.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
12.0	2,110	0.0100	2.93	11.71	**Channel Flow,** Area= 4.0 sf Perim= 8.8' r= 0.45' n= 0.030 Earth, grassed & winding
51.0	2,810	Total			

Subcatchment 130S: Onsite Undisturbed



Summary for Subcatchment 140X: City Reservoir

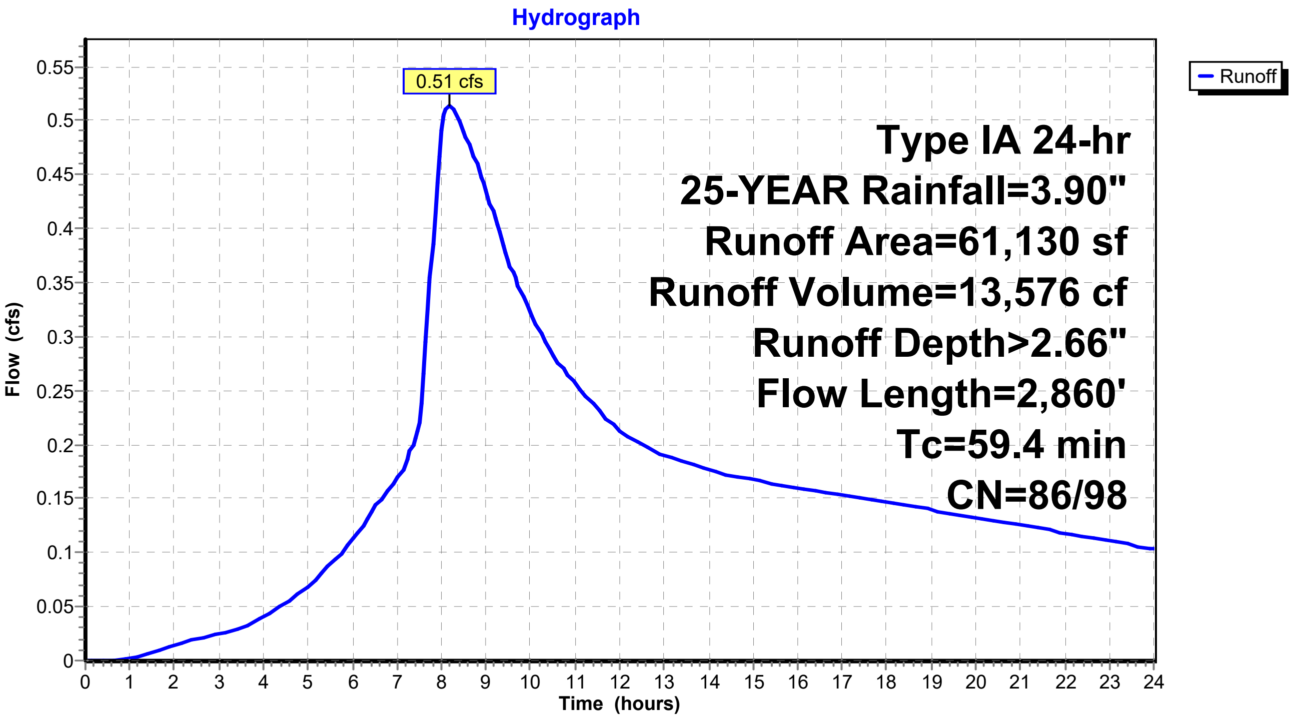
Runoff = 0.51 cfs @ 8.20 hrs, Volume= 13,576 cf, Depth> 2.66"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
14,216	98	Paved roads w/curbs & sewers, HSG C
46,914	86	<50% Grass cover, Poor, HSG C
61,130	89	Weighted Average
46,914	86	76.74% Pervious Area
14,216	98	23.26% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.4	50	0.0100	0.10		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.50"
30.9	200	0.0440	0.11		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.50"
8.1	500	0.0420	1.02		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
12.0	2,110	0.0100	2.93	11.71	**Channel Flow,** Area= 4.0 sf Perim= 8.8' r= 0.45' n= 0.030 Earth, grassed & winding
59.4	2,860	Total			

Subcatchment 140X: City Reservoir



Summary for Subcatchment 150X: Upstream Boones Ferry

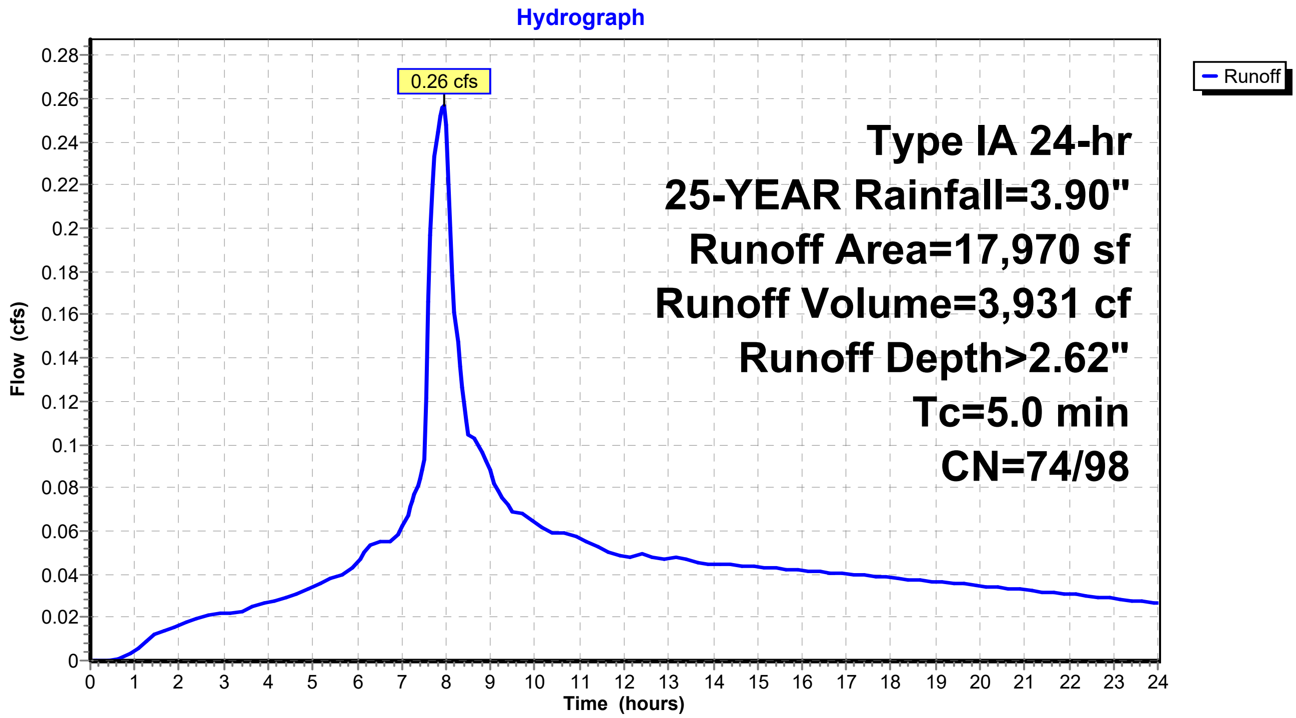
Runoff = 0.26 cfs @ 7.93 hrs, Volume= 3,931 cf, Depth> 2.62"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	9,285	98	Impervious Area
	8,685	74	>75% Grass cover, Good, HSG C
	17,970	86	Weighted Average
	8,685	74	48.33% Pervious Area
	9,285	98	51.67% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 150X: Upstream Boones Ferry



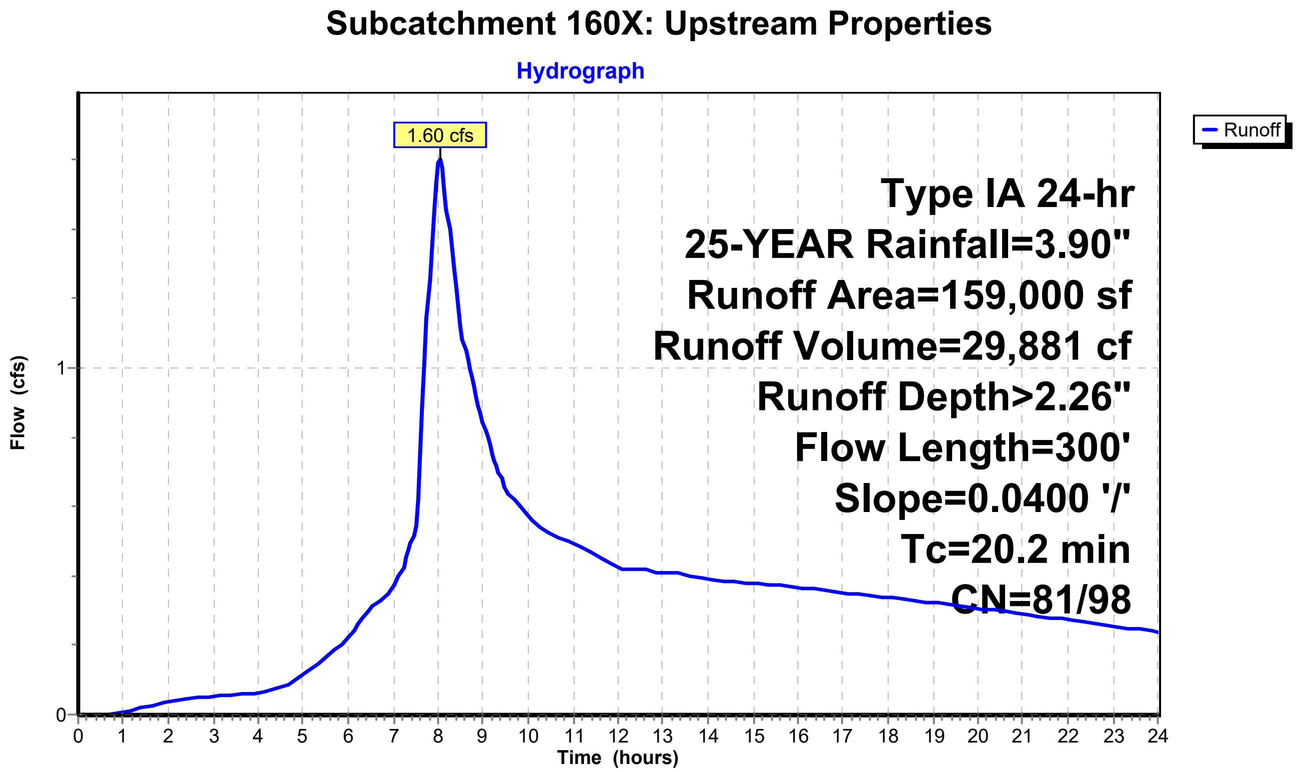
Summary for Subcatchment 160X: Upstream Properties

Runoff = 1.60 cfs @ 8.03 hrs, Volume= 29,881 cf, Depth> 2.26"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	23,371	98	Impervious Area
	12,930	96	Gravel surface, HSG C
	122,699	79	50-75% Grass cover, Fair, HSG C
	159,000	83	Weighted Average
	135,629	81	85.30% Pervious Area
	23,371	98	14.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.2	300	0.0400	0.25		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.50"

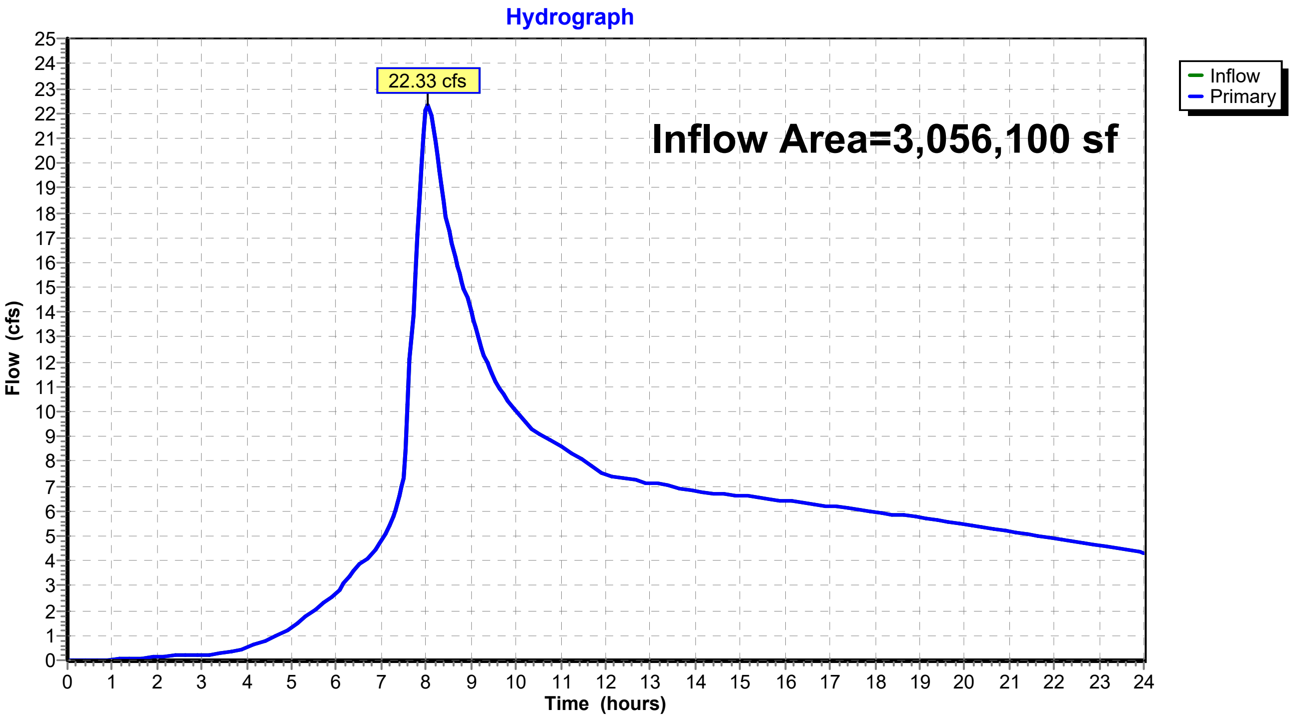


Summary for Link 1T: PRE TOTAL

Inflow Area = 3,056,100 sf, 3.45% Impervious, Inflow Depth > 1.92" for 25-YEAR event
Inflow = 22.33 cfs @ 8.04 hrs, Volume= 487,850 cf
Primary = 22.33 cfs @ 8.04 hrs, Volume= 487,850 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 1T: PRE TOTAL

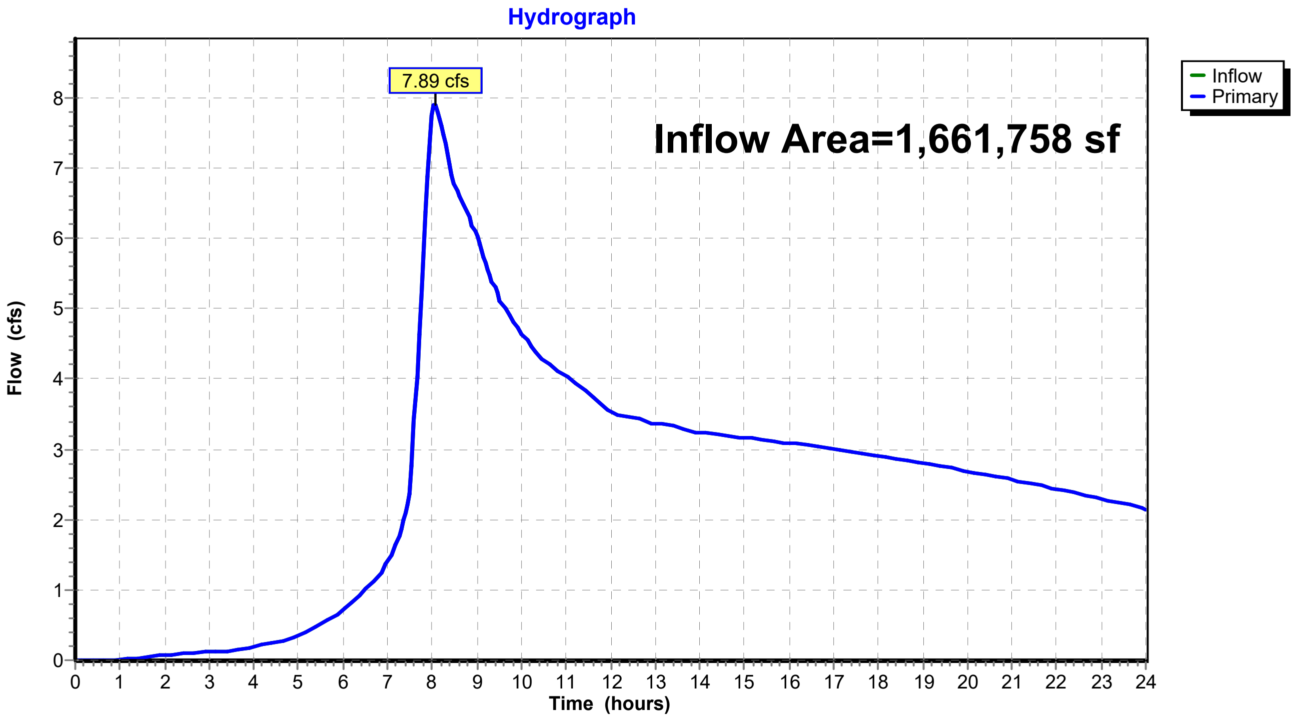


Summary for Link 2T: PRE DEV EAST

Inflow Area =	1,661,758 sf,	3.82% Impervious,	Inflow Depth > 1.57"	for 25-YEAR event
Inflow =	7.89 cfs @	8.06 hrs, Volume=	217,026 cf	
Primary =	7.89 cfs @	8.06 hrs, Volume=	217,026 cf, Atten= 0%,	Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 2T: PRE DEV EAST

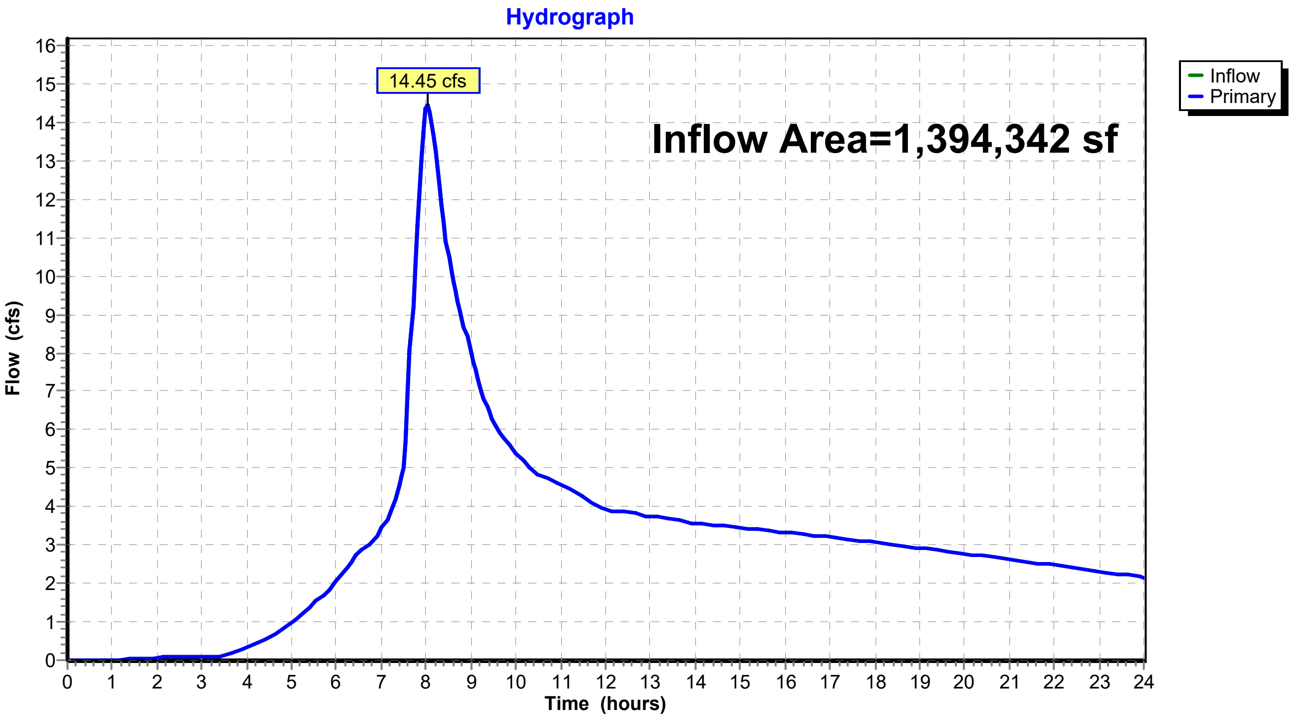


Summary for Link 3T: PRE DEV WEST

Inflow Area =	1,394,342 sf,	3.02% Impervious,	Inflow Depth > 2.33"	for 25-YEAR event
Inflow =	14.45 cfs @	8.04 hrs, Volume=	270,824 cf	
Primary =	14.45 cfs @	8.04 hrs, Volume=	270,824 cf, Atten= 0%,	Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Link 3T: PRE DEV WEST



Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment10S: Runoff Area=407,524 sf 1.28% Impervious Runoff Depth>2.72"
Flow Length=650' Tc=17.2 min CN=84/98 Runoff=5.41 cfs 92,485 cf

Subcatchment20S: Runoff Area=166,164 sf 0.80% Impervious Runoff Depth>2.89"
Flow Length=465' Tc=23.3 min CN=86/98 Runoff=2.18 cfs 40,030 cf

Subcatchment30S: Runoff Area=643,684 sf 0.45% Impervious Runoff Depth>2.79"
Flow Length=624' Tc=26.9 min CN=85/98 Runoff=7.71 cfs 149,622 cf

Subcatchment40S: Runoff Area=137,415 sf 0.00% Impervious Runoff Depth>2.80"
Flow Length=280' Tc=11.5 min CN=85/0 Runoff=2.07 cfs 32,105 cf

Subcatchment50S: Runoff Area=295,021 sf 0.00% Impervious Runoff Depth>2.18"
Flow Length=1,575' Tc=29.0 min CN=78/0 Runoff=2.43 cfs 53,510 cf

Subcatchment60S: Runoff Area=250,731 sf 0.00% Impervious Runoff Depth>1.56"
Flow Length=1,650' Tc=46.2 min CN=70/0 Runoff=1.00 cfs 32,519 cf

Subcatchment70S: Runoff Area=754,638 sf 0.00% Impervious Runoff Depth>1.55"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=2.86 cfs 97,549 cf

Subcatchment80S: Norwood Undisturbed Runoff Area=7,546 sf 15.66% Impervious Runoff Depth>2.58"
Tc=5.0 min CN=79/98 Runoff=0.11 cfs 1,622 cf

Subcatchment90S: Norwood Undisturbed Runoff Area=26,839 sf 13.26% Impervious Runoff Depth>2.53"
Tc=5.0 min CN=79/98 Runoff=0.37 cfs 5,670 cf

Subcatchment100S: Norwood Runoff Area=18,245 sf 17.23% Impervious Runoff Depth>2.61"
Tc=5.0 min CN=79/98 Runoff=0.26 cfs 3,967 cf

Subcatchment110S: Norwood Runoff Area=73,346 sf 56.47% Impervious Runoff Depth>3.28"
Tc=51.0 min CN=79/98 Runoff=0.80 cfs 20,048 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth>1.55"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.12 cfs 4,135 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth>1.55"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.02 cfs 628 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth>3.12"
Flow Length=2,860' Tc=59.4 min CN=86/98 Runoff=0.61 cfs 15,894 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth>3.06"
Tc=5.0 min CN=74/98 Runoff=0.30 cfs 4,585 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth>2.69"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=1.94 cfs 35,601 cf

Link 1T: PRE TOTAL
Inflow=27.72 cfs 589,969 cf
Primary=27.72 cfs 589,969 cf

Link 2T: PRE DEV EAST
Inflow=10.23 cfs 267,646 cf
Primary=10.23 cfs 267,646 cf

Link 3T: PRE DEV WEST
Inflow=17.51 cfs 322,323 cf
Primary=17.51 cfs 322,323 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 589,969 cf Average Runoff Depth = 2.32"
96.55% Pervious = 2,950,525 sf 3.45% Impervious = 105,575 sf

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment10S: Runoff Area=407,524 sf 1.28% Impervious Runoff Depth>1.89"
Flow Length=650' Tc=17.2 min CN=84/98 Runoff=3.61 cfs 64,333 cf

Subcatchment20S: Runoff Area=166,164 sf 0.80% Impervious Runoff Depth>2.04"
Flow Length=465' Tc=23.3 min CN=86/98 Runoff=1.49 cfs 28,255 cf

Subcatchment30S: Runoff Area=643,684 sf 0.45% Impervious Runoff Depth>1.95"
Flow Length=624' Tc=26.9 min CN=85/98 Runoff=5.18 cfs 104,723 cf

Subcatchment40S: Runoff Area=137,415 sf 0.00% Impervious Runoff Depth>1.96"
Flow Length=280' Tc=11.5 min CN=85/0 Runoff=1.40 cfs 22,467 cf

Subcatchment50S: Runoff Area=295,021 sf 0.00% Impervious Runoff Depth>1.43"
Flow Length=1,575' Tc=29.0 min CN=78/0 Runoff=1.45 cfs 35,279 cf

Subcatchment60S: Runoff Area=250,731 sf 0.00% Impervious Runoff Depth>0.95"
Flow Length=1,650' Tc=46.2 min CN=70/0 Runoff=0.49 cfs 19,750 cf

Subcatchment70S: Runoff Area=754,638 sf 0.00% Impervious Runoff Depth>0.94"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=1.44 cfs 59,224 cf

Subcatchment80S: Norwood Undisturbed Runoff Area=7,546 sf 15.66% Impervious Runoff Depth>1.79"
Tc=5.0 min CN=79/98 Runoff=0.07 cfs 1,124 cf

Subcatchment90S: Norwood Undisturbed Runoff Area=26,839 sf 13.26% Impervious Runoff Depth>1.75"
Tc=5.0 min CN=79/98 Runoff=0.25 cfs 3,907 cf

Subcatchment100S: Norwood Runoff Area=18,245 sf 17.23% Impervious Runoff Depth>1.81"
Tc=5.0 min CN=79/98 Runoff=0.18 cfs 2,758 cf

Subcatchment110S: Norwood Runoff Area=73,346 sf 56.47% Impervious Runoff Depth>2.43"
Tc=51.0 min CN=79/98 Runoff=0.59 cfs 14,843 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth>0.94"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.06 cfs 2,511 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth>0.94"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.01 cfs 381 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth>2.26"
Flow Length=2,860' Tc=59.4 min CN=86/98 Runoff=0.43 cfs 11,521 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth>2.24"
Tc=5.0 min CN=74/98 Runoff=0.22 cfs 3,354 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth>1.88"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=1.30 cfs 24,871 cf

Link 1T: PRE TOTAL
Inflow=17.69 cfs 399,301 cf
Primary=17.69 cfs 399,301 cf

Link 2T: PRE DEV EAST
Inflow=5.94 cfs 173,764 cf
Primary=5.94 cfs 173,764 cf

Link 3T: PRE DEV WEST
Inflow=11.77 cfs 225,538 cf
Primary=11.77 cfs 225,538 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 399,301 cf Average Runoff Depth = 1.57"
96.55% Pervious = 2,950,525 sf 3.45% Impervious = 105,575 sf

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment10S: Runoff Area=407,524 sf 1.28% Impervious Runoff Depth>1.60"
Flow Length=650' Tc=17.2 min CN=84/98 Runoff=2.98 cfs 54,368 cf

Subcatchment20S: Runoff Area=166,164 sf 0.80% Impervious Runoff Depth>1.74"
Flow Length=465' Tc=23.3 min CN=86/98 Runoff=1.24 cfs 24,056 cf

Subcatchment30S: Runoff Area=643,684 sf 0.45% Impervious Runoff Depth>1.66"
Flow Length=624' Tc=26.9 min CN=85/98 Runoff=4.28 cfs 88,776 cf

Subcatchment40S: Runoff Area=137,415 sf 0.00% Impervious Runoff Depth>1.66"
Flow Length=280' Tc=11.5 min CN=85/0 Runoff=1.16 cfs 19,043 cf

Subcatchment50S: Runoff Area=295,021 sf 0.00% Impervious Runoff Depth>1.18"
Flow Length=1,575' Tc=29.0 min CN=78/0 Runoff=1.12 cfs 28,998 cf

Subcatchment60S: Runoff Area=250,731 sf 0.00% Impervious Runoff Depth>0.74"
Flow Length=1,650' Tc=46.2 min CN=70/0 Runoff=0.35 cfs 15,540 cf

Subcatchment70S: Runoff Area=754,638 sf 0.00% Impervious Runoff Depth>0.74"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=1.02 cfs 46,586 cf

Subcatchment80S: Norwood Undisturbed Runoff Area=7,546 sf 15.66% Impervious Runoff Depth>1.51"
Tc=5.0 min CN=79/98 Runoff=0.06 cfs 949 cf

Subcatchment90S: Norwood Undisturbed Runoff Area=26,839 sf 13.26% Impervious Runoff Depth>1.47"
Tc=5.0 min CN=79/98 Runoff=0.20 cfs 3,290 cf

Subcatchment100S: Norwood Runoff Area=18,245 sf 17.23% Impervious Runoff Depth>1.53"
Tc=5.0 min CN=79/98 Runoff=0.15 cfs 2,334 cf

Subcatchment110S: Norwood Runoff Area=73,346 sf 56.47% Impervious Runoff Depth>2.12"
Tc=51.0 min CN=79/98 Runoff=0.51 cfs 12,971 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth>0.74"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.04 cfs 1,975 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth>0.74"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.01 cfs 300 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth>1.95"
Flow Length=2,860' Tc=59.4 min CN=86/98 Runoff=0.37 cfs 9,950 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth>1.95"
Tc=5.0 min CN=74/98 Runoff=0.19 cfs 2,917 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth>1.59"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=1.07 cfs 21,089 cf

Link 1T: PRE TOTAL
Inflow=14.27 cfs 333,143 cf
Primary=14.27 cfs 333,143 cf

Link 2T: PRE DEV EAST
Inflow=4.54 cfs 141,937 cf
Primary=4.54 cfs 141,937 cf

Link 3T: PRE DEV WEST
Inflow=9.74 cfs 191,206 cf
Primary=9.74 cfs 191,206 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 333,143 cf Average Runoff Depth = 1.31"
96.55% Pervious = 2,950,525 sf 3.45% Impervious = 105,575 sf

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment10S: Runoff Area=407,524 sf 1.28% Impervious Runoff Depth>1.12"
Flow Length=650' Tc=17.2 min CN=84/98 Runoff=1.95 cfs 38,035 cf

Subcatchment20S: Runoff Area=166,164 sf 0.80% Impervious Runoff Depth>1.24"
Flow Length=465' Tc=23.3 min CN=86/98 Runoff=0.84 cfs 17,119 cf

Subcatchment30S: Runoff Area=643,684 sf 0.45% Impervious Runoff Depth>1.17"
Flow Length=624' Tc=26.9 min CN=85/98 Runoff=2.83 cfs 62,543 cf

Subcatchment40S: Runoff Area=137,415 sf 0.00% Impervious Runoff Depth>1.17"
Flow Length=280' Tc=11.5 min CN=85/0 Runoff=0.77 cfs 13,412 cf

Subcatchment50S: Runoff Area=295,021 sf 0.00% Impervious Runoff Depth>0.77"
Flow Length=1,575' Tc=29.0 min CN=78/0 Runoff=0.62 cfs 18,997 cf

Subcatchment60S: Runoff Area=250,731 sf 0.00% Impervious Runoff Depth>0.44"
Flow Length=1,650' Tc=46.2 min CN=70/0 Runoff=0.17 cfs 9,135 cf

Subcatchment70S: Runoff Area=754,638 sf 0.00% Impervious Runoff Depth>0.44"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.51 cfs 27,369 cf

Subcatchment80S: Norwood Undisturbed Runoff Area=7,546 sf 15.66% Impervious Runoff Depth>1.06"
Tc=5.0 min CN=79/98 Runoff=0.04 cfs 666 cf

Subcatchment90S: Norwood Undisturbed Runoff Area=26,839 sf 13.26% Impervious Runoff Depth>1.02"
Tc=5.0 min CN=79/98 Runoff=0.13 cfs 2,292 cf

Subcatchment100S: Norwood Runoff Area=18,245 sf 17.23% Impervious Runoff Depth>1.08"
Tc=5.0 min CN=79/98 Runoff=0.10 cfs 1,644 cf

Subcatchment110S: Norwood Runoff Area=73,346 sf 56.47% Impervious Runoff Depth>1.61"
Tc=51.0 min CN=79/98 Runoff=0.38 cfs 9,844 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth>0.44"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.02 cfs 1,160 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth>0.44"
Flow Length=2,810' Tc=51.0 min CN=70/0 Runoff=0.00 cfs 176 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth>1.44"
Flow Length=2,860' Tc=59.4 min CN=86/98 Runoff=0.26 cfs 7,333 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth>1.46"
Tc=5.0 min CN=74/98 Runoff=0.14 cfs 2,193 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth>1.13"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=0.71 cfs 14,912 cf

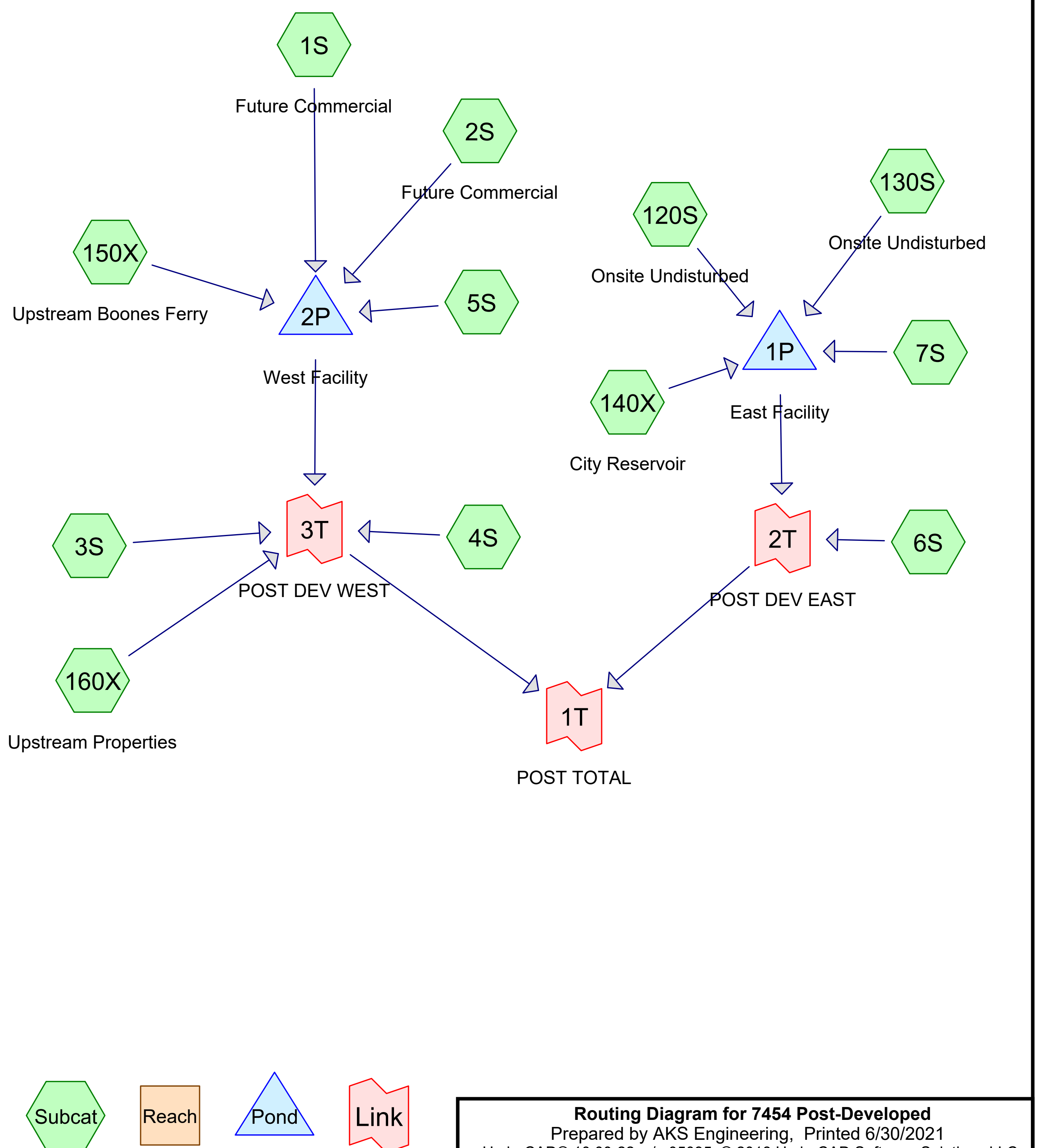
Link 1T: PRE TOTAL
Inflow=8.95 cfs 226,829 cf
Primary=8.95 cfs 226,829 cf

Link 2T: PRE DEV EAST
Inflow=2.51 cfs 92,027 cf
Primary=2.51 cfs 92,027 cf

Link 3T: PRE DEV WEST
Inflow=6.45 cfs 134,802 cf
Primary=6.45 cfs 134,802 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 226,829 cf Average Runoff Depth = 0.89"
96.55% Pervious = 2,950,525 sf 3.45% Impervious = 105,575 sf

Appendix B: HydroCAD Reports for Post-Developed Condition Storm Events (25-Year Storm Event Analysis) (50-Year Storm Event Summary) (10-Year Storm Event Summary) (5-Year Storm Event Summary) (2-Year Storm Event Summary)



Routing Diagram for 7454 Post-Developed
Prepared by AKS Engineering, Printed 6/30/2021
HydroCAD® 10.00-22 s/n 05095 © 2018 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
122,699	79	50-75% Grass cover, Fair, HSG C (160X)
74,761	98	85% Impervious - Future Commercial (1S, 2S)
46,914	86	<50% Grass cover, Poor, HSG C (140X)
1,024,439	74	>75% Grass cover, Good, HSG C (1S, 2S, 3S, 4S, 5S, 6S, 7S, 150X)
12,930	96	Gravel surface, HSG C (160X)
32,656	98	Impervious Area (150X, 160X)
1,056,000	98	Impervious Area on Lots (2,640 sq.ft. per lot) (5S, 7S)
648,854	98	Paved roads w/curbs & sewers, HSG C (3S, 4S, 5S, 7S, 140X)
36,847	70	Woods, Good, HSG C (120S, 130S)
3,056,100	**89**	**TOTAL AREA**

Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment1S: Future Commercial Runoff Area=26,911 sf 85.00% Impervious Runoff Depth=3.34"
Tc=5.0 min CN=74/98 Runoff=0.51 cfs 7,499 cf

Subcatchment2S: Future Commercial Runoff Area=61,043 sf 85.00% Impervious Runoff Depth=3.34"
Tc=5.0 min CN=74/98 Runoff=1.16 cfs 17,011 cf

Subcatchment3S: Runoff Area=68,508 sf 7.88% Impervious Runoff Depth=1.69"
Tc=5.0 min CN=74/98 Runoff=0.58 cfs 9,660 cf

Subcatchment4S: Runoff Area=9,392 sf 28.66% Impervious Runoff Depth=2.14"
Tc=5.0 min CN=74/98 Runoff=0.10 cfs 1,673 cf

Subcatchment5S: Runoff Area=1,198,943 sf 68.42% Impervious Runoff Depth=2.99"
Tc=5.0 min CN=74/98 Runoff=19.91 cfs 298,621 cf

Subcatchment6S: Runoff Area=121,306 sf 0.00% Impervious Runoff Depth=1.52"
Tc=5.0 min CN=74/0 Runoff=0.89 cfs 15,399 cf

Subcatchment7S: Runoff Area=1,295,050 sf 66.58% Impervious Runoff Depth=2.95"
Tc=5.0 min CN=74/98 Runoff=21.18 cfs 318,314 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth=1.26"
Flow Length=100' Slope=0.0440 '/' Tc=22.7 min CN=70/0 Runoff=0.12 cfs 3,368 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth=1.26"
Flow Length=50' Slope=0.0440 '/' Tc=15.2 min CN=70/0 Runoff=0.02 cfs 511 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth=2.74"
Flow Length=50' Slope=0.0100 '/' Tc=13.4 min CN=86/98 Runoff=0.87 cfs 13,944 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth=2.63"
Tc=5.0 min CN=74/98 Runoff=0.26 cfs 3,939 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth=2.28"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=1.60 cfs 30,169 cf

Pond 1P: East Facility Peak Elev=323.62' Storage=124,280 cf Inflow=22.13 cfs 336,137 cf
Outflow=6.53 cfs 322,788 cf

Pond 2P: West Facility Peak Elev=319.55' Storage=91,804 cf Inflow=21.83 cfs 327,069 cf
Outflow=12.32 cfs 321,718 cf

Link 1T: POST TOTAL Inflow=17.81 cfs 701,408 cf
Primary=17.81 cfs 701,408 cf

Link 2T: POST DEV EAST Inflow=6.87 cfs 338,187 cf
Primary=6.87 cfs 338,187 cf

Link 3T: POST DEV WEST Inflow=14.17 cfs 363,221 cf
Primary=14.17 cfs 363,221 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 720,108 cf Average Runoff Depth = 2.83"
40.70% Pervious = 1,243,829 sf 59.30% Impervious = 1,812,271 sf

Summary for Subcatchment 1S: Future Commercial

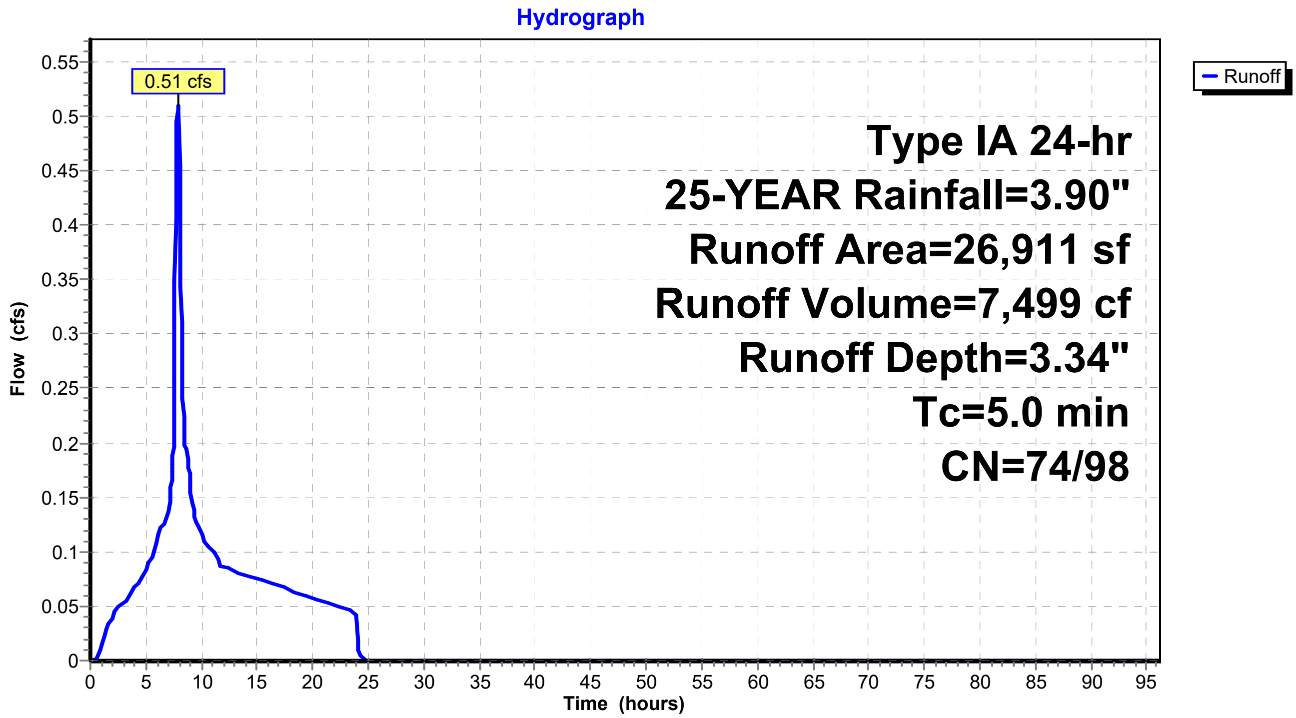
Runoff = 0.51 cfs @ 7.91 hrs, Volume= 7,499 cf, Depth= 3.34"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	22,874	98	85% Impervious - Future Commercial
	4,037	74	>75% Grass cover, Good, HSG C
	26,911	94	Weighted Average
	4,037	74	15.00% Pervious Area
	22,874	98	85.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 1S: Future Commercial



Summary for Subcatchment 2S: Future Commercial

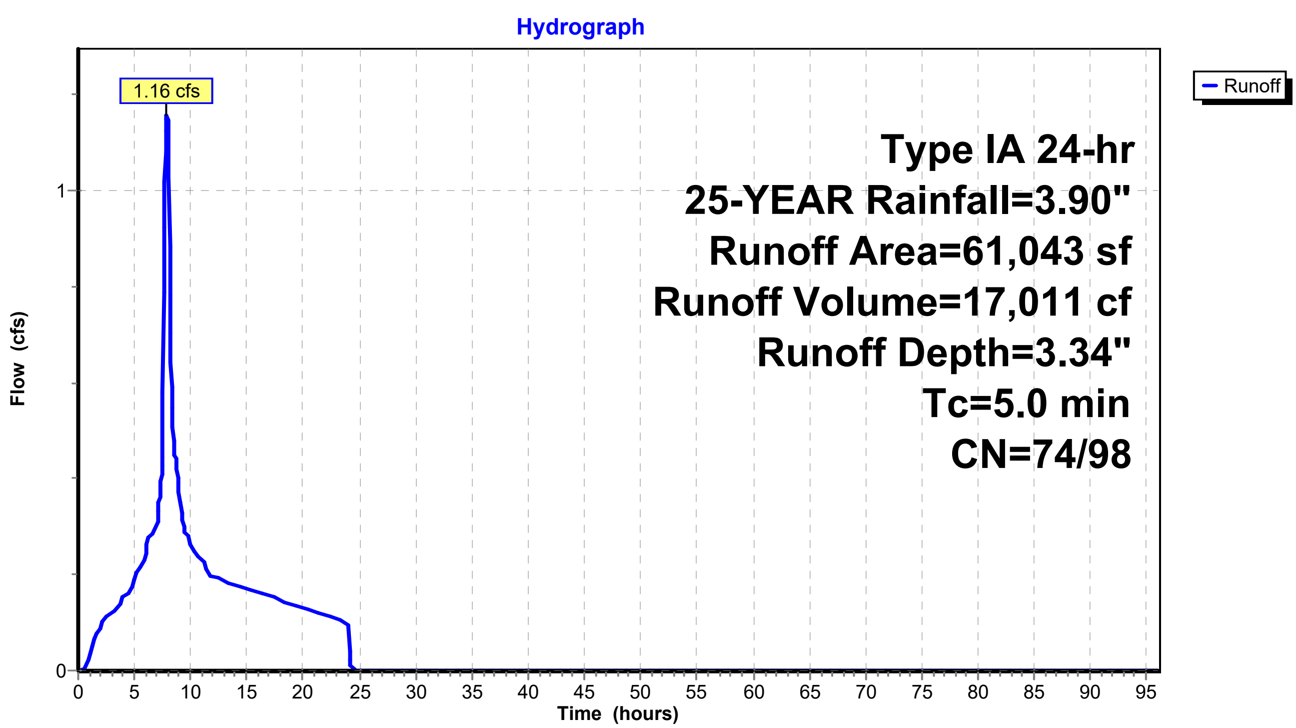
Runoff = 1.16 cfs @ 7.91 hrs, Volume= 17,011 cf, Depth= 3.34"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	51,887	98	85% Impervious - Future Commercial
	9,156	74	>75% Grass cover, Good, HSG C
	61,043	94	Weighted Average
	9,156	74	15.00% Pervious Area
	51,887	98	85.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 2S: Future Commercial



Summary for Subcatchment 3S:

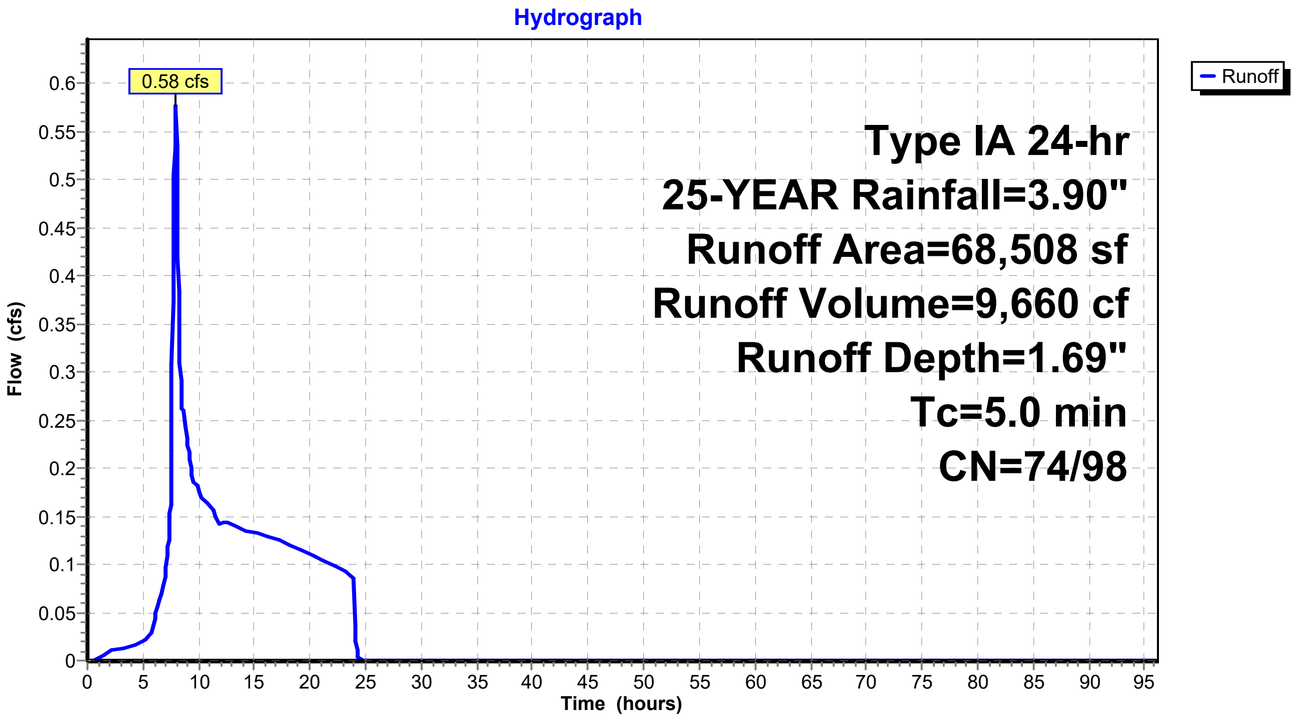
Runoff = 0.58 cfs @ 7.98 hrs, Volume= 9,660 cf, Depth= 1.69"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
5,399	98	Paved roads w/curbs & sewers, HSG C
63,109	74	>75% Grass cover, Good, HSG C
68,508	76	Weighted Average
63,109	74	92.12% Pervious Area
5,399	98	7.88% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 3S:



Summary for Subcatchment 4S:

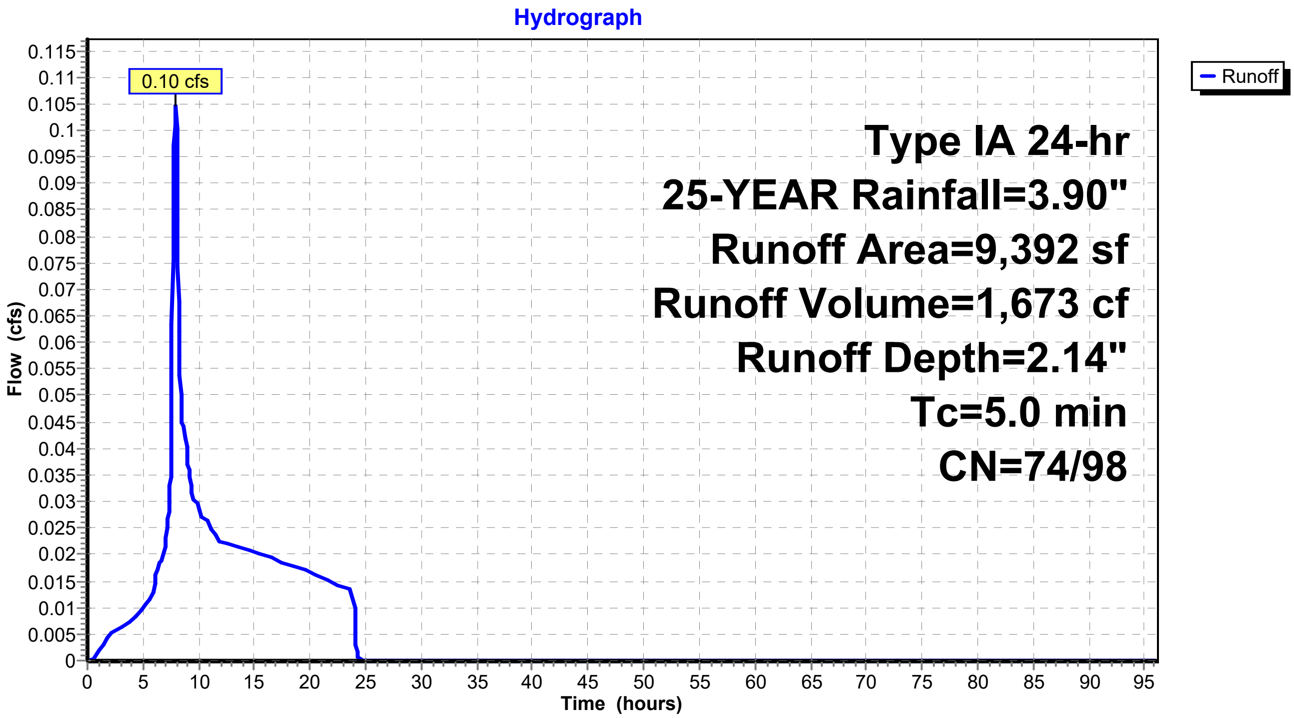
Runoff = 0.10 cfs @ 7.97 hrs, Volume= 1,673 cf, Depth= 2.14"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
2,692	98	Paved roads w/curbs & sewers, HSG C
6,700	74	>75% Grass cover, Good, HSG C
9,392	81	Weighted Average
6,700	74	71.34% Pervious Area
2,692	98	28.66% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 4S:



Summary for Subcatchment 5S:

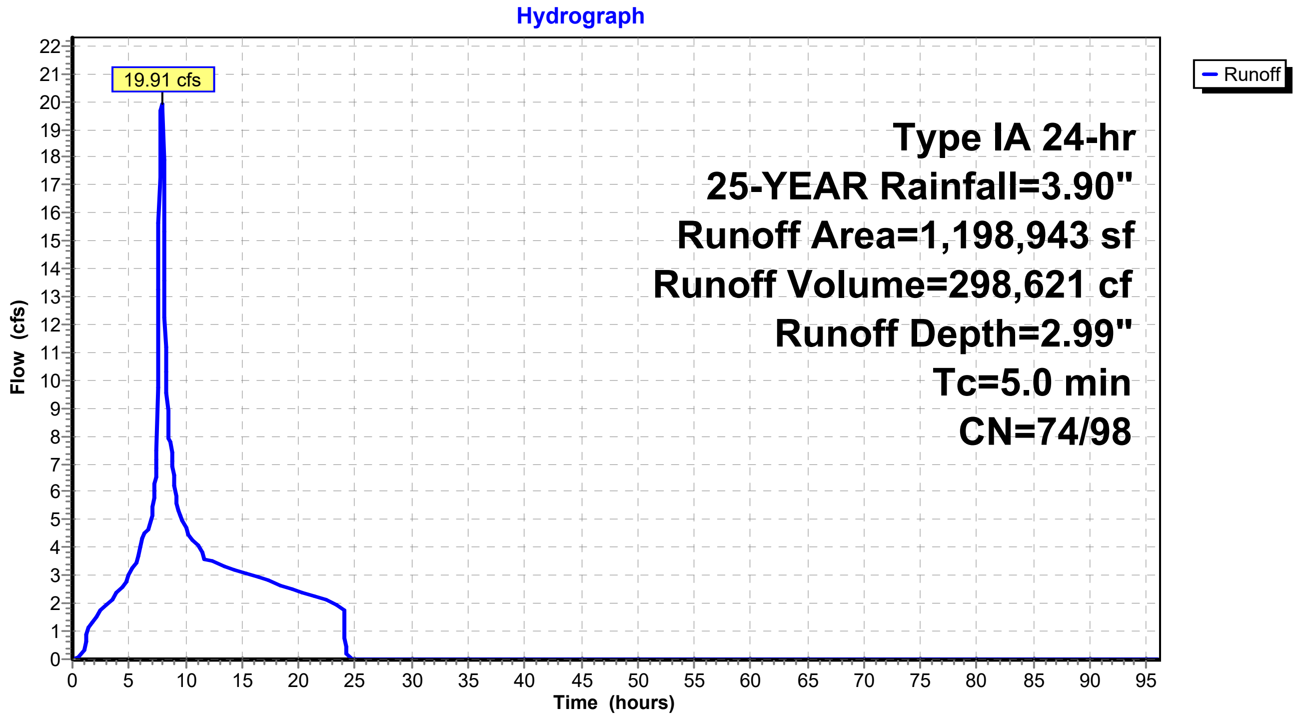
Runoff = 19.91 cfs @ 7.92 hrs, Volume= 298,621 cf, Depth= 2.99"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
	281,723	98	Paved roads w/curbs & sewers, HSG C
	378,660	74	>75% Grass cover, Good, HSG C
*	538,560	98	Impervious Area on Lots (2,640 sq.ft. per lot)
	1,198,943	90	Weighted Average
	378,660	74	31.58% Pervious Area
	820,283	98	68.42% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 5S:



Summary for Subcatchment 6S:

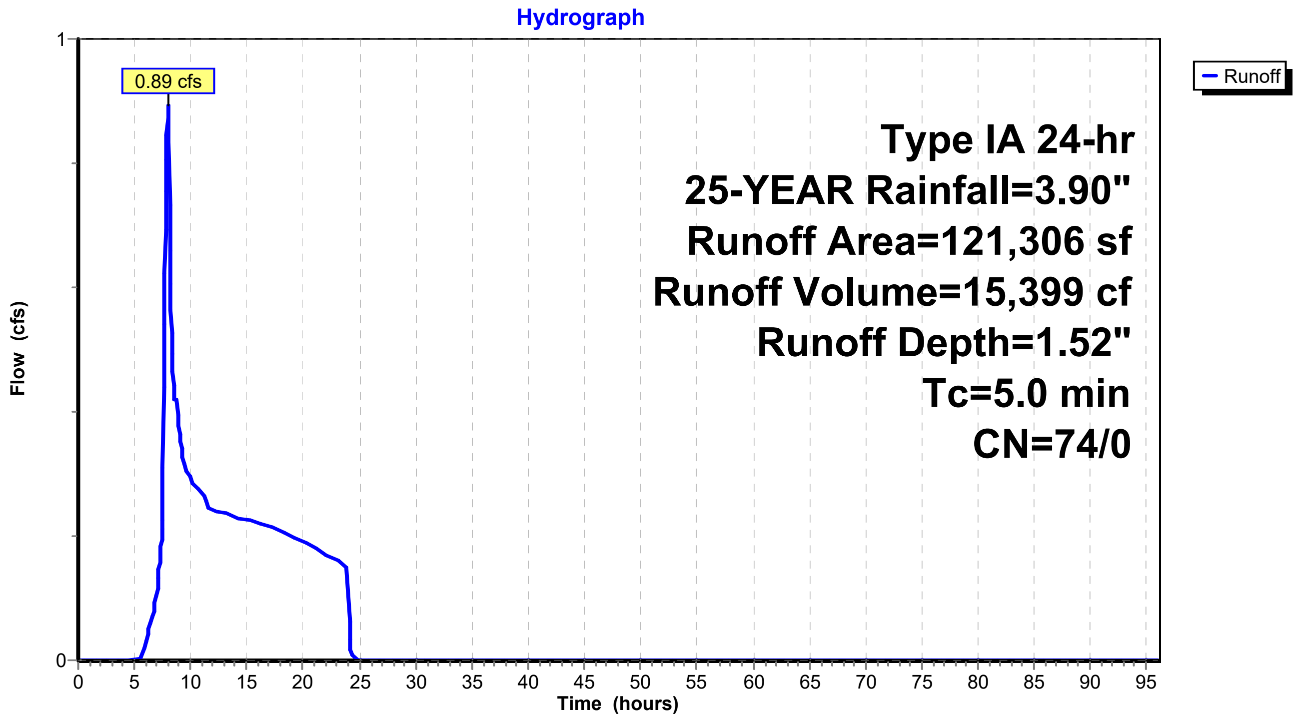
Runoff = 0.89 cfs @ 7.99 hrs, Volume= 15,399 cf, Depth= 1.52"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
121,306	74	>75% Grass cover, Good, HSG C
121,306	74	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 6S:



Summary for Subcatchment 7S:

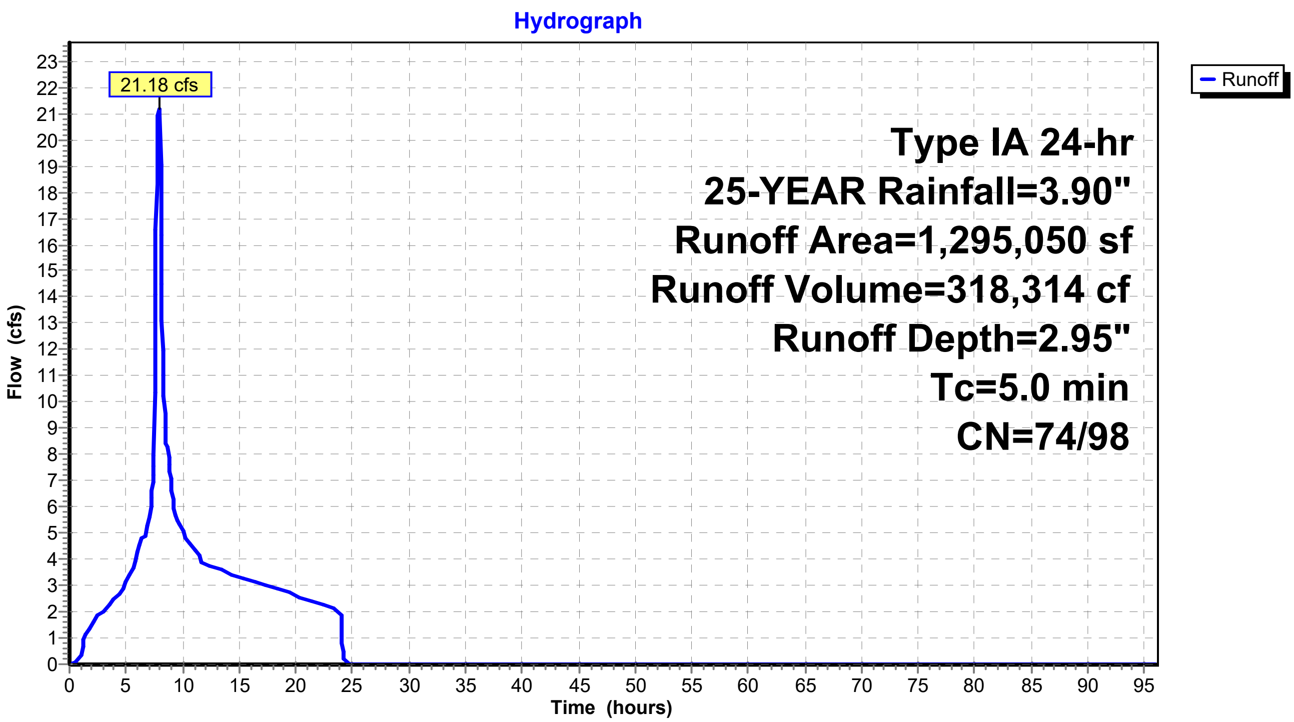
Runoff = 21.18 cfs @ 7.92 hrs, Volume= 318,314 cf, Depth= 2.95"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
	344,824	98	Paved roads w/curbs & sewers, HSG C
	432,786	74	>75% Grass cover, Good, HSG C
*	517,440	98	Impervious Area on Lots (2,640 sq.ft. per lot)
	1,295,050	90	Weighted Average
	432,786	74	33.42% Pervious Area
	862,264	98	66.58% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 7S:



Summary for Subcatchment 120S: Onsite Undisturbed

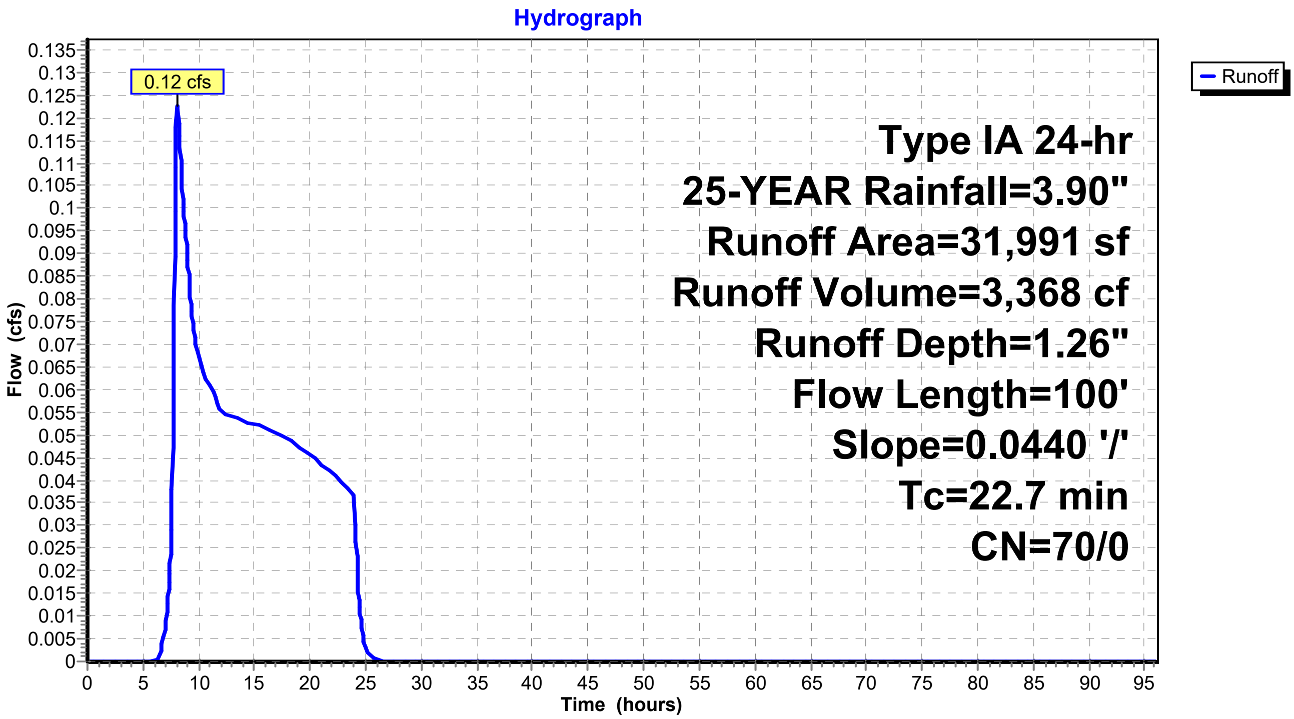
Runoff = 0.12 cfs @ 8.08 hrs, Volume= 3,368 cf, Depth= 1.26"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
31,991	70	Woods, Good, HSG C
31,991	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.7	100	0.0440	0.09		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.50"
5.0					**Direct Entry,**
22.7	100	Total			

Subcatchment 120S: Onsite Undisturbed



Summary for Subcatchment 130S: Onsite Undisturbed

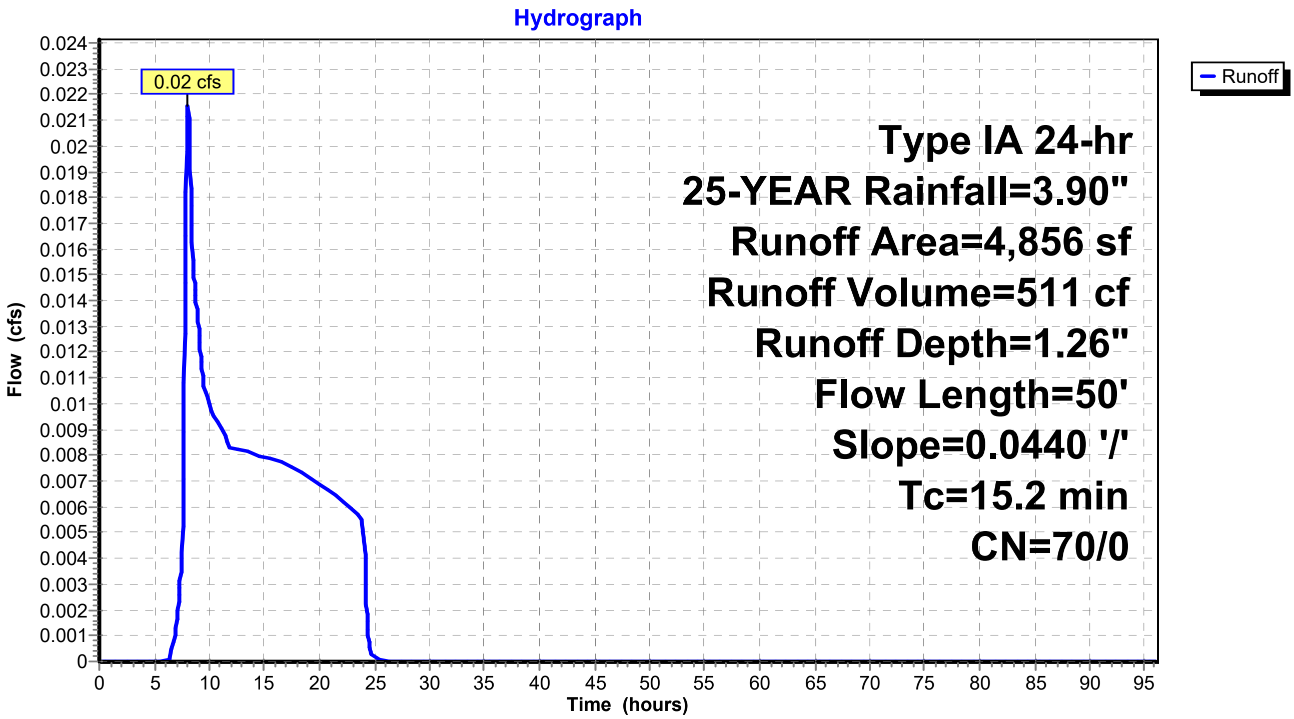
Runoff = 0.02 cfs @ 8.05 hrs, Volume= 511 cf, Depth= 1.26"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
4,856	70	Woods, Good, HSG C
4,856	70	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.2	50	0.0440	0.08		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 2.50"
5.0					**Direct Entry,**
15.2	50	Total			

Subcatchment 130S: Onsite Undisturbed



Summary for Subcatchment 140X: City Reservoir

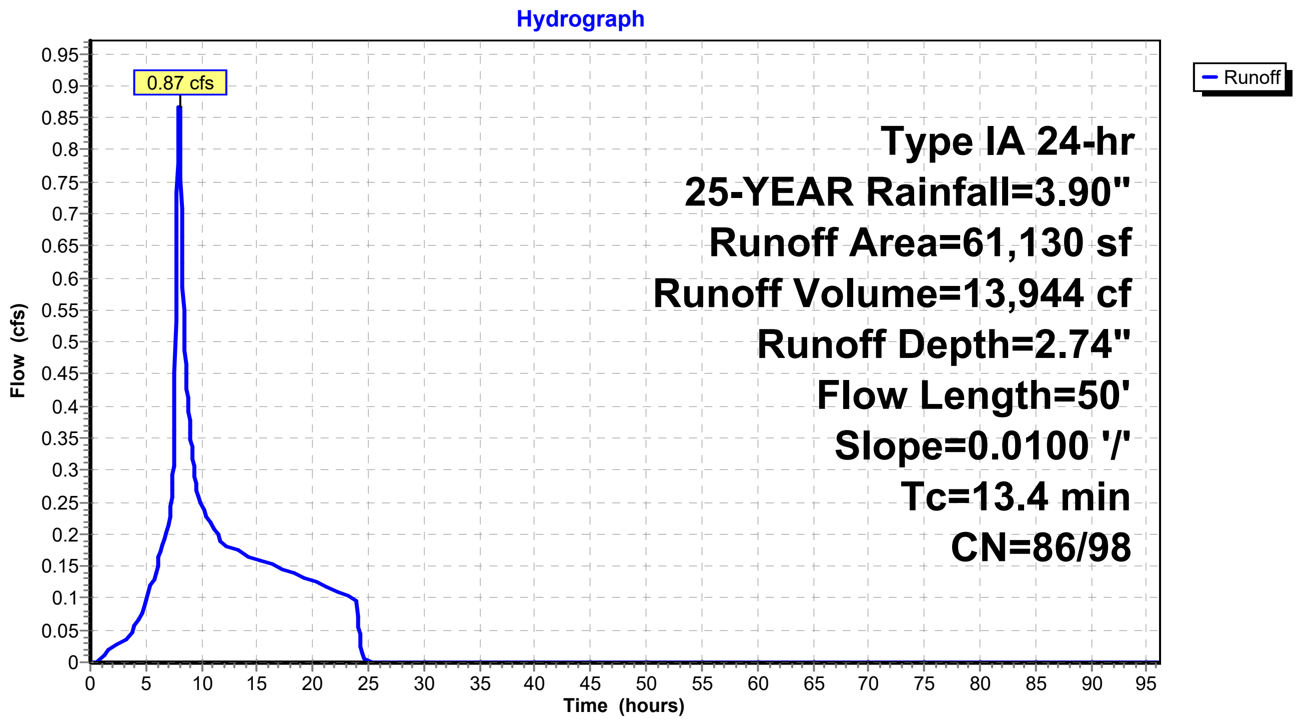
Runoff = 0.87 cfs @ 8.00 hrs, Volume= 13,944 cf, Depth= 2.74"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

Area (sf)	CN	Description
14,216	98	Paved roads w/curbs & sewers, HSG C
46,914	86	<50% Grass cover, Poor, HSG C
61,130	89	Weighted Average
46,914	86	76.74% Pervious Area
14,216	98	23.26% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.4	50	0.0100	0.10		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.50"
5.0					**Direct Entry,**
13.4	50	Total			

Subcatchment 140X: City Reservoir



Summary for Subcatchment 150X: Upstream Boones Ferry

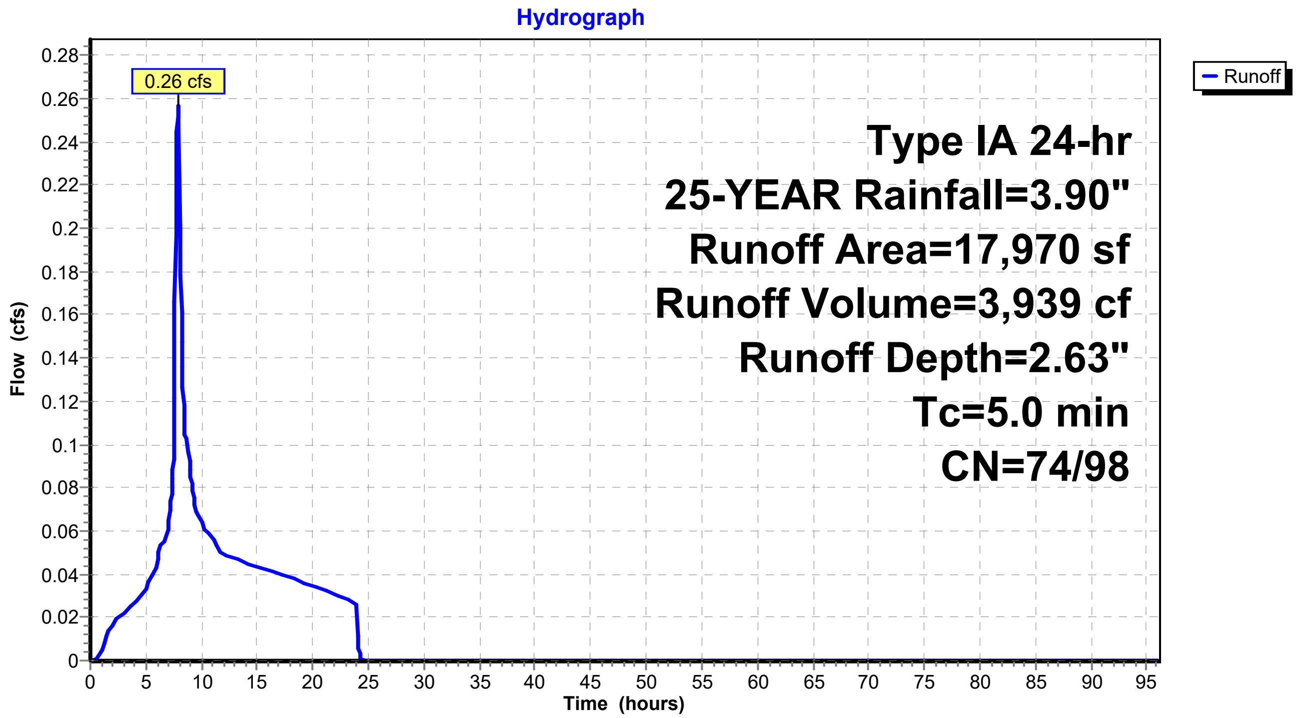
Runoff = 0.26 cfs @ 7.93 hrs, Volume= 3,939 cf, Depth= 2.63"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	9,285	98	Impervious Area
	8,685	74	>75% Grass cover, Good, HSG C
	17,970	86	Weighted Average
	8,685	74	48.33% Pervious Area
	9,285	98	51.67% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry,**

Subcatchment 150X: Upstream Boones Ferry



Summary for Subcatchment 160X: Upstream Properties

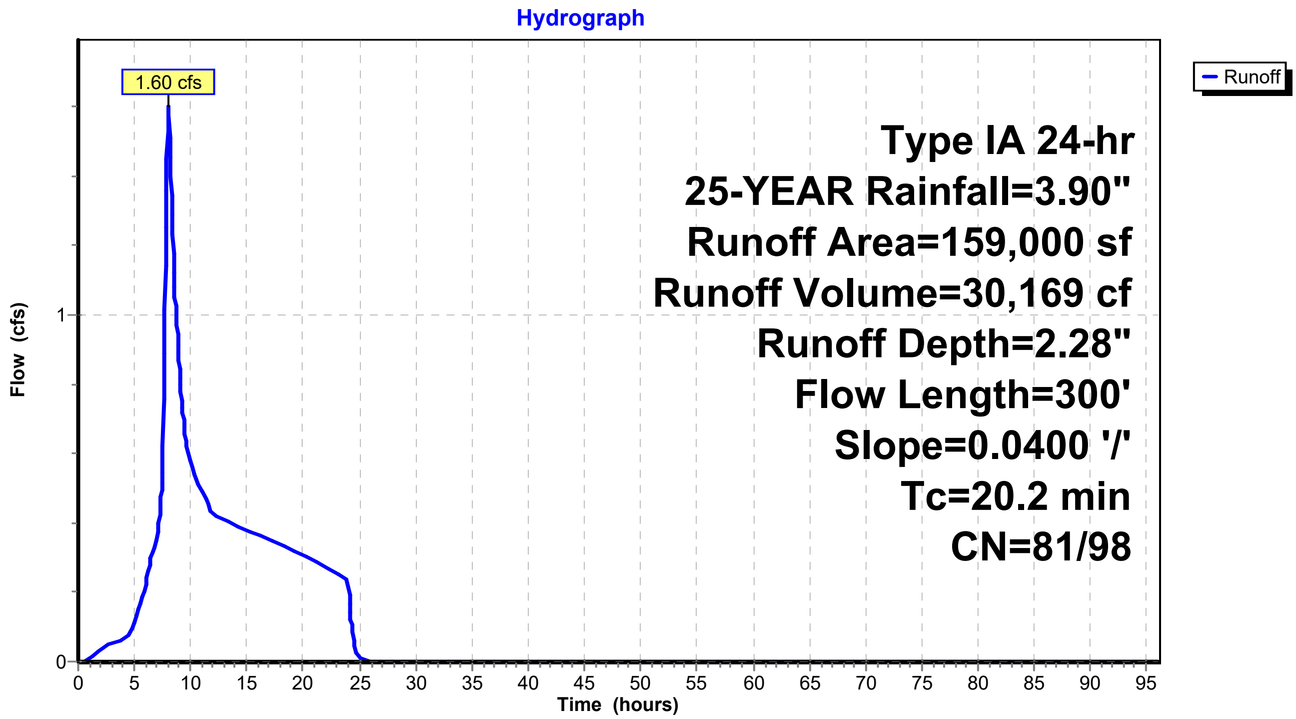
Runoff = 1.60 cfs @ 8.03 hrs, Volume= 30,169 cf, Depth= 2.28"

Runoff by SBUH method, Split Pervious/Imperv., Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type IA 24-hr 25-YEAR Rainfall=3.90"

	Area (sf)	CN	Description
*	23,371	98	Impervious Area
	12,930	96	Gravel surface, HSG C
	122,699	79	50-75% Grass cover, Fair, HSG C
	159,000	83	Weighted Average
	135,629	81	85.30% Pervious Area
	23,371	98	14.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.2	300	0.0400	0.25		**Sheet Flow,** Grass: Short n= 0.150 P2= 2.50"

Subcatchment 160X: Upstream Properties



Summary for Pond 1P: East Facility

Inflow Area = 1,393,027 sf, 62.92% Impervious, Inflow Depth = 2.90" for 25-YEAR event
Inflow = 22.13 cfs @ 7.93 hrs, Volume= 336,137 cf
Outflow = 6.53 cfs @ 9.22 hrs, Volume= 322,788 cf, Atten= 70%, Lag= 77.5 min
Primary = 6.53 cfs @ 9.22 hrs, Volume= 322,788 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Peak Elev= 323.62' @ 9.22 hrs Surf.Area= 39,100 sf Storage= 124,280 cf
Flood Elev= 324.00' Surf.Area= 40,147 sf Storage= 139,316 cf

Plug-Flow detention time= 756.8 min calculated for 322,788 cf (96% of inflow)
Center-of-Mass det. time= 727.8 min (1,423.9 - 696.1)

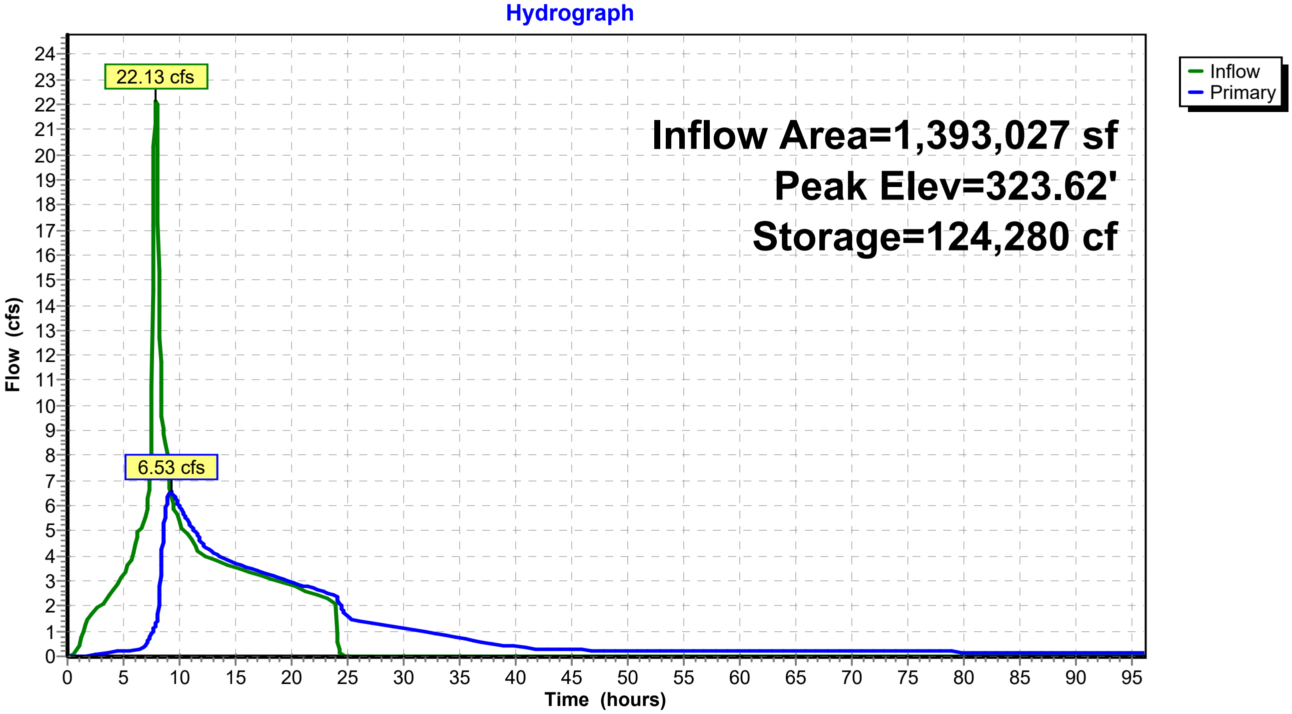
Volume	Invert	Avail.Storage	Storage Description
#1	319.00'	180,848 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
319.00	15,445	584.0	0	0	15,445
320.00	17,226	603.0	16,327	16,327	17,335
321.00	19,064	622.0	18,137	34,465	19,286
321.50	33,433	871.0	12,957	47,422	48,872
322.00	34,748	881.0	17,044	64,466	50,333
323.00	37,419	900.0	36,075	100,541	53,170
324.00	40,147	918.0	38,775	139,316	55,928
325.00	42,932	938.0	41,532	180,848	59,024

Device	Routing	Invert	Outlet Devices
#1	Primary	318.00'	**24.0" Round Culvert** L= 10.0' Ke= 0.500 Inlet / Outlet Invert= 318.00' / 317.00' S= 0.1000 '/' Cc= 0.900 n= 0.013, Flow Area= 3.14 sf
#2	Device 4	319.00'	**2.2' long Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 1.97 2.46 2.95 Coef. (English) 2.84 3.13 3.26 3.30 3.31 3.31
#3	Device 1	319.00'	**2.4" Vert. WQ Orifice** C= 0.620
#4	Device 1	321.50'	**6.0" Vert. Detention Orifice** C= 0.620
#5	Device 1	323.00'	**Grated Manhole, Cv= 3.19 (C= 3.99)** Head (feet) 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40 1.50 1.60 1.70 1.80 1.90 2.00 2.10 2.20 2.30 2.40 2.50 2.60 2.70 2.80 2.89 Width (feet) 0.00 1.83 2.54 3.05 3.45 3.79 4.06 4.29 4.48 4.63 4.76 4.86 4.93 4.98 5.00 5.00 4.97 4.92 4.84 4.74 4.61 4.45 4.26 4.02 3.74 3.40 2.98 2.45 1.69 0.00

Primary OutFlow Max=6.53 cfs @ 9.22 hrs HW=323.62' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 6.53 cfs of 32.52 cfs potential flow)
  ├─**3=WQ Orifice** (Orifice Controls 0.33 cfs @ 10.58 fps)
  ├─**4=Detention Orifice** (Orifice Controls 1.34 cfs @ 6.80 fps)
  │ └─**2=Broad-Crested Rectangular Weir** (Passes 1.34 cfs of 59.49 cfs potential flow)
  └─**5=Grated Manhole** (Weir Controls 4.86 cfs @ 2.78 fps)

Pond 1P: East Facility



Summary for Pond 2P: West Facility

Inflow Area = 1,304,867 sf, 69.30% Impervious, Inflow Depth = 3.01" for 25-YEAR event
Inflow = 21.83 cfs @ 7.92 hrs, Volume= 327,069 cf
Outflow = 12.32 cfs @ 8.25 hrs, Volume= 321,718 cf, Atten= 44%, Lag= 20.1 min
Primary = 12.32 cfs @ 8.25 hrs, Volume= 321,718 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Peak Elev= 319.55' @ 8.25 hrs Surf.Area= 24,329 sf Storage= 91,804 cf
Flood Elev= 320.00' Surf.Area= 25,193 sf Storage= 102,900 cf

Plug-Flow detention time= 470.3 min calculated for 321,551 cf (98% of inflow)
Center-of-Mass det. time= 460.0 min (1,148.9 - 688.9)

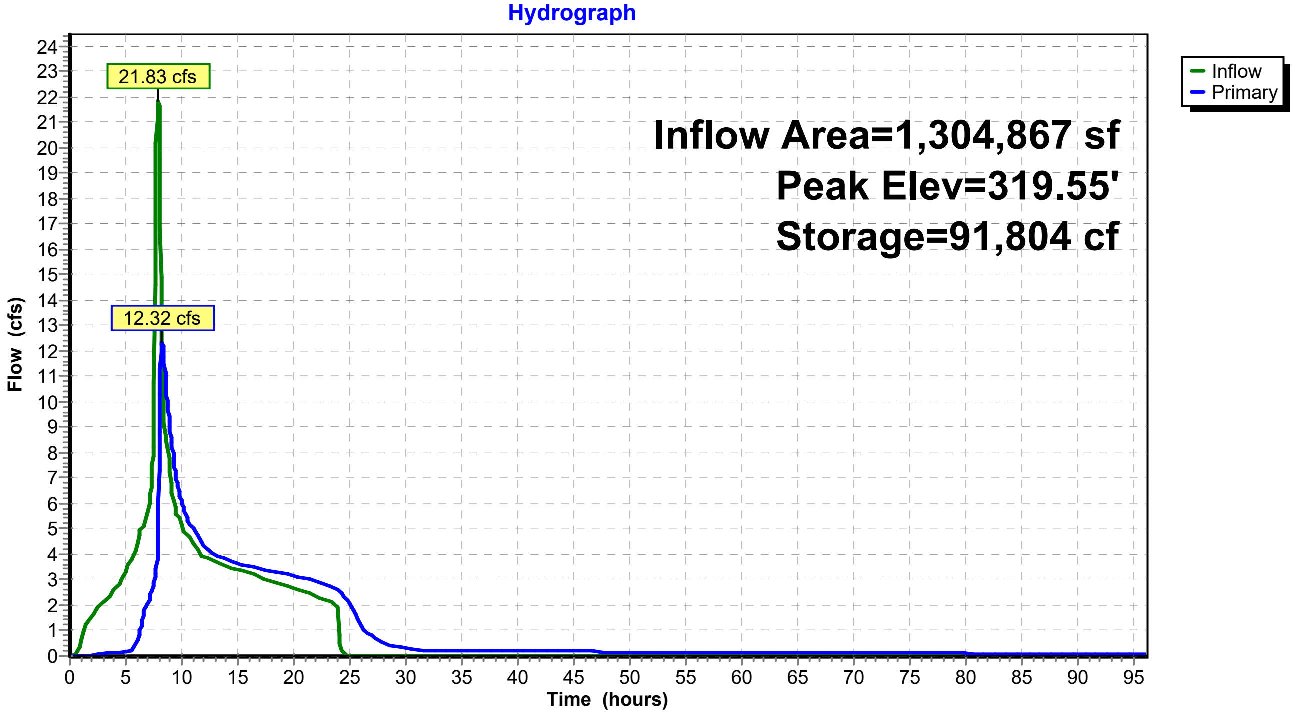
Volume	Invert	Avail.Storage	Storage Description
#1	315.00'	129,027 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
315.00	16,224	546.0	0	0	16,224
316.00	17,891	565.0	17,051	17,051	17,993
317.00	19,614	584.0	18,746	35,797	19,823
318.00	21,434	607.0	20,517	56,314	22,083
319.00	23,285	626.0	22,353	78,667	24,046
320.00	25,193	645.0	24,233	102,900	26,070
321.00	27,072	659.0	26,127	129,027	27,663

Device	Routing	Invert	Outlet Devices
#1	Primary	314.50'	**24.0" Round Culvert** L= 50.0' Ke= 0.500 Inlet / Outlet Invert= 314.50' / 314.00' S= 0.0100 '/' Cc= 0.900 n= 0.013, Flow Area= 3.14 sf
#2	Device 4	315.00'	**2.2' long Broad-Crested Rectangular Weir** Head (feet) 0.49 0.98 1.48 1.97 2.46 2.95 Coef. (English) 2.84 3.13 3.26 3.30 3.31 3.31
#3	Device 1	315.00'	**2.3" Vert. WQ Orifice** C= 0.620
#4	Device 1	317.00'	**10.0" Vert. Detention Orifice** C= 0.620
#5	Device 1	318.75'	**Grated Manhole, Cv= 3.19 (C= 3.99)** Head (feet) 0.00 0.10 0.20 0.30 0.40 0.50 0.60 0.70 0.80 0.90 1.00 1.10 1.20 1.30 1.40 1.50 1.60 1.70 1.80 1.90 2.00 2.10 2.20 2.30 2.40 2.50 2.60 2.70 2.80 2.89 Width (feet) 0.00 1.83 2.54 3.05 3.45 3.79 4.06 4.29 4.48 4.63 4.76 4.86 4.93 4.98 5.00 5.00 4.97 4.92 4.84 4.74 4.61 4.45 4.26 4.02 3.74 3.40 2.98 2.45 1.69 0.00

Primary OutFlow Max=12.32 cfs @ 8.25 hrs HW=319.55' TW=0.00' (Dynamic Tailwater)
└─**1=Culvert** (Passes 12.32 cfs of 30.45 cfs potential flow)
  ├─**3=WQ Orifice** (Orifice Controls 0.30 cfs @ 10.50 fps)
  ├─**4=Detention Orifice** (Orifice Controls 3.97 cfs @ 7.27 fps)
  │ └─**2=Broad-Crested Rectangular Weir** (Passes 3.97 cfs of 61.94 cfs potential flow)
  └─**5=Grated Manhole** (Weir Controls 8.05 cfs @ 3.18 fps)

Pond 2P: West Facility

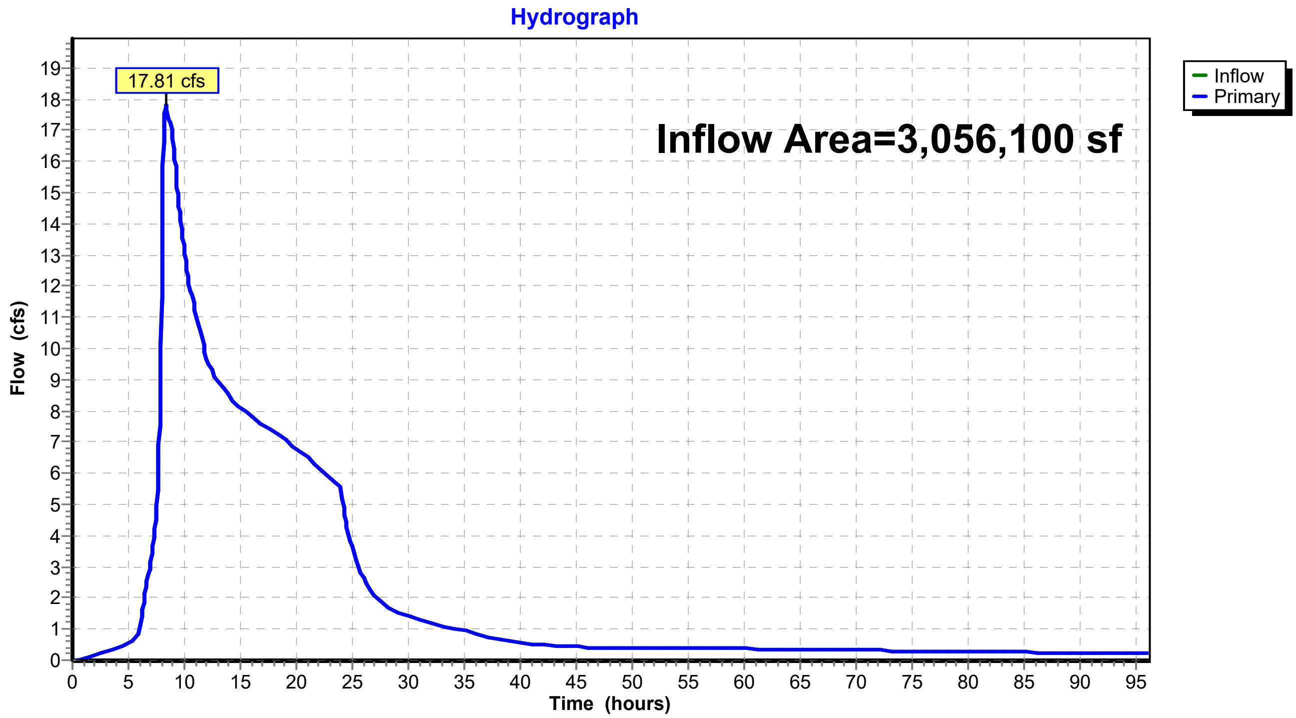


Summary for Link 1T: POST TOTAL

Inflow Area = 3,056,100 sf, 59.30% Impervious, Inflow Depth > 2.75" for 25-YEAR event
Inflow = 17.81 cfs @ 8.36 hrs, Volume= 701,408 cf
Primary = 17.81 cfs @ 8.36 hrs, Volume= 701,408 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Link 1T: POST TOTAL

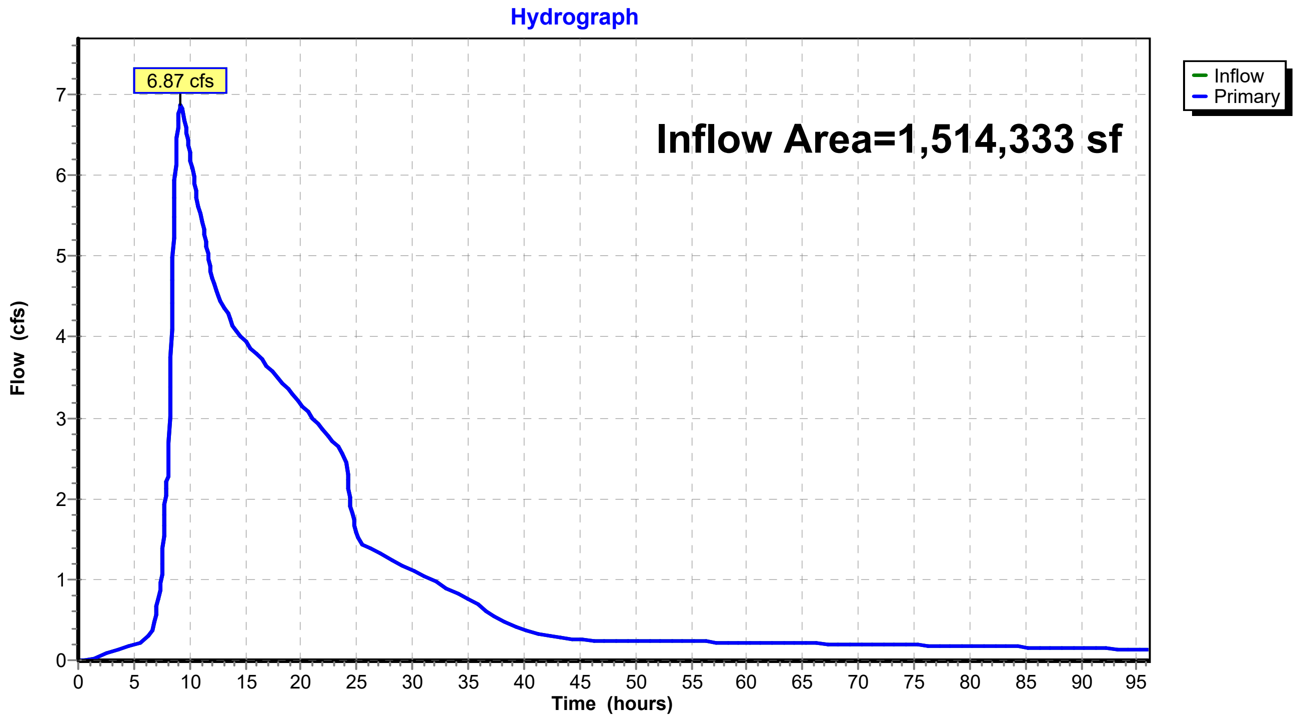


Summary for Link 2T: POST DEV EAST

Inflow Area = 1,514,333 sf, 57.88% Impervious, Inflow Depth > 2.68" for 25-YEAR event
Inflow = 6.87 cfs @ 9.19 hrs, Volume= 338,187 cf
Primary = 6.87 cfs @ 9.19 hrs, Volume= 338,187 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Link 2T: POST DEV EAST

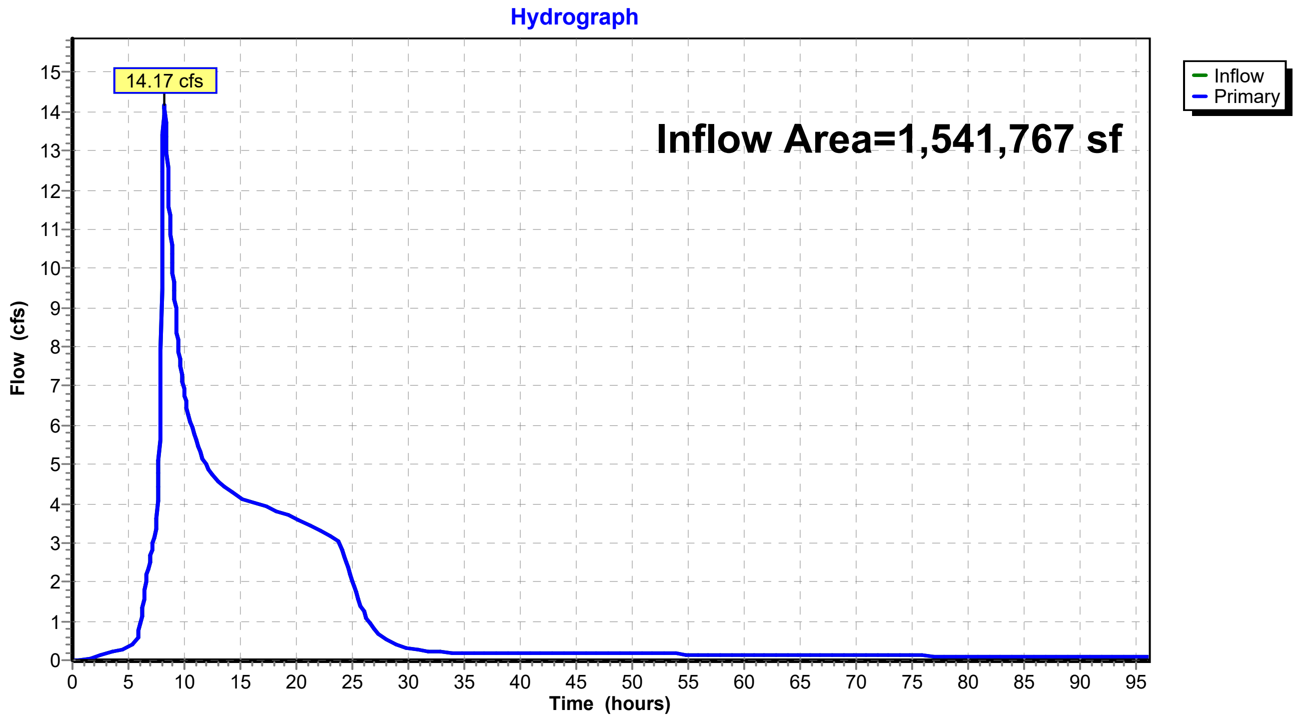


Summary for Link 3T: POST DEV WEST

Inflow Area = 1,541,767 sf, 60.70% Impervious, Inflow Depth > 2.83" for 25-YEAR event
Inflow = 14.17 cfs @ 8.22 hrs, Volume= 363,221 cf
Primary = 14.17 cfs @ 8.22 hrs, Volume= 363,221 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Link 3T: POST DEV WEST



Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment1S: Future Commercial Runoff Area=26,911 sf 85.00% Impervious Runoff Depth=3.82"
Tc=5.0 min CN=74/98 Runoff=0.58 cfs 8,575 cf

Subcatchment2S: Future Commercial Runoff Area=61,043 sf 85.00% Impervious Runoff Depth=3.82"
Tc=5.0 min CN=74/98 Runoff=1.32 cfs 19,452 cf

Subcatchment3S: Runoff Area=68,508 sf 7.88% Impervious Runoff Depth=2.07"
Tc=5.0 min CN=74/98 Runoff=0.73 cfs 11,844 cf

Subcatchment4S: Runoff Area=9,392 sf 28.66% Impervious Runoff Depth=2.55"
Tc=5.0 min CN=74/98 Runoff=0.13 cfs 1,993 cf

Subcatchment5S: Runoff Area=1,198,943 sf 68.42% Impervious Runoff Depth=3.45"
Tc=5.0 min CN=74/98 Runoff=23.03 cfs 344,475 cf

Subcatchment6S: Runoff Area=121,306 sf 0.00% Impervious Runoff Depth=1.90"
Tc=5.0 min CN=74/0 Runoff=1.17 cfs 19,164 cf

Subcatchment7S: Runoff Area=1,295,050 sf 66.58% Impervious Runoff Depth=3.41"
Tc=5.0 min CN=74/98 Runoff=24.53 cfs 367,594 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth=1.60"
Flow Length=100' Slope=0.0440 '/' Tc=22.7 min CN=70/0 Runoff=0.17 cfs 4,274 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth=1.60"
Flow Length=50' Slope=0.0440 '/' Tc=15.2 min CN=70/0 Runoff=0.03 cfs 649 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth=3.20"
Flow Length=50' Slope=0.0100 '/' Tc=13.4 min CN=86/98 Runoff=1.02 cfs 16,315 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth=3.07"
Tc=5.0 min CN=74/98 Runoff=0.30 cfs 4,594 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth=2.71"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=1.94 cfs 35,935 cf

Pond 1P: East Facility Peak Elev=323.80' Storage=131,153 cf Inflow=25.69 cfs 388,832 cf
Outflow=9.66 cfs 375,399 cf

Pond 2P: West Facility Peak Elev=319.77' Storage=97,234 cf Inflow=25.23 cfs 377,097 cf
Outflow=17.37 cfs 371,623 cf

Link 1T: POST TOTAL Inflow=27.53 cfs 815,957 cf
Primary=27.53 cfs 815,957 cf

Link 2T: POST DEV EAST Inflow=10.18 cfs 394,563 cf
Primary=10.18 cfs 394,563 cf

Link 3T: POST DEV WEST

Inflow=19.84 cfs 421,394 cf
Primary=19.84 cfs 421,394 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 834,863 cf Average Runoff Depth = 3.28"
40.70% Pervious = 1,243,829 sf 59.30% Impervious = 1,812,271 sf

Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment1S: Future Commercial Runoff Area=26,911 sf 85.00% Impervious Runoff Depth=2.91"
Tc=5.0 min CN=74/98 Runoff=0.44 cfs 6,537 cf

Subcatchment2S: Future Commercial Runoff Area=61,043 sf 85.00% Impervious Runoff Depth=2.91"
Tc=5.0 min CN=74/98 Runoff=1.01 cfs 14,828 cf

Subcatchment3S: Runoff Area=68,508 sf 7.88% Impervious Runoff Depth=1.36"
Tc=5.0 min CN=74/98 Runoff=0.44 cfs 7,787 cf

Subcatchment4S: Runoff Area=9,392 sf 28.66% Impervious Runoff Depth=1.78"
Tc=5.0 min CN=74/98 Runoff=0.09 cfs 1,395 cf

Subcatchment5S: Runoff Area=1,198,943 sf 68.42% Impervious Runoff Depth=2.58"
Tc=5.0 min CN=74/98 Runoff=17.15 cfs 257,920 cf

Subcatchment6S: Runoff Area=121,306 sf 0.00% Impervious Runoff Depth=1.21"
Tc=5.0 min CN=74/0 Runoff=0.66 cfs 12,187 cf

Subcatchment7S: Runoff Area=1,295,050 sf 66.58% Impervious Runoff Depth=2.54"
Tc=5.0 min CN=74/98 Runoff=18.21 cfs 274,610 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth=0.98"
Flow Length=100' Slope=0.0440 '/' Tc=22.7 min CN=70/0 Runoff=0.08 cfs 2,606 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth=0.98"
Flow Length=50' Slope=0.0440 '/' Tc=15.2 min CN=70/0 Runoff=0.01 cfs 396 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth=2.32"
Flow Length=50' Slope=0.0100 '/' Tc=13.4 min CN=86/98 Runoff=0.73 cfs 11,841 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth=2.24"
Tc=5.0 min CN=74/98 Runoff=0.22 cfs 3,361 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth=1.90"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=1.30 cfs 25,119 cf

Pond 1P: East Facility Peak Elev=323.47' Storage=118,344 cf Inflow=18.99 cfs 289,453 cf
Outflow=4.37 cfs 276,200 cf

Pond 2P: West Facility Peak Elev=319.32' Storage=86,218 cf Inflow=18.82 cfs 282,646 cf
Outflow=8.15 cfs 277,421 cf

Link 1T: POST TOTAL Inflow=11.41 cfs 600,109 cf
Primary=11.41 cfs 600,109 cf

Link 2T: POST DEV EAST Inflow=4.59 cfs 288,387 cf
Primary=4.59 cfs 288,387 cf

Link 3T: POST DEV WEST

Inflow=9.42 cfs 311,722 cf
Primary=9.42 cfs 311,722 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 618,586 cf Average Runoff Depth = 2.43"
40.70% Pervious = 1,243,829 sf 59.30% Impervious = 1,812,271 sf

Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment1S: Future Commercial Runoff Area=26,911 sf 85.00% Impervious Runoff Depth=2.58"
Tc=5.0 min CN=74/98 Runoff=0.39 cfs 5,794 cf

Subcatchment2S: Future Commercial Runoff Area=61,043 sf 85.00% Impervious Runoff Depth=2.58"
Tc=5.0 min CN=74/98 Runoff=0.89 cfs 13,142 cf

Subcatchment3S: Runoff Area=68,508 sf 7.88% Impervious Runoff Depth=1.12"
Tc=5.0 min CN=74/98 Runoff=0.35 cfs 6,404 cf

Subcatchment4S: Runoff Area=9,392 sf 28.66% Impervious Runoff Depth=1.52"
Tc=5.0 min CN=74/98 Runoff=0.07 cfs 1,186 cf

Subcatchment5S: Runoff Area=1,198,943 sf 68.42% Impervious Runoff Depth=2.27"
Tc=5.0 min CN=74/98 Runoff=15.04 cfs 226,719 cf

Subcatchment6S: Runoff Area=121,306 sf 0.00% Impervious Runoff Depth=0.97"
Tc=5.0 min CN=74/0 Runoff=0.50 cfs 9,829 cf

Subcatchment7S: Runoff Area=1,295,050 sf 66.58% Impervious Runoff Depth=2.23"
Tc=5.0 min CN=74/98 Runoff=15.94 cfs 241,138 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth=0.77"
Flow Length=100' Slope=0.0440 '/' Tc=22.7 min CN=70/0 Runoff=0.06 cfs 2,054 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth=0.77"
Flow Length=50' Slope=0.0440 '/' Tc=15.2 min CN=70/0 Runoff=0.01 cfs 312 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth=2.01"
Flow Length=50' Slope=0.0100 '/' Tc=13.4 min CN=86/98 Runoff=0.62 cfs 10,233 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth=1.95"
Tc=5.0 min CN=74/98 Runoff=0.19 cfs 2,923 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth=1.61"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=1.07 cfs 21,305 cf

Pond 1P: East Facility Peak Elev=323.36' Storage=114,301 cf Inflow=16.59 cfs 253,737 cf
Outflow=3.21 cfs 240,582 cf

Pond 2P: West Facility Peak Elev=319.14' Storage=81,884 cf Inflow=16.52 cfs 248,578 cf
Outflow=5.73 cfs 243,454 cf

Link 1T: POST TOTAL Inflow=8.15 cfs 522,760 cf
Primary=8.15 cfs 522,760 cf

Link 2T: POST DEV EAST Inflow=3.37 cfs 250,411 cf
Primary=3.37 cfs 250,411 cf

Link 3T: POST DEV WEST

Inflow=6.54 cfs 272,349 cf
Primary=6.54 cfs 272,349 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 541,038 cf Average Runoff Depth = 2.12"
40.70% Pervious = 1,243,829 sf 59.30% Impervious = 1,812,271 sf

Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 points
Runoff by SBUH method, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment1S: Future Commercial Runoff Area=26,911 sf 85.00% Impervious Runoff Depth=2.02"
Tc=5.0 min CN=74/98 Runoff=0.31 cfs 4,533 cf

Subcatchment2S: Future Commercial Runoff Area=61,043 sf 85.00% Impervious Runoff Depth=2.02"
Tc=5.0 min CN=74/98 Runoff=0.70 cfs 10,283 cf

Subcatchment3S: Runoff Area=68,508 sf 7.88% Impervious Runoff Depth=0.74"
Tc=5.0 min CN=74/98 Runoff=0.20 cfs 4,220 cf

Subcatchment4S: Runoff Area=9,392 sf 28.66% Impervious Runoff Depth=1.08"
Tc=5.0 min CN=74/98 Runoff=0.05 cfs 849 cf

Subcatchment5S: Runoff Area=1,198,943 sf 68.42% Impervious Runoff Depth=1.75"
Tc=5.0 min CN=74/98 Runoff=11.51 cfs 174,414 cf

Subcatchment6S: Runoff Area=121,306 sf 0.00% Impervious Runoff Depth=0.61"
Tc=5.0 min CN=74/0 Runoff=0.24 cfs 6,149 cf

Subcatchment7S: Runoff Area=1,295,050 sf 66.58% Impervious Runoff Depth=1.72"
Tc=5.0 min CN=74/98 Runoff=12.16 cfs 185,101 cf

Subcatchment120S: Onsite Undisturbed Runoff Area=31,991 sf 0.00% Impervious Runoff Depth=0.46"
Flow Length=100' Slope=0.0440 '/' Tc=22.7 min CN=70/0 Runoff=0.02 cfs 1,214 cf

Subcatchment130S: Onsite Undisturbed Runoff Area=4,856 sf 0.00% Impervious Runoff Depth=0.46"
Flow Length=50' Slope=0.0440 '/' Tc=15.2 min CN=70/0 Runoff=0.00 cfs 184 cf

Subcatchment140X: City Reservoir Runoff Area=61,130 sf 23.26% Impervious Runoff Depth=1.48"
Flow Length=50' Slope=0.0100 '/' Tc=13.4 min CN=86/98 Runoff=0.45 cfs 7,551 cf

Subcatchment150X: Upstream Boones Runoff Area=17,970 sf 51.67% Impervious Runoff Depth=1.47"
Tc=5.0 min CN=74/98 Runoff=0.14 cfs 2,197 cf

Subcatchment160X: Upstream Properties Runoff Area=159,000 sf 14.70% Impervious Runoff Depth=1.14"
Flow Length=300' Slope=0.0400 '/' Tc=20.2 min CN=81/98 Runoff=0.71 cfs 15,074 cf

Pond 1P: East Facility Peak Elev=323.17' Storage=106,985 cf Inflow=12.60 cfs 194,051 cf
Outflow=1.81 cfs 181,162 cf

Pond 2P: West Facility Peak Elev=318.58' Storage=68,967 cf Inflow=12.66 cfs 191,427 cf
Outflow=3.19 cfs 186,468 cf

Link 1T: POST TOTAL Inflow=4.86 cfs 393,923 cf
Primary=4.86 cfs 393,923 cf

Link 2T: POST DEV EAST Inflow=1.91 cfs 187,311 cf
Primary=1.91 cfs 187,311 cf

Link 3T: POST DEV WEST

Inflow=3.65 cfs 206,612 cf
Primary=3.65 cfs 206,612 cf

Total Runoff Area = 3,056,100 sf Runoff Volume = 411,770 cf Average Runoff Depth = 1.62"
40.70% Pervious = 1,243,829 sf 59.30% Impervious = 1,812,271 sf

Appendix C:
Stormwater Quality Calculations

STORMWATER QUALITY CALCULATIONS

ENGINEERING & FORESTRY

Client:	Lennar Northwest, INC
Project:	Autumn Sunrise - East Facility
AKS Job No.:	7454
Date:	6/29/2021
Done By:	DS
Checked By:	PAS

IMPERVIOUS AREA

Total Site Area:	61.71	acres
Total Site Area:	2,688,206	square feet (sf)
Number of Lots:	196	
Impervious Area Per Lot:	2,640	sf
Total Impervious Lot Area:	517,440	sf
Road & Sidewalk Impervious Area:	359,040	sf
Total Impervious Area:	876,480	sf

WATER DESIGN QUALITY VOLUME (WQV)

(Per CWS 4.08.5a2 - R&O 19-05)

$$WQV = \frac{0.36\text{" X Area (ft)}}{12\text{" per ft}} = \textbf{26294 cubic feet}$$

WATER QUALITY FLOW (WQF)

(Per CWS 4.08.5a3 - R&O 19-05)

$$WQF = \frac{\text{WQV (sf)}}{4*60*60} = \textbf{1.83 cfs}$$

EXTENDED DRY BASIN DESIGN & CALCULATIONS

Hydraulic Design Criteria (Per CWS 4.09.5a/b/c - R&O 19-05)

Permanent Pool Depth: 0.2 ft
Permanent Pool covers bottom of basin
Design Detention Volume: 1.0 x Water Quality Volume (WQV)
Water Quality Drawdown Time: 48 hours
Maximum Depth of WQ Pool: 5 ft
Avoid direct flow across WQ pond to avoid short circuiting

Extended Dry Basin Sizing Design:

Bottom Slope (ft/ft)	**Minimum Bottom Width** (ft)	**Side Slopes** H:V	**Top of Pond Elev.** (ft)	**Perm. Pool Depth** (ft)	**Pool Bottom Area** (sf)	**Bottom of Pool Elev.** (ft)
0.0	15445	3.0	325.00	0.2	27073	319.0

Water Quality Flow Hydraulic Calculations:

Q (cfs)	**Pool Elev. at WQV** (ft)	**Orifice CL Height** (ft)	**Calculated Orifice Diameter** (in)	**Max. Pool Elev., 25-yr Event** (ft)	**Calculated Pond WQV** (cubic feet)	**Calculated WQV Pool Depth** (ft)
0.15	320.6	319.10	2.41	323.56	26989	1.6

Check Against Design Criteria:

	Calculated		Meet CWS Criteria?			
Minimum Freeboard:	1.4	feet	**Yes**	more than	1	foot
Minimum Bottom Width:	15445	feet	**Yes**	greater than	4	feet
Maximum Pool Depth at WQV:	1.6	feet	**Yes**	less than	5	feet
Detained Water Quality Volume:	26989	cubic feet	**Yes**	greater than	26294	cf

STORMWATER QUALITY CALCULATIONS

Client:	Lennar Northwest, INC
Project:	Autumn Sunrise - West Facility
AKS Job No.:	7454
Date:	6/29/2021
Done By:	DS
Checked By:	PAS

IMPERVIOUS AREA

Total Site Area:	61.71	acres
Total Site Area:	2,688,206	square feet (sf)
Number of Lots:	204	
Impervious Area Per Lot:	2,640	sf
Total Impervious Lot Area:	538,560	sf
Future Commercial Impervious Area:	74,761	sf
Road & Sidewalk Impervious Area:	299,099	sf
Total Impervious Area:	912,420	sf

WATER DESIGN QUALITY VOLUME (WQV)

(Per CWS 4.08.5a2 - R&O 19-05)

$$WQV = \frac{0.36\text{" X Area (ft)}}{12\text{" per ft}} = \textbf{27373 cubic feet}$$

WATER QUALITY FLOW (WQF)

(Per CWS 4.08.5a3 - R&O 19-05)

$$WQF = \frac{\text{WQV (sf)}}{4*60*60} = \textbf{1.90 cfs}$$

EXTENDED DRY BASIN DESIGN & CALCULATIONS

Hydraulic Design Criteria (Per CWS 4.09.5a/b/c - R&O 19-05)

Permanent Pool Depth: 0.2 ft
Permanent Pool covers bottom of basin
Design Detention Volume: 1.0 x Water Quality Volume (WQV)
Water Quality Drawdown Time: 48 hours
Maximum Depth of WQ Pool: 5 ft
Avoid direct flow across WQ pond to avoid short circuiting

Extended Dry Basin Sizing Design:

Bottom Slope (ft/ft)	**Minimum Bottom Width** (ft)	**Side Slopes** H:V	**Top of Pond Elev.** (ft)	**Perm. Pool Depth** (ft)	**Pool Bottom Area** (sf)	**Bottom of Pool Elev.** (ft)
0.0	16224	3.0	321.00	0.2	12316	315.0

Water Quality Flow Hydraulic Calculations:

Q (cfs)	**Pool Elev. at WQV** (ft)	**Orifice CL Height** (ft)	**Calculated Orifice Diameter** (in)	**Max. Pool Elev., 25-yr Event** (ft)	**Calculated Pond WQV** (cubic feet)	**Calculated WQV Pool Depth** (ft)
0.16	317.0	315.10	2.32	319.82	27408	2.0

Check Against Design Criteria:

	Calculated		Meet CWS Criteria?			
Minimum Freeboard:	1.2	feet	**Yes**	more than	1	foot
Minimum Bottom Width:	16224	feet	**Yes**	greater than	4	feet
Maximum Pool Depth at WQV:	2.0	feet	**Yes**	less than	5	feet
Detained Water Quality Volume:	27408	cubic feet	**Yes**	greater than	27373	cf

Appendix D:
Site Geotechnical Report

Real-World Geotechnical Solutions
Investigation • Design • Construction Support

Preliminary Geotechnical Engineering Report

Autumn Sunrise Subdivision

SW Norwood Road & SW Boones Ferry Road
Tualatin, Oregon

GeoPacific Engineering, Inc. Project No. 20-5436
Updated May 18, 2021

14835 SW 72nd Avenue
Portland, Oregon 97224
Tel (503) 598-8445
Fax (503) 941-9281

Real-World Geotechnical Solutions
Investigation • Design • Construction Support

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Updated May 18, 2021
Project No. 20-5436

Ms. Terry New
Lennar Northwest
11807 NE 99th Street, Suite 1170
Vancouver, Washington 98682
Phone: (360) 258-7871
Email: terry.new@lennar.com

SUBJECT: PRELIMINARY GEOTECHNICAL ENGINEERING REPORT
AUTUMN SUNRISE SUBDIVISION
SW NORWOOD ROAD & SW BOONES FERRY ROAD
TUALATIN, OREGON

Reference: *Geotechnical Report, Norwood Property, SW Norwood Road – T2S R1W Section 35 Tax Lot 100, Tualatin, Oregon,* GeoPacific Engineering, Inc. report updated August 18, 2021.

1.0 PROJECT INFORMATION

This report presents the results of a geotechnical engineering study conducted by GeoPacific Engineering, Inc. (GeoPacific) for the above-referenced project. The purpose of our investigation was to evaluate subsurface conditions at the site, and to provide geotechnical recommendations for site development. This geotechnical study was performed in accordance with GeoPacific Proposal No. P-7209, dated January 22, 2020, and your subsequent authorization of our proposal and *General Conditions for Geotechnical Services*. GeoPacific had previously issued a report for the Norwood Property to the north (referenced above), which is being incorporated into the Autumn Sunrise Subdivision.

Site Location:	Northeast of SW Boones Ferry Rd & SW Greenhill Lane, South of SW Norwood Road Washington County Property No. R560164, R560253, R560262, R560271, R560280, R560299, R560306, & R560315 Tualatin, Oregon (see Figures 1 and 2)

Developer:	**Lennar Northwest** 11807 NE 99th Street, Suite 1170 Vancouver, Washington 98682 Phone: (360) 258-7871
Jurisdictional Agency:	City of Tualatin, Oregon
Civil Engineer:	Darko Simic AKS Engineering & Forestry, LLC. 12965 SW Herman Road, Unit 100 Tualatin, Oregon 97062 Tel (503) 563-6151

2.0 SITE AND PROJECT DESCRIPTION

The subject site is located northeast of the intersection of SW Boones Ferry Road and SW Greenhill Lane extending north to SW Norwood Road in the City of Tualatin, Washington County, Oregon (Figure 1). The site consists of Washington County Properties R560164, R560253, R560262, R560271, R560280, R560299, R560306, and R560315, totaling approximately 60.5 acres in size. The site latitude and longitude are 45.3496, -122.7694, and the legal description is the SE ¼ of Section 35, T2S, R1W, Willamette Meridian. The regulatory jurisdictional agency is the City of Tualatin, Oregon. The site is bordered by SW Greenhill Lane to the south, by SW Boones Ferry Road to the west, by Interstate 5 to the east, and by residential homes, Horizon Christian High School, and SW Norwood Road to the north. The site contains three existing residential homes in the southern portion of the site with street addresses of 9185 SW Greenhill Lane, 9335 SW Greenhill Lane, and 9415 SW Greenhill Lane. Each residential property contains various barns and outbuildings. Two of the homes have swimming pools. The majority of the property has been historically used for agricultural purposes and appears to have been regularly plowed and farmed with several individual plots. Two homes were historically present in the north western portion of the site on Property No. R560262, which had a street address of 23620 SW Boones Ferry Road; and Property No. R56253, which had a street address of 23740 SW Boones Ferry Road.

Based on our review of available historical aerial photography the southern portion of the site has been altered over the years by agricultural and residential activity. Prior to the year 2000 the eastern portion of the site was heavily wooded with coniferous trees. During the 2000's residential development of properties to the north and construction of the high school was conducted, and the northern portion of this site was used as a stockpile and fill location. The northeastern corner of the property was used to stockpile soil and a bike track was present for many years. It appears that several periods of farming, grading, and various land use was conducted during this time period which likely resulted in placement of undocumented fill soils particularly in the northern portions. At this time vegetation at the site consists of open grass areas in the central portion, heavily wooded areas adjacent Interstate 5 and SW Norwood Road, blackberries and brush in the northeastern portion, and minor trees and landscaping around the existing homes in the southern portion. Topography at the site is level to gently sloping with site elevations range from approximately 310 to 360 feet above mean sea level (amsl).

Based upon review of preliminary site plans, GeoPacific understands that the proposed development at the site will consist of a residential development supporting construction of ± 400 attached and detached homes, new streets, stormwater facilities, parks and open space, and associated new underground utilities. We anticipate that the homes will be constructed with typical spread foundations and wood framing, with maximum structural loading on column footings and continuous strip footings on the order of 10 to 35 kips, and 2 to 4 kips respectively. At this time grading plans have not been created, however based on the current site elevations and topography we estimate that cuts and fills may be on the order of 10 feet or less. We expect final grades to be relatively level.

3.0 REGIONAL AND LOCAL GEOLOGIC SETTING

The subject site lies within the Willamette Valley/Puget Sound lowland, a broad structural depression situated between the Coast Range on the west and the Cascade Range on the east. A series of discontinuous faults subdivide the Willamette Valley into a mosaic of fault-bounded, structural blocks (Yeats et al., 1996). Uplifted structural blocks form bedrock highlands, while down-warped structural blocks form sedimentary basins.

The subject site is underlain by the Miocene aged (about 14.5 to 16.5 million years ago) Columbia River Basalt Formation, which are a thick sequence of lava flows which form the crystalline basement of the Tualatin Valley (Beeson et al., 1989; Gannett and Caldwell, 1998). The basalts are composed of dense, finely crystalline rock that is commonly fractured along blocky and columnar vertical joints. Individual basalt flow units typically range from 25 to 125 feet thick and interflow zones are typically vesicular, scoriaceous, brecciated, and sometimes include sedimentary rocks.

4.0 REGIONAL SEISMIC SETTING

At least four major fault zones capable of generating damaging earthquakes are thought to exist in the vicinity of the subject site. These include the Portland Hills Fault Zone, the Gales Creek-Newberg-Mt. Angel Structural Zone, and the Cascadia Subduction Zone.

4.1 Portland Hills Fault Zone

The Portland Hills Fault Zone is a series of NW-trending faults that include the central Portland Hills Fault, the western Oatfield Fault, and the eastern East Bank Fault. These faults occur in a northwest-trending zone that varies in width between 3.5 and 5.0 miles. The combined three faults vertically displace the Columbia River Basalt by 1,130 feet and appear to control thickness changes in late Pleistocene (approx. 780,000 years) sediment (Madin, 1990). The Portland Hills Fault occurs along the Willamette River at the base of the Portland Hills and is approximately 9.4 miles northeast of the site. The East Bank Fault is oriented roughly parallel to the Portland Hills Fault, on the east bank of the Willamette River, and is located approximately 13.2 miles northeast of the site. The Oatfield Fault occurs along the western side of the Portland Hills and is approximately 7.7 miles northeast of the site. The Oatfield Fault is considered to be potentially seismogenic (Wong, et al., 2000). Madin and Mabey (1996) indicate the Portland Hills Fault Zone has experienced Late Quaternary (last 780,000 years) fault movement; however, movement has not been detected in the last 20,000 years. The accuracy of the fault mapping is stated to be within 500 meters (Wong, et al., 2000). No historical seismicity is correlated with the mapped portion of the Portland Hills Fault Zone, but in 1991 a M3.5 earthquake occurred on a NW-trending shear plane located 1.3 miles east of the fault (Yelin, 1992). Although there is no definitive evidence of recent activity, the Portland Hills Fault Zone is assumed to be potentially active (Geomatrix Consultants, 1995).

According to the USGS Earthquake Hazards Program, the fault was originally mapped as a down-to-the-northeast normal fault but has also been mapped as part of a regional-scale zone of right-lateral, oblique slip faults, and as a steep escarpment caused by asymmetrical folding above a south-west dipping, blind thrust fault. The Portland Hills fault offsets Miocene Columbia River Basalts, and Miocene to Pliocene sedimentary rocks of the Troutdale Formation. No fault scarps on surficial Quaternary deposits have been described along the fault trace, and the fault is mapped as buried by the Pleistocene aged Missoula flood deposits. No historical seismicity is correlated with the mapped portion of the Portland Hills Fault Zone, but in 1991 a M3.5 earthquake occurred on a NW-trending shear plane located 1.3 miles east of the fault (Yelin, 1992). Although there is no definitive evidence of recent activity, the Portland Hills Fault Zone is assumed to be potentially active (Geomatrix Consultants, 1995).

4.2 Gales Creek-Newberg-Mt. Angel Structural Zone

The Gales Creek-Newberg-Mt. Angel Structural Zone is a 50-mile-long zone of discontinuous, NW-trending faults that lies approximately 10.1 miles southwest of the subject site. These faults are recognized in the subsurface by vertical separation of the Columbia River Basalt and offset seismic reflectors in the overlying basin sediment (Yeats et al., 1996; Werner et al., 1992). A geologic reconnaissance and photogeologic analysis study conducted for the Scoggins Dam site in the Tualatin Basin revealed no evidence of deformed geomorphic surfaces along the structural zone (Unruh et al., 1994). No seismicity has been recorded on the Gales Creek Fault or Newberg Fault (the fault closest to the subject site); however, these faults are considered to be potentially active because they may connect with the seismically active Mount Angel Fault and the rupture plane of the 1993 M5.6 Scotts Mills earthquake (Werner et al. 1992; Geomatrix Consultants, 1995).

4.3 Cascadia Subduction Zone

The Cascadia Subduction Zone is a 680-mile-long zone of active tectonic convergence where oceanic crust of the Juan de Fuca Plate is subducting beneath the North American continent at a rate of 4 cm per year (Goldfinger et al., 1996). A growing body of geologic evidence suggests that prehistoric subduction zone earthquakes have occurred (Atwater, 1992; Carver, 1992; Peterson et al., 1993; Geomatrix Consultants, 1995). This evidence includes: (1) buried tidal marshes recording episodic, sudden subsidence along the coast of northern California, Oregon, and Washington, (2) burial of subsided tidal marshes by tsunami wave deposits, (3) paleoliquefaction features, and (4) geodetic uplift patterns on the Oregon coast. Radiocarbon dates on buried tidal marshes indicate a recurrence interval for major subduction zone earthquakes of 250 to 650 years with the last event occurring 300 years ago (Atwater, 1992; Carver, 1992; Peterson et al., 1993; Geomatrix Consultants, 1995). The inferred seismogenic portion of the plate interface lies approximately along the Oregon Coast at depths of between 20 and 40 kilometers below the surface.

5.0 FIELD EXPLORATION AND SUBSURFACE CONDITIONS

Our site-specific exploration for this report was conducted on March 11 & 12, April 13, and July 28, 2020. Six exploratory borings were drilled to depths of 5.5 to 25.5 feet and thirty seven exploratory test pits were excavated with a medium sized backhoe and a large excavator to depths ranging between 6.5 and 17 feet at the approximate locations presented on Figure 2. The explorations conducted on the northern property (Norwood) have been renumbered and consecutively added to the Autumn Sunrise explorations. It should be noted that exploration locations were located in the field by pacing or taping distances from apparent property corners and other site features shown on the plans provided. As such, the locations of the explorations should be considered approximate.

The boreholes were drilled using a trailer-mounted drill rig and solid stem auger methods. At each boring location, SPT (Standard Penetration Test) sampling was performed in general accordance with ASTM D1586 using a 2-inch outside diameter split-spoon sampler and a 140-pound hammer equipped with a rope and cathead mechanism. During the test, a sample is obtained by driving the sampler 18 inches into the soil with the hammer free-falling 30 inches. The number of blows for each 6 inches of penetration is recorded. The Standard Penetration Resistance ("N-value") of the soil is calculated as the number of blows required for the final 12 inches of penetration. If 50 or more blows are recorded within a single 6-inch interval, the test is terminated, and the blow count is recorded as 50 blows for the number of inches driven. This resistance, or N-value, provides a measure of the relative density of granular soils and the relative consistency of cohesive soils. At the completion of the borings, the holes were backfilled with bentonite.

A GeoPacific geologist continuously monitored the field exploration program and logged the explorations. Soils observed in the explorations were classified in general accordance with the Unified Soil Classification System (USCS). Rock hardness was classified in accordance with Table 1, modified from the ODOT Rock Hardness Classification Chart. During exploration, our geologist also noted geotechnical conditions such as soil consistency, moisture and groundwater conditions. Logs of the explorations are attached to this report. The following report sections are based on the exploration program and summarize subsurface conditions encountered at the site.

Table 1. Rock Hardness Classification Chart

ODOT Rock Hardness Rating	Field Criteria	Unconfined Compressive Strength	Typical Equipment Needed For Excavation
Extremely Soft (R0)	Indented by thumbnail	<100 psi	Small excavator
Very Soft (R1)	Scratched by thumbnail, crumbled by rock hammer	100-1,000 psi	Small excavator
Soft (R2)	Not scratched by thumbnail, indented by rock hammer	1,000-4,000 psi	Medium excavator (slow digging with small excavator)
Medium Hard (R3)	Scratched or fractured by rock hammer	4,000-8,000 psi	Medium to large excavator (slow to very slow digging), typically requires chipping with hydraulic hammer or mass excavation)
Hard (R4)	Scratched or fractured w/ difficulty	8,000-16,000 psi	Slow chipping with hydraulic hammer and/or blasting
Very Hard (R5)	Not scratched or fractured after many blows, hammer rebounds	>16,000 psi	Blasting

5.1 Soil Characteristics

Undocumented Fill: Undocumented fill soils were encountered in some portions of the site. As presented on Figure 3, GeoPacific encountered undocumented fill soils where a home had previously been present (test pit TP-1), and in the eastern portion of the property where soil stockpiles were created by the high school project (test pits TP-8, TP-9, TP-12, TP-18, and TP-19). Fill depths encountered ranged from approximately 3 to 14 feet bgs.

Fill materials around the demolished home at the location of test pit TP-1 were observed to consist of dark brown, soft, very moist, moderately organic Lean CLAY, containing fine roots extending to a depth of approximately 3 feet bgs. This material is likely unsuitable for re-use as engineered fill. Fill materials in the eastern portion of the property were observed to consist primarily of brown, very moist, moderately plastic, Gravel CLAY, and brown, moderately plastic Lean CLAY, extending to depths ranging from approximately 3 to 14 feet bgs. Layers of buried topsoil and buried organic soils were encountered within some of the explorations. In general, the fill material appeared to contain soils considered suitable for re-use as engineered fill, provided that the layers of buried organic soil and inorganic debris are separated during excavation.

Topsoil Horizon: The site is primarily vegetated with grasses and dense trees, however some areas contain brush, trees, blackberries, etc. The topsoil horizon in the grassy and open portions of the site was observed to consist of brown, organic Lean CLAY (OL-CL), containing fine roots extending to depths ranging from approximately 8 to 12 inches bgs, however some areas were observed to have roots extending to 18 inches, likely due to old farming till zones. In the highly treed northern portion of the site, the topsoil horizon consisted of moderately to highly organic silt (OL-ML), was generally loose, contained many fine roots, and extended to a depth of 8 to 12 inches. Root zones may be as deep as 18 inches in areas where extensive blackberries are present.

GeoPacific collect four samples of the topsoil from test pit explorations and submitted the samples to our soils laboratory for organic content and pH testing. The locations of the collected samples, and results of the laboratory testing are presented below in Table 2.

Table 2. Topsoil Organic Content and Soil pH

Test Pit	Depth of Sample (inches)	Soil Type	Organic Content by Weight % ASTM D2974	pH	Soil Moisture %
TP-2	0-12	OL-CL	11.9	6.4	49.7
TP-5	0-12	OL-CL	9.5	5.7	31.0
TP-6	0-12	OL-CL	7.3	5.9	35.1
TP-13	0-12	OL-CL	12.8	6.1	41.9

Lean CLAY/Gravelly CLAY (Residual Soil): Underlying the topsoil horizon and undocumented fill soils were residual soil resulting from in-place weathering of the underlying Columbia River Basalt Formation. The soils were observed to consist of brown, medium stiff to very stiff, moist to very moist, clayey SILT (ML), lean CLAY, and gravelly CLAY, containing varying degrees of subangular gravel to cobble-sized basalt fragments. Pocket penetrometer measurements conducted in the upper four feet of the ground surface indicated unconfined compressive strengths ranging from 1.5 to 4.5 tons/ft^2 (tsf). SPT N-Values ranged from 14 to 27 in the soil layer. Soils laboratory testing conducted on representative samples collected from test pit TP-1 indicated that the soil type classified as A-4(2), A-7-5(7), and A-7-5(28) according to AASHTO standards. Sieve analysis indicated 53 to 88 percent by weight passing the U.S. No. 200 sieve, and moisture content of 23 to 41 percent. Atterberg Limit testing indicated a liquid limit of 27 to 58, and a plasticity index of 2 to 31.

Columbia River Basalt Formation: Weathered basalt belonging to the Columbia River Basalt Formation was encountered underlying the residual soil. The weathered bedrock was encountered within soil borings B-1 through B-6 at depths ranging from approximately 2 to 20 feet. Drilling refusal with the solid-stem auger was encountered at depths ranging from 5.5 to 25.5 feet bgs. The bedrock was also encountered within test pits TP-11, TP-13, TP-17, and TP-21 through TP-37 at depths ranging from 0.5 to 10 feet bgs. Excavation refusal was achieved with a medium to large sized trackhoe equipped with rock teeth in test pits TP-6, TP-23, TP-25, and TP-28 at depths of 6.5 to 16 feet bgs. The basalt was weathered to Extremely Soft (R0) to Medium Hard (R3) consistency in accordance with the ODOT Rock Hardness Classification System (Table 1). A summary of the total depths of which basaltic bedrock was first encountered and the depth at which practical refusal was achieved is presented in Table 3. Please refer to the excavation logs for additional detail.

Table 3. Weathered Bedrock Excavation Depth Results

Exploration	Depth to Weathered Bedrock (Feet bgs)	Depth of Refusal (Feet bgs)	Excavator/ Drill Rig	ODOT Rock Hardness
B-1	15	17	Solid Stem Auger Drill	R1-R3
B-2	20	24	Solid Stem Auger Drill	R2-R3
B-3	10	11	Solid Stem Auger Drill	R1-R3
B-4	15	25.5	Solid Stem Auger Drill	R1-R3
B-5	2	5.5	Solid Stem Auger Drill	R1-R3
B-6	15	21	Solid Stem Auger Drill	R1-R3
TP-11	0.5	6	16,000 lbs Case Backhoe-Rock Teeth	R1-R3
TP-13	9	n/a-Stopped at 15 feet	16,000 lbs Case Backhoe-Rock Teeth	R1-R2
TP-17	7	n/a-Stopped at 10 feet	16,000 lbs Case Backhoe-Rock Teeth	R1-R2
TP-23	9	15	30,900 lbs Kobelco SK140 Trackhoe-Rock Teeth	R3
TP-25	13	16	30,900 lbs Kobelco SK140 Trackhoe-Rock Teeth	R3
TP-28	14	15.5	30,900 lbs Kobelco SK140 Trackhoe-Rock Teeth	R3

5.1 Shrink-Swell Potential

Lean CLAY soils present in the upper 10 feet of the ground surface display low to moderate plasticity characteristics. Atterberg Limit testing indicated a plasticity index ranging from 1 to 31 for the soil type. Based on our review of soil conditions, and experience on other local nearby projects, the shrink-swell potential of near surface soils are not anticipated to require special design measures where structures are proposed. However, the soil types are moisture sensitive, and will be difficult to work with during periods of wet weather.

5.2 Groundwater and Soil Moisture

On March 11 and 12, April 13, and July 28, 2020, observed soil moisture conditions were generally moist to very moist. Groundwater seepage was observed within some of our explorations which extended to a maximum depth of 25.5 feet bgs. Perched groundwater was encountered within soil boring B-4 at an approximate depth of 20 feet bgs and within test pit TP-12 at an approximate depth of 5.5 feet bgs. Light perched groundwater seepage was observed within test pits TP-1, TP-2, TP-11, and TP-22 at varying depths. Regional groundwater mapping indicates that static groundwater is present at a depth of approximately 120 feet below the ground surface (Snyder, 2008). Based on our review of available well logs from the State of Oregon, we understand that static groundwater is commonly encountered at depths ranging from 140 to 190 feet bgs in the vicinity of the subject site (Oregon Water Resources Department, 2021). During periods of wet weather, perched groundwater seepage may be encountered in localized areas. Seeps and springs may exist in areas not explored and may become evident during site grading. Shallow perched groundwater seepage may be encountered in utility trenches and deep excavations.

5.3 Infiltration Testing

Soil infiltration testing was performed using the open pit infiltration method in test pits TP-36 at a depth of 11 feet and test pit TP-37 at a depth of 5 feet. The soil was pre-saturated for a period of over 3 hours. The water level was measured to the nearest tenth of an inch every fifteen minutes to half hour with reference to the ground surface. Table 4 presents the results of our falling head infiltration testing and do not incorporate a factor of safety.

Table 4. Summary of Infiltration Test Results

Test Pit	Test Depth (feet)	Test Elevation (feet amsl)	Soil Type	Infiltration Rate (in/hr)	Hydraulic Head Range (inches)
TP-36	11	315	Weathered BASALT	***5.25***	5-27
TP-37	5	314	Weathered BASALT	0.75	5-12

Note: Storage capacity of fractured rock is extremely limited and the rate is unsustainable and not considered adequate for infiltration systems.

5.4 Hydrologic Soil Group Classification

Based on our soil infiltration testing, on site soils exhibit low permeability. The soils underlying the site contain consist of silty clay residual soils with abundant rock fragments underlain by weathered basalt bedrock. Although much of the site is mapped as having soils within Hydrologic Soil Group B by the Natural Resources Conservation Service Web Soil Survey (2021), the results of our test pit explorations indicate that the soils underlying the site classify as Hydrologic Soil Group C since they contain greater than 35 percent rock fragments (Natural Resources Conservation Service, 2009).

6.0 CONCLUSIONS AND RECOMMENDATIONS

Our investigation indicates that the proposed development is geotechnically feasible, provided that the recommendations of this report are incorporated into the design and sufficient geotechnical monitoring is incorporated into the construction phases of the project. In our opinion, the greatest geotechnical constraints for project completion include:

1. Undocumented fill soils. Undocumented fill was encountered in test pits TP-1, TP-8, TP-9, TP-18, and TP-19. Removal depths ranged from 3 to 14 feet, which include removal of the underlying buried topsoil.

2. The presence of shallow bedrock beneath the site. Weathered basalt bedrock was encountered throughout the site and basalt was first encountered at depths of 0.5 to 10 feet. Practical refusal was encountered on medium hard (R3) basalt at depths of 6.5 to 16 feet in test pits TP-11, TP-23, TP-25, and TP-28 and in borings B-1 through B-6 at depths of 5.5 to 25.5 feet. A larger excavator may be able to achieve greater depths; however, difficult excavating conditions should be expected.

3. Low permeability soils.

4. Native soils are considered moisture-sensitive and will be difficult to handle in wet weather.

6.1 Stormwater Disposal

The results of our infiltration testing indicate that soils have a limited infiltration capacity at depths of 5 and 11 feet below the ground surface (elevations of 314-315 feet above mean sea level) in weathered basalt, as presented in Table 4. Testing conducted in test pit TP-36 yielded a higher infiltration rate than testing conducted nearby in test pit TP-37 under similar geologic conditions. These higher rates may be due to fractures in the weathered basalt or rooted zones that would likely silt up over time or become saturated quickly in a storm event. Storage capacity of fractured rock is extremely limited and the rate is unsustainable and not considered adequate for infiltration systems.

Infiltration test methods and procedures attempt to simulate the as-built conditions of the planned subsurface disposal system. However, due to natural variations in soil properties, actual infiltration rates may vary from the measured and/or recommended design rates. All systems should be constructed such that potential overflow is discharged in a controlled manner away from structures, and all systems should include an adequate factor of safety. Infiltration rates presented in this report should not be applied to inappropriate or complex hydrological models such as a closed basin without extensive further studies. This report presents infiltration test results only, and should not be construed as an approval of a system design.

6.2 Site Preparation Recommendations

Areas of proposed construction and areas to receive fill should be cleared of any organic and inorganic debris, undocumented fill soils, and/or loose stockpiled soils. Inorganic debris and organic materials from clearing should be removed from the site. Organic-rich soils and root zones should then be stripped from construction areas of the site or where engineered fill is to be placed. Depth of stripping of existing topsoil is estimated to average approximately 6 to 9 inches in cut areas, between 9 to 12 inches in fill areas, and between 12 to 36 inches in areas where large trees are present.

As mentioned above and as shown on Figure 3, undocumented fill soils were encountered at the site. Fill was encountered where a house was demolished in the western portion of the site and where stockpiles had been previously created in the eastern portion of the site. In addition, the existing homes in the southern portion of the site contain swimming pools, and apparent landscaping fill areas which were not explored. We anticipate that much of the fill material may be suitable for re-use as engineered fill provided it is free of highly organic soils and debris. Some layers of highly organic soils were encountered within the large fill area in the northeastern portion of the site and should be separated from the clean fill material during grading. The area in the eastern portion of the site contains as much as 14 feet of undocumented fill.

The final depth of soil removal will be determined during site inspection after the stripping/excavation has been performed. Stripped topsoil should be removed from areas proposed for placement of engineered fill. Any remaining topsoil should be stockpiled only in designated areas and stripping operations should be observed and documented by the geotechnical engineer or his representative.

Where encountered, undocumented fills and any subsurface structures (dry wells, basements, swimming pools, driveway and landscaping fill, old utility lines, septic leach fields, etc.) should be completely removed and the excavations backfilled with engineered fill.

We recommend that areas proposed for placement of engineered fill are scarified and recompacted prior to placement of structural fill. The areas should be prepared by removing highly organic soil layers which contain abundant root concentration, or organic content in excess of approximately 4 to 5 percent by weight. Prior to placement of engineered fill, the underlying soils be over-excavated, ripped, aerated to optimum moisture content, and recompacted to project specifications for engineered fill as determined by the Standard Proctor (ASTM D698).

Areas proposed to be left at grade may require additional over-excavation of foundation areas in order to reach soils which will provide adequate bearing support for the proposed foundations. It is unlikely that site earthwork will be impacted by shallow groundwater, however native soils are moisture sensitive and will be difficult to handle during periods of wet weather. Stabilization of subgrade soils will require aeration and recompaction. If subgrade soils are found to be difficult to stabilize, over-excavation, placement of granular soils, or cement treatment of subgrade soils may be feasible options. GeoPacific should be onsite to observe preparation of subgrade soil conditions prior to placement of engineered fill.

6.3 Engineered Fill

All grading for the proposed development should be performed as engineered grading in accordance with the applicable building code at time of construction with the exceptions and additions noted herein. Proper test frequency and earthwork documentation usually requires daily observation and testing during stripping, rough grading, and placement of engineered fill. Imported fill material must be approved by the geotechnical engineer prior to being imported to the site. Oversize material greater than 6 inches in size should not be used within 3 feet of foundation footings, and material greater than 12 inches in diameter should not be used in engineered fill.

Engineered fill should be compacted in horizontal lifts not exceeding 8 inches using standard compaction equipment. We recommend that engineered fill be compacted to at least 95% of the maximum dry density determined by ASTM D698 (Standard Proctor) or equivalent. Field density testing should conform to ASTM D2922 and D3017, or D1556. All engineered fill should be observed and tested by the project geotechnical engineer or his representative. Typically, one density test is performed for at least every 2 vertical feet of fill placed or every 500 yd^3, whichever requires more testing. Because testing is performed on an on-call basis, we recommend that the earthwork contractor be held contractually responsible for test scheduling and frequency.

Site earthwork will be impacted by soil moisture and shallow groundwater conditions. Earthwork in wet weather would likely require extensive use of cement or lime treatment, or other special measures, at a considerable additional cost compared to earthwork performed under dry-weather conditions.

6.4 Excavating Conditions and Utility Trench Backfill

We anticipate that on-site soils can be excavated using conventional heavy equipment such as scrapers and trackhoes. Highly weathered basalt bedrock was encountered in test pits throughout the site at depths of 0.5 to 10 feet and practical refusal was encountered on medium hard (R3) basalt at depths of 6.5 to 16 feet in test pits TP-11, TP-23, TP-25, and TP-28 and in borings B-1 through B-6 at depths of 5.5 to 25.5 feet. A larger excavator may be able to achieve greater depths; however, difficult excavating conditions should be expected.

All temporary cuts in excess of 4 feet in height should be sloped in accordance with U.S. Occupational Safety and Health Administration (OSHA) regulations (29 CFR Part 1926), or be shored. The existing upper native soils are classified as Type B Soil and temporary excavation side slope inclinations as steep as 1H:1V may be assumed for planning purposes. This cut slope inclination is applicable to excavations above groundwater seepage zones only. Maintenance of safe working conditions, including temporary excavation stability, is the responsibility of the contractor. Actual slope inclinations at the time of construction should be determined based on safety requirements and actual soil and groundwater conditions.

Saturated soils and groundwater may be encountered in utility trenches, particularly during the wet season. We anticipate that dewatering systems consisting of ditches, sumps and pumps would be adequate for control of perched groundwater. Regardless of the dewatering system used, it should be installed and operated such that in-place soils are prevented from being removed along with the groundwater.

Vibrations created by traffic and construction equipment may cause some caving and raveling of excavation walls. In such an event, lateral support for the excavation walls should be provided by the contractor to prevent loss of ground support and possible distress to existing or previously constructed structural improvements.

PVC pipe should be installed in accordance with the procedures specified in ASTM D2321. We recommend that trench backfill be compacted to at least 95% of the maximum dry density obtained by Modified Proctor ASTM D1557 or equivalent. Initial backfill lift thickness for a ¾”-0 crushed aggregate base may need to be as great as 4 feet to reduce the risk of flattening underlying flexible pipe. Subsequent lift thickness should not exceed 1 foot. If imported granular fill material is used, then the lifts for large vibrating plate-compaction equipment (e.g. hoe compactor attachments) may be up to 2 feet, provided that proper compaction is being achieved and each lift is tested. Use of large vibrating compaction equipment should be carefully monitored near existing structures and improvements due to the potential for vibration-induced damage.

Adequate density testing should be performed during construction to verify that the recommended relative compaction is achieved. Typically, one density test is taken for every 4 vertical feet of backfill on each 200-lineal-foot section of trench.

6.5 Erosion Control Considerations

During our field exploration program, we did not observe soil types that would be considered highly susceptible to erosion except in areas of moderately sloping topography. In our opinion, the primary concern regarding erosion potential will occur during construction, in areas that have been stripped of vegetation. Erosion at the site during construction can be minimized by implementing the project erosion control plan, which should include judicious use of straw wattles and silt fences. If used, these erosion control devices should be in place and remain in place throughout site preparation and construction.

Erosion and sedimentation of exposed soils can also be minimized by quickly re-vegetating exposed areas of soil, and by staging construction such that large areas of the project site are not denuded and exposed at the same time. Areas of exposed soil requiring immediate and/or temporary protection against exposure should be covered with either mulch or erosion control netting/blankets. Areas of exposed soil requiring permanent stabilization should be seeded with an approved grass seed mixture, or hydroseeded with an approved seed-mulch-fertilizer mixture.

6.6 Wet Weather Earthwork

Soils underlying the site are likely to be moisture sensitive and may be difficult to handle or traverse with construction equipment during periods of wet weather. Earthwork is typically most economical when performed under dry weather conditions. Earthwork performed during the wet-weather season will probably require expensive measures such as cement treatment or imported granular material to compact fill to the recommended engineering specifications. If earthwork is to be performed or fill is to be placed in wet weather or under wet conditions when soil moisture content is difficult to control, the following recommendations should be incorporated into the contract specifications:

- Earthwork should be performed in small areas to minimize exposure to wet weather. Excavation or the removal of unsuitable soils should be followed promptly by the placement and compaction of clean engineered fill. The size and type of construction equipment used may have to be limited to prevent soil disturbance. Under some circumstances, it may be necessary to excavate soils with a backhoe to minimize subgrade disturbance caused by equipment traffic;
- The ground surface within the construction area should be graded to promote run-off of surface water and to prevent the ponding of water;
- Material used as engineered fill should consist of clean, granular soil containing less than 5 percent fines. The fines should be non-plastic. Alternatively, cement treatment of on-site soils may be performed to facilitate wet weather placement;
- The ground surface within the construction area should be sealed by a smooth drum vibratory roller, or equivalent, and under no circumstances should be left uncompacted and exposed to moisture. Soils which become too wet for compaction should be removed and replaced with clean granular materials;
- Excavation and placement of fill should be observed by the geotechnical engineer to verify that all unsuitable materials are removed and suitable compaction and site drainage is achieved; and
- Geotextile silt fences, straw wattles, and fiber rolls should be strategically located to control erosion.

If cement or lime treatment is used to facilitate wet weather construction, GeoPacific should be contacted to provide additional recommendations and field monitoring.

6.7 Spread Foundations

Based upon review of preliminary site plans, GeoPacific understands that the proposed development at the site will consist of a residential and commercial development supporting construction of 248 homes. We anticipate that the homes will be constructed with typical spread foundations and wood framing, with maximum structural loading on column footings and continuous strip footings on the order of 10 to 35 kips, and 2 to 4 kips respectively. Information regarding commercial development is preliminary at this time but we understand that 2.89-acres will be dedicated in the southwestern portion of the site. At this time grading plans have not been created, however based on the current site elevations and topography we estimate that cuts and fills may be on the order of 10 feet or less. We expect final grades to be relatively level.

The proposed structures may be supported on shallow foundations bearing on stiff, native soils and/or engineered fill, appropriately designed and constructed as recommended in this report. Foundation design, construction, and setback requirements should conform to the applicable building code at the time of construction. For maximization of bearing strength and protection against frost heave, spread footings should be embedded at a minimum depth of 12 inches below exterior grade. If soft soil conditions are encountered at footing subgrade elevation, they should be removed and replaced with compacted crushed aggregate.

The anticipated allowable soil bearing pressure is 1,500 lbs/ft^2 for footings bearing on competent, native soil and/or engineered fill. The recommended maximum allowable bearing pressure may be increased by 1/3 for short-term transient conditions such as wind and seismic loading. For loads heavier than 35 kips, the geotechnical engineer should be consulted. If heavier loads than described above are proposed, it may be necessary to over-excavate point load areas and replace with additional compacted crushed aggregate. The coefficient of friction between on-site soil and poured-in-place concrete may be taken as 0.42, which includes no factor of safety. The maximum anticipated total and differential footing movements (generally from soil expansion and/or settlement) are 1 inch and ¾ inch over a span of 20 feet, respectively. We anticipate that the majority of the estimated settlement will occur during construction, as loads are applied. Excavations near structural footings should not extend within a 1H:1V plane projected downward from the bottom edge of footings.

Footing excavations should penetrate through topsoil and any disturbed soil to competent subgrade that is suitable for bearing support. All footing excavations should be trimmed neat, and all loose or softened soil should be removed from the excavation bottom prior to placing reinforcing steel bars. Due to the moisture sensitivity of on-site native soils, foundations constructed during the wet weather season may require over-excavation of footings and backfill with compacted, crushed aggregate.

Our recommendations are for residential construction incorporating raised wood floors and conventional spread footing foundations. After site development, a Final Soil Engineer's Report should either confirm or modify the above recommendations.

6.8 Permanent Below-Grade Walls

Lateral earth pressures against below-grade retaining walls will depend upon the inclination of any adjacent slopes, type of backfill, degree of wall restraint, method of backfill placement, degree of backfill compaction, drainage provisions, and magnitude and location of any adjacent surcharge loads. At-rest soil pressure is exerted on a retaining wall when it is restrained against rotation. In contrast, active soil pressure will be exerted on a wall if its top is allowed to rotate or yield a distance of roughly 0.001 times its height or greater.

If the subject retaining walls will be free to rotate at the top, they should be designed for an active earth pressure equivalent to that generated by a fluid weighing 35 pcf for level backfill against the wall. For restrained wall, an at-rest equivalent fluid pressure of 55 pcf should be used in design, again assuming level backfill against the wall. These values assume that the recommended drainage provisions are incorporated, and hydrostatic pressures are not allowed to develop against the wall.

During a seismic event, lateral earth pressures acting on below-grade structural walls will increase by an incremental amount that corresponds to the earthquake loading. Based on the Mononobe-Okabe equation and peak horizontal accelerations appropriate for the site location, seismic loading should be modeled using the active or at-rest earth pressures recommended above, plus an incremental rectangular-shaped seismic load of magnitude 6.5H, where H is the total height of the wall.

We assume relatively level ground surface below the base of the walls. As such, we recommend passive earth pressure of 300 pcf for use in design, assuming wall footings are cast against competent native soils or engineered fill. If the ground surface slopes down and away from the base of any of the walls, a lower passive earth pressure should be used and GeoPacific should be contacted for additional recommendations.

A coefficient of friction of 0.42 may be assumed along the interface between the base of the wall footing and subgrade soils. The recommended coefficient of friction and passive earth pressure values do not include a safety factor, and an appropriate safety factor should be included in design. The upper 12 inches of soil should be neglected in passive pressure computations unless it is protected by pavement or slabs on grade.

The above recommendations for lateral earth pressures assume that the backfill behind the subsurface walls will consist of properly compacted structural fill, and no adjacent surcharge loading. If the walls will be subjected to the influence of surcharge loading within a horizontal distance equal to or less than the height of the wall, the walls should be designed for the additional horizontal pressure. For uniform surcharge pressures, a uniformly distributed lateral pressure of 0.3 times the surcharge pressure should be added. Traffic surcharges may be estimated using an additional vertical load of 250 psf (2 feet of additional fill), in accordance with local practice.

The recommended equivalent fluid densities assume a free-draining condition behind the walls so that hydrostatic pressures do not build-up. This can be accomplished by placing a 12 to 18-inch wide zone of sand and gravel containing less than 5 percent passing the No. 200 sieve against the walls. A 3-inch minimum diameter perforated, plastic drain pipe should be installed at the base of the walls and connected to a suitable discharge point to remove water in this zone of sand and gravel. The drain pipe should be wrapped in filter fabric (Mirafi 140N or other as approved by the geotechnical engineer) to minimize clogging.

Wall drains are recommended to prevent detrimental effects of surface water runoff on foundations – not to dewater groundwater. Drains should not be expected to eliminate all potential sources of water entering a basement or beneath a slab-on-grade. An adequate grade to a low point outlet drain in the crawlspace is required by code. Underslab drains are sometimes added beneath the slab when placed over soils of low permeability and shallow, perched groundwater.

Water collected from the wall drains should be directed into the local storm drain system or other suitable outlet. A minimum 0.5 percent fall should be maintained throughout the drain and non-perforated pipe outlet. Down spouts and roof drains should not be connected to the wall drains in order to reduce the potential for clogging. The drains should include clean-outs to allow periodic maintenance and inspection. Grades around the proposed structure should be sloped such that surface water drains away from the building.

GeoPacific should be contacted during construction to verify subgrade strength in wall keyway excavations, to verify that backslope soils are in accordance with our assumptions, and to take density tests on the wall backfill materials.

Structures should be located a horizontal distance of at least 1.5H away from the back of the retaining wall, where H is the total height of the wall. GeoPacific should be contacted for additional foundation recommendations where structures are located closer than 1.5H to the top of any wall.

6.9 Concrete Slabs-on-Grade

Preparation of areas beneath concrete slab-on-grade floors should be performed as recommended in the *Site Preparation Recommendations* section. Care should be taken during excavation for foundations and floor slabs, to avoid disturbing subgrade soils. If subgrade soils have been adversely impacted by wet weather or otherwise disturbed, the surficial soils should be scarified to a minimum depth of 8 inches, moisture conditioned to within about 3 percent of optimum moisture content, and compacted to engineered fill specifications. Alternatively, disturbed soils may be removed and the removal zone backfilled with additional crushed rock.

For evaluation of the concrete slab-on-grade floors using the beam on elastic foundation method, a modulus of subgrade reaction of 150 kcf (87 pci) should be assumed for the medium stiff, fine-grained soils anticipated to be present at foundation subgrade elevation following adequate site preparation as described above. This value assumes the concrete slab system is designed and constructed as recommended herein, with a minimum thickness of 8 inches of 1½”-0 crushed aggregate beneath the slab. The total thickness of crushed aggregate will be dependent on the subgrade conditions at the time of construction, and should be verified visually by proof-rolling. Under-slab aggregate should be compacted to at least 95 percent of its maximum dry density as determined by ASTM D1557 (Modified Proctor) or equivalent.

In areas where moisture will be detrimental to floor coverings or equipment inside the proposed structure, appropriate vapor barrier and damp-proofing measures should be implemented. A commonly applied vapor barrier system consists of a 10-mil polyethylene vapor barrier placed directly over the capillary break material. Other damp/vapor barrier systems may also be feasible. Appropriate design professionals should be consulted regarding vapor barrier and damp proofing systems, ventilation, building material selection and mold prevention issues, which are outside GeoPacific’s area of expertise.

6.10 Footing and Roof Drains

Construction should include typical measures for controlling subsurface water beneath the structure, including positive crawlspace drainage to an adequate low-point drain exiting the foundation, visqueen covering the expose ground in the crawlspace, and crawlspace ventilation (foundation vents). The client should be informed and educated that some slow flowing water in the crawlspaces is considered normal and not necessarily detrimental to the home given these other design elements incorporated into its construction. Appropriate design professionals should be consulting regarding crawlspace ventilation, building material selection and mold prevention issues, which are outside GeoPacific's area of expertise.

Down spouts and roof drains should collect roof water in a system separate from the footing drains to reduce the potential for clogging. Roof drain water should be directed to an appropriate discharge point and storm system well away from structural foundations. Grades should be sloped downward and away from buildings to reduce the potential for ponded water near structures.

If the proposed structure will have a raised floor, and no concrete slab-on-grade floors are used, perimeter footing drains may be eliminated at the discretion of the geotechnical engineer based on soil conditions encountered at the site and experience with standard local construction practices. Where it is desired to reduce the potential for moist crawl spaces, footing drains may be installed. If concrete slab-on-grade floors are used, perimeter footing drains should be installed as recommended below.

Where necessary, perimeter footing drains should consist of 3 or 4-inch diameter, perforated plastic pipe embedded in a minimum of 1 ft^3 per lineal foot of clean, free-draining drain rock. The drain pipe and surrounding drain rock should be wrapped in non-woven geotextile (Mirafi 140N, or approved equivalent) to minimize the potential for clogging and/or ground loss due to piping. A minimum 0.5 percent fall should be maintained throughout the drain and non-perforated pipe outlet. Figure 4 presents a typical perimeter footing drain detail. In our opinion, footing drains may outlet at the curb, or on the back sides of lots where sufficient fall is not available to allow drainage to meet the street.

6.11 Public Streets

GeoPacific conducted design calculations for the proposed new public streets in the project interior. Based upon our understanding of the anticipated traffic which includes light-duty passenger vehicles, weekly trash pickups, and occasional fire trucks weighing up to 75,000 lbs, we calculated an anticipated 18-kip ESAL count of approximately 143,620 over 20 years. Table 5 presents our flexible pavement design input parameters. Table 6 presents our recommended minimum dry-weather pavement section supporting 20 years of vehicle traffic per Washington County standards.

Table 5: Flexible Pavement Section Design Input Parameters for Interior Public Streets

Input Parameter	Design Value
18-kip ESAL Initial Performance Period (20 Years)	143,620
Initial Serviceability	4.2
Terminal Serviceability	2.5
Reliability Level	85 Percent
Overall Standard Deviation	0.5
Roadbed Soil Resilient Modulus (PSI)	7,500
Structural Number	**2.46**

Table 6: Recommended Minimum Dry-Weather Pavement Section: Interior Public Streets

Material Layer	Section Thickness (in.)	Structural Coefficient	Compaction Standard
Asphaltic Concrete (AC)	3.5 in.	.42	91%/ 92% of Rice Density AASHTO T-209
Crushed Aggregate Base ¾"-0 (leveling course)	2 in.	.10	95% of Modified Proctor AASHTO T-180
Crushed Aggregate Base 1½"-0	8 in.	.10	95% of Modified Proctor AASHTO T-180
Subgrade	12 in.	7,500 PSI	95% of Standard Proctor AASHTO T-99 or equivalent
Total Calculated Structural Number		**2.47**	

6.12 Subgrade Preparation

Roadway subgrade soils should be compacted and inspected by GeoPacific prior to the placement of crushed aggregate base for pavement. Typically, a proofroll with a fully loaded water or haul truck is conducted by travelling slowly across the grade and observing the subgrade for rutting, deflection, or movement. Any pockets of organic debris or loose fill encountered during ripping or tilling should be removed and replaced with engineered fill (see Section 6.1, *Site Preparation Recommendations*). In order to verify subgrade strength, we recommend proof-rolling directly on subgrade with a loaded dump truck during dry weather and on top of base course in wet weather. Soft areas that pump, rut, or weave should be stabilized prior to paving.

If pavement areas are to be constructed during wet weather, the subgrade and construction plan should be reviewed by the project geotechnical engineer at the time of construction so that condition specific recommendations can be provided. The moisture sensitive subgrade soils make the site a difficult wet weather construction project. General recommendations for wet weather pavement sections are provided below.

During placement of pavement section materials, density testing should be performed to verify compliance with project specifications. Generally, one subgrade, one base course, and one asphalt compaction test is performed for every 100 to 200 linear feet of paving.

6.13 Wet Weather Construction Pavement Section

This section presents our recommendations for wet weather pavement sections and construction for new pavement sections at the project. These wet weather pavement section recommendations are intended for use in situations where it is not feasible to compact the subgrade soils to project requirements, due to wet subgrade soil conditions, and/or construction during wet weather. Based on our site review, we recommend a wet weather section with a minimum subgrade deepening of 6 to 12 inches to accommodate a working subbase of additional 1½"-0 crushed rock. Geotextile fabric, Mirafi 500X or equivalent, should be placed on subgrade soils prior to placement of base rock.

In some instances, it may be preferable to use a subbase material in combination with over-excavation and increasing the thickness of the rock section. GeoPacific should be consulted for additional recommendations regarding use of additional subbase in wet weather pavement sections if it is desired to pursue this alternative. Cement treatment of the subgrade may also be considered instead of over-excavation. For planning purposes, we anticipate that treatment of the onsite soils would involve mixing cement powder to approximately 6 percent cement content and a mixing depth on the order of 12 to 18 inches.

With implementation of the above recommendations, it is our opinion that the resulting pavement section will provide equivalent or greater structural strength than the dry weather pavement section currently planned. However, it should be noted that construction in wet weather is risky and the performance of pavement subgrades depend on a number of factors including the weather conditions, the contractor's methods, and the amount of traffic the road is subjected to. There is a potential that soft spots may develop even with implementation of the wet weather provisions recommended in this letter. If soft spots in the subgrade are identified during roadway excavation, or develop prior to paving, the soft spots should be over-excavated and backfilled with additional crushed rock.

During subgrade excavation, care should be taken to avoid disturbing the subgrade soils. Removals should be performed using an excavator with a smooth-bladed bucket. Truck traffic should be limited until an adequate working surface has been established. We suggest that the crushed rock be spread using bulldozer equipment rather than dump trucks, to reduce the amount of traffic and potential disturbance of subgrade soils. Care should be taken to avoid over-compaction of the base course materials, which could create pumping, unstable subgrade soil conditions. Heavy and/or vibratory compaction efforts should be applied with caution. Following placement and compaction of the crushed rock to project specifications (95 percent of Modified Proctor), a finish proof-roll should be performed before paving.

The above recommendations are subject to field verification. GeoPacific should be on-site during construction to verify subgrade strength and to take density tests on the engineered fill, base rock and asphaltic pavement materials.

7.0 SEISMIC DESIGN

The Oregon Department of Geology and Mineral Industries (DOGAMI), Oregon HazVu: 2021 Statewide GeoHazards Viewer indicates that the site is in an area where *very strong* to *severe* ground shaking is anticipated during an earthquake. Structures should be designed to resist earthquake loading in accordance with the methodology described in the 2018 International Building Code (IBC) with applicable Oregon Structural Specialty Code (OSSC) revisions (current 2019). We recommend Site Class C be used for design as defined in ASCE 7-16, Chapter 20, and Table 20.3-1. Design values determined for the site using the Applied Technology Council (ATC) 2020 Hazards By Location Online Tool are summarized in Table 7.

Table 7. Recommended Earthquake Ground Motion Parameters (ASCE 7-16)

Parameter	Value
Location (Lat, Long), degrees	45.350, -122.769
Probabilistic Ground Motion Values, 2% Probability of Exceedance in 50 yrs	
Peak Ground Acceleration PGA_M	0.454 g
Short Period, S_s	0.83 g
1.0 Sec Period, S_1	0.385 g
Soil Factors for Site Class C:	
F_a	1.2
F_v	1.5
$SD_s = 2/3 \times F_a \times S_s$	0.664 g
$SD_1 = 2/3 \times F_v \times S_1$	0.385 g
Residential Seismic Design Category	D

7.1 Soil Liquefaction

The Oregon Department of Geology and Mineral Industries (DOGAMI), Oregon HazVu: 2021Statewide GeoHazards Viewer indicates that the site is in an area considered to be at *low* risk for soil liquefaction during an earthquake. Soil liquefaction is a phenomenon wherein saturated soil deposits temporarily lose strength and behave as a liquid in response to ground shaking caused by strong earthquakes. Soil liquefaction is generally limited to loose, sands and granular soils located below the water table, and fine-grained soils with a plasticity index less than 15. The upper 12 feet of the site was observed to be underlain by very stiff, fine-grained soils with moderate plasticity. Groundwater was not encountered within our subsurface explorations. Regional geologic mapping indicates static groundwater is present at a depth of 120 feet below the ground surface (Snyder, 2008). Based upon the results of our study, it is our opinion that the soils underlying the site are not prone to liquefaction.

If deemed necessary, quantitative liquefaction assessment, beyond the scope of this study, may be conducted at the subject site to determine whether or not liquefiable soil layers are present underneath the subject site beyond the depths explored. Cone penetrometer testing (CPT) would be conducted at a selected location within the site boundaries to explore deeper subsurface soil layers, and the data would be used to estimate anticipated dynamic settlement at the subject site during a seismic ground shaking event.

8.0 UNCERTAINTIES AND LIMITATIONS

We have prepared this report for the owner and their consultants for use in design of this project only. This report should be provided in its entirety to prospective contractors for bidding and estimating purposes; however, the conclusions and interpretations presented in this report should not be construed as a warranty of the subsurface conditions. Experience has shown that soil and groundwater conditions can vary significantly over small distances. Inconsistent conditions can occur between explorations that may not be detected by a geotechnical study. If, during future site operations, subsurface conditions are encountered which vary appreciably from those described herein, GeoPacific should be notified for review of the recommendations of this report, and revision of such if necessary.

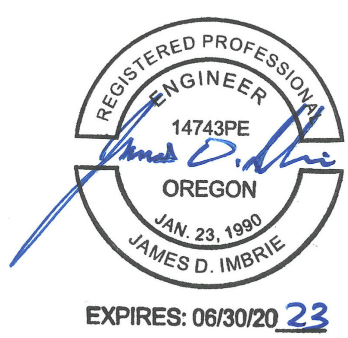
Sufficient geotechnical monitoring, testing and consultation should be provided during construction to confirm that the conditions encountered are consistent with those indicated by explorations. The checklist attached to this report outlines recommended geotechnical observations and testing for the project. Recommendations for design changes will be provided should conditions revealed during construction differ from those anticipated, and to verify that the geotechnical aspects of construction comply with the contract plans and specifications.

Within the limitations of scope, schedule and budget, GeoPacific attempted to execute these services in accordance with generally accepted professional principles and practices in the fields of geotechnical engineering and engineering geology at the time the report was prepared. No warranty, expressed or implied, is made. The scope of our work did not include environmental assessments or evaluations regarding the presence or absence of wetlands or hazardous or toxic substances in the soil, surface water, or groundwater at this site.

We appreciate this opportunity to be of service.

Sincerely,

GEOPACIFIC ENGINEERING, INC.



Beth K. Rapp, C.E.G.
Senior Engineering Geologist

Reviewed by: James D. Imbrie, G.E., C.E.G.
Principal Geotechnical Engineer

Appendix E:
TR55 Runoff Curve Numbers

TR55 RUNOFF CURVE NUMBERS

Table 2-2a Runoff curve numbers for urban areas [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2/]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3/]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4/]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas					
Newly graded areas (pervious areas only, no vegetation) [5/]		77	86	91	94
Idle lands (CN's are determined using cover types similar to those in table 2-2c).					

[1] Average runoff condition, and $I_a = 0.2S$.
[2] The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.
[3] CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.
[4] Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.
[5] Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Table 2-2b Runoff curve numbers for cultivated agricultural lands [1]

Cover description			Curve numbers for hydrologic soil group			
Cover type	Treatment [2]	Hydrologic condition [3]	A	B	C	D
Fallow	Bare soil	—	77	86	91	94
	Crop residue cover (CR)	Poor	76	85	90	93
		Good	74	83	88	90
Row crops	Straight row (SR)	Poor	72	81	88	91
		Good	67	78	85	89
	SR + CR	Poor	71	80	87	90
		Good	64	75	82	85
	Contoured (C)	Poor	70	79	84	88
		Good	65	75	82	86
	C + CR	Poor	69	78	83	87
		Good	64	74	81	85
	Contoured & terraced (C&T)	Poor	66	74	80	82
		Good	62	71	78	81
	C&T+ CR	Poor	65	73	79	81
		Good	61	70	77	80
Small grain	SR	Poor	65	76	84	88
		Good	63	75	83	87
	SR + CR	Poor	64	75	83	86
		Good	60	72	80	84
	C	Poor	63	74	82	85
		Good	61	73	81	84
	C + CR	Poor	62	73	81	84
		Good	60	72	80	83
	C&T	Poor	61	72	79	82
		Good	59	70	78	81
	C&T+ CR	Poor	60	71	78	81
		Good	58	69	77	80
Close-seeded or broadcast legumes or rotation meadow	SR	Poor	66	77	85	89
		Good	58	72	81	85
	C	Poor	64	75	83	85
		Good	55	69	78	83
	C&T	Poor	63	73	80	83
		Good	51	67	76	80

1 Average runoff condition, and I_a=0.2S
2 Crop residue cover applies only if residue is on at least 5% of the surface throughout the year.
3 Hydraulic condition is based on combination factors that affect infiltration and runoff, including (a) density and canopy of vegetative areas, (b) amount of year-round cover, (c) amount of grass or close-seeded legumes, (d) percent of residue cover on the land surface (good ≥ 20%), and (e) degree of surface roughness.

Poor: Factors impair infiltration and tend to increase runoff.

Good: Factors encourage average and better than average infiltration and tend to decrease runoff.

Table 2-2c Runoff curve numbers for other agricultural lands [1]

Cover description — Cover type	Hydrologic condition	Curve numbers for hydrologic soil group — A	B	C	D
Pasture, grassland, or range—continuous forage for grazing [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.
2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.
3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.
4 Actual curve number is less than 30; use CN = 30 for runoff computations.
5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.
6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Table 2-2d Runoff curve numbers for arid and semiarid rangelands [1/]

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition [2/]	A [3/]	B	C	D
Herbaceous—mixture of grass, weeds, and low-growing brush, with brush the minor element.	Poor		80	87	93
	Fair		71	81	89
	Good		62	74	85
Oak-aspen—mountain brush mixture of oak brush, aspen, mountain mahogany, bitter brush, maple, and other brush.	Poor		66	74	79
	Fair		48	57	63
	Good		30	41	48
Pinyon-juniper—pinyon, juniper, or both; grass understory.	Poor		75	85	89
	Fair		58	73	80
	Good		41	61	71
Sagebrush with grass understory.	Poor		67	80	85
	Fair		51	63	70
	Good		35	47	55
Desert shrub—major plants include saltbush, greasewood, creosotebush, blackbrush, bursage, palo verde, mesquite, and cactus.	Poor	63	77	85	88
	Fair	55	72	81	86
	Good	49	68	79	84

1 Average runoff condition, and I_a, = 0.2S. For range in humid regions, use table 2-2c.
2 Poor: <30% ground cover (litter, grass, and brush overstory).
Fair: 30 to 70% ground cover.
Good: > 70% ground cover.
3 Curve numbers for group A have been developed only for desert shrub.