

# STORMWATER REPORT

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**79 Hill Street  
Topsfield, Massachusetts**

**February 15, 2023  
Revised: August 4, 2023**

**Applicant:  
Barbara Crowley  
15 Timber Lane  
Topsfield, MA 01983**

**Prepared By  
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**W&S Project Data**

TOPS-0077  
Shill#79.dwg  
EXISTING.hcp  
PROPOSED.hcp  
p:\TOPS-0077(79 Hill Street)\drainage\stormwater\_report.docx



### Project Narrative

The subject property is located at 79 Hill Street in Topsfield located within the O-R-A Zoning District. It is currently an undeveloped lot covered by trees and undergrowth with remains of old foundations and stone walls present on the lot.

The proposal is to construct a four-bedroom (9 Habitable Room Max.) single family house on the lot. Coinciding with this proposal will be the construction of a paved driveway, regrading a portion of the lot, a proposed septic system and proposed stormwater management area to capture roof runoff.

### Peak Rate Runoff Tables

Examining the following Peak Rate/Volume of Runoff and Basin Performance table, the proposed stormwater management system is effective for mitigating the peak flow rates from the limit of watershed analysis for the 2-year, 10-year and 100-year storm events using the NOAA-14 Atlas Point Precipitation Frequency Estimates in order to be conservative. See attached table.

### Total Peak Runoff Tables

<b>Table 1.0: Total Peak Rate of Runoff   Comparison Location 1L</b>				
Description	2 Year	10 Year		100 Year
Existing Peak Rate of Runoff (cfs)	1.23	3.29		7.18
Proposed Peak Rate of Runoff (cfs)	1.20	3.08		6.52
Difference	-0.03	-0.21		-0.66

<b>Table 1.1: Total Peak Volume of Runoff   Comparison Location 1L</b>				
Description	2 Year	10 Year		100 Year
Existing Peak Volume of Runoff (cf)	6,247	15,447		32,942
Proposed Peak Volume of Runoff (cf)	5,814	13,896		29,363
Difference	-433	-1,551		-3,579



**Drawdown Within 72 Hours:**

$$T_{\text{drawdown}} = [R_{v \text{ total}} / (K)(\text{Bottom Area})]$$

**Stormwater Management Area 1P – Rear ½ of Roof Recharge System**

$R_{v \text{ 1P}} = 827 \text{ ft}^3$  (peak volume in 100yr storm to be conservative)

$K = 1.02 \text{ in/hr}$  (Rawls Rate)

Bottom Area =  $275 \text{ ft}^2$

$$T_{\text{drawdown}} = 827 / [(1.02)(275)/12] = 35.4 \text{ hours} < 72 \text{ hours}$$

**Stormwater Management Area 2P – Stormwater Management Area for front ½ roof, driveway & front yard**

$R_{v \text{ 2P}} = 3,984 \text{ ft}^3$  (peak volume in 100yr storm)

$K = 1.02 \text{ in/hr}$  (Rawls Rate)

Bottom Area =  $1150 \text{ ft}^2$

$$T_{\text{drawdown}} = 3984 / [(1.02)(1150)/12] = 40.7 \text{ hours} < 72 \text{ hours}$$

**Recharge Volume:**

$$R_{v \text{ required}} = (\text{Impervious Area}) (F)$$

Site consists of Hydrologic Soils Group C:  $F_C = 0.25 \text{ in.}$

**Site Impervious Area Draining to Recharge Facilities:**

**Stormwater Management Area 1P– Roof Recharge System**

$A_{\text{imp C soils}} = 1391 \text{ ft}^2$

$$R_{v \text{ required}} = [(1391) (0.25)/12] = 29.0 \text{ ft}^3$$

$R_{v \text{ provided}} = 545 \text{ ft}^3$ ; Therefore Okay

**Stormwater Management Area 2P Stormwater Management Area for front ½ driveway & front yard**

$A_{\text{imp C soils}} = 5739 \text{ ft}^2$

$$R_{v \text{ required}} = [(5739) (0.25)/12] = 119.6 \text{ ft}^3$$

$R_{v \text{ provided}} = 6990 \text{ ft}^3$  below outlet; Therefore Okay

**Water Quality Volume:**

$$V_{wq \text{ required}} = (A_{\text{imp}})(D_{wq})$$

$$D_{wq} = 0.5 \text{ in}$$

**Stormwater Management Area 1P– Rear ½ Roof Recharge System**

$$V_{wq \text{ required}} = [(0) (0.5)/12] = 0 \text{ ft}^3$$

**Exempt from this requirement, roof runoff only considered clean by DEP for certain types**

**Stormwater Management Area 1P– Stormwater Management Area for front ½ roof, driveway & front yard**

$$V_{wq \text{ required}} = [(4419) (0.5)/12] = 184.1 \text{ ft}^3$$

$V_{wq \text{ provided}} = 3717 \text{ ft}^3$  below outlet; Therefore Okay

**Front ½ roof Exempt from this requirement, roof runoff only considered clean by DEP for certain types**

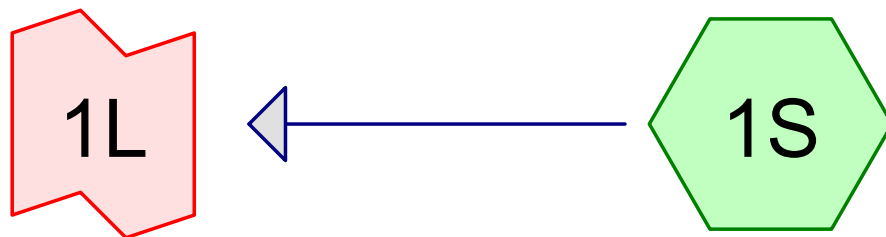


**HydroCAD Data**



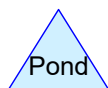
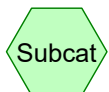
*Existing Condition - No Change*





Flow to the West

Existing Condition



**Routing Diagram for EXISTING**

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**Rainfall Events Listing (selected events)**

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-yr	Type III 24-hr		Default	24.00	1	3.29	2
2	10-yr	Type III 24-hr		Default	24.00	1	5.19	2
3	100-yr	Type III 24-hr		Default	24.00	1	8.21	2

**EXISTING**

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**Area Listing (all nodes)**

Area (sq-ft)	CN	Description (subcatchment-numbers)
2,375	74	>75% Grass cover, Good, HSG C (1S)
82,722	70	Woods, Good, HSG C (1S)
<b>85,097</b>	<b>70</b>	<b>TOTAL AREA</b>



**EXISTING**

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**Soil Listing (all nodes)**

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
85,097	HSG C	1S
0	HSG D	
0	Other	
<b>85,097</b>		<b>TOTAL AREA</b>

**EXISTING**

Type III 24-hr 2-yr Rainfall=3.29"

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**Summary for Subcatchment 1S: Existing Condition**

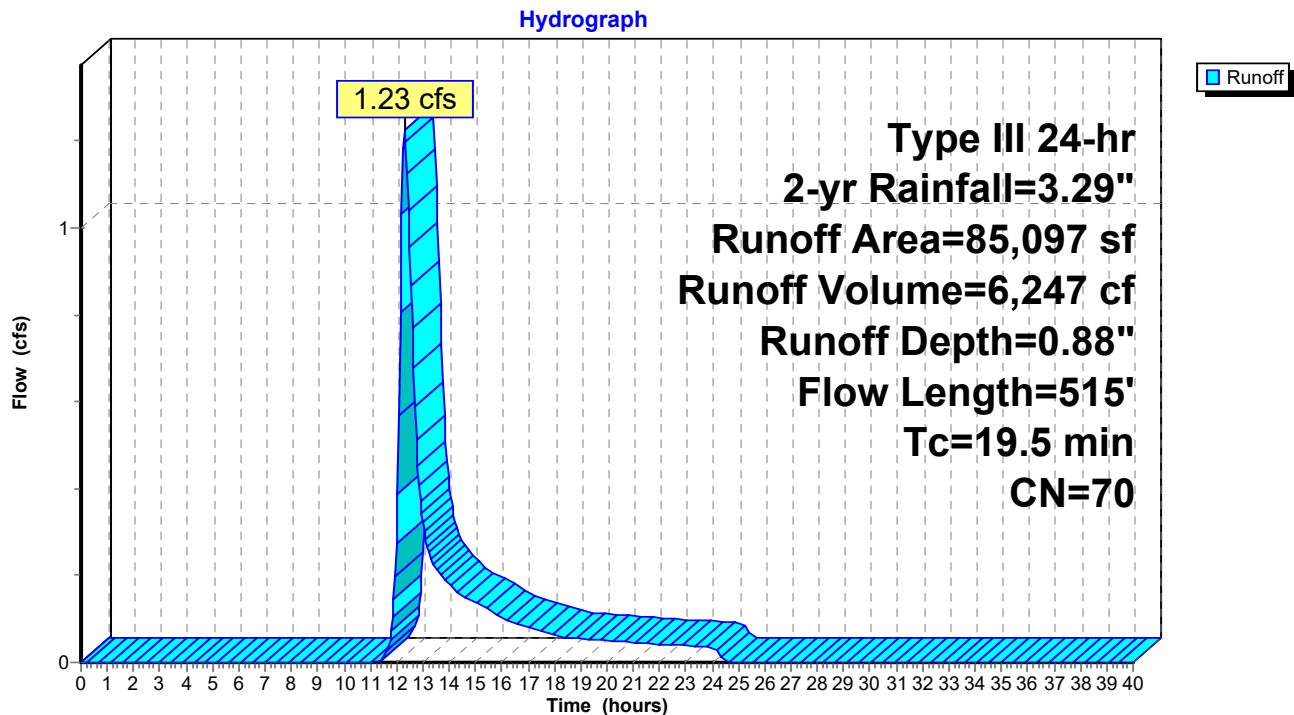
Runoff = 1.23 cfs @ 12.31 hrs, Volume= 6,247 cf, Depth= 0.88"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 2-yr Rainfall=3.29"

Area (sf)	CN	Description
82,722	70	Woods, Good, HSG C
2,375	74	>75% Grass cover, Good, HSG C
85,097	70	Weighted Average
85,097		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.0	100	0.0680	0.13		<b>Sheet Flow,</b> Woods: Light underbrush n= 0.400 P2= 3.28"
6.5	415	0.0450	1.06		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
19.5	515	Total			

**Subcatchment 1S: Existing Condition**

## EXISTING

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Existing Condition Watershed Analysis - 79 Hill Street Topsfield MA

Type III 24-hr 2-yr Rainfall=3.29"

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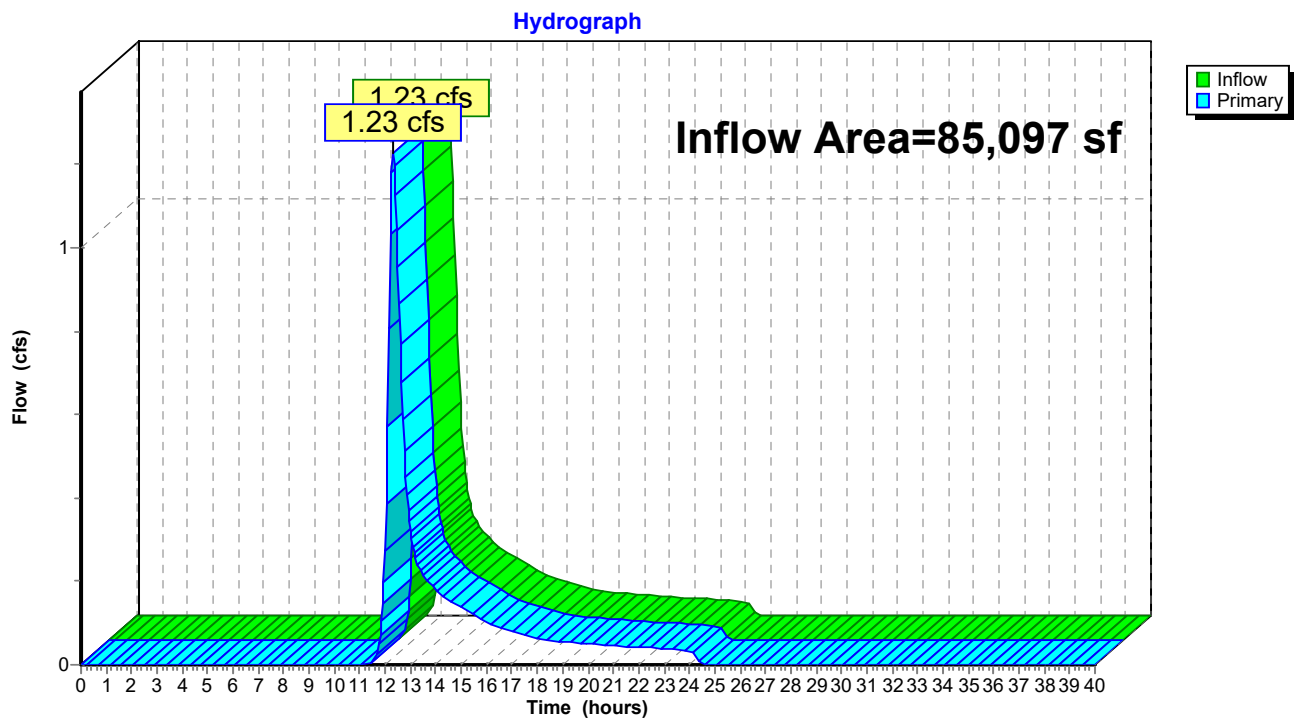
Page 6

### Summary for Link 1L: Flow to the West

Inflow Area = 85,097 sf, 0.00% Impervious, Inflow Depth = 0.88" for 2-yr event  
Inflow = 1.23 cfs @ 12.31 hrs, Volume= 6,247 cf  
Primary = 1.23 cfs @ 12.31 hrs, Volume= 6,247 cf, Atten= 0%, Lag= 0.0 min  
Routed to nonexistent node 3L

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

### Link 1L: Flow to the West



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**Summary for Subcatchment 1S: Existing Condition**

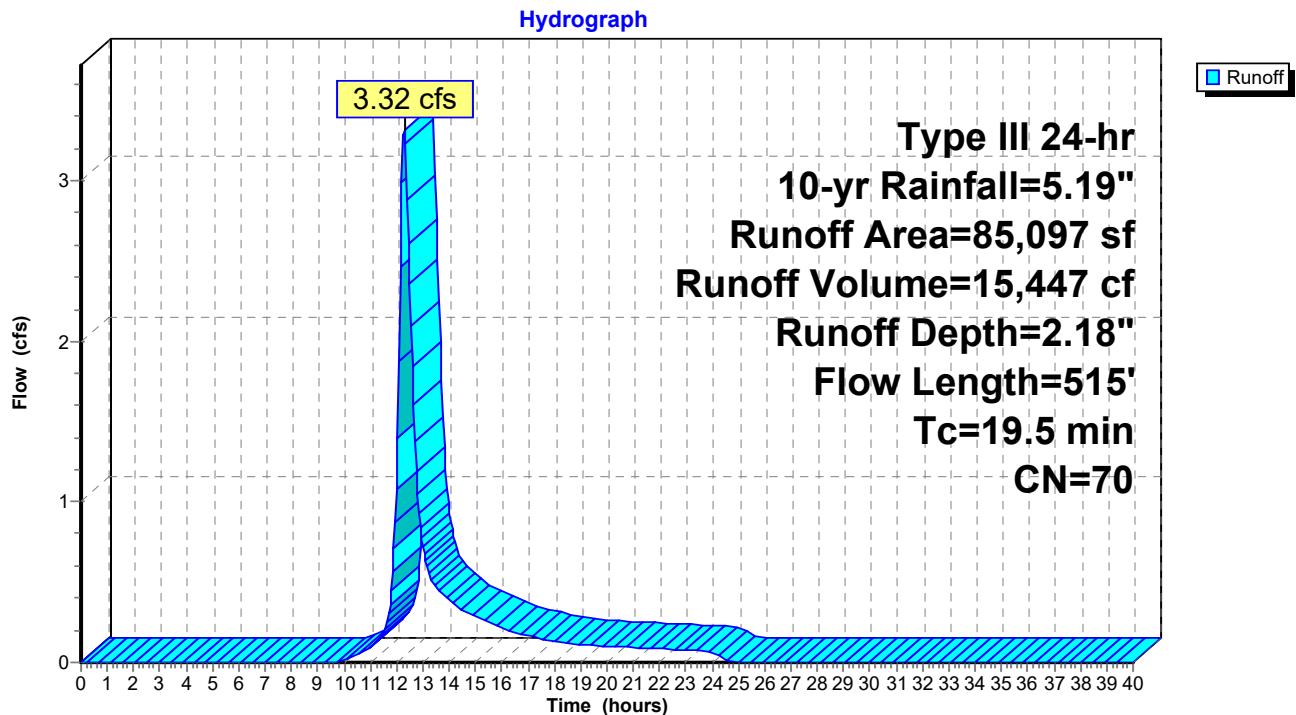
Runoff = 3.32 cfs @ 12.28 hrs, Volume= 15,447 cf, Depth= 2.18"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 10-yr Rainfall=5.19"

Area (sf)	CN	Description
82,722	70	Woods, Good, HSG C
2,375	74	>75% Grass cover, Good, HSG C
85,097	70	Weighted Average
85,097		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.0	100	0.0680	0.13		<b>Sheet Flow,</b> Woods: Light underbrush n= 0.400 P2= 3.28"
6.5	415	0.0450	1.06		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
19.5	515	Total			

**Subcatchment 1S: Existing Condition**

## EXISTING

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Existing Condition Watershed Analysis - 79 Hill Street Topsfield MA

Type III 24-hr 10-yr Rainfall=5.19"

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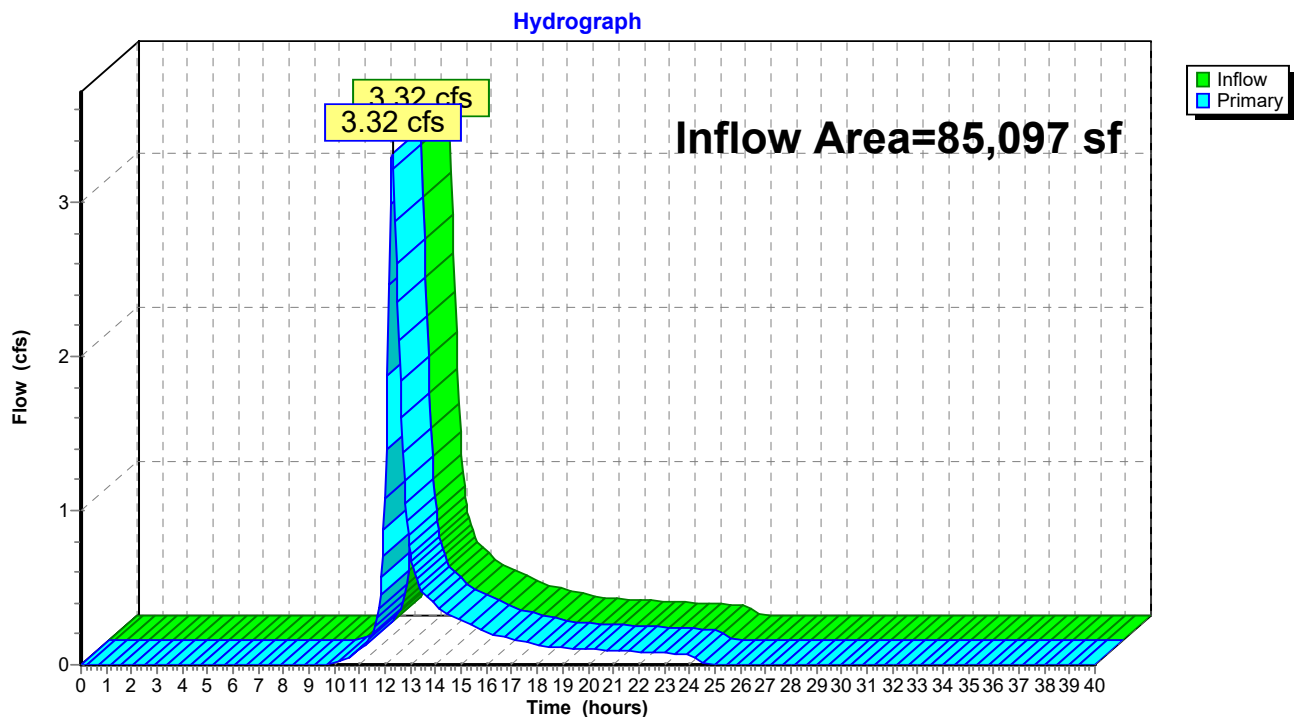
Page 8

### Summary for Link 1L: Flow to the West

Inflow Area = 85,097 sf, 0.00% Impervious, Inflow Depth = 2.18" for 10-yr event  
Inflow = 3.32 cfs @ 12.28 hrs, Volume= 15,447 cf  
Primary = 3.32 cfs @ 12.28 hrs, Volume= 15,447 cf, Atten= 0%, Lag= 0.0 min  
Routed to nonexistent node 3L

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

### Link 1L: Flow to the West



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**Summary for Subcatchment 1S: Existing Condition**

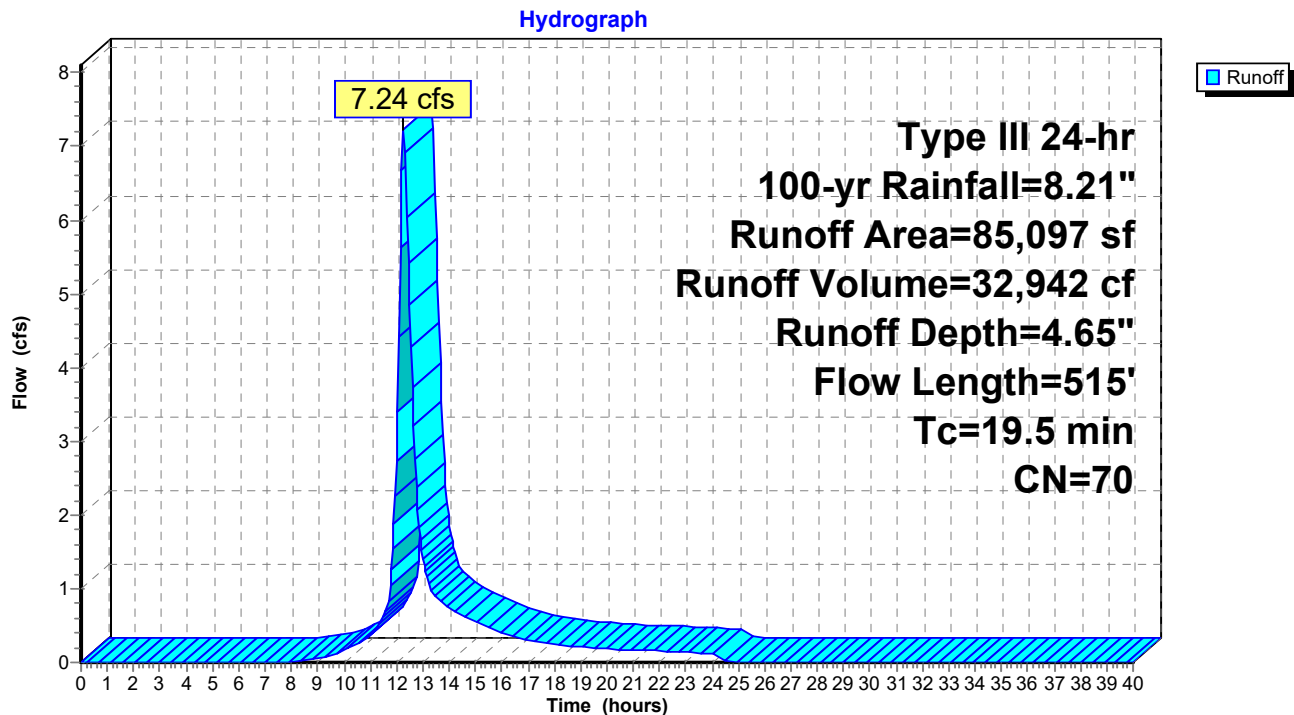
Runoff = 7.24 cfs @ 12.27 hrs, Volume= 32,942 cf, Depth= 4.65"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 100-yr Rainfall=8.21"

Area (sf)	CN	Description
82,722	70	Woods, Good, HSG C
2,375	74	>75% Grass cover, Good, HSG C
85,097	70	Weighted Average
85,097		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
13.0	100	0.0680	0.13		<b>Sheet Flow,</b> Woods: Light underbrush n= 0.400 P2= 3.28"
6.5	415	0.0450	1.06		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
19.5	515	Total			

**Subcatchment 1S: Existing Condition**

**EXISTING**

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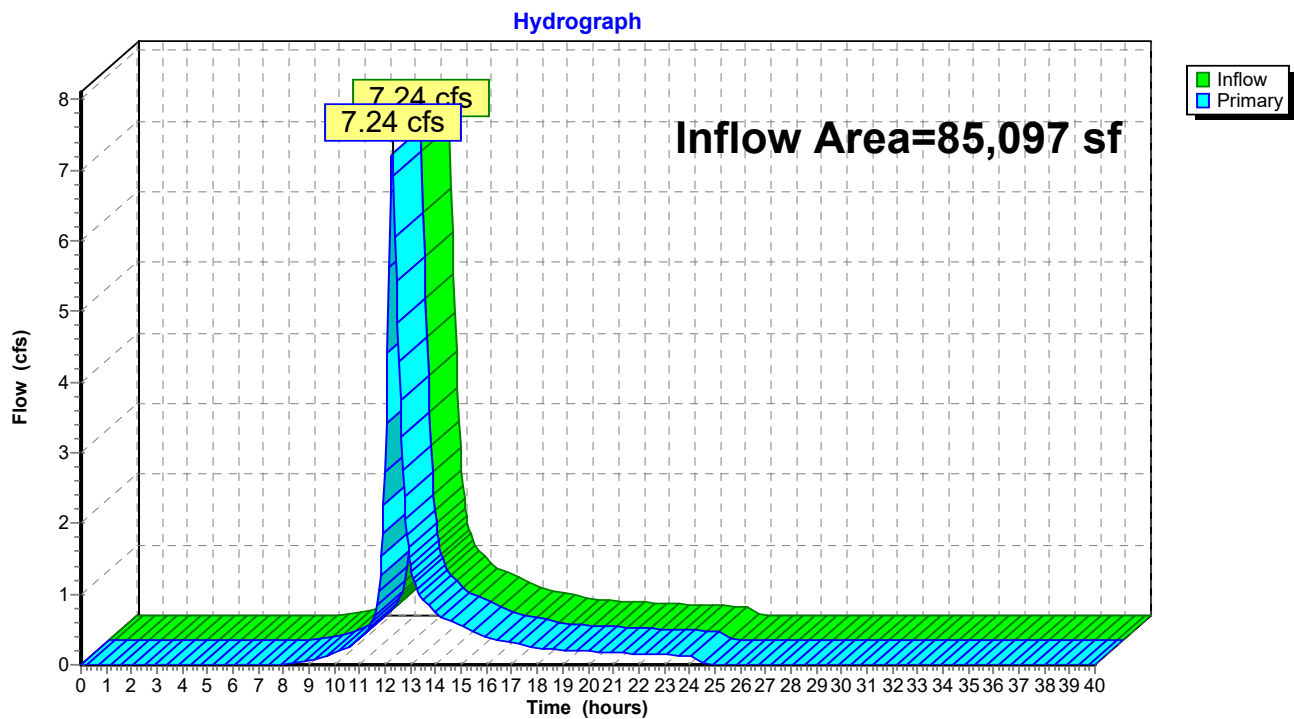
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**Summary for Link 1L: Flow to the West**

Inflow Area = 85,097 sf, 0.00% Impervious, Inflow Depth = 4.65" for 100-yr event  
Inflow = 7.24 cfs @ 12.27 hrs, Volume= 32,942 cf  
Primary = 7.24 cfs @ 12.27 hrs, Volume= 32,942 cf, Atten= 0%, Lag= 0.0 min  
Routed to nonexistent node 3L

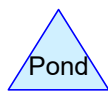
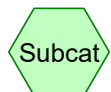
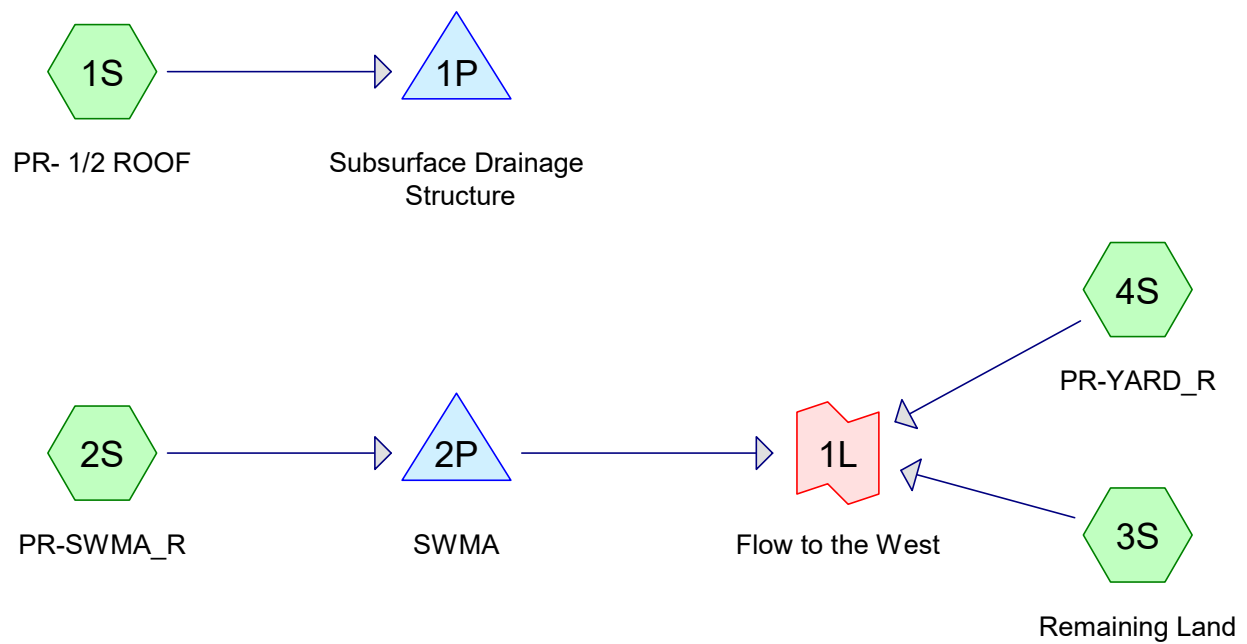
Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

**Link 1L: Flow to the West**

**Proposed Condition**







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**Project Notes**

Defined 4 rainfall events from MA-Topsfield IDF

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**Rainfall Events Listing (selected events)**

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-yr	Type III 24-hr		Default	24.00	1	3.29	2
2	10-yr	Type III 24-hr		Default	24.00	1	5.19	2
3	100-yr	Type III 24-hr		Default	24.00	1	8.21	2

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**Area Listing (all nodes)**

Area (sq-ft)	CN	Description (subcatchment-numbers)
37,964	74	>75% Grass cover, Good, HSG C (2S, 3S, 4S)
4,410	98	Paved parking, HSG C (2S)
1,391	98	Roofs, HSG C (1S)
1,329	98	Unconnected roofs, HSG C (2S)
40,003	70	Woods, Good, HSG C (3S, 4S)
<b>85,097</b>	<b>74</b>	<b>TOTAL AREA</b>

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**Soil Listing (all nodes)**

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
85,097	HSG C	1S, 2S, 3S, 4S
0	HSG D	
0	Other	
<b>85,097</b>		<b>TOTAL AREA</b>

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**Ground Covers (all nodes)**

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover
0	0	37,964	0	0	37,964	>75% Grass cover, Good
0	0	4,410	0	0	4,410	Paved parking
0	0	1,391	0	0	1,391	Roofs
0	0	1,329	0	0	1,329	Unconnected roofs
0	0	40,003	0	0	40,003	Woods, Good
<b>0</b>	<b>0</b>	<b>85,097</b>	<b>0</b>	<b>0</b>	<b>85,097</b>	<b>TOTAL AREA</b>

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**Pipe Listing (all nodes)**

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Width (inches)	Diam/Height (inches)	Inside-Fill (inches)
1	2P	99.25	98.00	45.0	0.0278	0.010	0.0	4.0	0.0

**PROPOSED\_R***Type III 24-hr 2-yr Rainfall=3.29"*

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Time span=0.00-40.00 hrs, dt=0.05 hrs, 801 points  
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
 Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

<b>Subcatchment 1S: PR- 1/2 ROOF</b>	Runoff Area=1,391 sf 100.00% Impervious Runoff Depth=3.06" Tc=6.0 min CN=98 Runoff=0.10 cfs 354 cf
<b>Subcatchment 2S: PR-SWMA_R</b>	Runoff Area=11,800 sf 48.64% Impervious Runoff Depth=1.91" Tc=6.0 min CN=86 Runoff=0.60 cfs 1,882 cf
<b>Subcatchment 3S: Remaining Land</b>	Runoff Area=31,753 sf 0.00% Impervious Runoff Depth=0.88" Flow Length=345' Tc=21.3 min CN=70 Runoff=0.44 cfs 2,331 cf
<b>Subcatchment 4S: PR-YARD_R</b>	Runoff Area=40,153 sf 0.00% Impervious Runoff Depth=1.04" Flow Length=345' Slope=0.0350 '/' Tc=12.1 min CN=73 Runoff=0.85 cfs 3,483 cf
<b>Pond 1P: Subsurface Drainage Structure</b>	Peak Elev=90.41' Storage=143 cf Inflow=0.10 cfs 354 cf Outflow=0.01 cfs 354 cf
<b>Pond 2P: SWMA</b>	Peak Elev=97.70' Storage=905 cf Inflow=0.60 cfs 1,882 cf Discarded=0.03 cfs 1,882 cf Primary=0.00 cfs 0 cf Outflow=0.03 cfs 1,882 cf
<b>Link 1L: Flow to the West</b>	Inflow=1.20 cfs 5,814 cf Primary=1.20 cfs 5,814 cf
<b>Total Runoff Area = 85,097 sf Runoff Volume = 8,050 cf Average Runoff Depth = 1.14"</b>	
<b>91.62% Pervious = 77,967 sf 8.38% Impervious = 7,130 sf</b>	



**PROPOSED\_R**

Type III 24-hr 2-yr Rainfall=3.29"

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**Summary for Subcatchment 1S: PR- 1/2 ROOF**

Runoff = 0.10 cfs @ 12.09 hrs, Volume= 354 cf, Depth= 3.06"  
 Routed to Pond 1P : Subsurface Drainage Structure

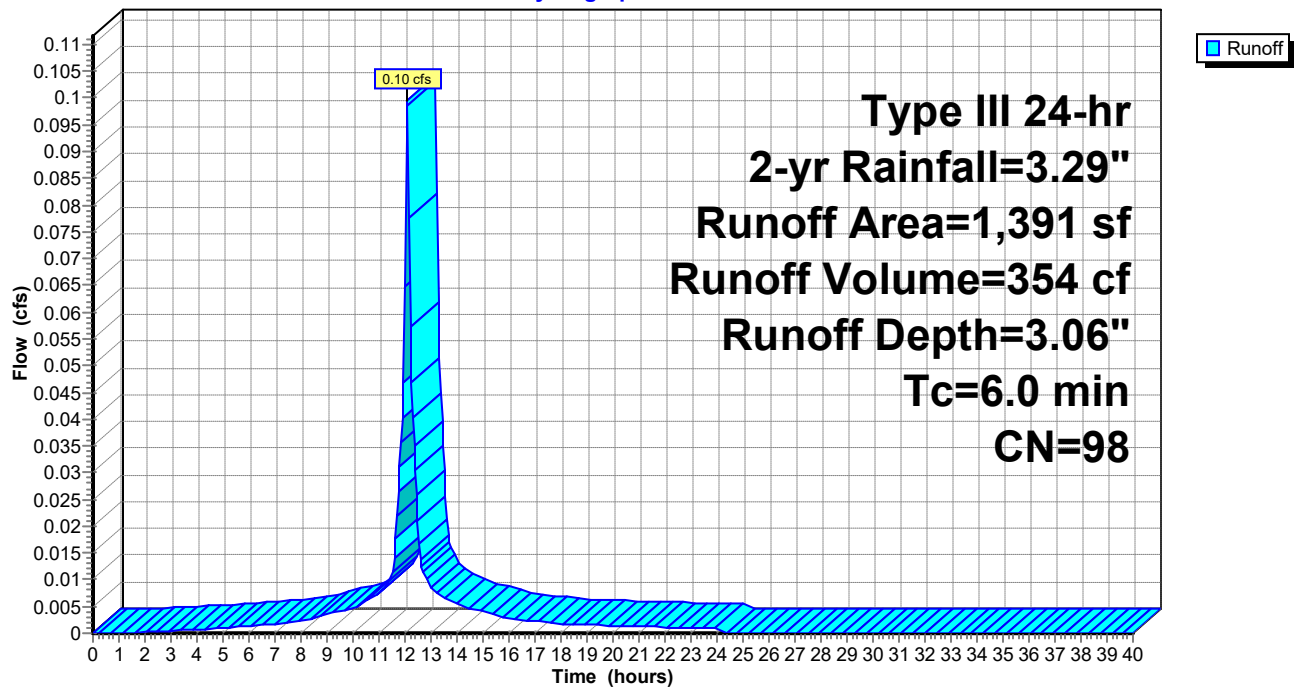
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 2-yr Rainfall=3.29"

Area (sf)	CN	Description
1,391	98	Roofs, HSG C
1,391		100.00% Impervious Area

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

**Subcatchment 1S: PR- 1/2 ROOF**

Hydrograph



**PROPOSED\_R**

Type III 24-hr 2-yr Rainfall=3.29"

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**Summary for Subcatchment 2S: PR-SWMA\_R**

Runoff = 0.60 cfs @ 12.09 hrs, Volume= 1,882 cf, Depth= 1.91"  
 Routed to Pond 2P : SWMA

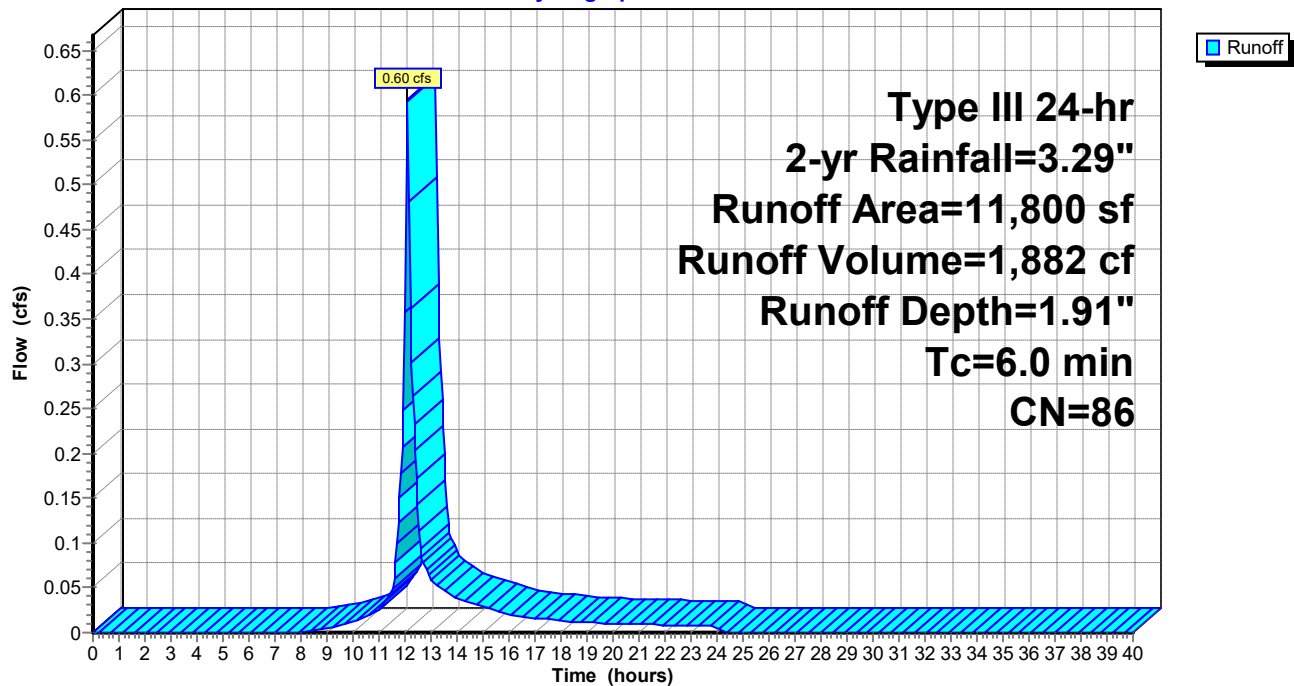
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 2-yr Rainfall=3.29"

Area (sf)	CN	Description
4,410	98	Paved parking, HSG C
6,061	74	>75% Grass cover, Good, HSG C
1,329	98	Unconnected roofs, HSG C
11,800	86	Weighted Average
6,061		51.36% Pervious Area
5,739		48.64% Impervious Area
1,329		23.16% Unconnected

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

**Subcatchment 2S: PR-SWMA\_R**

Hydrograph



**PROPOSED\_R**

Type III 24-hr 2-yr Rainfall=3.29"

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**Summary for Subcatchment 3S: Remaining Land**

Runoff = 0.44 cfs @ 12.33 hrs, Volume= 2,331 cf, Depth= 0.88"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 2-yr Rainfall=3.29"

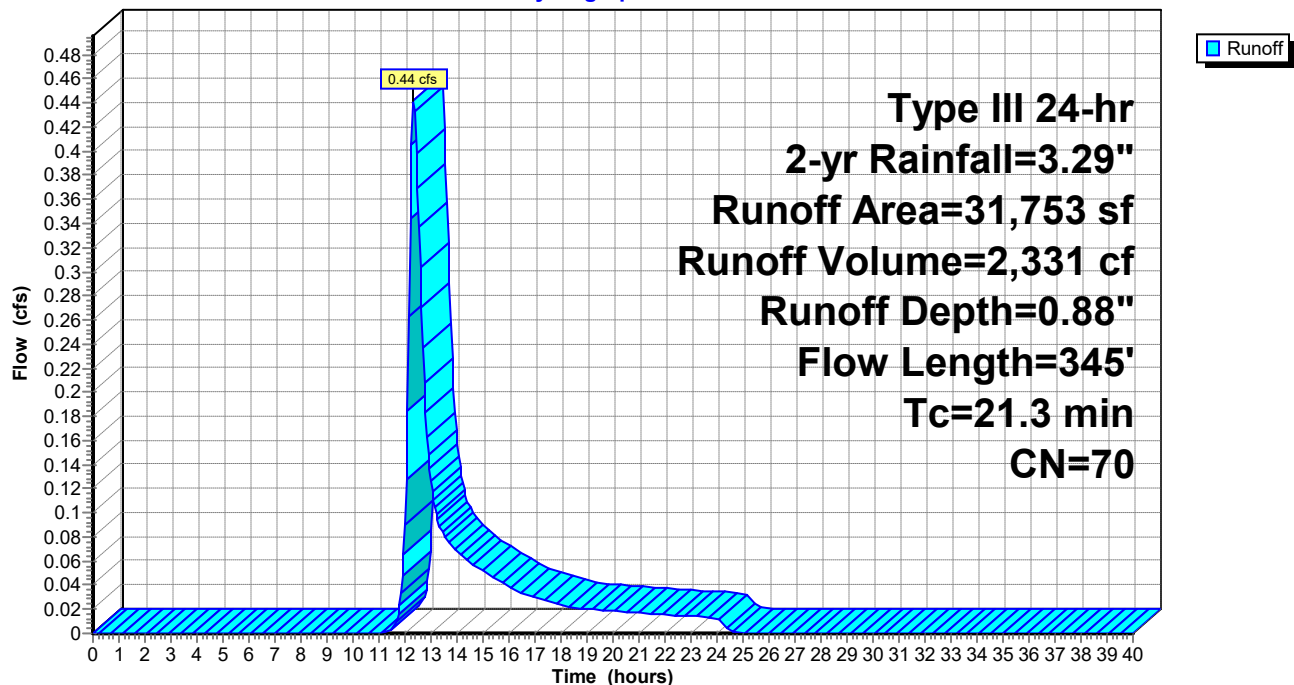
Area (sf)	CN	Description
30,003	70	Woods, Good, HSG C
1,750	74	>75% Grass cover, Good, HSG C
31,753	70	Weighted Average
31,753		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.0	100	0.0350	0.10		<b>Sheet Flow,</b> Woods: Light underbrush n= 0.400 P2= 3.28"
4.3	245	0.0360	0.95		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
21.3	345	Total			

**Subcatchment 3S: Remaining Land**

Hydrograph



**PROPOSED\_R**

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**Summary for Subcatchment 4S: PR-YARD\_R**

Runoff = 0.85 cfs @ 12.18 hrs, Volume= 3,483 cf, Depth= 1.04"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 2-yr Rainfall=3.29"

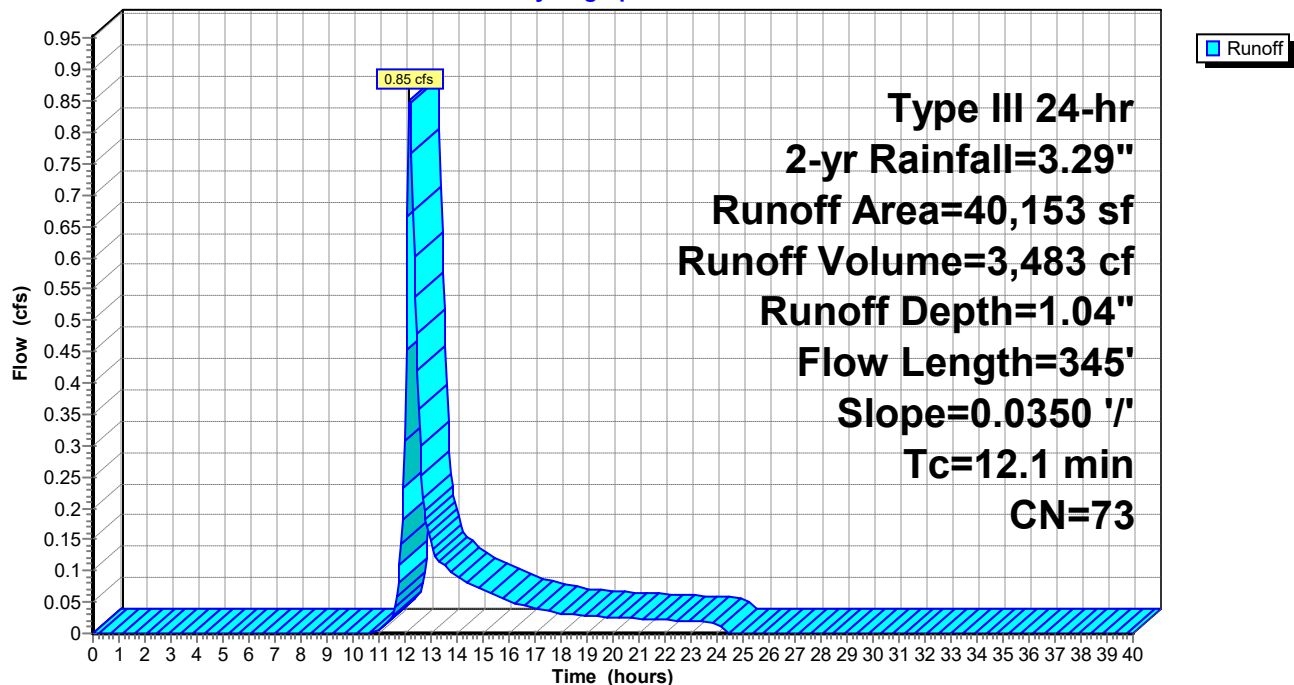
Area (sf)	CN	Description
30,153	74	>75% Grass cover, Good, HSG C
10,000	70	Woods, Good, HSG C
40,153	73	Weighted Average
40,153		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	100	0.0350	0.22		<b>Sheet Flow,</b> Grass: Short n= 0.150 P2= 3.28"
4.4	245	0.0350	0.94		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
12.1	345	Total			

**Subcatchment 4S: PR-YARD\_R**

Hydrograph



**PROPOSED\_R***Type III 24-hr 2-yr Rainfall=3.29"*

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**Summary for Pond 1P: Subsurface Drainage Structure**

[87] Warning: Oscillations may require smaller dt or Finer Routing (severity=9)

Inflow Area = 1,391 sf, 100.00% Impervious, Inflow Depth = 3.06" for 2-yr event  
 Inflow = 0.10 cfs @ 12.09 hrs, Volume= 354 cf  
 Outflow = 0.01 cfs @ 11.45 hrs, Volume= 354 cf, Atten= 94%, Lag= 0.0 min  
 Discarded = 0.01 cfs @ 11.45 hrs, Volume= 354 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

Peak Elev= 90.41' @ 13.58 hrs Surf.Area= 274 sf Storage= 143 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)

Center-of-Mass det. time= 171.0 min ( 926.8 - 755.8 )

Volume	Invert	Avail.Storage	Storage Description
#1A	89.50'	253 cf	<b>11.17'W x 24.50'L x 3.54'H Field A</b> 969 cf Overall - 335 cf Embedded = 634 cf x 40.0% Voids
#2A	90.00'	335 cf	<b>Cultec R-330XLHD</b> x 6 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 2 rows
		589 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	89.50'	<b>1.020 in/hr Exfiltration over Surface area</b>

**Discarded OutFlow** Max=0.01 cfs @ 11.45 hrs HW=89.54' (Free Discharge)↑ **1=Exfiltration** (Exfiltration Controls 0.01 cfs)

**PROPOSED\_R**

Type III 24-hr 2-yr Rainfall=3.29"

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**Pond 1P: Subsurface Drainage Structure - Chamber Wizard Field A**

**Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)**

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 2 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

2 Rows x 52.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.17' Base Width

6.0" Stone Base + 30.5" Chamber Height + 6.0" Stone Cover = 3.54' Field Height

6 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 2 Rows = 335.3 cf Chamber Storage

968.9 cf Field - 335.3 cf Chambers = 633.6 cf Stone x 40.0% Voids = 253.5 cf Stone Storage

Chamber Storage + Stone Storage = 588.8 cf = 0.014 af

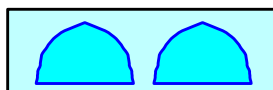
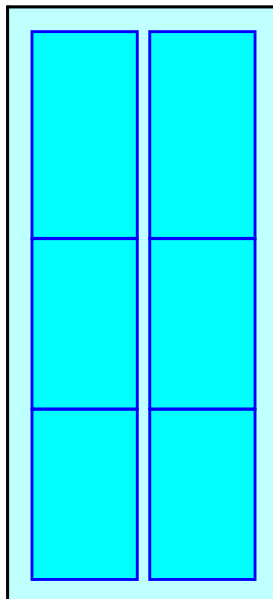
Overall Storage Efficiency = 60.8%

Overall System Size = 24.50' x 11.17' x 3.54'

6 Chambers

35.9 cy Field

23.5 cy Stone



## PROPOSED\_R

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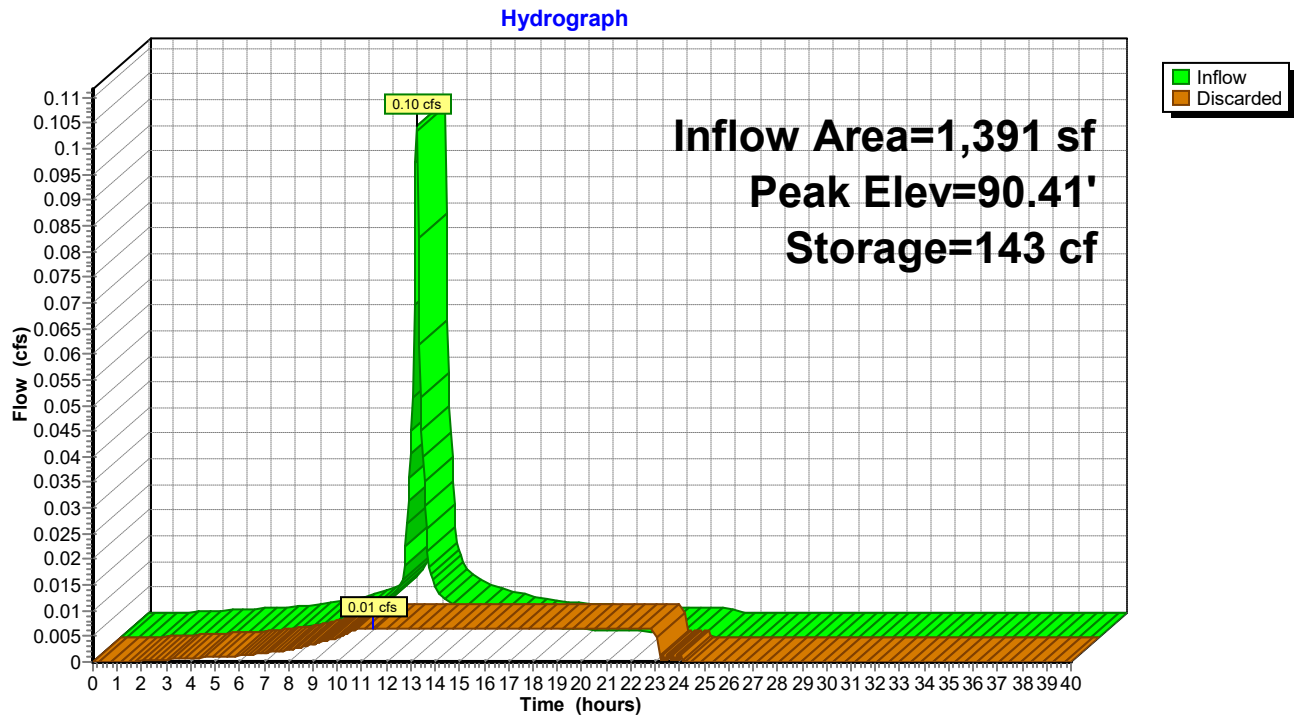
Proposed Condition Watershed Analysis Revised August 4, 2023

Type III 24-hr 2-yr Rainfall=3.29"

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### Pond 1P: Subsurface Drainage Structure



**PROPOSED\_R***Type III 24-hr 2-yr Rainfall=3.29"*

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**Summary for Pond 2P: SWMA**

Inflow Area = 11,800 sf, 48.64% Impervious, Inflow Depth = 1.91" for 2-yr event  
 Inflow = 0.60 cfs @ 12.09 hrs, Volume= 1,882 cf  
 Outflow = 0.03 cfs @ 14.39 hrs, Volume= 1,882 cf, Atten= 94%, Lag= 138.0 min  
 Discarded = 0.03 cfs @ 14.39 hrs, Volume= 1,882 cf  
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf  
 Routed to Link 1L : Flow to the West

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Peak Elev= 97.70' @ 14.39 hrs Surf.Area= 1,449 sf Storage= 905 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)  
 Center-of-Mass det. time= 269.6 min ( 1,090.9 - 821.3 )

Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	6,990 cf	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
97.00	1,150	0	0
98.00	1,580	1,365	1,365
99.00	2,060	1,820	3,185
100.00	2,600	2,330	5,515
100.50	3,300	1,475	6,990

Device	Routing	Invert	Outlet Devices
#1	Discarded	97.00'	<b>1.020 in/hr Exfiltration over Surface area</b>
#2	Primary	99.25'	<b>4.0" Round Culvert</b> L= 45.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 99.25' / 98.00' S= 0.0278 '/' Cc= 0.900 n= 0.010, Flow Area= 0.09 sf

**Discarded OutFlow** Max=0.03 cfs @ 14.39 hrs HW=97.70' (Free Discharge)

↑ **1=Exfiltration** (Exfiltration Controls 0.03 cfs)

**Primary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=97.00' TW=0.00' (Dynamic Tailwater)

↑ **2=Culvert** ( Controls 0.00 cfs)



**PROPOSED\_R**

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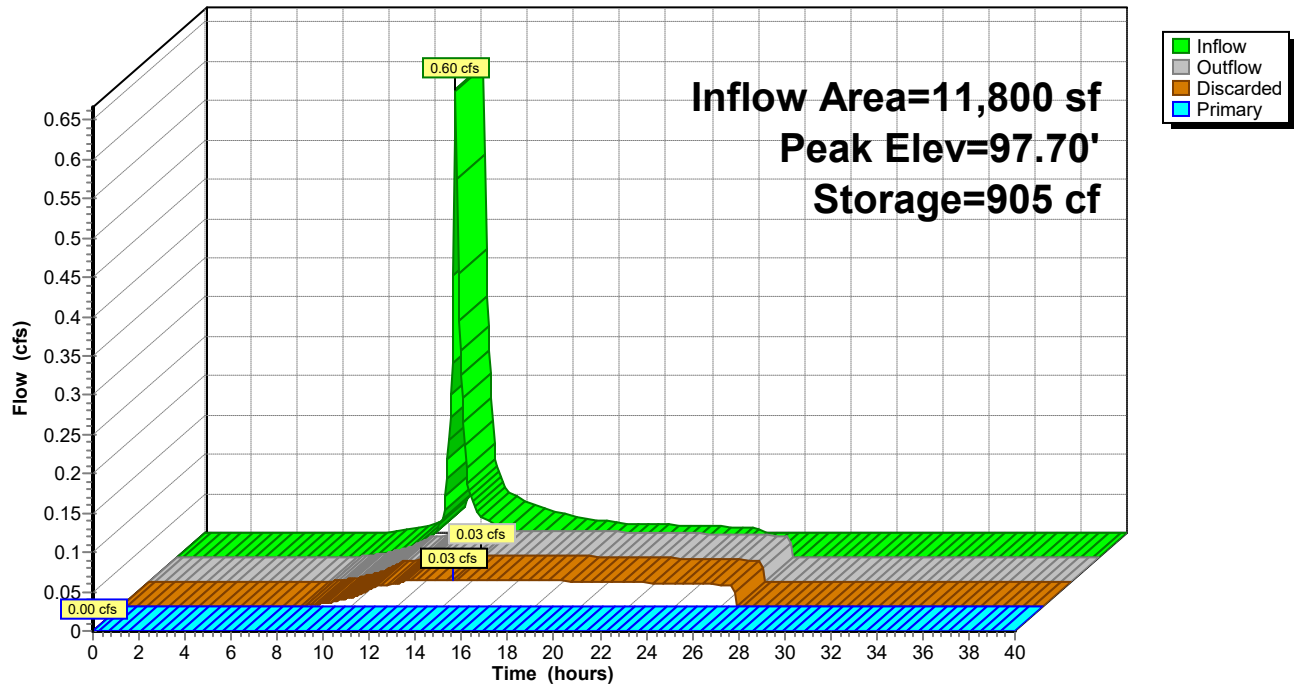
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**Pond 2P: SWMA**

Hydrograph



## PROPOSED\_R

Type III 24-hr 2-yr Rainfall=3.29"

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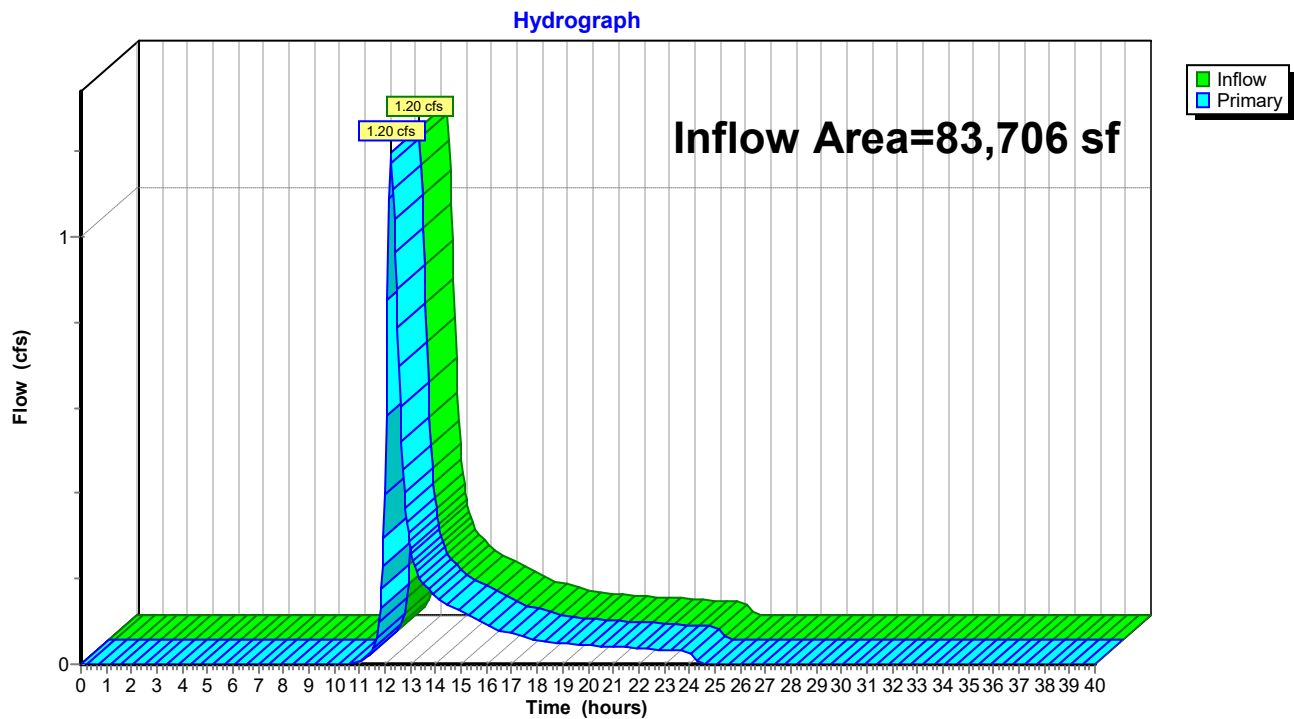
Page 18

### Summary for Link 1L: Flow to the West

Inflow Area = 83,706 sf, 6.86% Impervious, Inflow Depth = 0.83" for 2-yr event  
 Inflow = 1.20 cfs @ 12.22 hrs, Volume= 5,814 cf  
 Primary = 1.20 cfs @ 12.22 hrs, Volume= 5,814 cf, Atten= 0%, Lag= 0.0 min  
 Routed to nonexistent node 3L

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

### Link 1L: Flow to the West



**PROPOSED\_R**

*Type III 24-hr 10-yr Rainfall=5.19"*

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Time span=0.00-40.00 hrs, dt=0.05 hrs, 801 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment 1S: PR- 1/2 ROOF** Runoff Area=1,391 sf 100.00% Impervious Runoff Depth=4.95"  
Tc=6.0 min CN=98 Runoff=0.16 cfs 574 cf

**Subcatchment 2S: PR-SWMA\_R** Runoff Area=11,800 sf 48.64% Impervious Runoff Depth=3.64"  
Tc=6.0 min CN=86 Runoff=1.11 cfs 3,584 cf

**Subcatchment 3S: Remaining Land** Runoff Area=31,753 sf 0.00% Impervious Runoff Depth=2.18"  
Flow Length=345' Tc=21.3 min CN=70 Runoff=1.20 cfs 5,764 cf

**Subcatchment 4S: PR-YARD\_R** Runoff Area=40,153 sf 0.00% Impervious Runoff Depth=2.43"  
Flow Length=345' Slope=0.0350 '/' Tc=12.1 min CN=73 Runoff=2.12 cfs 8,132 cf

**Pond 1P: Subsurface Drainage Structure** Peak Elev=91.08' Storage=283 cf Inflow=0.16 cfs 574 cf  
Outflow=0.01 cfs 574 cf

**Pond 2P: SWMA** Peak Elev=98.42' Storage=2,074 cf Inflow=1.11 cfs 3,584 cf  
Discarded=0.04 cfs 3,584 cf Primary=0.00 cfs 0 cf Outflow=0.04 cfs 3,584 cf

**Link 1L: Flow to the West** Inflow=3.08 cfs 13,896 cf  
Primary=3.08 cfs 13,896 cf

**Total Runoff Area = 85,097 sf Runoff Volume = 18,054 cf Average Runoff Depth = 2.55"**  
**91.62% Pervious = 77,967 sf 8.38% Impervious = 7,130 sf**

**PROPOSED\_R**

Type III 24-hr 10-yr Rainfall=5.19"

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**Summary for Subcatchment 1S: PR- 1/2 ROOF**

Runoff = 0.16 cfs @ 12.09 hrs, Volume= 574 cf, Depth= 4.95"  
 Routed to Pond 1P : Subsurface Drainage Structure

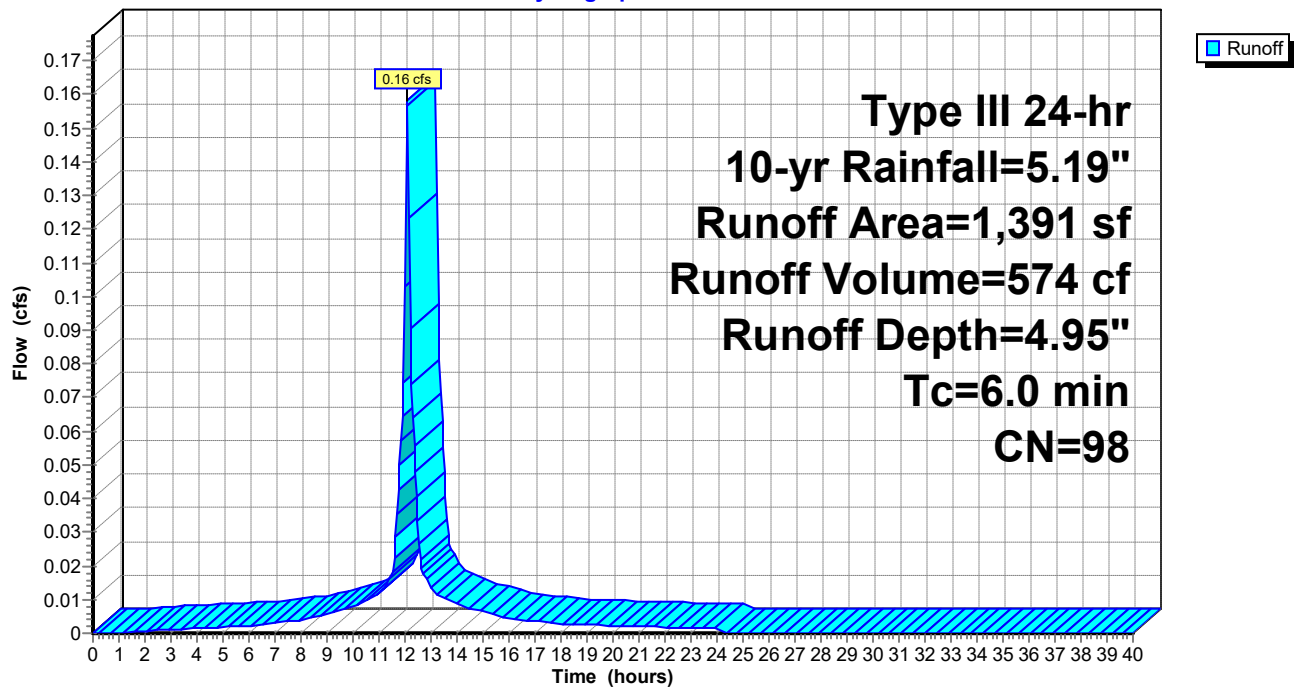
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 10-yr Rainfall=5.19"

Area (sf)	CN	Description
1,391	98	Roofs, HSG C
1,391		100.00% Impervious Area

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

**Subcatchment 1S: PR- 1/2 ROOF**

Hydrograph



**PROPOSED\_R**

Type III 24-hr 10-yr Rainfall=5.19"

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**Summary for Subcatchment 2S: PR-SWMA\_R**

Runoff = 1.11 cfs @ 12.09 hrs, Volume= 3,584 cf, Depth= 3.64"  
 Routed to Pond 2P : SWMA

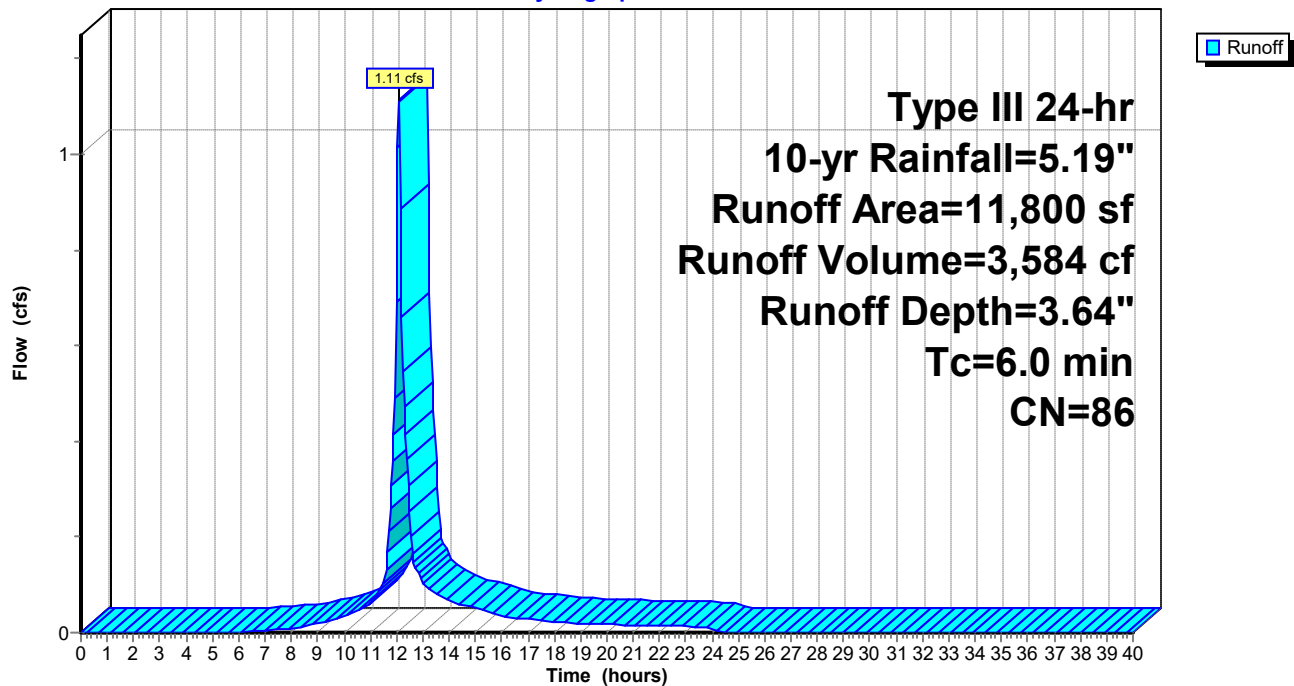
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 10-yr Rainfall=5.19"

Area (sf)	CN	Description
4,410	98	Paved parking, HSG C
6,061	74	>75% Grass cover, Good, HSG C
1,329	98	Unconnected roofs, HSG C
11,800	86	Weighted Average
6,061		51.36% Pervious Area
5,739		48.64% Impervious Area
1,329		23.16% Unconnected

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

**Subcatchment 2S: PR-SWMA\_R**

Hydrograph



**PROPOSED\_R**

Type III 24-hr 10-yr Rainfall=5.19"

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**Summary for Subcatchment 3S: Remaining Land**

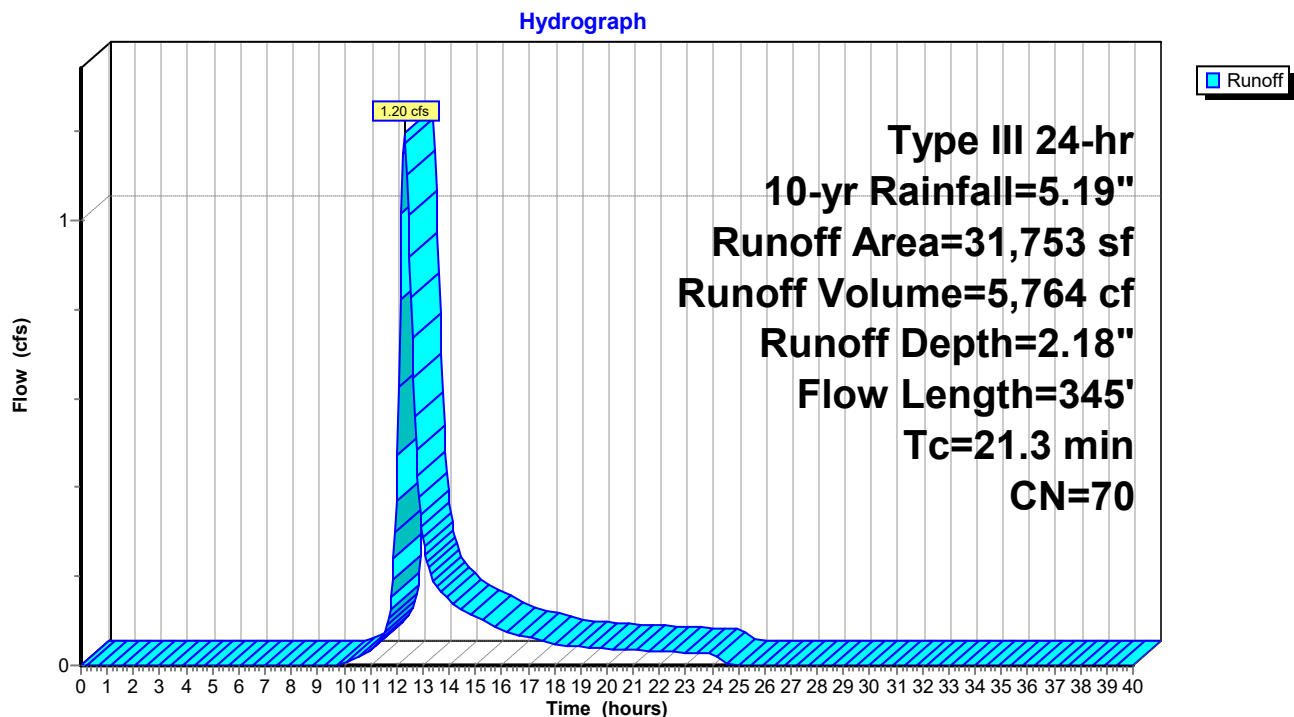
Runoff = 1.20 cfs @ 12.31 hrs, Volume= 5,764 cf, Depth= 2.18"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 10-yr Rainfall=5.19"

Area (sf)	CN	Description
30,003	70	Woods, Good, HSG C
1,750	74	>75% Grass cover, Good, HSG C
31,753	70	Weighted Average
31,753		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.0	100	0.0350	0.10		<b>Sheet Flow,</b> Woods: Light underbrush n= 0.400 P2= 3.28"
4.3	245	0.0360	0.95		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
21.3	345	Total			

**Subcatchment 3S: Remaining Land**

**PROPOSED\_R**

Type III 24-hr 10-yr Rainfall=5.19"

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**Summary for Subcatchment 4S: PR-YARD\_R**

Runoff = 2.12 cfs @ 12.17 hrs, Volume= 8,132 cf, Depth= 2.43"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 10-yr Rainfall=5.19"

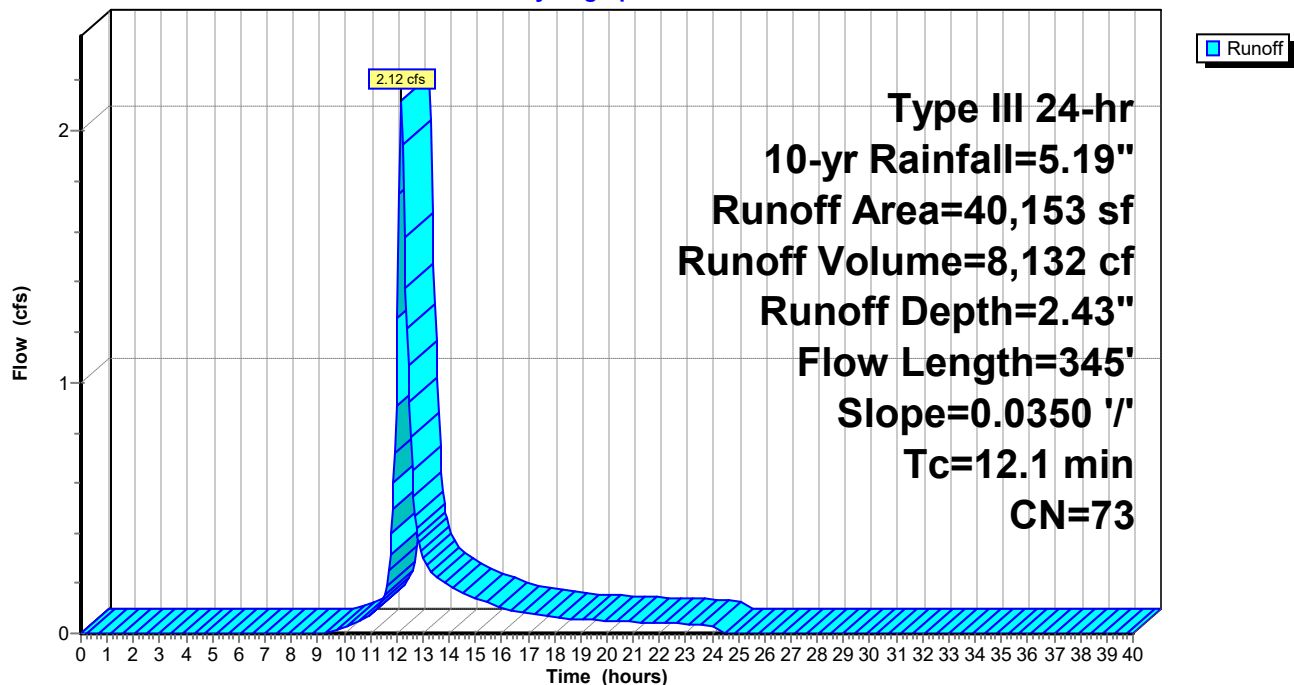
Area (sf)	CN	Description
30,153	74	>75% Grass cover, Good, HSG C
10,000	70	Woods, Good, HSG C
40,153	73	Weighted Average
40,153		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	100	0.0350	0.22		<b>Sheet Flow,</b> Grass: Short n= 0.150 P2= 3.28"
4.4	245	0.0350	0.94		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
12.1	345	Total			

**Subcatchment 4S: PR-YARD\_R**

Hydrograph



**PROPOSED\_R**

Type III 24-hr 10-yr Rainfall=5.19"

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**Summary for Pond 1P: Subsurface Drainage Structure**

Inflow Area = 1,391 sf, 100.00% Impervious, Inflow Depth = 4.95" for 10-yr event  
 Inflow = 0.16 cfs @ 12.09 hrs, Volume= 574 cf  
 Outflow = 0.01 cfs @ 10.40 hrs, Volume= 574 cf, Atten= 96%, Lag= 0.0 min  
 Discarded = 0.01 cfs @ 10.40 hrs, Volume= 574 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

Peak Elev= 91.08' @ 14.99 hrs Surf.Area= 274 sf Storage= 283 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)

Center-of-Mass det. time= 365.0 min ( 1,112.4 - 747.4 )

Volume	Invert	Avail.Storage	Storage Description
#1A	89.50'	253 cf	<b>11.17'W x 24.50'L x 3.54'H Field A</b> 969 cf Overall - 335 cf Embedded = 634 cf x 40.0% Voids
#2A	90.00'	335 cf	<b>Cultec R-330XLHD</b> x 6 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 2 rows
		589 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	89.50'	<b>1.020 in/hr Exfiltration over Surface area</b>

**Discarded OutFlow** Max=0.01 cfs @ 10.40 hrs HW=89.54' (Free Discharge)↑**1=Exfiltration** (Exfiltration Controls 0.01 cfs)



**PROPOSED\_R**

Type III 24-hr 10-yr Rainfall=5.19"

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**Pond 1P: Subsurface Drainage Structure - Chamber Wizard Field A**

**Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)**

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 2 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

2 Rows x 52.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.17' Base Width

6.0" Stone Base + 30.5" Chamber Height + 6.0" Stone Cover = 3.54' Field Height

6 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 2 Rows = 335.3 cf Chamber Storage

968.9 cf Field - 335.3 cf Chambers = 633.6 cf Stone x 40.0% Voids = 253.5 cf Stone Storage

Chamber Storage + Stone Storage = 588.8 cf = 0.014 af

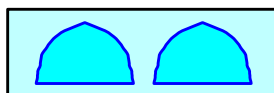
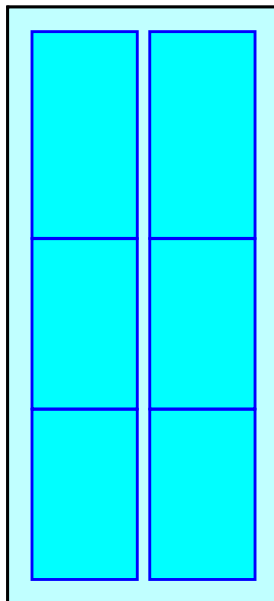
Overall Storage Efficiency = 60.8%

Overall System Size = 24.50' x 11.17' x 3.54'

6 Chambers

35.9 cy Field

23.5 cy Stone



**PROPOSED\_R**

Prepared by Williams & Sparages

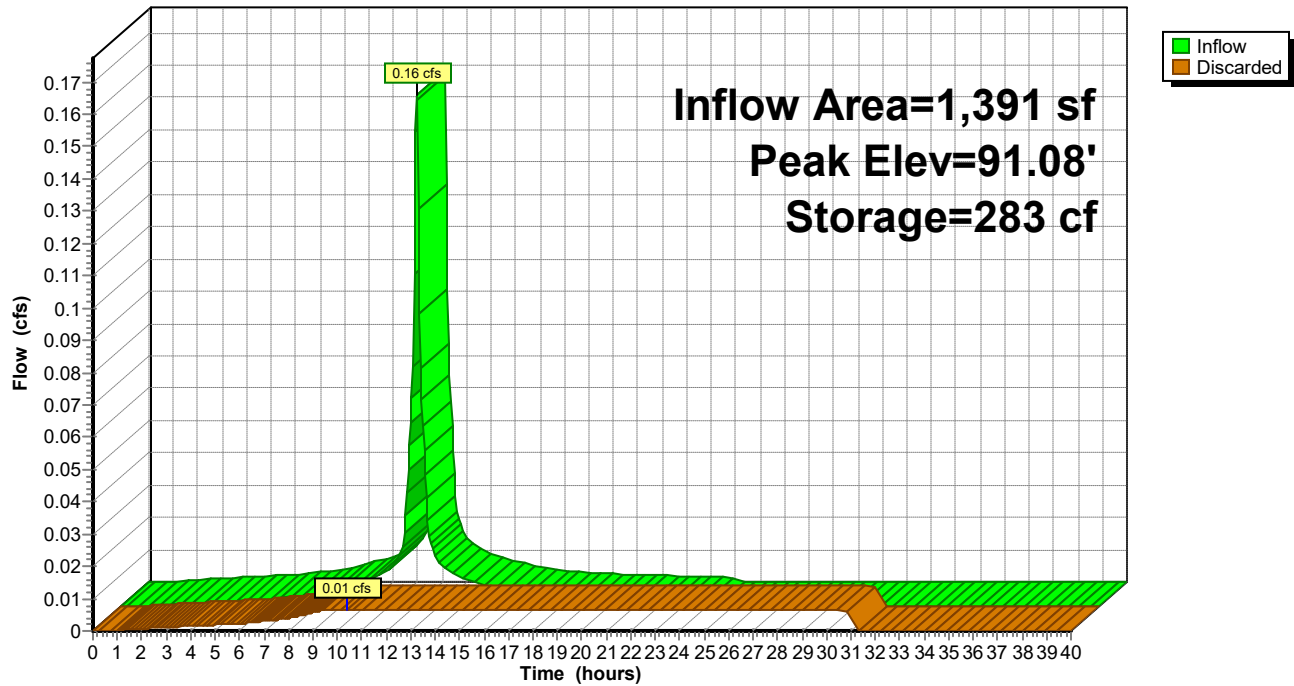
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**Pond 1P: Subsurface Drainage Structure**

Hydrograph



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Type III 24-hr 10-yr Rainfall=5.19"

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**Summary for Pond 2P: SWMA**

Inflow Area = 11,800 sf, 48.64% Impervious, Inflow Depth = 3.64" for 10-yr event  
 Inflow = 1.11 cfs @ 12.09 hrs, Volume= 3,584 cf  
 Outflow = 0.04 cfs @ 15.55 hrs, Volume= 3,584 cf, Atten= 96%, Lag= 207.8 min  
 Discarded = 0.04 cfs @ 15.55 hrs, Volume= 3,584 cf  
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf  
 Routed to Link 1L : Flow to the West

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Peak Elev= 98.42' @ 15.55 hrs Surf.Area= 1,782 sf Storage= 2,074 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)  
 Center-of-Mass det. time= 516.5 min ( 1,319.5 - 803.0 )

Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	6,990 cf	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
97.00	1,150	0	0
98.00	1,580	1,365	1,365
99.00	2,060	1,820	3,185
100.00	2,600	2,330	5,515
100.50	3,300	1,475	6,990

Device	Routing	Invert	Outlet Devices
#1	Discarded	97.00'	<b>1.020 in/hr Exfiltration over Surface area</b>
#2	Primary	99.25'	<b>4.0" Round Culvert</b> L= 45.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 99.25' / 98.00' S= 0.0278 ' / S= 0.0278 ' / Cc= 0.900 n= 0.010, Flow Area= 0.09 sf

**Discarded OutFlow** Max=0.04 cfs @ 15.55 hrs HW=98.42' (Free Discharge)

↑ **1=Exfiltration** (Exfiltration Controls 0.04 cfs)

**Primary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=97.00' TW=0.00' (Dynamic Tailwater)

↑ **2=Culvert** ( Controls 0.00 cfs)

**PROPOSED\_R**

Prepared by Williams & Sparages

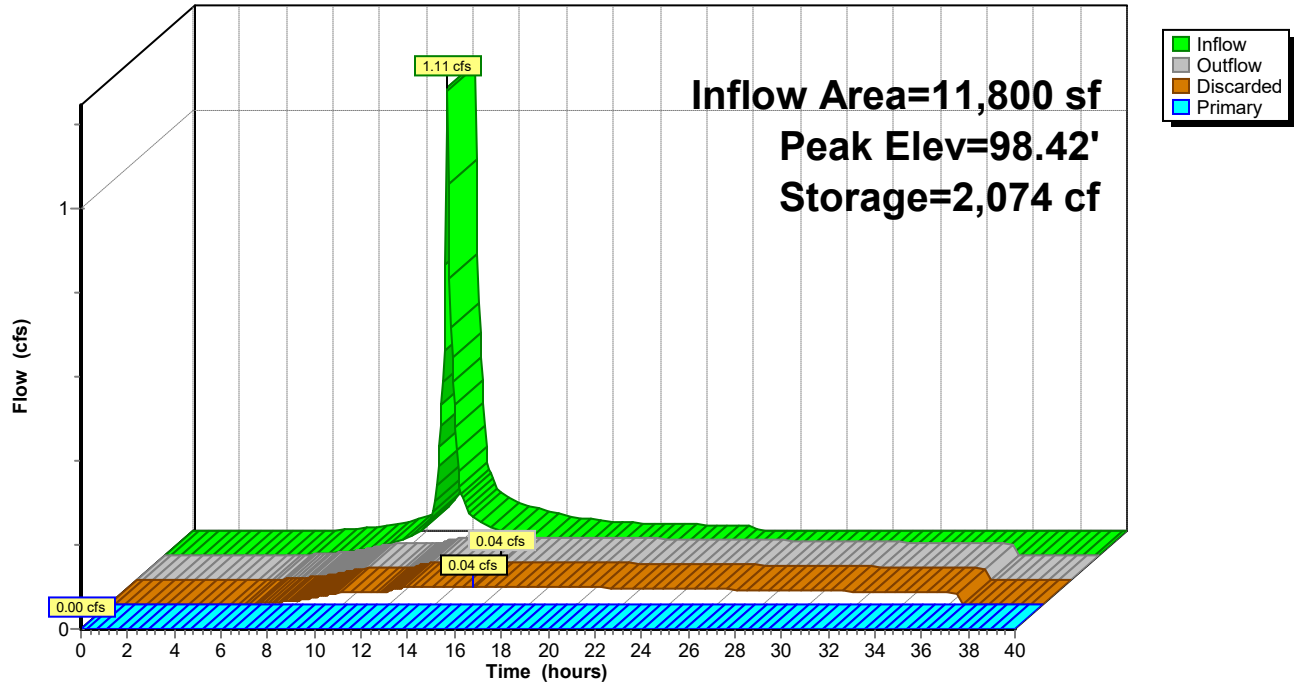
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**Pond 2P: SWMA**

Hydrograph



## PROPOSED\_R

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Type III 24-hr 10-yr Rainfall=5.19"

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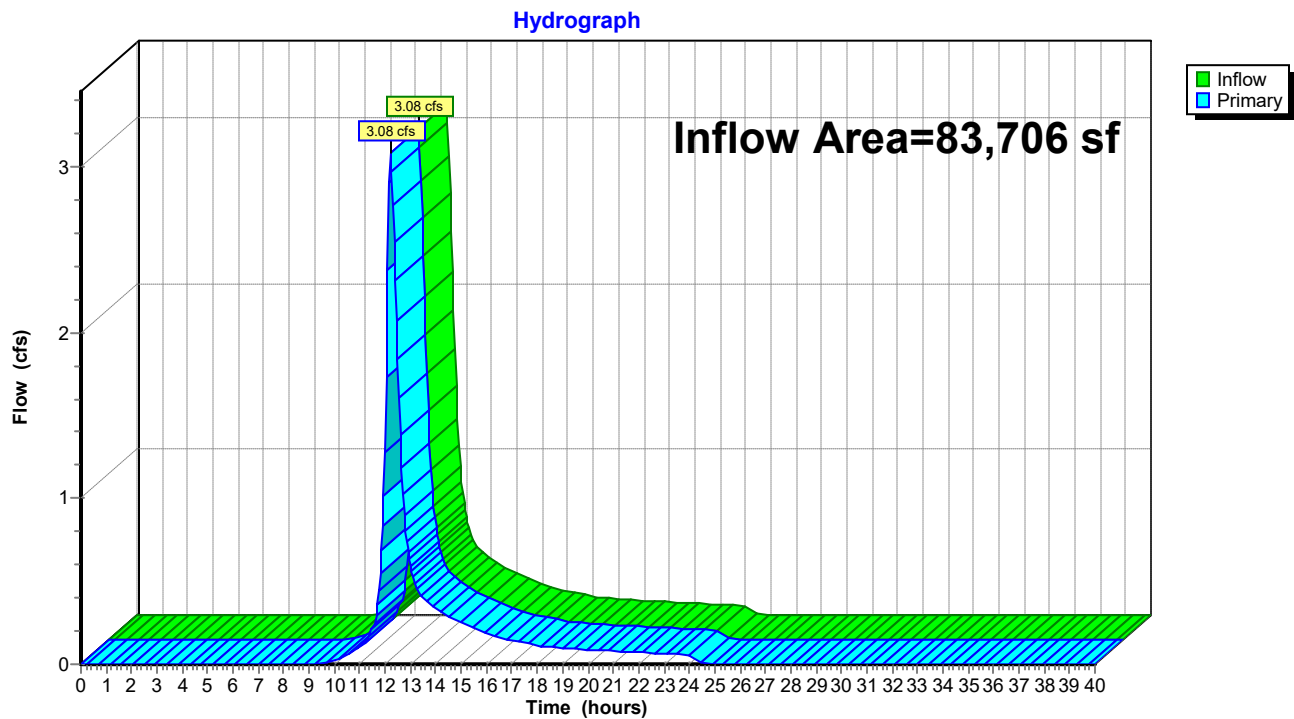
Page 29

### Summary for Link 1L: Flow to the West

Inflow Area = 83,706 sf, 6.86% Impervious, Inflow Depth = 1.99" for 10-yr event  
 Inflow = 3.08 cfs @ 12.21 hrs, Volume= 13,896 cf  
 Primary = 3.08 cfs @ 12.21 hrs, Volume= 13,896 cf, Atten= 0%, Lag= 0.0 min  
 Routed to nonexistent node 3L

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

### Link 1L: Flow to the West



**PROPOSED\_R***Type III 24-hr 100-yr Rainfall=8.21"*

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Time span=0.00-40.00 hrs, dt=0.05 hrs, 801 points  
 Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
 Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

**Subcatchment 1S: PR- 1/2 ROOF** Runoff Area=1,391 sf 100.00% Impervious Runoff Depth=7.97"  
 Tc=6.0 min CN=98 Runoff=0.25 cfs 924 cf

**Subcatchment 2S: PR-SWMA\_R** Runoff Area=11,800 sf 48.64% Impervious Runoff Depth=6.54"  
 Tc=6.0 min CN=86 Runoff=1.94 cfs 6,426 cf

**Subcatchment 3S: Remaining Land** Runoff Area=31,753 sf 0.00% Impervious Runoff Depth=4.65"  
 Flow Length=345' Tc=21.3 min CN=70 Runoff=2.60 cfs 12,292 cf

**Subcatchment 4S: PR-YARD\_R** Runoff Area=40,153 sf 0.00% Impervious Runoff Depth=5.00"  
 Flow Length=345' Slope=0.0350 '/ Tc=12.1 min CN=73 Runoff=4.39 cfs 16,719 cf

**Pond 1P: Subsurface Drainage Structure** Peak Elev=92.64' Storage=545 cf Inflow=0.25 cfs 924 cf  
 Outflow=0.01 cfs 827 cf

**Pond 2P: SWMA** Peak Elev=99.37' Storage=3,985 cf Inflow=1.94 cfs 6,426 cf  
 Discarded=0.05 cfs 5,191 cf Primary=0.03 cfs 352 cf Outflow=0.09 cfs 5,543 cf

**Link 1L: Flow to the West** Inflow=6.52 cfs 29,363 cf  
 Primary=6.52 cfs 29,363 cf

**Total Runoff Area = 85,097 sf Runoff Volume = 36,360 cf Average Runoff Depth = 5.13"**  
**91.62% Pervious = 77,967 sf 8.38% Impervious = 7,130 sf**

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**Summary for Subcatchment 1S: PR- 1/2 ROOF**

Runoff = 0.25 cfs @ 12.09 hrs, Volume= 924 cf, Depth= 7.97"  
 Routed to Pond 1P : Subsurface Drainage Structure

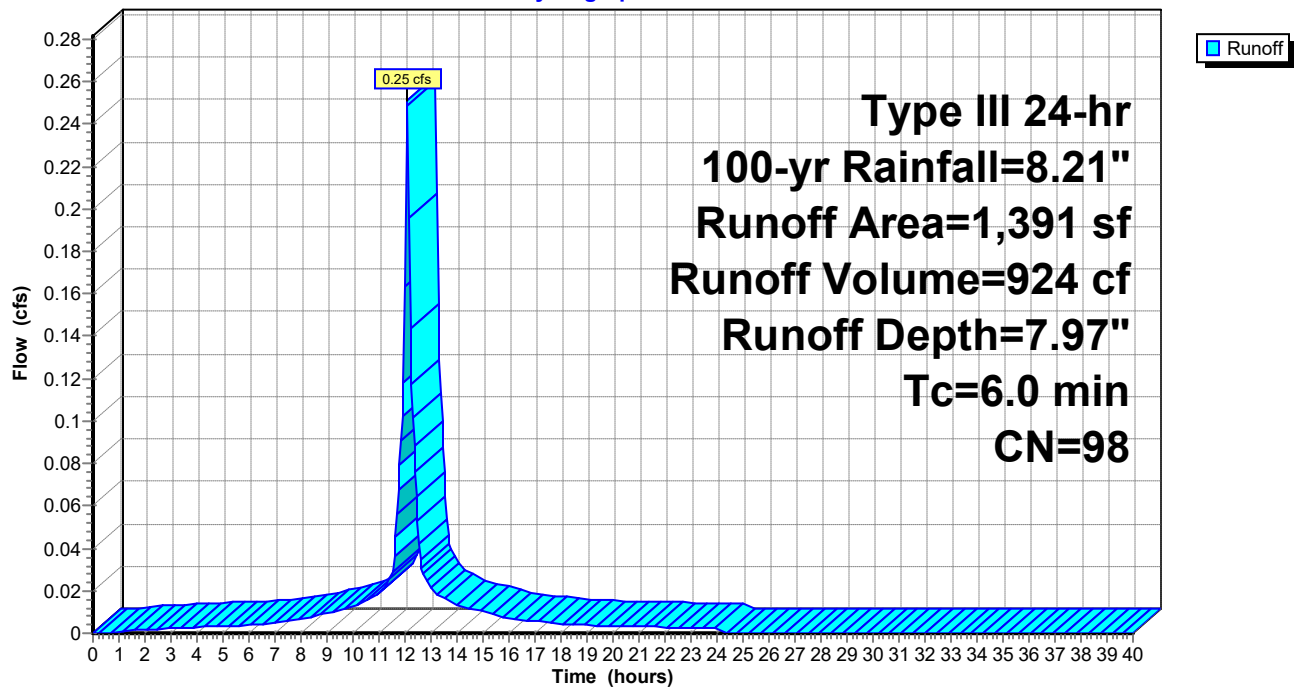
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 100-yr Rainfall=8.21"

Area (sf)	CN	Description
1,391	98	Roofs, HSG C
1,391		100.00% Impervious Area

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

**Subcatchment 1S: PR- 1/2 ROOF**

Hydrograph



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Type III 24-hr 100-yr Rainfall=8.21"

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**Summary for Subcatchment 2S: PR-SWMA\_R**

Runoff = 1.94 cfs @ 12.09 hrs, Volume= 6,426 cf, Depth= 6.54"  
 Routed to Pond 2P : SWMA

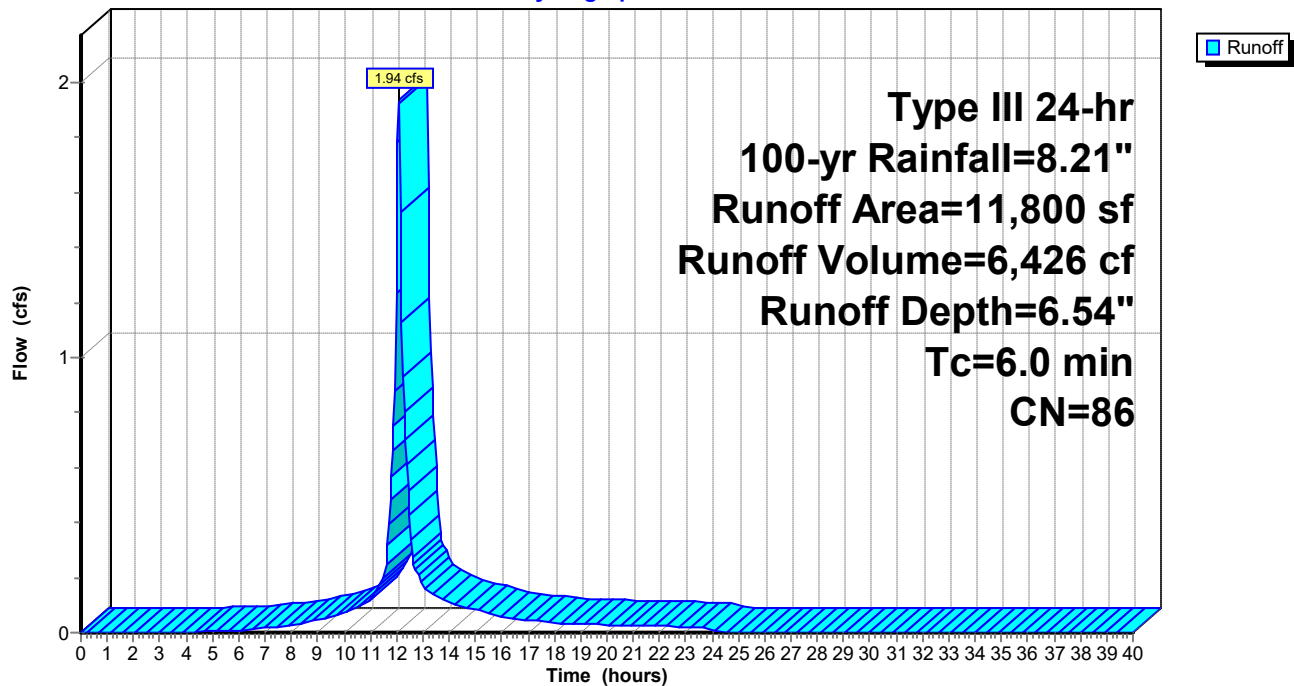
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 100-yr Rainfall=8.21"

Area (sf)	CN	Description
4,410	98	Paved parking, HSG C
6,061	74	>75% Grass cover, Good, HSG C
1,329	98	Unconnected roofs, HSG C
11,800	86	Weighted Average
6,061		51.36% Pervious Area
5,739		48.64% Impervious Area
1,329		23.16% Unconnected

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

**Subcatchment 2S: PR-SWMA\_R**

Hydrograph





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Type III 24-hr 100-yr Rainfall=8.21"

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**Summary for Subcatchment 3S: Remaining Land**

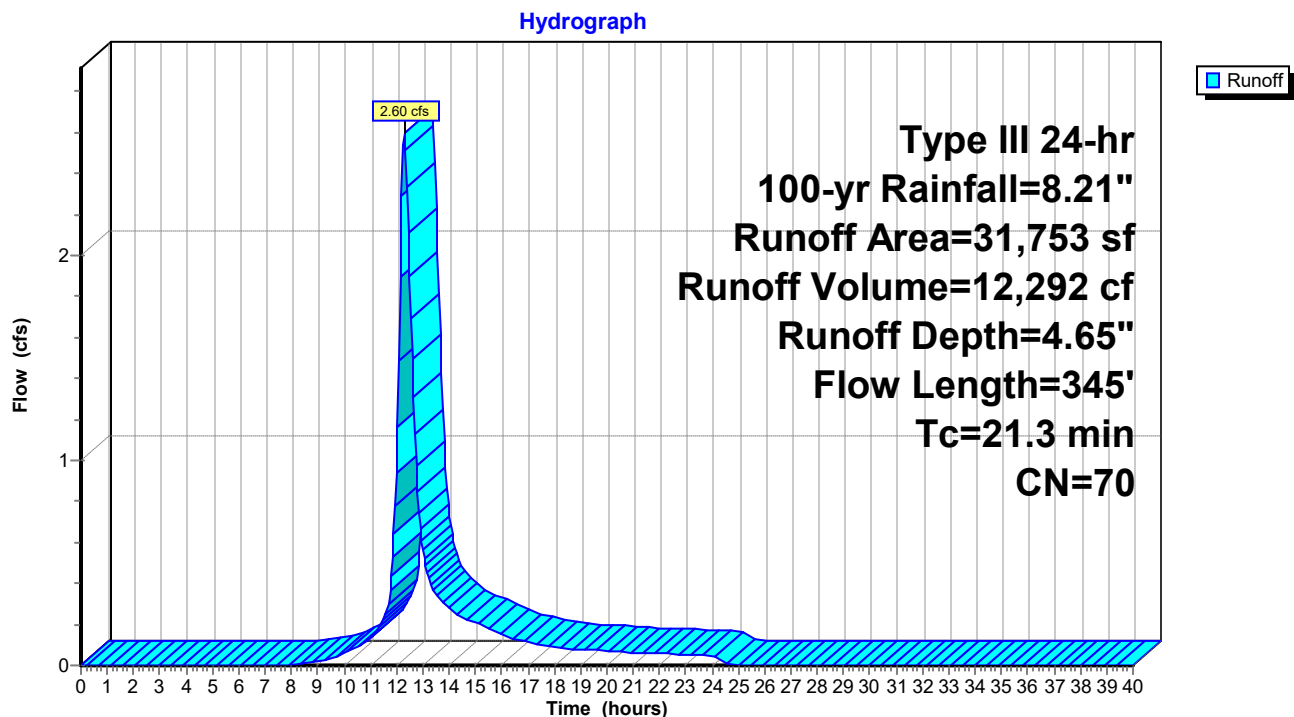
Runoff = 2.60 cfs @ 12.30 hrs, Volume= 12,292 cf, Depth= 4.65"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 100-yr Rainfall=8.21"

Area (sf)	CN	Description
30,003	70	Woods, Good, HSG C
1,750	74	>75% Grass cover, Good, HSG C
31,753	70	Weighted Average
31,753		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.0	100	0.0350	0.10		<b>Sheet Flow,</b> Woods: Light underbrush n= 0.400 P2= 3.28"
4.3	245	0.0360	0.95		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
21.3	345	Total			

**Subcatchment 3S: Remaining Land**

**PROPOSED\_R**

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**Summary for Subcatchment 4S: PR-YARD\_R**

Runoff = 4.39 cfs @ 12.17 hrs, Volume= 16,719 cf, Depth= 5.00"  
 Routed to Link 1L : Flow to the West

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Type III 24-hr 100-yr Rainfall=8.21"

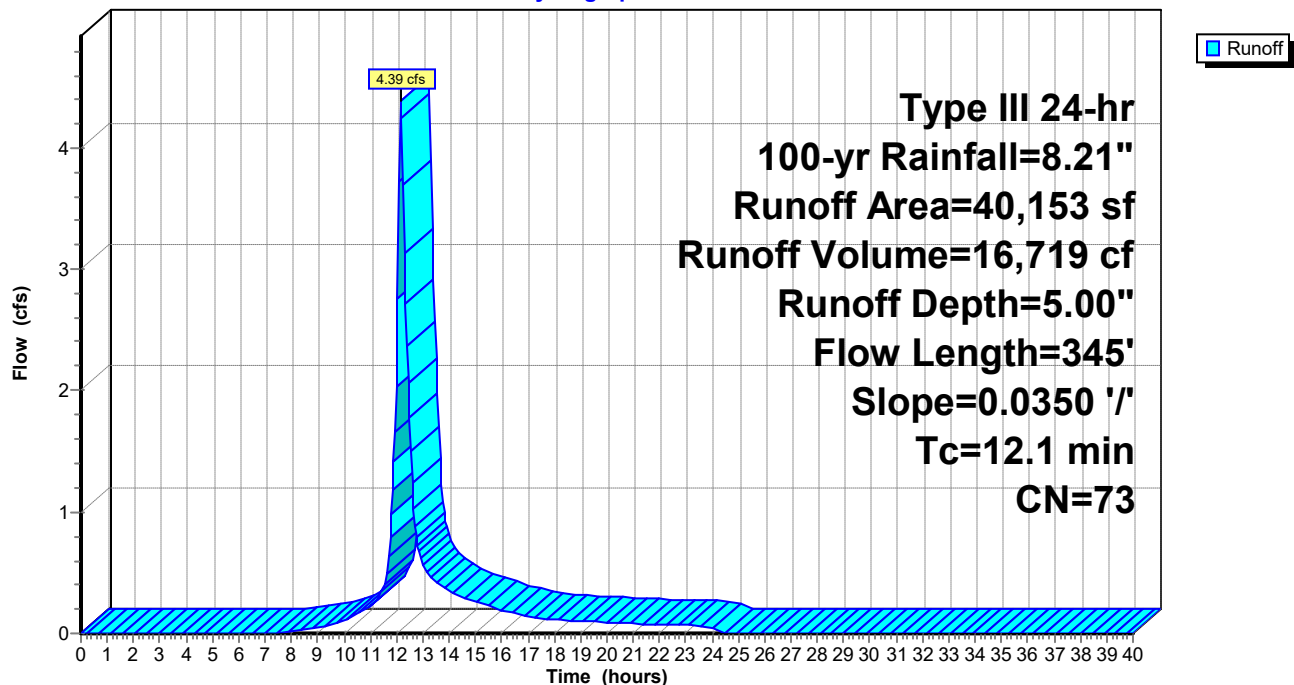
Area (sf)	CN	Description
30,153	74	>75% Grass cover, Good, HSG C
10,000	70	Woods, Good, HSG C
40,153	73	Weighted Average
40,153		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.7	100	0.0350	0.22		<b>Sheet Flow,</b> Grass: Short n= 0.150 P2= 3.28"
4.4	245	0.0350	0.94		<b>Shallow Concentrated Flow,</b> Woodland Kv= 5.0 fps
12.1	345	Total			

**Subcatchment 4S: PR-YARD\_R**

Hydrograph



**PROPOSED\_R**

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**Summary for Pond 1P: Subsurface Drainage Structure**

Inflow Area = 1,391 sf, 100.00% Impervious, Inflow Depth = 7.97" for 100-yr event  
 Inflow = 0.25 cfs @ 12.09 hrs, Volume= 924 cf  
 Outflow = 0.01 cfs @ 8.90 hrs, Volume= 827 cf, Atten= 97%, Lag= 0.0 min  
 Discarded = 0.01 cfs @ 8.90 hrs, Volume= 827 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

Peak Elev= 92.64' @ 16.40 hrs Surf.Area= 274 sf Storage= 545 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)

Center-of-Mass det. time= 588.6 min ( 1,329.5 - 740.9 )

Volume	Invert	Avail.Storage	Storage Description
#1A	89.50'	253 cf	<b>11.17'W x 24.50'L x 3.54'H Field A</b> 969 cf Overall - 335 cf Embedded = 634 cf x 40.0% Voids
#2A	90.00'	335 cf	<b>Cultec R-330XLHD</b> x 6 Inside #1 Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap Row Length Adjustment= +1.50' x 7.45 sf x 2 rows
		589 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	89.50'	<b>1.020 in/hr Exfiltration over Surface area</b>

**Discarded OutFlow** Max=0.01 cfs @ 8.90 hrs HW=89.54' (Free Discharge)↑**1=Exfiltration** (Exfiltration Controls 0.01 cfs)

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Type III 24-hr 100-yr Rainfall=8.21"

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**Pond 1P: Subsurface Drainage Structure - Chamber Wizard Field A**

**Chamber Model = Cultec R-330XLHD (Cultec Recharger® 330XLHD)**

Effective Size= 47.8"W x 30.0"H => 7.45 sf x 7.00'L = 52.2 cf

Overall Size= 52.0"W x 30.5"H x 8.50'L with 1.50' Overlap

Row Length Adjustment= +1.50' x 7.45 sf x 2 rows

52.0" Wide + 6.0" Spacing = 58.0" C-C Row Spacing

3 Chambers/Row x 7.00' Long +1.50' Row Adjustment = 22.50' Row Length +12.0" End Stone x 2 = 24.50' Base Length

2 Rows x 52.0" Wide + 6.0" Spacing x 1 + 12.0" Side Stone x 2 = 11.17' Base Width

6.0" Stone Base + 30.5" Chamber Height + 6.0" Stone Cover = 3.54' Field Height

6 Chambers x 52.2 cf +1.50' Row Adjustment x 7.45 sf x 2 Rows = 335.3 cf Chamber Storage

968.9 cf Field - 335.3 cf Chambers = 633.6 cf Stone x 40.0% Voids = 253.5 cf Stone Storage

Chamber Storage + Stone Storage = 588.8 cf = 0.014 af

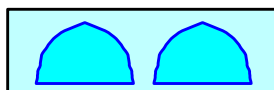
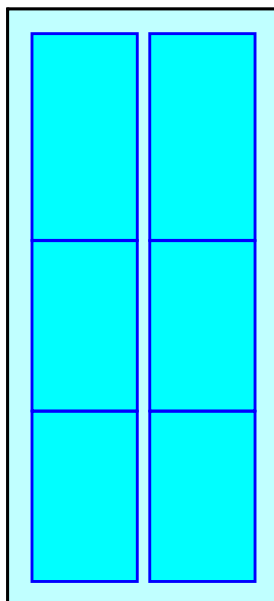
Overall Storage Efficiency = 60.8%

Overall System Size = 24.50' x 11.17' x 3.54'

6 Chambers

35.9 cy Field

23.5 cy Stone



## PROPOSED\_R

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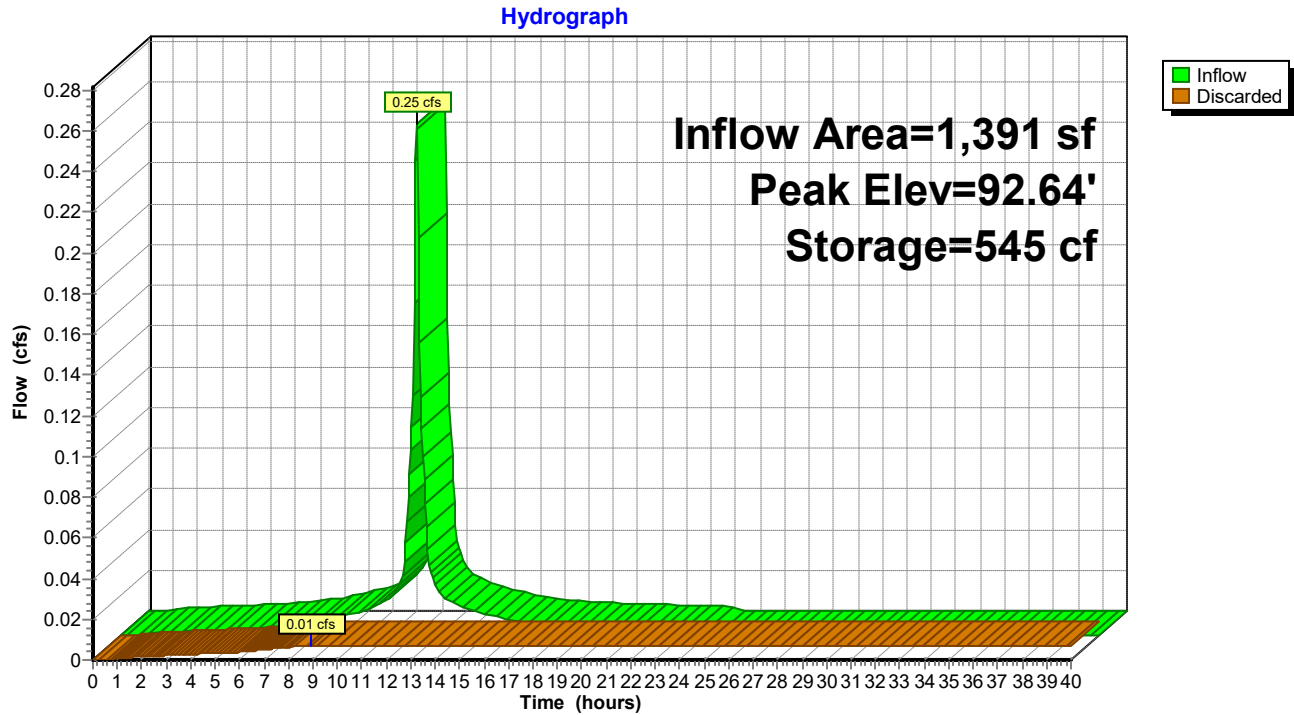
Proposed Condition Watershed Analysis Revised August 4, 2023

Type III 24-hr 100-yr Rainfall=8.21"

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### Pond 1P: Subsurface Drainage Structure



**PROPOSED\_R**

Type III 24-hr 100-yr Rainfall=8.21"

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**Summary for Pond 2P: SWMA**

Inflow Area = 11,800 sf, 48.64% Impervious, Inflow Depth = 6.54" for 100-yr event  
 Inflow = 1.94 cfs @ 12.09 hrs, Volume= 6,426 cf  
 Outflow = 0.09 cfs @ 14.85 hrs, Volume= 5,543 cf, Atten= 96%, Lag= 165.6 min  
 Discarded = 0.05 cfs @ 14.85 hrs, Volume= 5,191 cf  
 Primary = 0.03 cfs @ 14.85 hrs, Volume= 352 cf  
 Routed to Link 1L : Flow to the West

Routing by Dyn-Stor-Ind method, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs  
 Peak Elev= 99.37' @ 14.85 hrs Surf.Area= 2,260 sf Storage= 3,985 cf

Plug-Flow detention time= 637.8 min calculated for 5,543 cf (86% of inflow)  
 Center-of-Mass det. time= 577.5 min ( 1,364.4 - 786.9 )

Volume	Invert	Avail.Storage	Storage Description
#1	97.00'	6,990 cf	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
97.00	1,150	0	0
98.00	1,580	1,365	1,365
99.00	2,060	1,820	3,185
100.00	2,600	2,330	5,515
100.50	3,300	1,475	6,990

Device	Routing	Invert	Outlet Devices
#1	Discarded	97.00'	<b>1.020 in/hr Exfiltration over Surface area</b>
#2	Primary	99.25'	<b>4.0" Round Culvert</b> L= 45.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 99.25' / 98.00' S= 0.0278 '/' Cc= 0.900 n= 0.010, Flow Area= 0.09 sf

**Discarded OutFlow** Max=0.05 cfs @ 14.85 hrs HW=99.37' (Free Discharge)

↑ **1=Exfiltration** (Exfiltration Controls 0.05 cfs)

**Primary OutFlow** Max=0.03 cfs @ 14.85 hrs HW=99.37' TW=0.00' (Dynamic Tailwater)

↑ **2=Culvert** (Inlet Controls 0.03 cfs @ 1.18 fps)

**PROPOSED\_R**

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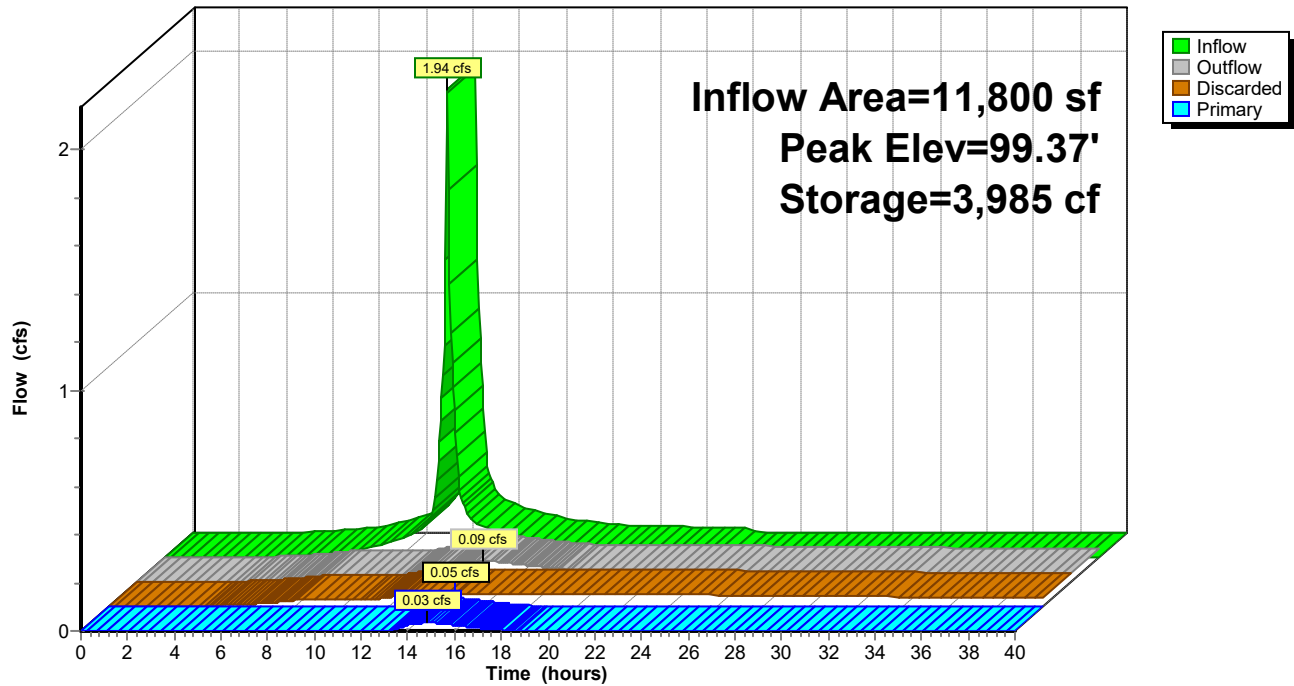
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**Pond 2P: SWMA**

Hydrograph



# PROPOSED\_R

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Type III 24-hr 100-yr Rainfall=8.21"

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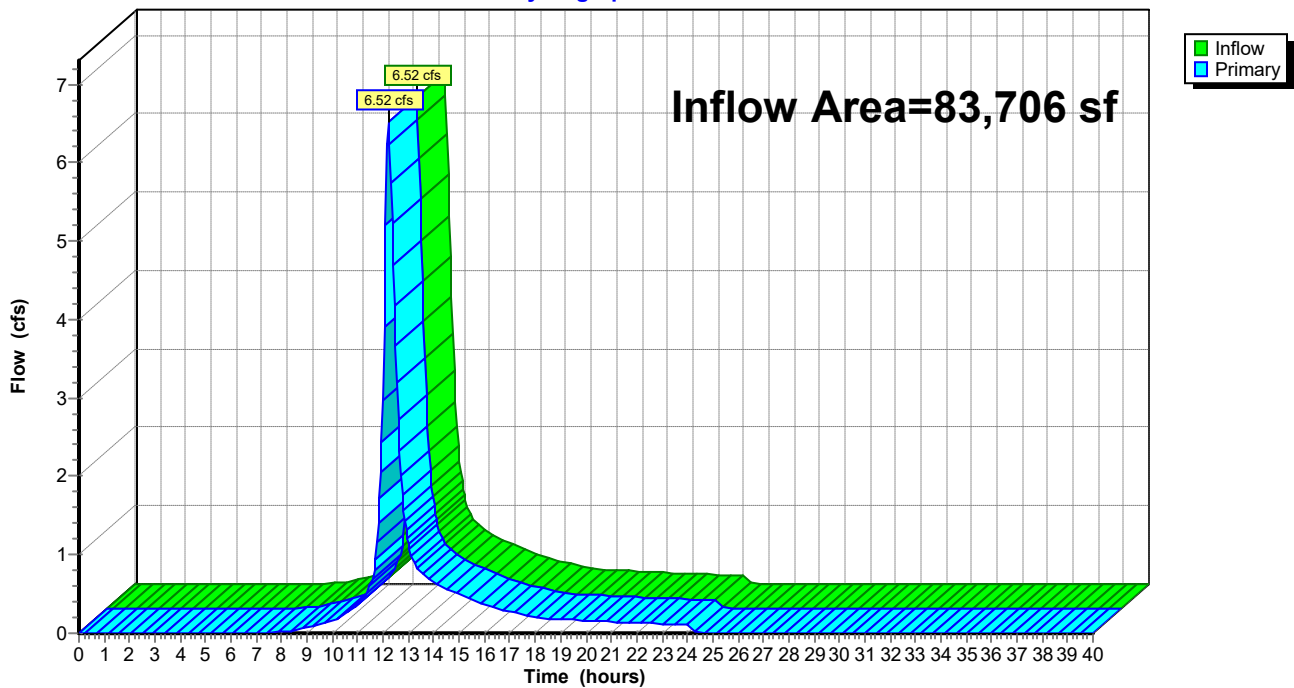
## Summary for Link 1L: Flow to the West

Inflow Area = 83,706 sf, 6.86% Impervious, Inflow Depth = 4.21" for 100-yr event  
 Inflow = 6.52 cfs @ 12.20 hrs, Volume= 29,363 cf  
 Primary = 6.52 cfs @ 12.20 hrs, Volume= 29,363 cf, Atten= 0%, Lag= 0.0 min  
 Routed to nonexistent node 3L

Primary outflow = Inflow, Time Span= 0.00-40.00 hrs, dt= 0.05 hrs

## Link 1L: Flow to the West

Hydrograph





## ***| Long Term Operation & Maintenance Plan – No Change***

This Operation & Maintenance Plan is prepared to comply with provisions set forth in the Massachusetts Department of Environmental Protection (MassDEP) Stormwater Management Standards.

Structural Best Management Practices (BMPs) require periodic maintenance to ensure proper function and efficiency in pollutant removal from stormwater discharges that would otherwise reach wetland resource areas untreated. Maintenance schedules found below are as recommended in MassDEP's Massachusetts Stormwater Handbook and/or as recommended in the manufacturer's specifications.

### ***The following BMP provides groundwater recharge***

#### ***Subsurface Infiltration Chambers – Pond 1P***

Chamber maintenance is not generally required. However, recharge systems are prone to failure due to clogging. Regulating the sediment and petroleum product input into the proposed recharge system is the priority maintenance activity. Sediments and any oil spillage should be trapped and removed before they reach the chambers. Any upstream devices connected to the infiltration system (catch basins, deep sump manholes, proprietary devices) shall be inspected and cleaned at least twice per year to prevent sediments and debris from entering and clogging the recharge system.

Sediments must also be removed whenever the depth of deposits is greater than or equal to 3".

The contractor shall verify that the required washed crushed stone and geotechnical fabric materials are clean and free of sediments and petroleum residue prior to, during and after chamber system installation. Inspections of the chamber system shall be made by after every major storm for the first few months after construction to verify that proper functioning has been achieved. During the initial inspection the water level should be measured and recorded in a permanent log over several days to check the drainage duration and verify that sediments are not accumulating. If ponded water is present after 24 hours or an accumulation of sediment or debris is noted within the chambers the owner or designated property manager and engineer shall determine the cause for this condition and devise an action plan to improve system functionality.

Once the chamber system has been verified to perform as designed, interior chamber conditions shall be inspected at least twice per year. Post construction inspections (to be conducted through inspection ports) shall consist of documenting interior and stone bed conditions, measured water depth and presence of sediment. Should inspection indicate that the system is clogged (ponding water present after 24 hours and/or sediment accumulations) replacement or major repair actions may be required. Should the system require replacement or major repair actions the owner or designated property manager and engineer shall determine the cause for this condition and devise an action plan

The inspection and maintenance of the subsurface infiltration system shall belong to the owner or designated property manager.

### ***Stormwater Management Area-Pond 2P***

Basins are prone to clogging and failure so it is imperative to develop and implement aggressive maintenance plans and schedules. If required, installing the required pretreatment BMPs, e.g. deep-sump catch basins and sediment forebays, will significantly reduce the maintenance requirements for the basin.

Inspections and preventative maintenance shall be performed at least twice a year, and after every time drainage discharges through the high outlet orifice or a major storm event which is defined as a storm that is equal to or greater than the 2-year, 24-hour storm (3.1 inches in a 24-hour storm).

After the basin is on line, inspect it after every major storm for the first few months to ensure that it is stabilized and functioning properly. Take corrective action if necessary.

Note the time that water remains standing in the basin after a storm event. Standing water within the basin 48 to 72 hours after a storm indicates that the infiltration capacity of the basin may have been overestimated or the bottom has been clogged.

If the reason is clogging, determine the cause, e.g. erosion, excessive compaction, or low spots and take the necessary corrective action. Thereafter, inspect the infiltration basin at least twice per year.

Important items to check during the inspections include:

1. Signs of differential settlement,
2. Cracking,
3. Erosion,
4. Leakage in the embankments,
5. Tree growth on the embankments,
6. Condition of riprap,
7. Sediment accumulation and,
8. Health of the turf.

At least twice a year the buffer area, side slopes, and basin bottom shall be mowed. Remove the grass clippings and accumulated organic matter to prevent an impervious organic mat from forming. Remove trash and debris at this time as well as using deep tilling to break up any clogged surfaces, revegetate immediately.

Remove sediment from the basin as necessary only when the floor of the basin is completely dry. Use light equipment to remove the top layer to prevent compacting the underlying soil. Deep till the remaining soil and revegetate as soon as possible.

### ***Inspection and Maintenance Form***

Refer to Sections above for frequency of inspection

Inspector:

Date:

Inspector Title:

Days since last rainfall:

Amount of last rainfall:

### ***Structural Controls: Subsurface Drainage Structure***

Structure Identification	Location	Condition Stone Bed	Settlement over system	Sediment Buildup in Basin
Pond 1P	Rear of house	Poor Fair Good	Yes No	Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>
				Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>
				Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>
				Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>
				Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>
				Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>

Maintenance required

To be performed by:

On or before:



### Inspection and Maintenance Form

Refer to Sections above for frequency of inspection

Inspector:

Date:

Inspector Title:

Days since last rainfall:

Amount of last  
rainfall:

#### Structural Controls: Stormwater Management Area

Structure Identification	Location	Condition of side slope % vegetated	Sediment buildup in basin % accumulation	Rilling or gullyng <input type="checkbox"/>
Pond 2P	Front of house			Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>
				Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>
				Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>
				Minor <input type="checkbox"/> Moderate <input type="checkbox"/> Major <input type="checkbox"/>

Maintenance required

To be performed by:

On or before:





# Hydrologic Soil Group—Essex County, Massachusetts, Northern Part (79 Hill Street Topsfield MA)



Soil Map may not be valid at this scale.

Map Scale: 1:1,670 if printed on A landscape (11" x 8.5") sheet.

0 20 40 80 120 Meters

0 50 100 200 300 Feet

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84



**Natural Resources  
Conservation Service**

Web Soil Survey  
National Cooperative Soil Survey

2/17/2023  
Page 1 of 4

## MAP LEGEND

### Area of Interest (AOI)









 Area of Interest (AOI)

### Soils

#### Soil Rating Polygons





 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Lines

 A  
 A/D  
 B  
 B/D  
 C  
 C/D  
 D  
 Not rated or not available

#### Soil Rating Points

 A  
 A/D  
 B  
 B/D

 C  
 C/D  
 D  
 Not rated or not available

### Water Features

 Streams and Canals

### Transportation

 Rails  
 Interstate Highways  
 US Routes  
 Major Roads  
 Local Roads

### Background

 Aerial Photography

## MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

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

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

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

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

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

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

Soil Survey Area: Essex County, Massachusetts, Northern Part  
 Survey Area Data: Version 18, Sep 9, 2022

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

Date(s) aerial images were photographed: May 22, 2022—Jun 5, 2022

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

## Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	C/D	5.0	44.4%
311B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	C/D	4.4	39.2%
311C	Woodbridge fine sandy loam, 8 to 15 percent slopes, very stony	C/D	1.8	16.4%
<b>Totals for Area of Interest</b>			<b>11.2</b>	<b>100.0%</b>

## Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

## Rating Options

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Higher





## POINT PRECIPITATION FREQUENCY ESTIMATES

Sanja Perica, Sandra Pavlovic, Michael St. Laurent, Carl Trypaluk, Dale Unruh, Orlan Wilhite

NOAA, National Weather Service, Silver Spring, Maryland

[PF\\_tabular](#) | [PF\\_graphical](#) | [Maps & aeriels](#)

### PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches) <sup>1</sup>										
Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.311 (0.241-0.390)	0.374 (0.289-0.469)	0.476 (0.367-0.599)	0.561 (0.430-0.710)	0.677 (0.504-0.895)	0.765 (0.557-1.03)	0.857 (0.608-1.20)	0.961 (0.647-1.38)	1.11 (0.720-1.64)	1.23 (0.781-1.86)
10-min	0.441 (0.342-0.553)	0.530 (0.410-0.665)	0.675 (0.521-0.850)	0.795 (0.610-1.01)	0.960 (0.714-1.27)	1.08 (0.791-1.46)	1.21 (0.861-1.70)	1.36 (0.915-1.95)	1.57 (1.02-2.33)	1.75 (1.11-2.64)
15-min	0.519 (0.402-0.650)	0.623 (0.482-0.782)	0.793 (0.612-0.999)	0.934 (0.717-1.18)	1.13 (0.840-1.49)	1.27 (0.929-1.72)	1.43 (1.01-2.00)	1.60 (1.08-2.29)	1.85 (1.20-2.74)	2.06 (1.30-3.10)
30-min	0.716 (0.554-0.897)	0.858 (0.664-1.08)	1.09 (0.840-1.37)	1.28 (0.983-1.62)	1.55 (1.15-2.05)	1.75 (1.27-2.36)	1.96 (1.39-2.74)	2.19 (1.48-3.14)	2.54 (1.64-3.75)	2.82 (1.78-4.25)
60-min	0.913 (0.707-1.14)	1.09 (0.845-1.37)	1.39 (1.07-1.74)	1.63 (1.25-2.06)	1.97 (1.46-2.60)	2.22 (1.62-3.00)	2.48 (1.76-3.48)	2.79 (1.87-3.98)	3.22 (2.09-4.77)	3.58 (2.27-5.41)
2-hr	1.18 (0.919-1.47)	1.43 (1.11-1.78)	1.84 (1.43-2.30)	2.17 (1.68-2.74)	2.64 (1.99-3.49)	2.99 (2.20-4.03)	3.36 (2.42-4.73)	3.82 (2.57-5.43)	4.50 (2.93-6.62)	5.09 (3.23-7.63)
3-hr	1.36 (1.07-1.69)	1.66 (1.30-2.06)	2.15 (1.68-2.68)	2.56 (1.99-3.20)	3.11 (2.35-4.10)	3.53 (2.61-4.75)	3.98 (2.88-5.59)	4.53 (3.06-6.42)	5.38 (3.50-7.89)	6.12 (3.90-9.15)
6-hr	1.75 (1.39-2.16)	2.14 (1.69-2.64)	2.78 (2.19-3.44)	3.31 (2.60-4.13)	4.05 (3.08-5.30)	4.58 (3.42-6.15)	5.17 (3.77-7.24)	5.91 (4.01-8.32)	7.05 (4.60-10.3)	8.04 (5.13-11.9)
12-hr	2.21 (1.77-2.71)	2.71 (2.16-3.33)	3.53 (2.80-4.34)	4.20 (3.32-5.20)	5.13 (3.93-6.67)	5.82 (4.37-7.74)	6.57 (4.81-9.11)	7.49 (5.11-10.5)	8.91 (5.84-12.9)	10.1 (6.49-14.9)
24-hr	2.65 (2.14-3.23)	3.29 (2.65-4.00)	4.33 (3.47-5.29)	5.19 (4.13-6.37)	6.38 (4.92-8.24)	7.25 (5.49-9.60)	8.21 (6.06-11.4)	9.40 (6.44-13.1)	11.3 (7.42-16.2)	12.9 (8.29-18.9)
2-day	3.02 (2.45-3.65)	3.82 (3.10-4.62)	5.12 (4.14-6.21)	6.20 (4.98-7.57)	7.69 (6.00-9.91)	8.77 (6.71-11.6)	9.98 (7.46-13.8)	11.6 (7.95-16.0)	14.1 (9.29-20.1)	16.3 (10.5-23.7)
3-day	3.32 (2.71-3.99)	4.18 (3.41-5.03)	5.58 (4.53-6.75)	6.74 (5.45-8.20)	8.35 (6.54-10.7)	9.51 (7.31-12.5)	10.8 (8.12-14.9)	12.5 (8.63-17.2)	15.3 (10.1-21.7)	17.7 (11.4-25.7)
4-day	3.60 (2.95-4.32)	4.49 (3.67-5.39)	5.93 (4.84-7.15)	7.13 (5.78-8.64)	8.78 (6.90-11.2)	9.98 (7.70-13.1)	11.3 (8.53-15.6)	13.1 (9.04-18.0)	15.9 (10.6-22.6)	18.5 (11.9-26.7)
7-day	4.38 (3.61-5.22)	5.29 (4.36-6.32)	6.79 (5.57-8.14)	8.03 (6.55-9.68)	9.73 (7.69-12.4)	11.0 (8.50-14.3)	12.4 (9.33-16.9)	14.2 (9.84-19.3)	17.1 (11.4-24.1)	19.7 (12.7-28.3)
10-day	5.07 (4.21-6.03)	6.01 (4.98-7.16)	7.54 (6.22-9.01)	8.81 (7.22-10.6)	10.6 (8.37-13.3)	11.8 (9.19-15.3)	13.3 (10.0-17.9)	15.1 (10.5-20.5)	17.9 (11.9-25.2)	20.5 (13.3-29.3)
20-day	7.03 (5.88-8.30)	8.05 (6.73-9.53)	9.73 (8.10-11.5)	11.1 (9.20-13.3)	13.0 (10.4-16.2)	14.5 (11.2-18.4)	16.0 (12.0-21.1)	17.8 (12.5-23.9)	20.3 (13.6-28.3)	22.5 (14.6-32.0)
30-day	8.64 (7.27-10.2)	9.74 (8.19-11.5)	11.5 (9.66-13.6)	13.0 (10.8-15.5)	15.1 (12.0-18.6)	16.7 (12.9-21.0)	18.3 (13.6-23.7)	20.0 (14.1-26.7)	22.3 (15.0-31.0)	24.2 (15.8-34.3)
45-day	10.7 (9.04-12.5)	11.9 (10.0-13.9)	13.8 (11.6-16.2)	15.4 (12.9-18.2)	17.6 (14.1-21.6)	19.3 (15.0-24.1)	21.0 (15.6-27.0)	22.7 (16.1-30.2)	24.9 (16.8-34.3)	26.5 (17.3-37.3)
60-day	12.4 (10.6-14.5)	13.7 (11.6-16.0)	15.7 (13.3-18.4)	17.4 (14.6-20.5)	19.7 (15.8-24.0)	21.5 (16.8-26.7)	23.3 (17.3-29.7)	24.9 (17.7-33.1)	27.0 (18.3-37.1)	28.5 (18.6-40.0)

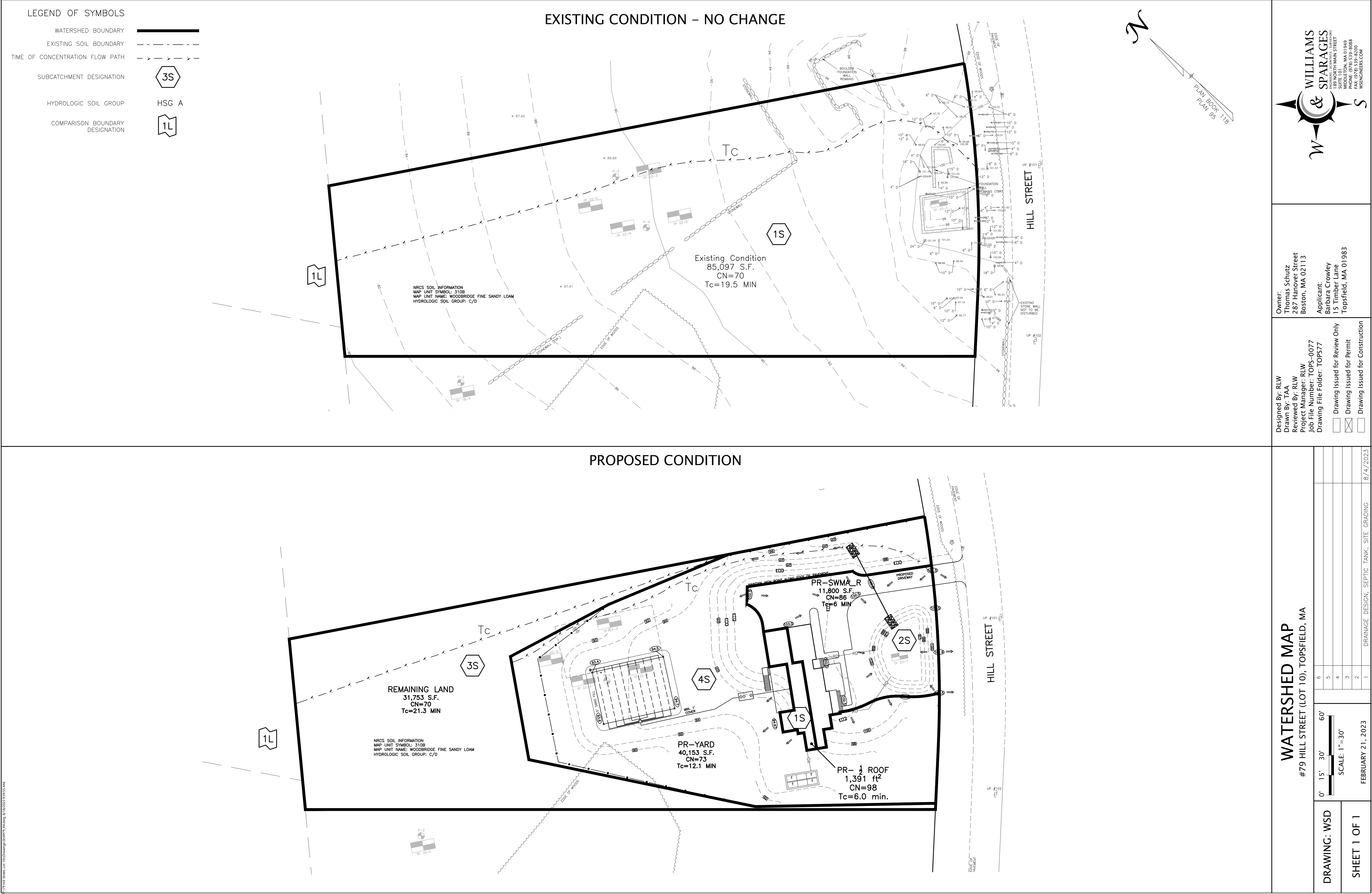
<sup>1</sup> Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at lower and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) will be greater than the upper bound (or less than the lower bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

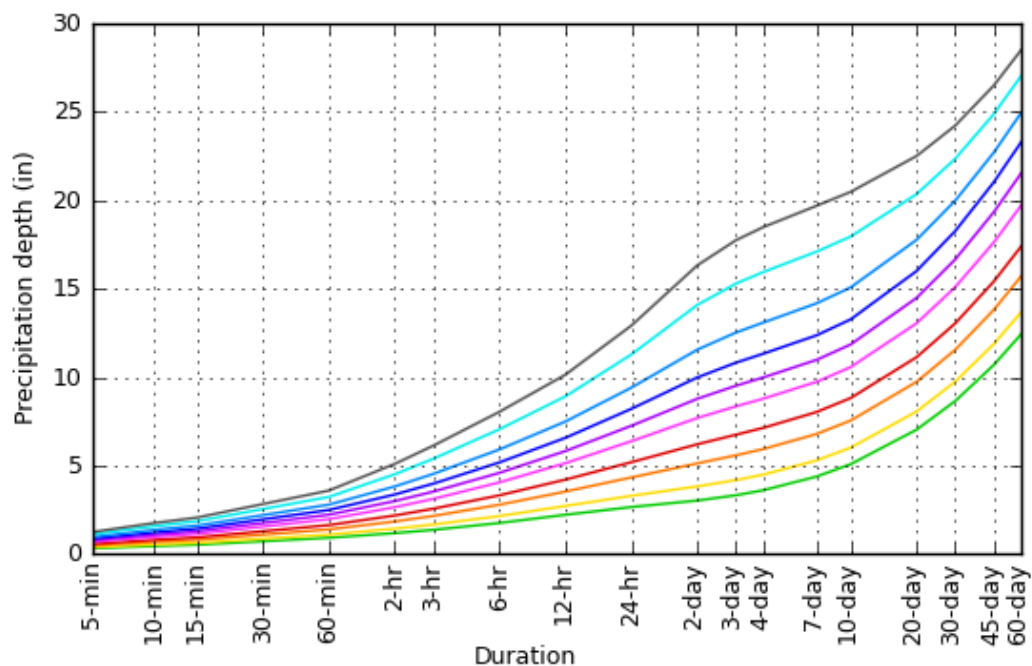
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### PF graphical

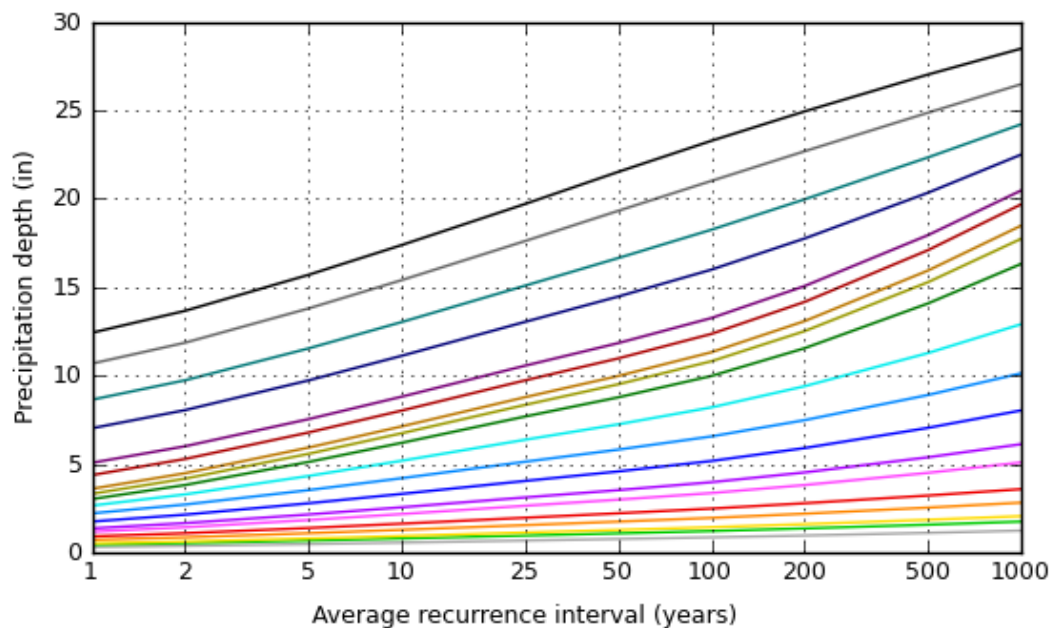


## PDS-based depth-duration-frequency (DDF) curves

Latitude: 42.6184°, Longitude: -70.9633°



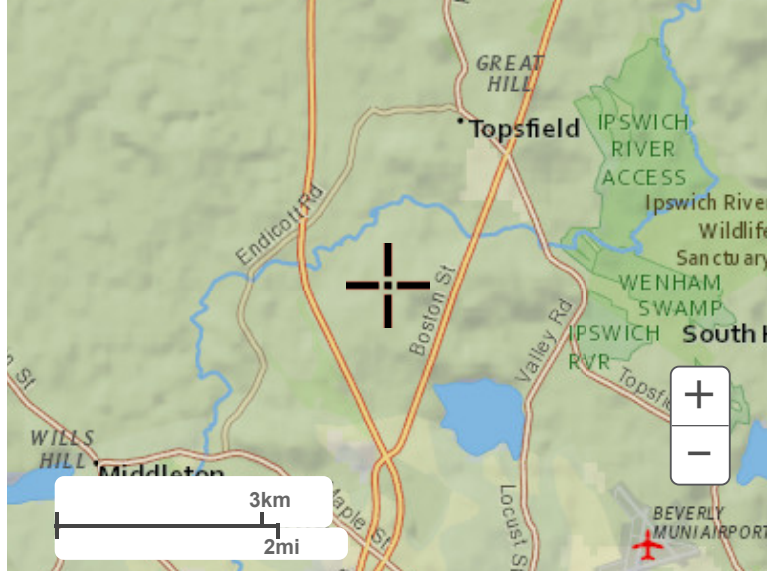
Average recurrence interval (years)
1
2
5
10
25
50
100
200
500
1000



Duration	
5-min	2-day
10-min	3-day
15-min	4-day
30-min	7-day
60-min	10-day
2-hr	20-day
3-hr	30-day
6-hr	45-day
12-hr	60-day
24-hr	

## Maps & aeriels

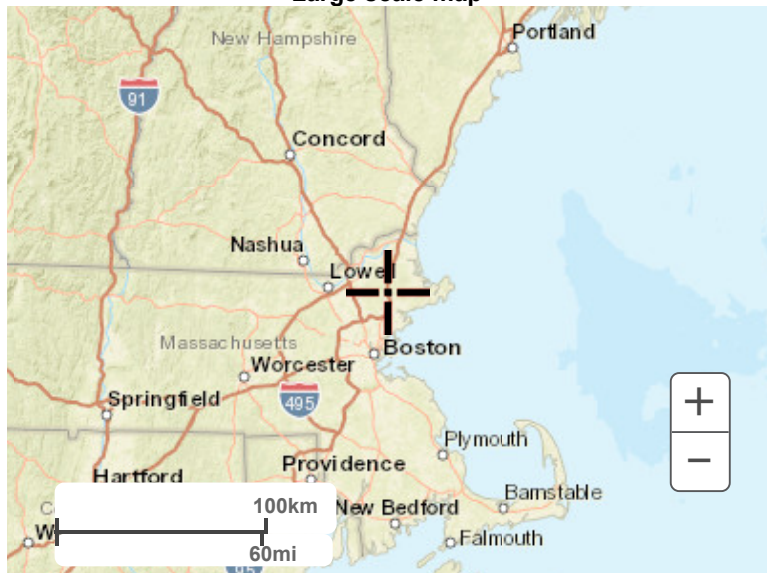
Small scale terrain



Large scale terrain



Large scale map



Large scale aerial





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