APPENDIX B

Subsurface Exploration Logs

HALEY ALDRICH TEST BORING REPORT

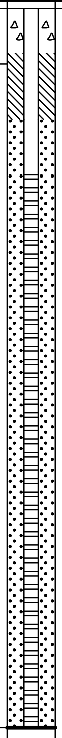
Boring No. HA-1(OW)

Project 580 MAIN STREET, BOLTON, MA
Client WP EAST ACQUISITIONS, LCC
Contractor NORTHERN DRILL SERVICE, INC.

File No. 135678-002
Sheet No. 1 of 1
Start October 6, 2020
Finish October 6, 2020
Driller Z. Miller
H&A Rep. A. Fleming
Elevation 349.0
Datum
Location See Plan

	Casing	Sampler	Barrel
Type	HW	S	--
Inside Diameter (in.)	4.0	1 3/8	--
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures
Rig Make & Model: Mobile Drill B57, Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Drive to 13.0 ft
Hoist/Hammer: Winch / Automatic Hammer
PID Make & Model: NA



Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Well Diagram	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	3 5 15 16	S1 14	0.0 2.0	OL/ OH			Loose dark brown sandy ORGANIC SOIL (OL/OH), mps 0.3 in., no structure, no odor, moist, trace roots -FILL-					30	70				
				SM		348.0 1.0	Medium dense light brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, moist	5	10	10	20	30	25				
	14 24 25 24	S2 11	2.0 4.0	SM			Dense light brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, moist Note: Laboratory grainsize test completed.	9	18	8	14	28	23				
5	15 16 15 13	S3 12	4.0 6.0	SM			Dense light brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, wet	10	10	10	15	35	20				
							-GLACIAL TILL-										
10	18 97 45 19	S4 7	9.0 11.0	SM			Very dense gray brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, wet	10	10	10	20	30	20				
							Note: Potential bedrock encountered at 13.0 ft. Drill action from 13.0 ft to 15.5 ft indicates bedrock.										
						336.0 13.0	TOP OF PROBABLE BEDROCK 13.0 FT- -PROBABLE BEDROCK-										
15						333.5 15.5	BOTTOM OF EXPLORATION 15.5 FT Note: Observation well installed upon completion. See well installation report for details.										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Depth (ft) to: Bottom of Hole	Depth (ft) to: Water
10/7/20	0932	2.0			8.85

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
▯ Riser Pipe
▤ Screen
⁙ Filter Sand
▨ Cuttings
■ Grout
△ Concrete
▧ Bentonite Seal

Summary
Overburden (ft) 15.5
Rock Cored (ft) -
Samples S4

Boring No. HA-1(OW)

Field Tests:
Dilatancy: R - Rapid S - Slow N - None
Toughness: L - Low M - Medium H - High
Plasticity: N - Nonplastic L - Low M - Medium H - High
Dry Strength: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

GROUNDWATER OBSERVATION WELL INSTALLATION REPORT

Well No. HA-1(OW)

Project 580 MAIN STREET
Location BOLTON, MA
Client WP EAST ACQUISITIONS, LCC
Contractor NORTHERN DRILL SERVICE, INC.
Driller Z. Miller

Initial Water Level (depth bgs) ~8.0 ft

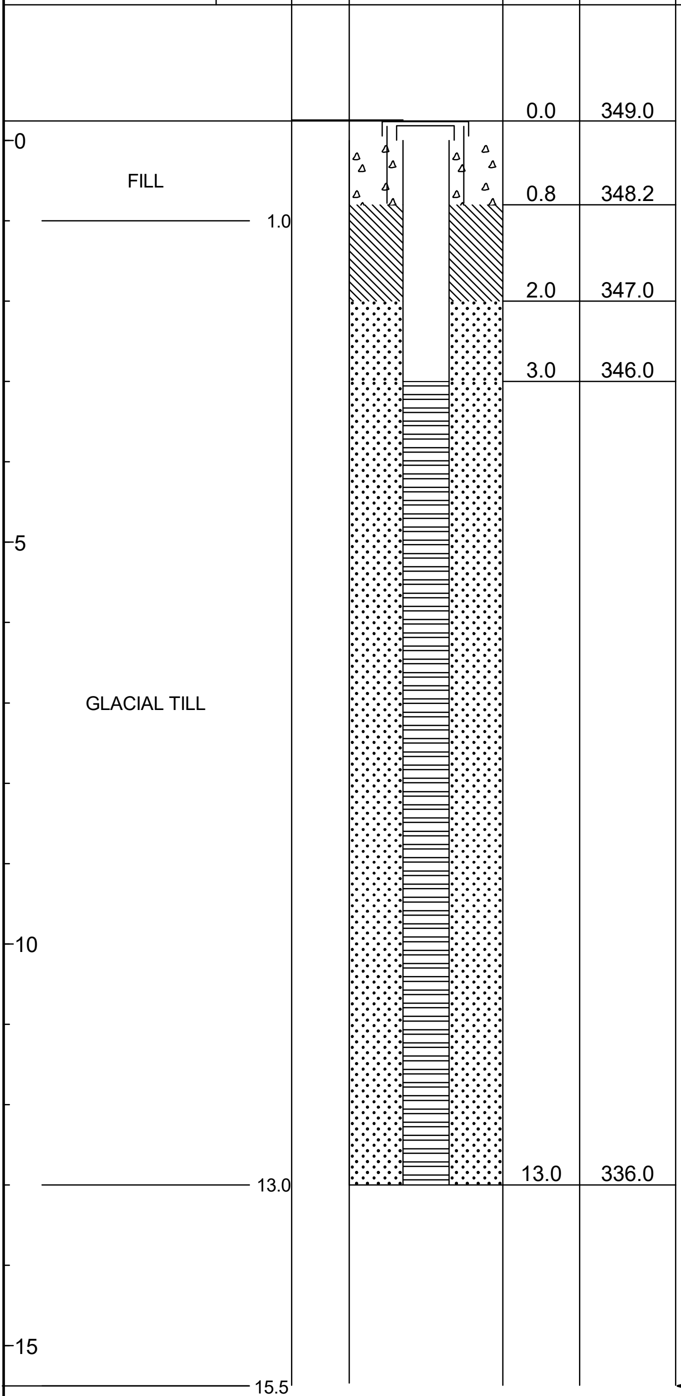
Well Diagram

- ◫ Riser Pipe
- ▤ Screen
- ░ Filter Sand
- ▒ Cuttings
- ■ Grout
- △ Concrete
- ▧ Bentonite Seal

File No. 135678-002
Date Installed 6 Oct 2020
H&A Rep. A. Fleming
Location See Plan

Ground El. 349.0
Datum

SOIL/ROCK CONDITIONS	DEPTH (ft.)	GRAPHIC	WELL DETAILS	DEPTH (ft.)	ELEVATION (ft.)



WELL CONSTRUCTION DETAILS

Type of protective cover Roadway Box

Depth of Roadway Box below ground surface 0.0 ft

Depth of top of riser below ground surface 0.3 ft

Type of protective casing Roadway Box

Length 10.0 ft

Inside diameter 4.0 in.

Depth of bottom of Roadway Box 10.0 ft

Type of riser pipe Schedule 40 PVC

Inside diameter of riser pipe 2.0 in.

Depth of bottom of riser pipe 3.0 ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Concrete	0.0	0.8
Bentonite	0.8	1.2
Filter Sand	2.0	11.0
	-	-

Diameter of borehole 4.0 in.

Depth to top of well screen 3.0 ft

Type of screen Machine slotted Sch 40 PVC

Screen gauge or size of openings 0.010 in.

Diameter of screen 2.0 in.

Type of Backfill around Screen Filter Sand

Depth to bottom of well screen 13.0 ft

Bottom of silt trap 13.0 ft

Depth of bottom of well 13.0 ft

Depth of bottom of borehole 15.5 ft

COMMENTS:

TEST BORING REPORT

Boring No. HA-2

Project	580 MAIN STREET, BOLTON, MA	File No.	135678-002
Client	WP EAST ACQUISITIONS, LCC	Sheet No.	1 of 1
Contractor	NORTHERN DRILL SERVICE, INC.	Start	October 6, 2020
		Finish	October 6, 2020
		Driller	Z. Miller
		H&A Rep.	A. Fleming
		Elevation	349.0
		Datum	
		Location	See Plan

	Casing	Sampler	Barrel
Type	HW	S	--
Inside Diameter (in.)	4.0	1 3/8	--
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B57, Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Drive to 7.4 ft
Hoist/Hammer: Winch / Automatic Hammer
PID Make & Model: NA

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	3 8 25 39	S1 16	0.0 2.0	OL/OH	348.4 0.6	Medium dense dark brown sandy ORGANIC SOIL (OL/OH), mps 0.2 in., no structure, no odor, moist, trace roots -FILL-					30	70				
				SM		Dense light brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, moist	10	10	5	15	40	20				
	53 61 43 42	S2 9	2.0 4.0	SM		Similar to above	10	10	5	15	40	20				
5	12 14 14 11	S3 7	4.0 6.0	SM		Medium dense light brown to brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, wet -GLACIAL TILL-	10	10	10	15	35	20				
					341.6 7.4	TOP OF PROBABLE BEDROCK 7.4 FT- Note: Probable bedrock encountered at 7.4 ft. Drill action from 7.4 to 10.0 ft indicates bedrock. -PROBABLE BEDROCK-										
10					339.0 10.0	BOTTOM OF EXPLORATION 10.0 FT										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Depth (ft) to: Bottom of Hole	Depth (ft) to: Water

Sample ID

O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram

▯	Riser Pipe
▤	Screen
░	Filter Sand
▒	Cuttings
■	Grout
△	Concrete
▨	Bentonite Seal

Summary

Overburden (ft)	10.0
Rock Cored (ft)	-
Samples	S3
Boring No.	**HA-2**

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Plasticity**: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†**Note: Maximum particle size is determined by direct observation within the limitations of sampler size.**

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

TEST BORING REPORT

Boring No. HA-3

Project	580 MAIN STREET, BOLTON, MA	File No.	135678-002
Client	WP EAST ACQUISITIONS, LCC	Sheet No.	1 of 1
Contractor	NORTHERN DRILL SERVICE, INC.	Start	October 7, 2020
		Finish	October 7, 2020
		Driller	Z. Miller
		H&A Rep.	A. Fleming
		Elevation	347.0
		Datum	
		Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HW	S	--	Rig Make & Model: Mobile Drill B57, Truck
Inside Diameter (in.)	4.0	1 3/8	--	Bit Type: Roller Bit Drill Mud: None
Hammer Weight (lb)	300	140	-	Casing: HW Drive to 14.0 ft
Hammer Fall (in.)	24	30	-	Hoist/Hammer: Winch / Automatic Hammer PID Make & Model: NA

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	3 6 11 31	S1 14	0.0 2.0	OL/OH	346.6 0.4	Loose dark brown sandy ORGANIC SOIL (OL/OH), mp 0.2 in., no structure, no odor, moist -FILL-					30	70				
				SM		Medium dense light brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, moist	5	10	5	20	40	20				
	32 100/5"	S2 4	2.0 2.9	SM		Very dense light brown silty SAND with gravel (SM), mps 1.0 in., no structure, no odor, moist Note: Drill action from 2.9 ft to 3.7 ft indicates boulder.	10	10	10	15	35	20				
5	19 24 24 20	S3 8	4.0 6.0	SM		Dense light brown to brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, wet	10	10	10	15	35	20				
10	10 10 11 14	S4 6	9.0 11.0	SM		Medium dense gray silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, wet	10	15	15	25	20	15				
						-GLACIAL TILL-										
15	19 21 14 18	S5 5	14.0 16.0	SM		Dense gray silty SAND with gravel (SM), mps 0.9 in.,n no structure, no odor, wet	10	15	15	25	20	15				
					331.0 16.0	BOTTOM OF EXPLORATION 16.0 FT										

Water Level Data					
Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Depth (ft) to: Bottom of Hole	Depth (ft) to: Water
10/7/2020	0925	0.25	9.0	16.0	3.11

Sample ID
- O - Open End Rod
- T - Thin Wall Tube
- U - Undisturbed Sample
- S - Split Spoon Sample

Well Diagram
- ▯ Riser Pipe
- ▤ Screen
- ⁘ Filter Sand
- ▩ Cuttings
- ■ Grout
- △ Concrete
- ▨ Bentonite Seal

Summary

Overburden (ft) 16.0

Rock Cored (ft) -

Samples S5

Boring No. HA-3

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Plasticity**: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

TEST BORING REPORT

Boring No. HA-4

Project	580 MAIN STREET, BOLTON, MA
Client	WP EAST ACQUISITIONS, LCC
Contractor	NORTHERN DRILL SERVICE, INC.

File No.	135678-002
Sheet No.	1 of 1
Start	October 7, 2020
Finish	October 7, 2020
Driller	Z. Miller
H&A Rep.	A. Fleming
Elevation	350.0
Datum	
Location	See Plan

	Casing	Sampler	Barrel
Type	HW	S	--
Inside Diameter (in.)	4.0	1 3/8	--
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B57, Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Drive to 14.0 ft
Hoist/Hammer: Winch / Automatic Hammer
PID Make & Model: NA

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	2 2 5 6	S1 8	0.0 2.0	OL/OH	349.7 0.3	Very loose dark brown sandy ORGANIC SOIL (OL/OH), mps 0.1 in., no structure, no odor, moist					30	70				
				SM		Loose tan to light brown silty SAND (SM), mps 0.2 in., no structure, no odor, moist				5	65	30				
	3 4 3 5	S2 11	2.0 4.0	SM		Loose tan to light brown silty SAND (SM), mps 0.3 in., no structure, no odor, moist Note: Laboratory grainsize test completed.		11	4	12	47	26				
5	4 4 7 5	S3 5	4.0 6.0	SM		Medium dense brown to light brown silty SAND (SM), mps 0.7 in., no structure, no odor, moist	5	5	5	15	55	15				
						-FILL-										
					343.0 7.0	Note: Casing advancement and drill action indicate significant increase in density at 7.0 ft.										
10	20 18 16 15	S5 9	9.0 11.0	SM		Dense brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, wet	5	10	5	20	40	20				
						-GLACIAL TILL-										
15	17 29 29 39	S5 3	14.0 16.0	SM		Very dense brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, wet	10	10	10	15	35	20				
					334.0 16.0	BOTTOM OF EXPLORATION 16.0 FT										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
10/7/20	1455	0.2	9.0	16.0	7.41

Sample ID

O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram

▥ Riser Pipe
▤ Screen
⠿ Filter Sand
▨ Cuttings
■ Grout
△ Concrete
▧ Bentonite Seal

Summary

Overburden (ft)	16.0
Rock Cored (ft)	-
Samples	S5

Boring No. HA-4

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Toughness**: L - Low M - Medium H - High **Plasticity**: N - Nonplastic L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

TEST BORING REPORT

Boring No. HA-5

Project	580 MAIN STREET, BOLTON, MA	File No.	135678-002
Client	WP EAST ACQUISITIONS, LCC	Sheet No.	1 of 1
Contractor	NORTHERN DRILL SERVICE, INC.	Start	October 7, 2020
		Finish	October 7, 2020
		Driller	Z. Miller
		H&A Rep.	A. Fleming
		Elevation	346.0
		Datum	
		Location	See Plan

	Casing	Sampler	Barrel
Type	HW	S	--
Inside Diameter (in.)	4.0	1 3/8	--
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B57, Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Drive to 14.0 ft
Hoist/Hammer: Winch / Automatic Hammer
PID Make & Model: NA

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0	4 5 10 18	S1 16	0.0 2.0	OL/OH		Loose dark brown sandy ORGANIC SOIL (OL/OH), mps 0.3 in., no structure, no odor, moist		5			25	70				
				SM	345.1 0.9	Medium dense brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, moist	5	10	10	20	35	20				
	20 21 13 11	S2 9	2.0 4.0	SM		Similar to above	5	10	10	20	35	20				
5	17 14 30 27	S3 7	4.0 6.0	SM		Dense light brown to brown silty SAND (SM), mps 0.9 in., no structure, no odor, wet	5	10	10	15	40	20				
10	11 9 20 14	S4 8	9.0 11.0	SM		Medium dense brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, wet	5	10	10	40	20	15				
						-GLACIAL TILL-										
15	25 32 42 19	S5 8	14.0 16.0	SM		Very dense brown to gray brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, wet	10	10	10	30	25	15				
					330.0 16.0	BOTTOM OF EXPLORATION 16.0 FT										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
10/7/20	1230	0.25	9.0	16.0	5.22

Sample ID

O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram

◫ Riser Pipe
▤ Screen
⁙ Filter Sand
▦ Cuttings
■ Grout
△ Concrete
▧ Bentonite Seal

Summary

Overburden (ft)	16.0
Rock Cored (ft)	-
Samples	S5
Boring No.	**HA-5**

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Plasticity**: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST BORING REPORT

Boring No. HA-6

Project	580 MAIN STREET, BOLTON, MA
Client	WP EAST ACQUISITIONS, LCC
Contractor	NORTHERN DRILL SERVICE, INC.

File No.	135678-002
Sheet No.	1 of 1
Start	October 5, 2020
Finish	October 6, 2020
Driller	Z. Miller
H&A Rep.	A. Fleming
Elevation	346.0
Datum	
Location	See Plan

	Casing	Sampler	Barrel
Type	HW	S	--
Inside Diameter (in.)	4.0	1 3/8	--
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B57, Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Drive to 9.0 ft
Hoist/Hammer: Winch / Automatic Hammer
PID Make & Model: NA

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0					345.8 0.2	-BITUMINOUS CONCRETE-										
	5 5 6	S1 13	0.5 2.0	SM		Medium dense brown silty SAND (SM), mps 0.4 in., no structure, no odor, moist -FILL-		5		25	55	15				
	7 11 13 46	S2 7	2.0 4.0	SM		Similar to above		5		25	55	15				
				SM	343.5 2.5	Medium dense brown to light brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, moist Note: From 4.0-4.4 ft drill action indicates cobble.										
5	11 6 10 25	S3 8	4.5 6.5	SM		Medium dense brown to light brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, wet Note: Laboratory grainsize test completed.		29	11	25	19	16				
						-GLACIAL TILL-										
10	23 37 47 44	S4 5	9.0 11.0	SM		Very dense brown light brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, wet	10	10	5	15	40	20				
					335.0 11.0	BOTTOM OF EXPLORATION 11.0 FT										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Depth (ft) to: Bottom of Hole	Depth (ft) to: Water
10/6/20	0710	16.0	9.0	11.0	7.19

Sample ID

O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram

◫	Riser Pipe
▤	Screen
⛆	Filter Sand
▦	Cuttings
■	Grout
△	Concrete
▨	Bentonite Seal

Summary

Overburden (ft)	11.0
Rock Cored (ft)	-
Samples	S4

Boring No. HA-6

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Plasticity**: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

TEST BORING REPORT

Boring No. HA-7(OW)

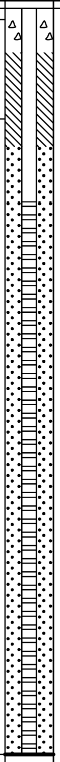
Project	580 MAIN STREET, BOLTON, MA
Client	WP EAST ACQUISITIONS, LCC
Contractor	NORTHERN DRILL SERVICE, INC.

File No.	135678-002
Sheet No.	1 of 1
Start	October 5, 2020
Finish	October 5, 2020
Driller	Z. Miller
H&A Rep.	A. Fleming
Elevation	346.0
Datum	
Location	See Plan

	Casing	Sampler	Barrel
Type	HW	S	--
Inside Diameter (in.)	4.0	1 3/8	--
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B57, Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Drive to 13.5 ft
Hoist/Hammer: Winch / Automatic Hammer
PID Make & Model: NA

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Well Diagram	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0						345.8 0.2	-BITUMINOUS CONCRETE-										
	6 6 10	S1 9	0.5 2.0	SP-SM			Medium dense brown to light brown poorly graded SAND with silt (SP-SM), mps 0.3 in.,no structure, no odor, moist Note: Laboratory grainsize test completed.		3	2	7	39	49				
						344.0 2.0	-FILL-										
	14 16 11 16	S2 11	2.0 4.0	SM			Medium dense brown to gray brown silty SAND with gravel (SM), mps 0.7 in., no structure, no odor, moist	5	10	10	35	25	15				
5	9 7 7 5	S3 12	4.0 6.0	SM			Medium dense brown to gray brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, moist	5	10	10	30	25	20				
10	15 23 13 16	S4 6	9.0 11.0	SM			Dense brown to light brown silty SAND with gravel (SM), mps 0.8 in., no structure, no odor, wet	5	10	10	20	35	20				
							-GLACIAL TILL-										
						332.5 13.5	Note: Advanced roller bit from 13.5-16.0ft. Drill action indicates probable bedrock. TOP OF PROBABLE BEDROCK 13.5 FT-										
15							-PROBABLE BEDROCK-										
						330.0 16.0	BOTTOM OF EXPLORATION 16.0 FT										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Bottom of Hole	Water
10/6/20	0715		OW Reading		5.56
10/7/20	0939		OW READING		5.55

Sample ID

O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram

⊞	Riser Pipe
☰	Screen
⁘	Filter Sand
⁂	Cuttings
■	Grout
△	Concrete
▨	Bentonite Seal

Summary

Overburden (ft)	16.0
Rock Cored (ft)	-
Samples	S4

Boring No. HA-7(OW)

Field Tests:
Dilatancy: R - Rapid S - Slow N - None
Toughness: L - Low M - Medium H - High
Plasticity: N - Nonplastic L - Low M - Medium H - High
Dry Strength: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

GROUNDWATER OBSERVATION WELL INSTALLATION REPORT

Well No. HA-7(OW)

Project 580 MAIN STREET
Location BOLTON, MA
Client WP EAST ACQUISITIONS, LCC
Contractor NORTHERN DRILL SERVICE, INC.
Driller Z. Miller

Initial Water Level (depth bgs) 4.5 ft

File No. 135678-002
Date Installed 5 Oct 2020
H&A Rep. A. Fleming
Location See Plan

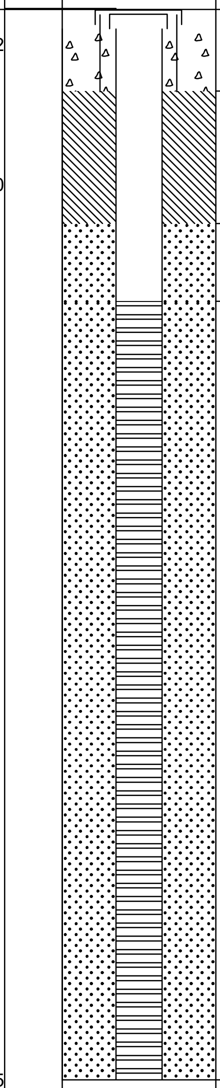
Ground El. 346.0
Datum

Well Diagram

▯	Riser Pipe
☰	Screen
░	Filter Sand
▒	Cuttings
■	Grout
▵	Concrete
▨	Bentonite Seal

SOIL/ROCK

CONDITIONS	DEPTH (ft.)
BITUMINOUS CONCRETE	0.2
FILL	2.0
GLACIAL TILL	13.5
	16.0



DEPTH (ft.)	ELEVATION (ft.)
0.0	346.0
0.8	345.2
2.5	343.5
3.5	342.5
13.5	332.5

WELL CONSTRUCTION DETAILS

Type of protective cover Roadway Box

Depth of Roadway Box below ground surface 0.0 ft

Depth of top of riser below ground surface 0.3 ft

Type of protective casing Roadway Box

Length 10.0 ft

Inside diameter 4.0 in.

Depth of bottom of Roadway Box 10.0 ft

Type of riser pipe Schedule 40 PVC

Inside diameter of riser pipe 2.0 in.

Depth of bottom of riser pipe 3.5 ft

Type of Seals	Top of Seal (ft)	Thickness (ft)
Concrete	0.0	0.8
Bentonite	0.8	1.7
Filter Sand	2.5	11.0
	-	-

Diameter of borehole 4.0 in.

Depth to top of well screen 3.5 ft

Type of screen Machine slotted Sch 40 PVC

Screen gauge or size of openings 0.010 in.

Diameter of screen 2.0 in.

Type of Backfill around Screen Filter Sand

Depth to bottom of well screen 13.5 ft

Bottom of silt trap 13.5 ft

Depth of bottom of well 13.5 ft

Depth of bottom of borehole 16.0 ft

COMMENTS:

HALEY ALDRICH

TEST BORING REPORT

Boring No. HA-8

Project 580 MAIN STREET, BOLTON, MA
Client WP EAST ACQUISITIONS, LCC
Contractor NORTHERN DRILL SERVICE, INC.

File No. 135678-002
Sheet No. 1 of 1
Start October 5, 2020
Finish October 5, 2020
Driller Z. Miller
H&A Rep. A. Fleming
Elevation 347.0
Datum
Location See Plan

	Casing	Sampler	Barrel
Type	HW	S	--
Inside Diameter (in.)	4.0	1 3/8	--
Hammer Weight (lb)	300	140	-
Hammer Fall (in.)	24	30	-

Drilling Equipment and Procedures

Rig Make & Model: Mobile Drill B57, Truck
Bit Type: Roller Bit
Drill Mud: None
Casing: HW Drive to 4.1 ft
Hoist/Hammer: Winch / Automatic Hammer
PID Make & Model: NA

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0					346.8 0.2	-BITUMINOUS CONCRETE-										
	12 14 33	S1 9	0.5 2.0	SM		Medium dense brown silty SAND (SM), mps 0.6 in., no structure, no odor, moist, trace pocket of gray brown poorly graded sand -FILL-		5	10	30	35	20				
	18 16 12 25	S2 10	2.0 4.0	SM	345.0 2.0	Medium dense brown to light brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, moist -GLACIAL TILL-	5	10	10	20	35	20				
5					343.0 4.0	TOP OF PROBABLE BEDROCK 4.0 FT- Note: Drill action indicates bedrock. Advanced drill bit from 4.0-7.0 ft. -PROBABLE BEDROCK-										
					340.0 7.0	BOTTOM OF EXPLORATION 7.0 FT										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Depth (ft) to: Bottom of Hole	Water
					NE

Sample ID
O - Open End Rod
T - Thin Wall Tube
U - Undisturbed Sample
S - Split Spoon Sample

Well Diagram
Riser Pipe
Screen
Filter Sand
Cuttings
■ Grout
Concrete
▨ Bentonite Seal

Summary
Overburden (ft) 7.0
Rock Cored (ft) -
Samples S2

Boring No. HA-8

Field Tests:
Dilatancy: R - Rapid S - Slow N - None
Toughness: L - Low M - Medium H - High
Plasticity: N - Nonplastic L - Low M - Medium H - High
Dry Strength: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

H&A-TEST BORING-09 REV HA-LIB09-BOS - COPY2.GLB HA-TB+CORE+WELL-09 W FENCE.GDT \\HALEYALDRICH.COM\SHARE\CF\PROJECTS\135679\GINT\135679-002-TBOW.GPJ Oct 16, 20

TEST BORING REPORT

Boring No. HA-9

Project	580 MAIN STREET, BOLTON, MA	File No.	135678-002
Client	WP EAST ACQUISITIONS, LCC	Sheet No.	1 of 1
Contractor	NORTHERN DRILL SERVICE, INC.	Start	October 6, 2020
		Finish	October 6, 2020
		Driller	Z. Miller
		H&A Rep.	A. Fleming
		Elevation	351.0
		Datum	
		Location	See Plan

	Casing	Sampler	Barrel	Drilling Equipment and Procedures
Type	HW	S	--	Rig Make & Model: Mobile Drill B57, Truck
Inside Diameter (in.)	4.0	1 3/8	--	Bit Type: Roller Bit Drill Mud: None
Hammer Weight (lb)	300	140	-	Casing: HW Drive to 6.4 ft
Hammer Fall (in.)	24	30	-	Hoist/Hammer: Winch / Automatic Hammer PID Make & Model: NA

Depth (ft)	Sampler Blows per 6 in.	Sample No. & Rec. (in.)	Sample Depth (ft)	USCS Symbol	Stratum Change Elev/Depth (ft)	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Density/consistency, color, GROUP NAME, max. particle size†, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Test Dilatancy	Field Test Toughness	Field Test Plasticity	Field Test Strength
0					350.8 0.2	-BITUMINOUS CONCRETE-										
	7 8 16	S1 7	0.5 2.0	SP		Medium dense brown to light brown poorly graded SAND (SP), mps 0.4 in., no structure, no odor, moist -FILL-		5	5	55	30	5				
	12 12 10 11	S2 10	2.0 4.0	SM	349.0 2.0	Medium dense brown to light brown silty SAND with gravel (SM), mps 0.9 in., no structure, no odor, moist	10	10	10	15	35	20				
5	4 10 16 9	S3 6	4.0 6.0	SM		Medium dense brown to light brown silty SAND with gravel (SM), mps 0.7 in., no structure, no odor, wet -GLACIAL TILL-		15	15	25	20	25				
					344.6 6.4	TOP OF PROBABLE BEDROCK 6.4 FT Note: Probable bedrock encountered at 6.4 ft. Drill action 6.4 to 9.0 ft indicates bedrock. -PROBABLE BEDROCK-										
	50/2"	S4 1	9.0 9.1		341.9 9.1	Note: Attempted spoon at 9.0 ft. Recovery less than 1 in. of bedrock chips. BOTTOM OF EXPLORATION 9.1 FT										

Water Level Data

Date	Time	Elapsed Time (hr.)	Depth (ft) to: Bottom of Casing	Depth (ft) to: Bottom of Hole	Water
					5.0

Sample ID

- O - Open End Rod
- T - Thin Wall Tube
- U - Undisturbed Sample
- S - Split Spoon Sample

Well Diagram

- ▯ Riser Pipe
- ▤ Screen
- ⁘ Filter Sand
- ▨ Cuttings
- ■ Grout
- △ Concrete
- ▧ Bentonite Seal

Summary

Overburden (ft)	9.1
Rock Cored (ft)	-
Samples	S4

Boring No. HA-9

Field Tests: **Dilatancy**: R - Rapid S - Slow N - None **Plasticity**: N - Nonplastic L - Low M - Medium H - High
Toughness: L - Low M - Medium H - High **Dry Strength**: N - None L - Low M - Medium H - High V - Very High

†Note: Maximum particle size is determined by direct observation within the limitations of sampler size.

Note: Soil identification based on visual-manual methods of the USCS as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

Test Pit No. TP20-1

Project 580 MAIN STREET
Location BOLTON, MA
Client WP EAST ACQUISTIONS, LLC
Contractor EARTHWORK INDUSTRIES, INC.
Equipment Used Doosan DX50

File No. 135679-002
H&A Rep S. Shay
Date 11 Dec 2020
Weather Mostly Sunny, 30s-40s

Ground El.: 351.0 (est.)
El. Datum:
Location: See Plan
Groundwater depths/entry rates (in./min.): 6.8

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel		Sand				Field Tests			
					% Coarse	% Fine	% Coarse	% Medium	% Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0		350.0 1.0	OL/ OH	Dark brown sandy ORGANIC SOIL (OL/OH), no oversized, mps 0.5 in., no structure, no odor, moist				20	20	60				
1 2		348.8 2.2	SP-SM	Dark brown poorly graded SAND with silt and gravel (SP-SM), 5% oversized, mps 4.0 in., no structure, no odor, moist -FILL-	5	10	20	20	35	10				
3		347.0 4.0	SP	Brown poorly graded SAND with gravel (SP), 5% oversized, mps 1.0 in., no structure, although moderately bonded, odor, moist	5	10	20	35	30					
4 5 6		344.0 7.0	SP-SM	Gray brown poorly graded SAND with silt and gravel (SP-SM), 10-12% oversized, mps 3.3 in., no structure, no odor, moist, difficult to excavate -GLACIAL TILL-	10	15	15	20	30	10				
7				BOTTOM OF EXPLORATION 7.0 FT										

Obstructions: None

Remarks: Dave Formato, on site engineer reviewed open pit. See also Form 11 table. Standard TP backfill.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth	6.8	ft
measured after	3.0	hours elapsed

Boulders

Diameter (in.)	Number		Approx. Vol. (cu.ft)
12 to 24	3.0	=	4.5
over 24	1	=	12.0

Test Pit Dimensions (ft)

Pit Length x Width (ft) 10.0x3.0
Pit Depth (ft) 7.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

Test Pit No. TP20-2

Project 580 MAIN STREET
Location BOLTON, MA
Client WP EAST ACQUISTIONS, LLC
Contractor EARTHWORK INDUSTRIES, INC.
Equipment Used Doosan DX50

File No. 135679-002
H&A Rep S. Shay
Date 11 Dec 2020
Weather Mostly Sunny, 30s-40s

Ground El.: 351.0 (est.)
El. Datum:
Location: See Plan
Groundwater depths/entry rates (in./min.): 7.2

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel		Sand				Field Tests			
					% Coarse	% Fine	% Coarse	% Medium	% Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0			OL/ OH	Dark brown sandy ORGANIC SOIL (OL/OH), no oversized, mps 0.5 in., no structure, no odor, moist				15	20	65				
2		350.0 1.0	SM	Olive brown to brown silty SAND with gravel (SM), 10-12% oversie, mps 1.0 in., no structure, no odor, moist appears to be disturbed -FILL-	10	10	10	15	30	25				
4 6		348.0 3.0	SP-SM	Brown poorly graded SAND with silt and gravel (SP-SM), 30% oversized, mps 3.5 in. (2 large boulders), no structure, moderately difficult to excavate, no odor, moist -GLACIAL TILL DEPOSITS-	10	20	15	30	15	10				
		343.5 7.5		BOTTOM OF EXPLORATION 7.5 FT										

Obstructions: None

Remarks: Dave Formato, on site engineer reviewed open pit. See also Form 11 table. Standard TP backfill.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth	7.2	ft
measured after	3.0	hours elapsed

Boulders

Diameter (in.)	Number		Approx. Vol. (cu.ft)
12 to 24	2.0	=	2.0
over 24	2	=	21

Test Pit Dimensions (ft)

Pit Length x Width (ft) 7.0x5.0
Pit Depth (ft) 7.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

TEST PIT LOG

Test Pit No. TP20-3

Project	580 MAIN STREET	**File No.**	135679-002
Location	BOLTON, MA	**H&A Rep**	S. Shay
Client	WP EAST ACQUISTIONS, LLC	**Date**	11 Dec 2020
Contractor	EARTHWORK INDUSTRIES, INC.		
Equipment Used	Doosan DX50	**Weather**	Mostly Sunny, 30s-40s

Ground El.: 351.0 (est.)
El. Datum:
Location: See Plan
Groundwater depths/entry rates (in./min.): Dry

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0			OL/ OH	Dark brown sandy ORGANIC SOIL(OL/OH), no oversized, mps 1.0 in., no structure, no odor, moist				20	20	60				
		350.0 1.0		Gray brown silty SAND with gravel (SM), 5-10% oversized, mps 6.0 in., no structure within layers, no odor, moist										
2			SM	Several distinct layers noted within FILL layer. Color of layers of varied from gray brown, dark brown, to olive. Material composition was consistent.	10	10	15	20	20	25				
			SM											
4				-FILL-										
		346.0 5.0		Note: Discontinuous tan medium stand at 5.0 ft thin layer. 5.0-5.4 ft brown/orange brown mottled										
6			SP-SM	Brown poorly graded SAND with silt and gravel (SP-SM), 30% oversized, mostly as well rounded cobbles, 3-4 in. dense, mps 5.0 in., weakly stratified, no odor, moist	10	15	15	35	15	10				
				-GLACIAL TILL DEPOSITS-										
8														
		342.0 9.0		BOTTOM OF EXPLORATION 9.0 FT										

Obstructions: None

Remarks: Dave Formato, on site engineer reviewed open pit. See also Form 11 table. Standard TP backfill.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth	Dry	ft
measured after	1.0	hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24	-	= -
over 24	-	= -

Test Pit Dimensions (ft)

Pit Length x Width (ft) 10.0x3.0
Pit Depth (ft) 9.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

Test Pit No. **TP20-4**

Project	**580 MAIN STREET**	**File No.**	135679-002
Location	BOLTON, MA	**H&A Rep**	S. Shay
Client	WP EAST ACQUISTIONS, LLC	**Date**	11 Dec 2020
Contractor	EARTHWORK INDUSTRIES, INC.		
Equipment Used	Doosan DX50	**Weather**	Mostly Sunny, 30s-40s

Ground El.: 352.0 (est.)
El. Datum:
Location: See Plan
Groundwater depths/entry rates (in./min.): Dry

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel		Sand				Field Tests			
					% Coarse	% Fine	% Coarse	% Medium	% Fine	% Fines	Dilatancy	Toughness	Plasticity	Strength
0 2			SM	Dark brown silty SAND (SM), no oversized, mps 0.5 in., no oversized, mps 0.5 in., no structure, no odor, moist, 15% roots with organic debris -FILL-		10	10	15	25	40				
4		349.4 2.6	GP	Brown poorly graded GRAVEL with sand (SP), 30% oversized as rounded cobbles, mps 8.0 in., no structure, no odor, moist	15	40	20	10	10	5				
		346.5 5.5	SP	Brown poorly graded SAND (SP), no oversized, mps 0.1 in., stratified, no odor, moist, faint brown mottling -GLACIOFLUVIAL DEPOSITS-				20	75	5				
6 8		346.0 6.0	SP-SM	Brown poorly graded SAND with silt and gravel (SP-SM), 20% oversized -GLACIAL TILL DEPOSITS-	10	15	15	15	35	10				
		343.5 8.5		BOTTOM OF EXPLORATION 8.5 FT										

Obstructions: None

Remarks: Dave Formato, on site engineer reviewed open pit. See also Form 11 table. Standard TP backfill.

Field Tests

Dilatancy	R - Rapid S - Slow N - None
Toughness	L - Low M - Medium H - High
Plasticity	N - Nonplastic L - Low M - Medium H - High
Dry Strength	N - None L - Low M - Medium H - High V - Very High

Standing Water in Completed Pit

at depth	Dry	ft
measured after	0.75	hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24	-	= -
over 24	-	= -

Test Pit Dimensions (ft)

Pit Length x Width (ft) 10.0x3.0
Pit Depth (ft) 8.5

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

HALEY ALDRICH

TEST PIT LOG

Test Pit No. TP20-5

Project 580 MAIN STREET
Location BOLTON, MA
Client WP EAST ACQUISTIONS, LLC
Contractor EARTHWORK INDUSTRIES, INC.
Equipment Used Doosan DX50

File No. 135679-002
H&A Rep S. Shay
Date 11 Dec 2020
Weather Mostly Sunny, 30s-40s

Ground El.: 352.0 (est.)
El. Datum:
Location: See Plan
Groundwater depths/entry rates (in./min.): Dry

Depth (ft)	Sample ID	Stratum Change Elev./ Depth (ft)	USCS Symbol	VISUAL-MANUAL IDENTIFICATION AND DESCRIPTION (Color GROUP NAME & SYMBOL, % oversized, maximum particle size, structure, odor, moisture, optional descriptions GEOLOGIC INTERPRETATION)	Gravel % Coarse	Gravel % Fine	Sand % Coarse	Sand % Medium	Sand % Fine	% Fines	Field Tests Dilatancy	Field Tests Toughness	Field Tests Plasticity	Field Tests Strength
0				Dark brown sandy ORGANIC SOIL (OL/OH)				5	30	65				
			OL/ OH											
1		351.0 1.0		-FILL-										
2			SM	Dark brown silty SAND with gravel (SM), 3% oversized, mps 3.5 in., no structure, no odor, moist	10	10	15	20	20	25				
3				Note: Red electric warning tape electric warning tape for existing buried electric utility. Concrete exposed in hand digginat 4.0 ft.										
4		348.0 4.0		BOTTOM OF EXPLORATION 4.0 FT Note: Concrete exposed in hang digging.										

Obstructions: Buried electric concrete encased conduit.

Remarks: Dave Formato, on site engineer reviewed open pit. Form 11 table not required. Standard TP backfill.

Field Tests

Dilatancy	R - Rapid	S - Slow	N - None		
Toughness	L - Low	M - Medium	H - High		
Plasticity	N - Nonplastic	L - Low	M - Medium	H - High	
Dry Strength	N - None	L - Low	M - Medium	H - High	V - Very High

Standing Water in Completed Pit

at depth	Dry	ft
measured after	-	hours elapsed

Boulders

Diameter (in.)	Number	Approx. Vol. (cu.ft)
12 to 24	-	= -
over 24	-	= -

Test Pit Dimensions (ft)

Pit Length x Width (ft) 8.0x3.0
Pit Depth (ft) 4.0

NOTE: Soil identification based on visual-manual methods of the USCS system as practiced by Haley & Aldrich, Inc.

580 Main St., Bolton, MA
135679-002
12/11/20

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-1

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0 1.0	Fill	2.5Y 3/2		Not present		SILT LOAM	0	0	Structureless	Loose	
1.0 2.2	Fill	10YR 3/3				SANDY LOAM	20	5	"	Friable	
2.2 4.0	Fill	10YR 4/6				LOAMY SAND	40	10	Massive	Friable	Variegated colors
4.0 7.0	C	10YR 4/3	5.6	5YR 4/4	10-15	SANDY LOAM	35	10	Massive	Very friable	weak mottling discontinuous

Additional Notes:

ESHGW at 5.6'

Standing water in pit at 6.8' after 3 hr.

A. Shay

580 Main St, Bolton, MA
135679-002
12/11/20

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-2

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0 1.0	Fill	2.5Y 2.5/1		not present		SILT LOAM	2	0	structure-less	Loose	
1.0 3.0	Fill	10YR 5/2				SILT LOAM	20	20	structure-less	Friable	
3.0 7.5	C	7.5YR 3/2	5.5	2.5YR 3/2	8-10	SANDY LOAM	25	30	Massive	Friable	Discontinuous mottles, few

Additional Notes:

3 large boulders 3-7.0'

ESHW at 5.5', standing water in pit at 7.2 after 30 hrs.

Commonwealth of Massachusetts
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Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-3

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0 1.0	Fill	10YR 2/1		Not present		SILT LOAM	0	0	structureless	Friable	
1.0 1.8		10YR 5/2					5	5			
1.8 2.8		10YR 3/2					2-4	5			
2.8 4.0		2.5Y 4/3					5-8	2			
4.0 5.0		10YR 3/2					5	2			
5.0 9.0	C	10YR 3/3	5.0 5.4	5YR 4/3	30	Loamy SAND	35	25	Massive	Friable	

Additional Notes:

ESHW @ 5.0'.

580 Main St., Bolton, MA
135679-002
12/11/20

Commonwealth of Massachusetts
City/Town of

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review (continued)

Deep Observation Hole Number: TP-4

Depth (in.)	Soil Horizon/ Layer	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Soil Texture (USDA)	Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
			Depth	Color	Percent		Gravel	Cobbles & Stones			
0 2.6	Fill	10 YR 2/2		not present		SILT LOAM	10	10	Structureless	Friable	
2.6 5.5'	Fill	10 YR 4/2				SILT LOAM	60	25	"	Friable	
5.5' 6.0	C1	2.5Y 5/1	5.7	5 YR 5/2	8-10	SAND	0	0	Single-grain	very friable	Thin mottling
6.0 8.5'	C2	10 YR 4/3		not apparent		Loamy SAND	20	10	massive	Friable	

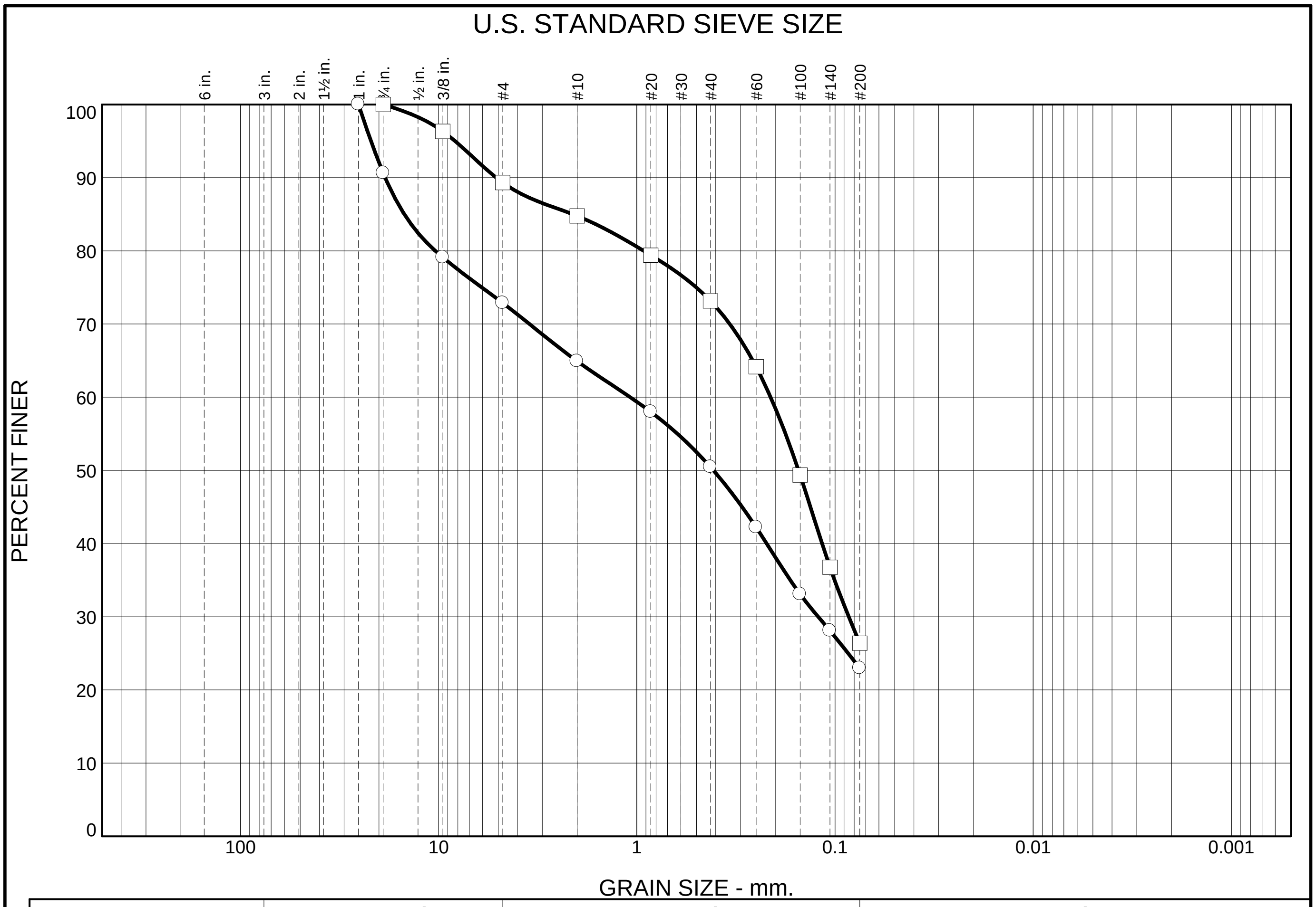
Additional Notes:

ESHW AT 5.7'

S. Shay

APPENDIX C

Laboratory Testing Results



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	9.4	17.7	8.0	14.4	27.5	23.0	
☐	0.0	0.0	10.7	4.5	11.7	46.7	26.4	

	Expl. No.	Sample No.	Depth (ft)	Atterberg Limits %			Water Content (%)	C_u	C_c	USCS
				w_L	w_P	I_P				
○	HA-1	S02	2.0-4.0				5.9			SM
☐	HA-4	S02	2.0-4.0				4.1			SM

Sample Description

○ Yellow brown silty sand with gravel

☐ Olive brown silty sand

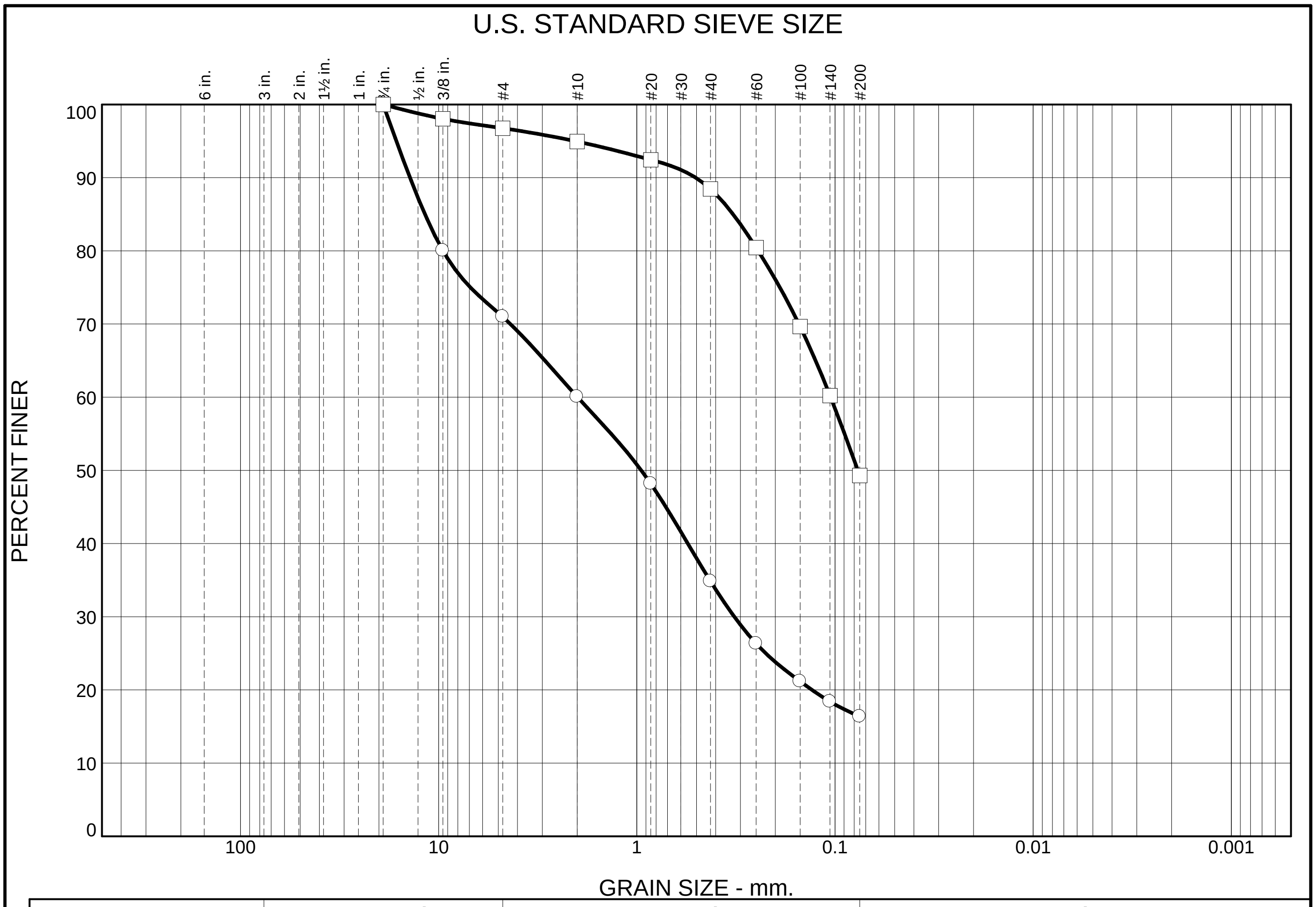
Remarks:

580 Main Street - Geotechnical Due Diligence
Medford, Massachusetts

GRAIN SIZE DISTRIBUTION

DATE: 10/15/2020

FILE NO: 135679-002



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	29.0	10.9	25.2	18.5	16.4	
☐	0.0	0.0	3.2	1.9	6.4	39.2	49.3	

	Expl. No.	Sample No.	Depth (ft)	Atterberg Limits %			Water Content (%)	C_u	C_c	USCS
				w_L	w_P	I_P				
○	HA-6	S03	4.5-6.5				10.1			SM
☐	HA-7	S01	0.5-2.0				16.7			SM

	Sample Description
○	Olive brown silty sand with gravel
☐	Yellow brown silty sand

Remarks:

HALEY ALDRICH

580 Main Street - Geotechnical Due Diligence
Medford, Massachusetts

GRAIN SIZE DISTRIBUTION

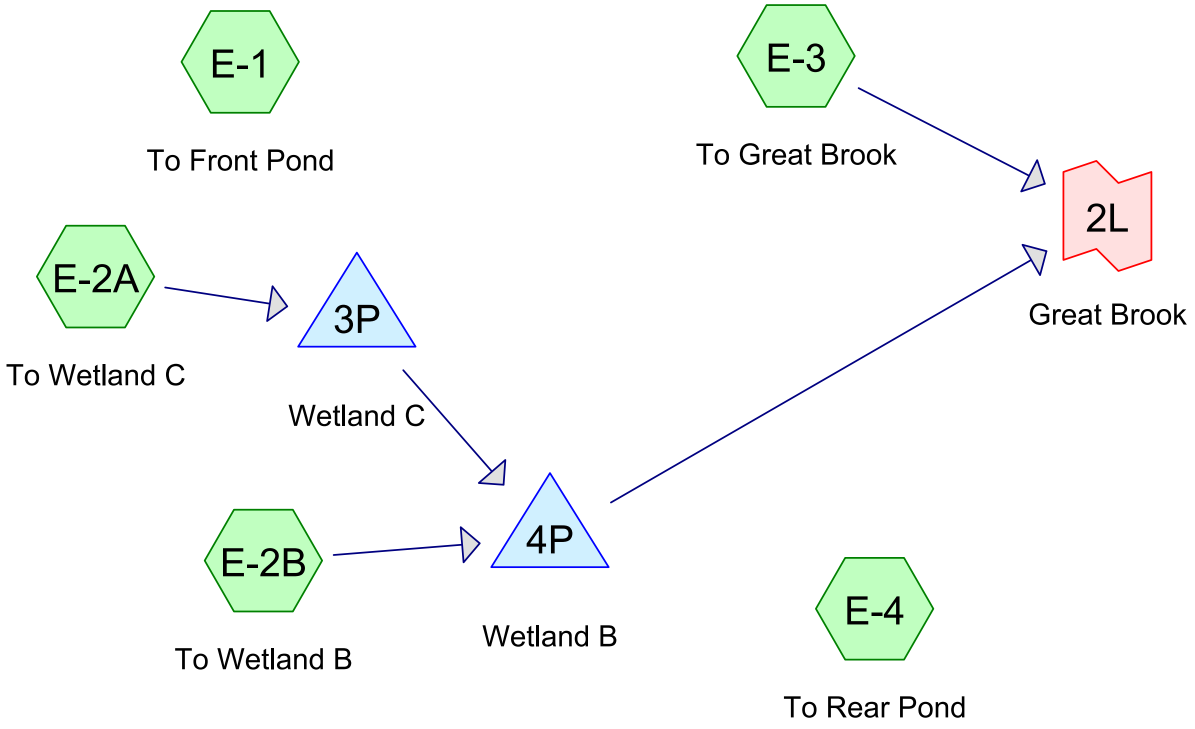
DATE: 10/15/2020

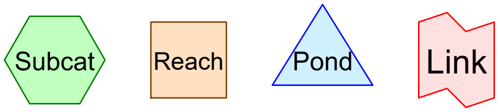
FILE NO: 135679-002

APPENDIX G

HYDROCAD

PRE-DEVELOPMENT





Routing Diagram for 1670-15 Existing HydroCAD
Prepared by Allen & Major Associates, Inc., Printed 9/10/2021
HydroCAD® 10.10-6a s/n 02946 © 2020 HydroCAD Software Solutions LLC

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	Type III 24-hr		Default	24.00	1	3.27	2
2	10-Year	Type III 24-hr		Default	24.00	1	5.02	2
3	25-Year	Type III 24-hr		Default	24.00	1	6.11	2
4	100-Year	Type III 24-hr		Default	24.00	1	7.79	2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
570,054	61	>75% Grass cover, Good, HSG B (E-1, E-2A, E-2B, E-3, E-4)
3,171	80	>75% Grass cover, Good, HSG D Wetlands (E-2B)
9,139	96	Gravel surface, HSG B (E-3)
83,392	98	Paved parking, HSG B (E-1)
48,239	98	Roofs, HSG B (E-1, E-3)
143,079	98	Unconnected pavement, HSG B (E-2A, E-2B, E-3, E-4)
103,504	98	Water Surface, HSG B (E-1, E-4)
156,682	55	Woods, Good, HSG B (E-1, E-2A, E-2B, E-3, E-4)
4,081	77	Woods, Good, HSG D Wetlands (E-2A)
1,121,341	**73**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
1,114,089	HSG B	E-1, E-2A, E-2B, E-3, E-4
0	HSG C	
7,252	HSG D	E-2A, E-2B
0	Other	
1,121,341		**TOTAL AREA**

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	Sub Num
0	570,054	0	3,171	0	573,225	>75% Grass cover, Good	
0	9,139	0	0	0	9,139	Gravel surface	
0	83,392	0	0	0	83,392	Paved parking	
0	48,239	0	0	0	48,239	Roofs	
0	143,079	0	0	0	143,079	Unconnected pavement	
0	103,504	0	0	0	103,504	Water Surface	
0	156,682	0	4,081	0	160,763	Woods, Good	
0	**1,114,089**	**0**	**7,252**	**0**	**1,121,341**	**TOTAL AREA**	

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	E-1	0.00	0.00	184.0	0.0155	0.013	0.0	12.0	0.0
2	4P	344.59	342.78	107.0	0.0169	0.013	0.0	18.0	0.0

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E-1: To Front Pond Runoff Area=345,377 sf 53.30% Impervious Runoff Depth>1.45"
Flow Length=405' Tc=10.4 min CN=80 Runoff=11.54 cfs 41,807 cf

Subcatchment E-2A: To Wetland C Runoff Area=63,246 sf 6.89% Impervious Runoff Depth>0.51"
Flow Length=314' Tc=7.8 min UI Adjusted CN=62 Runoff=0.56 cfs 2,687 cf

Subcatchment E-2B: To Wetland B Runoff Area=62,941 sf 6.46% Impervious Runoff Depth>0.51"
Flow Length=203' Tc=5.7 min UI Adjusted CN=62 Runoff=0.61 cfs 2,676 cf

Subcatchment E-3: To Great Brook Runoff Area=423,611 sf 1.82% Impervious Runoff Depth>0.47"
Flow Length=353' Tc=8.6 min CN=61 Runoff=3.16 cfs 16,641 cf

Subcatchment E-4: To Rear Pond Runoff Area=226,166 sf 78.70% Impervious Runoff Depth>2.14"
Flow Length=219' Tc=7.2 min CN=89 Runoff=12.44 cfs 40,386 cf

Pond 3P: Wetland C Peak Elev=344.67' Storage=2,687 cf Inflow=0.56 cfs 2,687 cf
Outflow=0.00 cfs 0 cf

Pond 4P: Wetland B Peak Elev=344.75' Storage=823 cf Inflow=0.61 cfs 2,676 cf
18.0" Round Culvert n=0.013 L=107.0' S=0.0169 '/' Outflow=0.11 cfs 2,086 cf

Link 2L: Great Brook Inflow=3.16 cfs 18,728 cf
Primary=3.16 cfs 18,728 cf

Total Runoff Area = 1,121,341 sf Runoff Volume = 104,198 cf Average Runoff Depth = 1.12"
66.27% Pervious = 743,127 sf 33.73% Impervious = 378,214 sf

Summary for Subcatchment E-1: To Front Pond

[47] Hint: Peak is 260% of capacity of segment #4

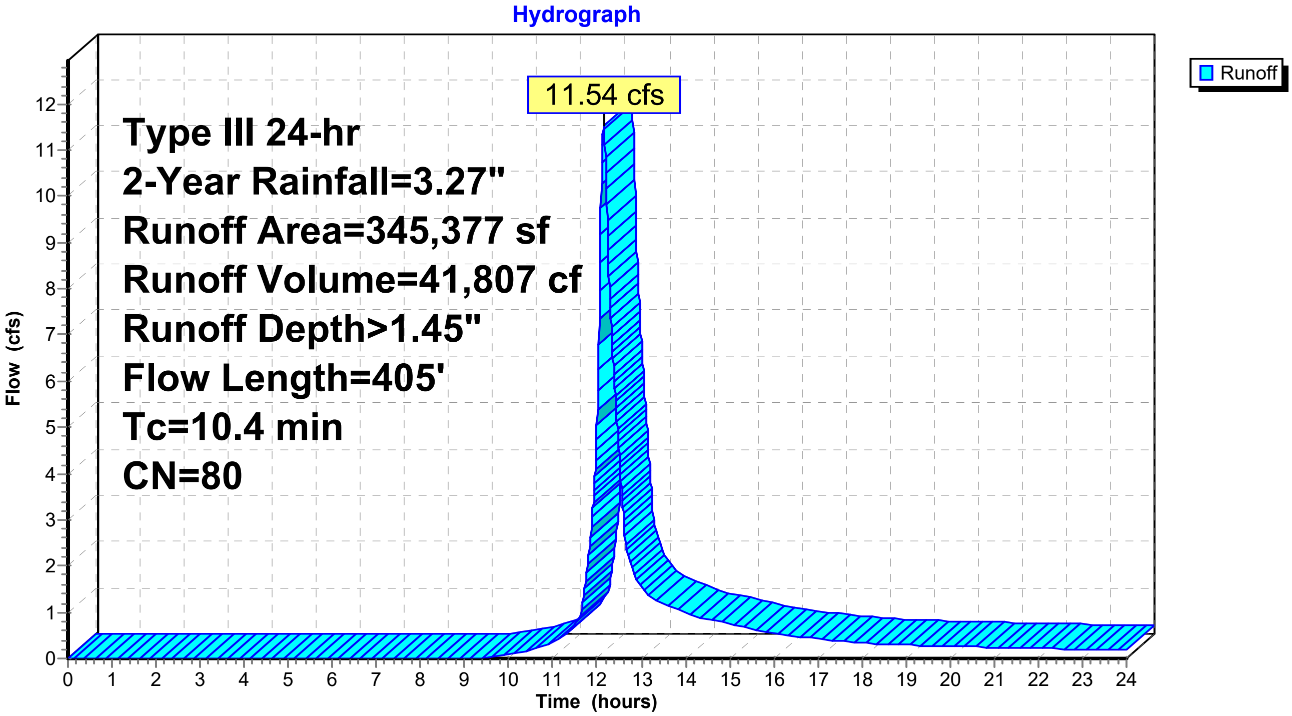
Runoff = 11.54 cfs @ 12.15 hrs, Volume= 41,807 cf, Depth> 1.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

Area (sf)	CN	Description
22,632	55	Woods, Good, HSG B
138,642	61	>75% Grass cover, Good, HSG B
83,392	98	Paved parking, HSG B
48,095	98	Roofs, HSG B
52,616	98	Water Surface, HSG B
345,377	80	Weighted Average
161,274		46.70% Pervious Area
184,103		53.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	50	0.0060	0.09		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.4	58	0.0190	2.22		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
0.1	20	0.0850	5.92		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
0.5	184	0.0155	5.65	4.44	**Pipe Channel, D-E** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013
0.4	93	0.0699	3.97		**Shallow Concentrated Flow, E-F** Grassed Waterway Kv= 15.0 fps
10.4	405	Total			

Subcatchment E-1: To Front Pond



Summary for Subcatchment E-2A: To Wetland C

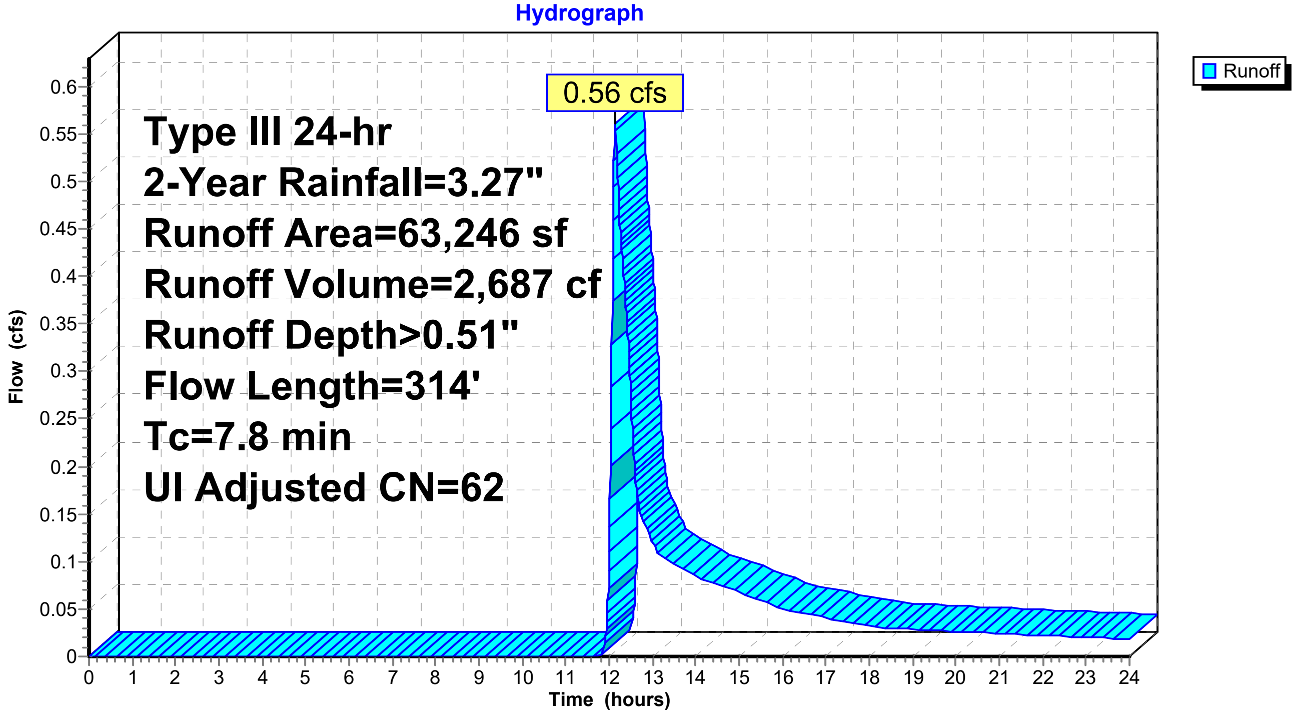
Runoff = 0.56 cfs @ 12.14 hrs, Volume= 2,687 cf, Depth> 0.51"
Routed to Pond 3P : Wetland C

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

	Area (sf)	CN	Adj	Description
	13,064	55		Woods, Good, HSG B
	41,744	61		>75% Grass cover, Good, HSG B
	3,778	98		Unconnected pavement, HSG B
	579	98		Unconnected pavement, HSG B
*	4,081	77		Woods, Good, HSG D Wetlands
	63,246	63	62	Weighted Average, UI Adjusted
	58,889			93.11% Pervious Area
	4,357			6.89% Impervious Area
	4,357			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.1	50	0.0160	0.14		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
1.7	264	0.0257	2.58		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
7.8	314	Total			

Subcatchment E-2A: To Wetland C



Summary for Subcatchment E-2B: To Wetland B

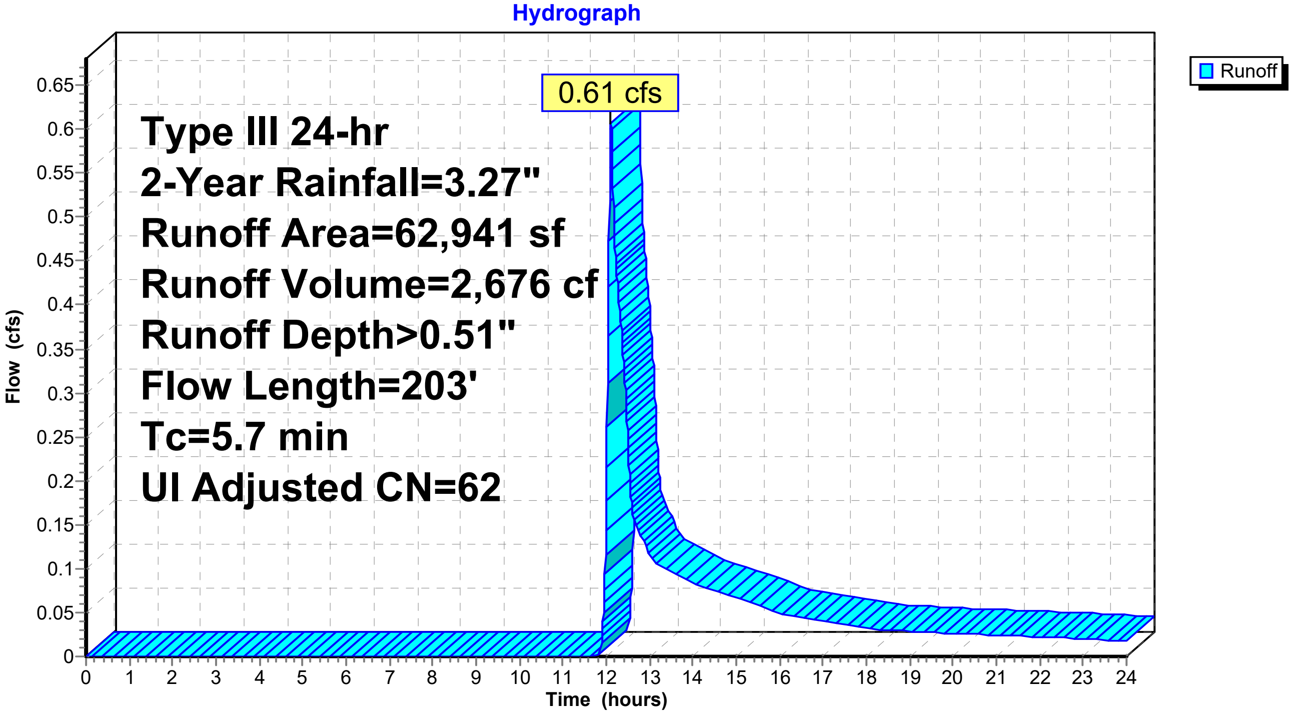
Runoff = 0.61 cfs @ 12.11 hrs, Volume= 2,676 cf, Depth> 0.51"
Routed to Pond 4P : Wetland B

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

	Area (sf)	CN	Adj	Description
	13,824	55		Woods, Good, HSG B
	41,883	61		>75% Grass cover, Good, HSG B
	1,522	98		Unconnected pavement, HSG B
	2,541	98		Unconnected pavement, HSG B
*	3,171	80		>75% Grass cover, Good, HSG D Wetlands
	62,941	63	62	Weighted Average, UI Adjusted
	58,878			93.54% Pervious Area
	4,063			6.46% Impervious Area
	4,063			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	50	0.0320	0.18		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
1.1	153	0.0196	2.25		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
5.7	203	Total			

Subcatchment E-2B: To Wetland B



Summary for Subcatchment E-3: To Great Brook

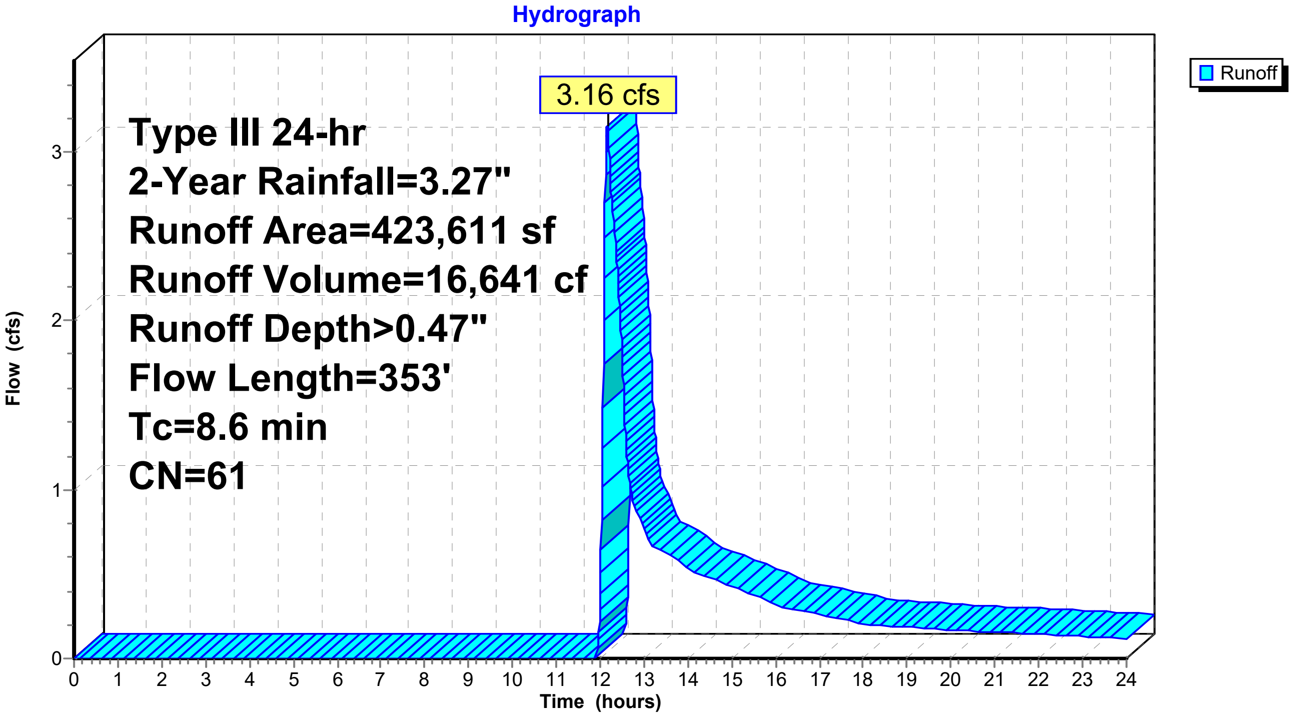
Runoff = 3.16 cfs @ 12.16 hrs, Volume= 16,641 cf, Depth> 0.47"
Routed to Link 2L : Great Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

Area (sf)	CN	Description
80,008	55	Woods, Good, HSG B
326,758	61	>75% Grass cover, Good, HSG B
9,139	96	Gravel surface, HSG B
7,562	98	Unconnected pavement, HSG B
144	98	Roofs, HSG B
423,611	61	Weighted Average
415,905		98.18% Pervious Area
7,706		1.82% Impervious Area
7,562		98.13% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.2	57	0.0789	4.52		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
2.8	246	0.0081	1.45		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
8.6	353	Total			

Subcatchment E-3: To Great Brook



Summary for Subcatchment E-4: To Rear Pond

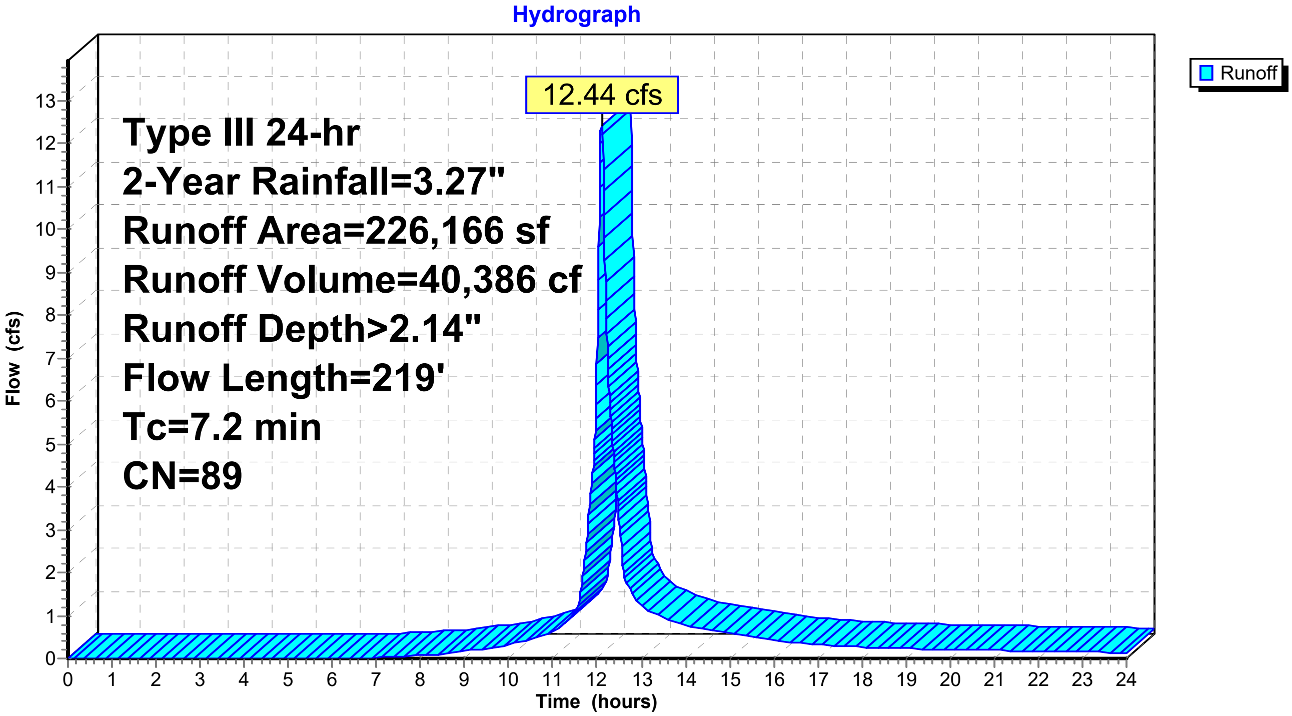
Runoff = 12.44 cfs @ 12.10 hrs, Volume= 40,386 cf, Depth> 2.14"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

Area (sf)	CN	Description
27,154	55	Woods, Good, HSG B
21,027	61	>75% Grass cover, Good, HSG B
127,097	98	Unconnected pavement, HSG B
50,888	98	Water Surface, HSG B
226,166	89	Weighted Average
48,181		21.30% Pervious Area
177,985		78.70% Impervious Area
127,097		71.41% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.0	20	0.2500	8.05		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
1.3	105	0.0067	1.32		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.3	44	0.0364	2.86		**Shallow Concentrated Flow, D-E** Grassed Waterway Kv= 15.0 fps
7.2	219	Total			

Subcatchment E-4: To Rear Pond



Summary for Pond 3P: Wetland C

Inflow Area = 63,246 sf, 6.89% Impervious, Inflow Depth > 0.51" for 2-Year event
Inflow = 0.56 cfs @ 12.14 hrs, Volume= 2,687 cf
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf
Routed to Pond 4P : Wetland B

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 344.67' @ 24.00 hrs Surf.Area= 3,223 sf Storage= 2,687 cf

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)
Center-of-Mass det. time= (not calculated: no outflow)

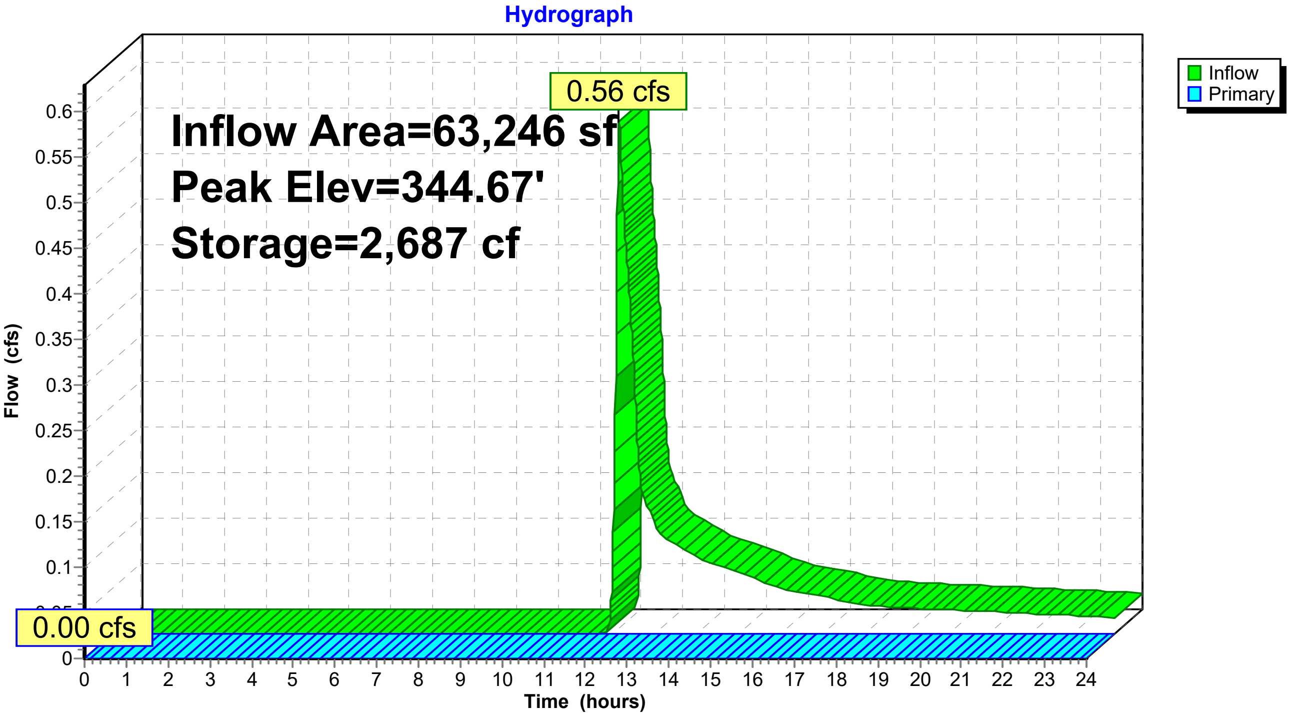
Volume	Invert	Avail.Storage	Storage Description
#1	343.00'	8,932 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
343.00	238	0	0
344.00	1,785	1,012	1,012
345.00	3,934	2,860	3,871
346.00	6,187	5,061	8,932

Device	Routing	Invert	Outlet Devices
#1	Primary	345.30'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=343.00' (Free Discharge)
└—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 3P: Wetland C



Summary for Pond 4P: Wetland B

```
Inflow Area =        126,187 sf,   6.67% Impervious,  Inflow Depth >   0.25"    for  2-Year event
Inflow      =        0.61 cfs @   12.11 hrs,  Volume=           2,676 cf
Outflow     =        0.11 cfs @   13.02 hrs,  Volume=           2,086 cf,  Atten= 81%,  Lag= 54.2 min
Primary     =        0.11 cfs @   13.02 hrs,  Volume=           2,086 cf
    Routed to Link 2L : Great Brook
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 344.75' @ 13.02 hrs Surf.Area= 2,761 sf Storage= 823 cf

Plug-Flow detention time= 167.5 min calculated for 2,085 cf (78% of inflow)
Center-of-Mass det. time= 77.5 min (983.1 - 905.6)

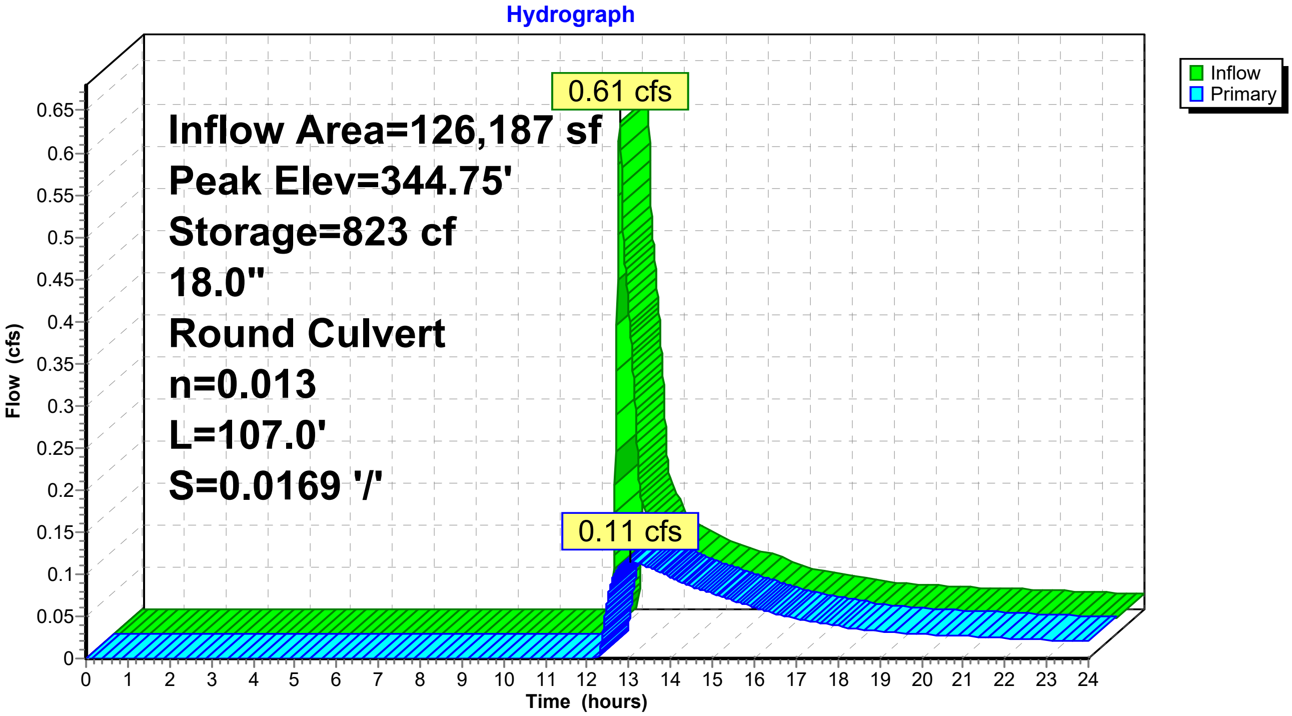
Volume	Invert	Avail.Storage	Storage Description
#1	344.25'	10,492 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
344.25	563	0	0
345.00	3,891	1,670	1,670
346.00	13,752	8,822	10,492

Device	Routing	Invert	Outlet Devices
#1	Primary	344.59'	**18.0" Round Culvert** L= 107.0' RCP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 344.59' / 342.78' S= 0.0169 '/' Cc= 0.900 n= 0.013, Flow Area= 1.77 sf

Primary OutFlow Max=0.11 cfs @ 13.02 hrs HW=344.75' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 0.11 cfs @ 1.18 fps)

Pond 4P: Wetland B

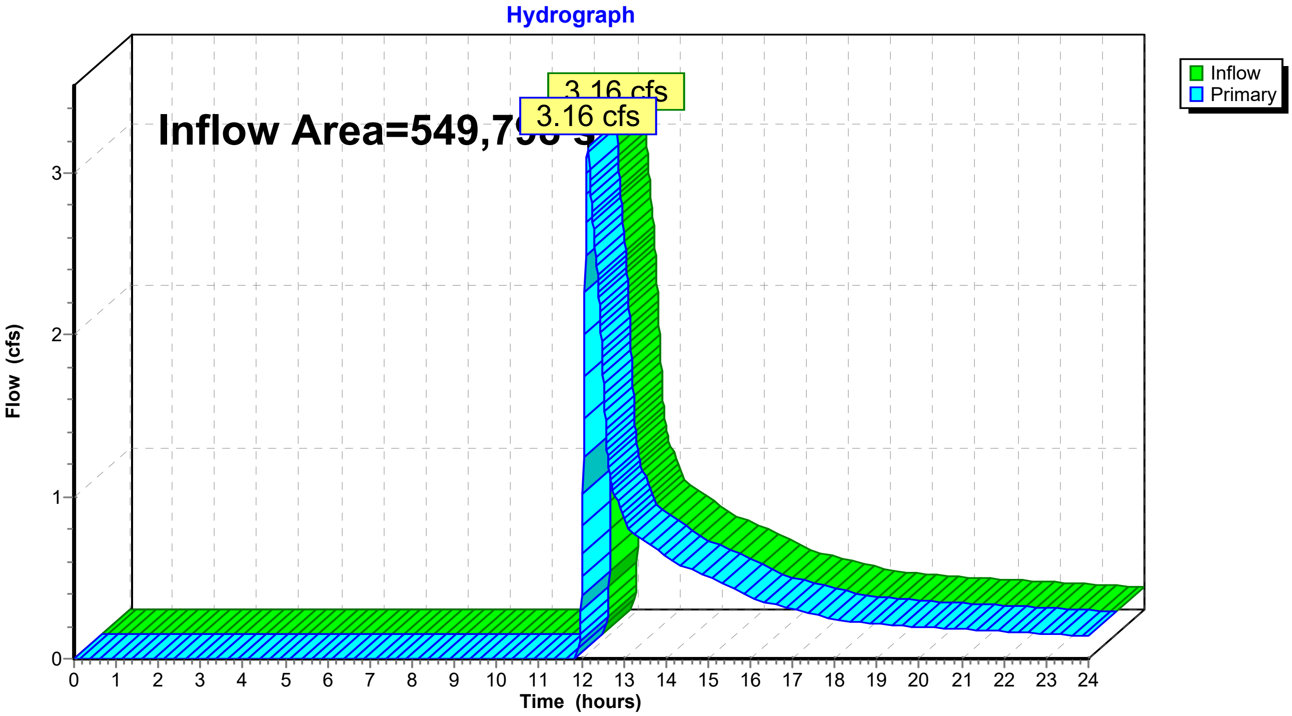


Summary for Link 2L: Great Brook

Inflow Area =	549,798 sf,	2.93% Impervious,	Inflow Depth > 0.41"	for 2-Year event	
Inflow =	3.16 cfs @	12.16 hrs,	Volume=	18,728 cf	
Primary =	3.16 cfs @	12.16 hrs,	Volume=	18,728 cf,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 2L: Great Brook



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E-1: To Front Pond Runoff Area=345,377 sf 53.30% Impervious Runoff Depth>2.90"
Flow Length=405' Tc=10.4 min CN=80 Runoff=23.34 cfs 83,594 cf

Subcatchment E-2A: To Wetland C Runoff Area=63,246 sf 6.89% Impervious Runoff Depth>1.45"
Flow Length=314' Tc=7.8 min UI Adjusted CN=62 Runoff=2.14 cfs 7,630 cf

Subcatchment E-2B: To Wetland B Runoff Area=62,941 sf 6.46% Impervious Runoff Depth>1.45"
Flow Length=203' Tc=5.7 min UI Adjusted CN=62 Runoff=2.29 cfs 7,598 cf

Subcatchment E-3: To Great Brook Runoff Area=423,611 sf 1.82% Impervious Runoff Depth>1.38"
Flow Length=353' Tc=8.6 min CN=61 Runoff=13.06 cfs 48,638 cf

Subcatchment E-4: To Rear Pond Runoff Area=226,166 sf 78.70% Impervious Runoff Depth>3.79"
Flow Length=219' Tc=7.2 min CN=89 Runoff=21.50 cfs 71,369 cf

Pond 3P: Wetland C Peak Elev=345.32' Storage=5,239 cf Inflow=2.14 cfs 7,630 cf
Outflow=0.15 cfs 2,440 cf

Pond 4P: Wetland B Peak Elev=345.05' Storage=1,891 cf Inflow=2.29 cfs 10,037 cf
18.0" Round Culvert n=0.013 L=107.0' S=0.0169 '/' Outflow=0.95 cfs 9,274 cf

Link 2L: Great Brook Inflow=13.62 cfs 57,912 cf
Primary=13.62 cfs 57,912 cf

Total Runoff Area = 1,121,341 sf Runoff Volume = 218,828 cf Average Runoff Depth = 2.34"
66.27% Pervious = 743,127 sf 33.73% Impervious = 378,214 sf

Summary for Subcatchment E-1: To Front Pond

[47] Hint: Peak is 526% of capacity of segment #4

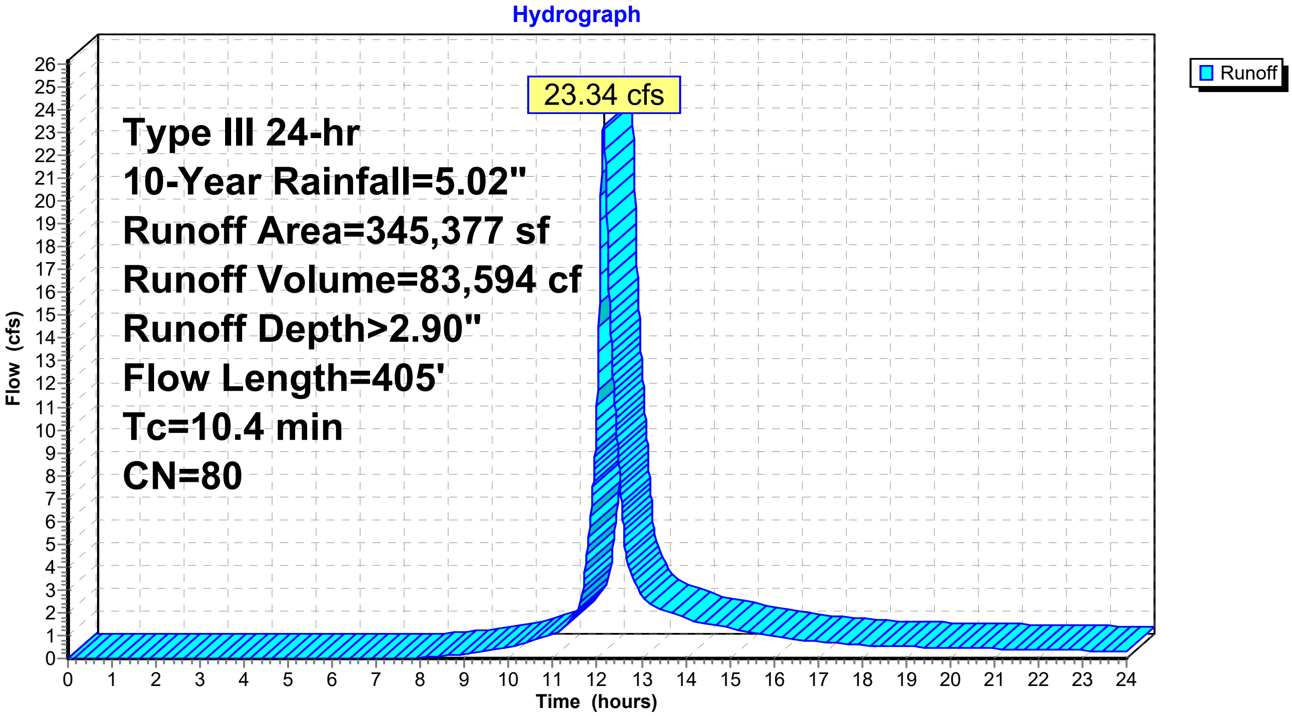
Runoff = 23.34 cfs @ 12.14 hrs, Volume= 83,594 cf, Depth> 2.90"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

Area (sf)	CN	Description
22,632	55	Woods, Good, HSG B
138,642	61	>75% Grass cover, Good, HSG B
83,392	98	Paved parking, HSG B
48,095	98	Roofs, HSG B
52,616	98	Water Surface, HSG B
345,377	80	Weighted Average
161,274		46.70% Pervious Area
184,103		53.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	50	0.0060	0.09		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.4	58	0.0190	2.22		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
0.1	20	0.0850	5.92		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
0.5	184	0.0155	5.65	4.44	**Pipe Channel, D-E** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013
0.4	93	0.0699	3.97		**Shallow Concentrated Flow, E-F** Grassed Waterway Kv= 15.0 fps
10.4	405	Total			

Subcatchment E-1: To Front Pond



Summary for Subcatchment E-2A: To Wetland C

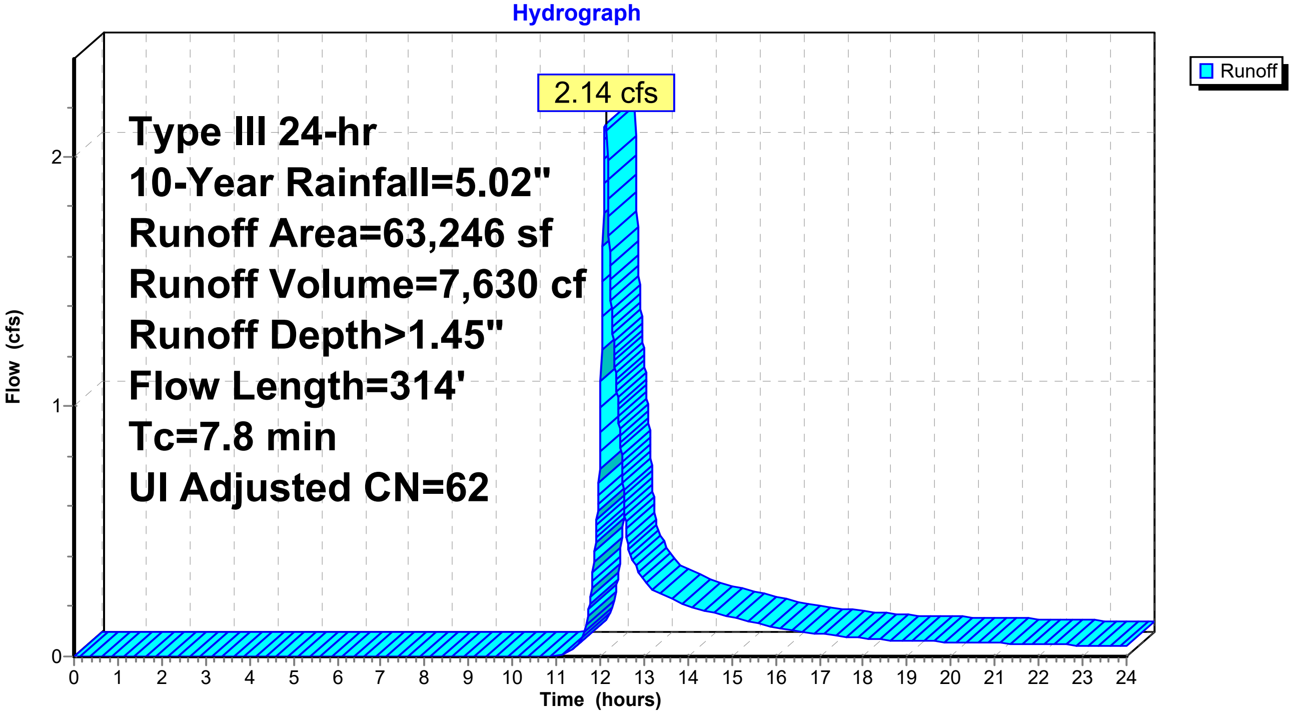
Runoff = 2.14 cfs @ 12.12 hrs, Volume= 7,630 cf, Depth> 1.45"
Routed to Pond 3P : Wetland C

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

	Area (sf)	CN	Adj	Description
	13,064	55		Woods, Good, HSG B
	41,744	61		>75% Grass cover, Good, HSG B
	3,778	98		Unconnected pavement, HSG B
	579	98		Unconnected pavement, HSG B
*	4,081	77		Woods, Good, HSG D Wetlands
	63,246	63	62	Weighted Average, UI Adjusted
	58,889			93.11% Pervious Area
	4,357			6.89% Impervious Area
	4,357			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.1	50	0.0160	0.14		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
1.7	264	0.0257	2.58		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
7.8	314	Total			

Subcatchment E-2A: To Wetland C



Summary for Subcatchment E-2B: To Wetland B

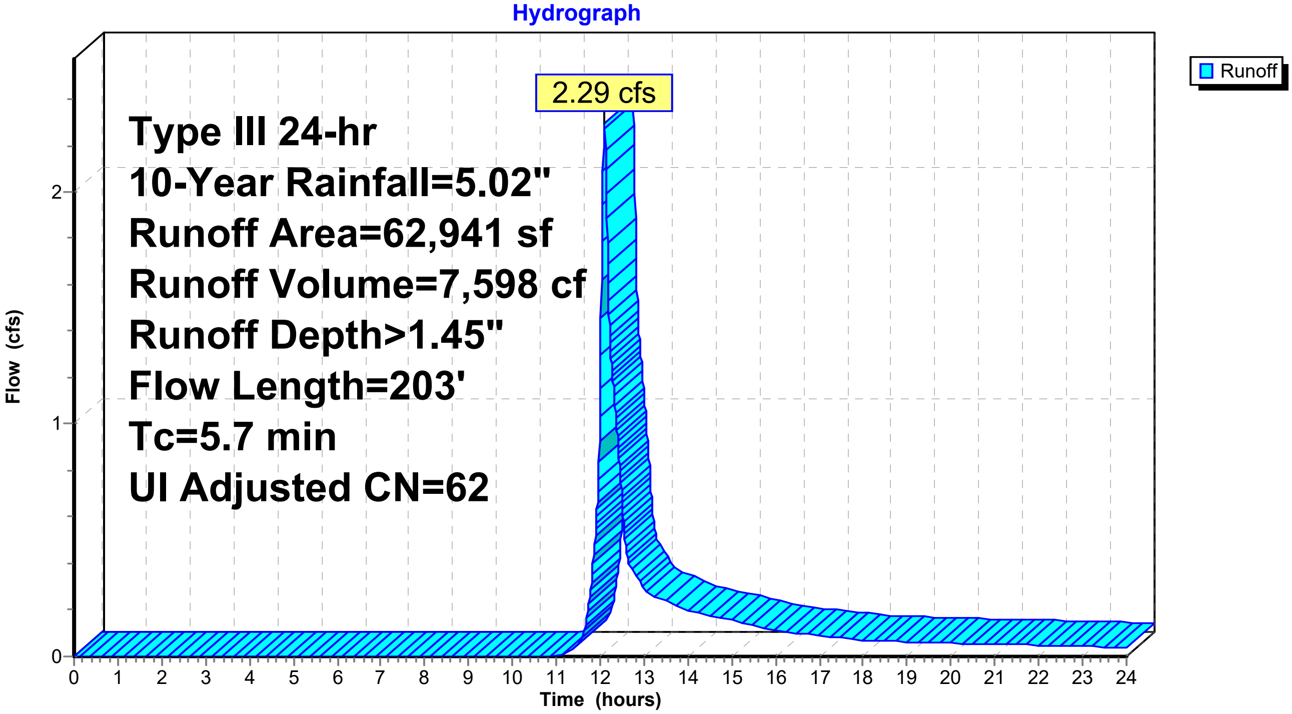
Runoff = 2.29 cfs @ 12.09 hrs, Volume= 7,598 cf, Depth> 1.45"
Routed to Pond 4P : Wetland B

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

	Area (sf)	CN	Adj	Description
	13,824	55		Woods, Good, HSG B
	41,883	61		>75% Grass cover, Good, HSG B
	1,522	98		Unconnected pavement, HSG B
	2,541	98		Unconnected pavement, HSG B
*	3,171	80		>75% Grass cover, Good, HSG D Wetlands
	62,941	63	62	Weighted Average, UI Adjusted
	58,878			93.54% Pervious Area
	4,063			6.46% Impervious Area
	4,063			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	50	0.0320	0.18		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
1.1	153	0.0196	2.25		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
5.7	203	Total			

Subcatchment E-2B: To Wetland B



Summary for Subcatchment E-3: To Great Brook

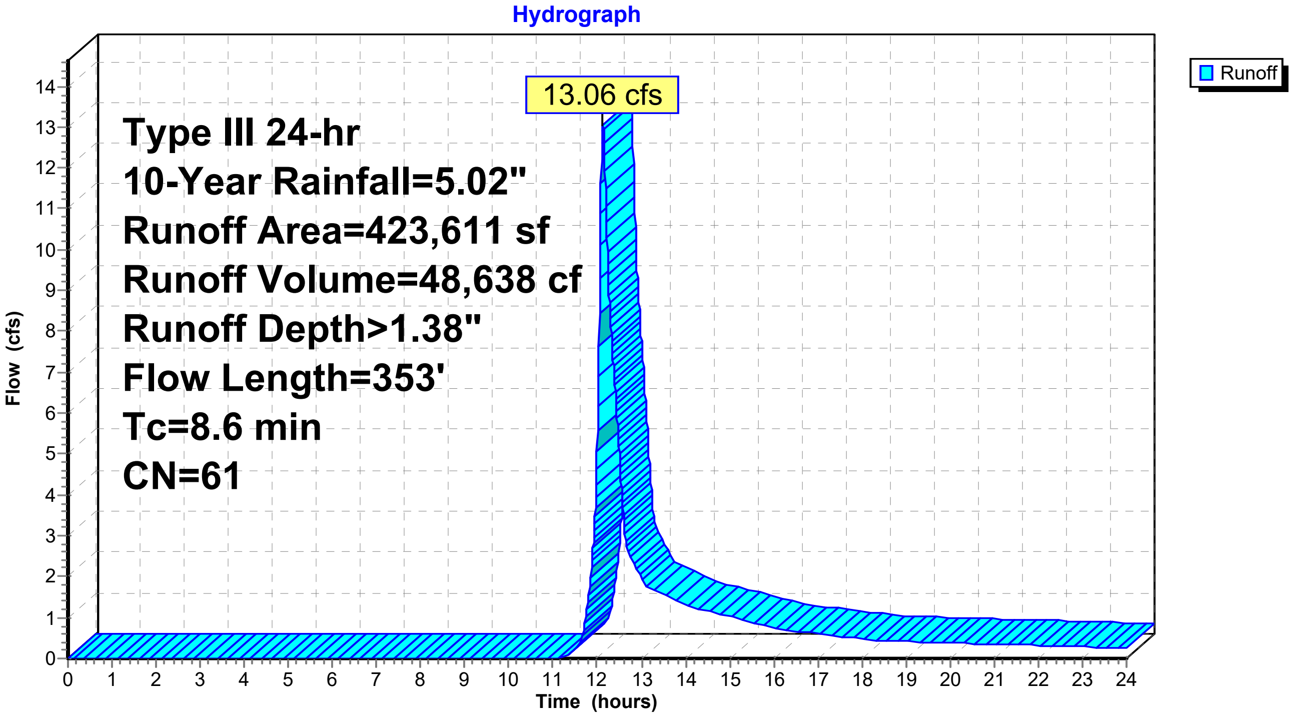
Runoff = 13.06 cfs @ 12.13 hrs, Volume= 48,638 cf, Depth> 1.38"
Routed to Link 2L : Great Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

Area (sf)	CN	Description
80,008	55	Woods, Good, HSG B
326,758	61	>75% Grass cover, Good, HSG B
9,139	96	Gravel surface, HSG B
7,562	98	Unconnected pavement, HSG B
144	98	Roofs, HSG B
423,611	61	Weighted Average
415,905		98.18% Pervious Area
7,706		1.82% Impervious Area
7,562		98.13% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.2	57	0.0789	4.52		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
2.8	246	0.0081	1.45		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
8.6	353	Total			

Subcatchment E-3: To Great Brook



Summary for Subcatchment E-4: To Rear Pond

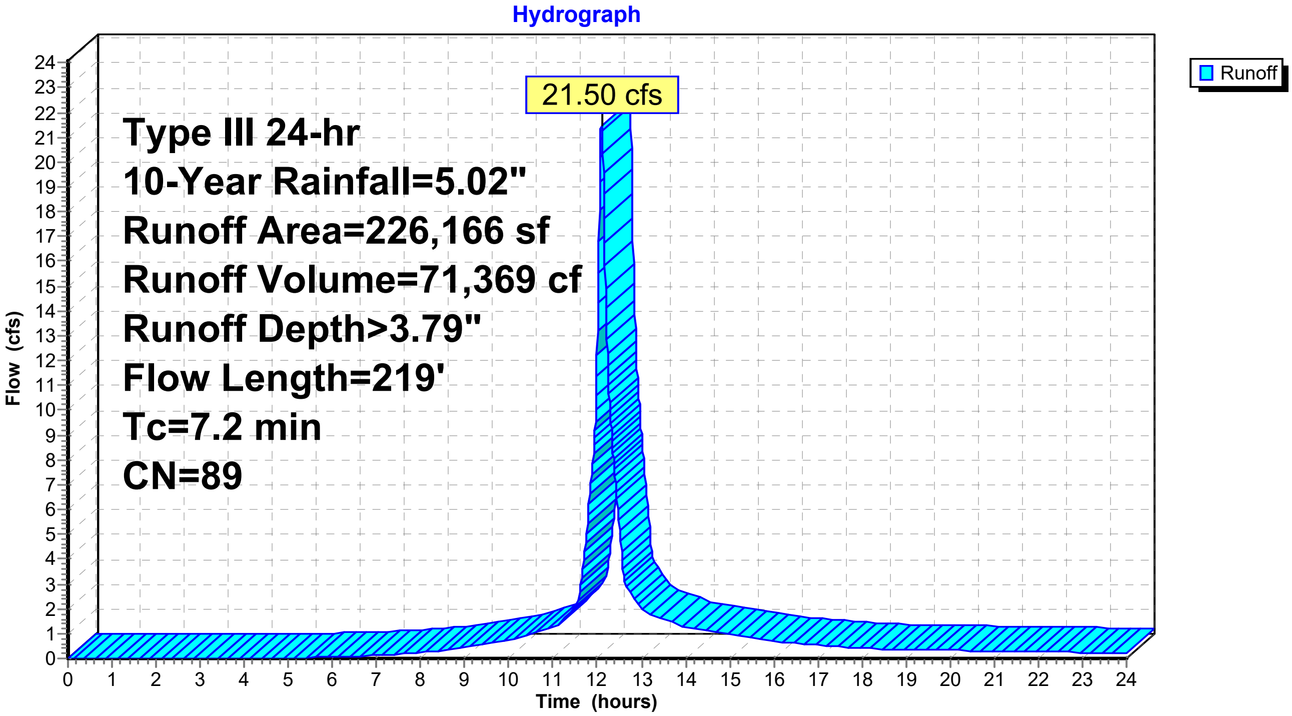
Runoff = 21.50 cfs @ 12.10 hrs, Volume= 71,369 cf, Depth> 3.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

Area (sf)	CN	Description
27,154	55	Woods, Good, HSG B
21,027	61	>75% Grass cover, Good, HSG B
127,097	98	Unconnected pavement, HSG B
50,888	98	Water Surface, HSG B
226,166	89	Weighted Average
48,181		21.30% Pervious Area
177,985		78.70% Impervious Area
127,097		71.41% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.0	20	0.2500	8.05		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
1.3	105	0.0067	1.32		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.3	44	0.0364	2.86		**Shallow Concentrated Flow, D-E** Grassed Waterway Kv= 15.0 fps
7.2	219	Total			

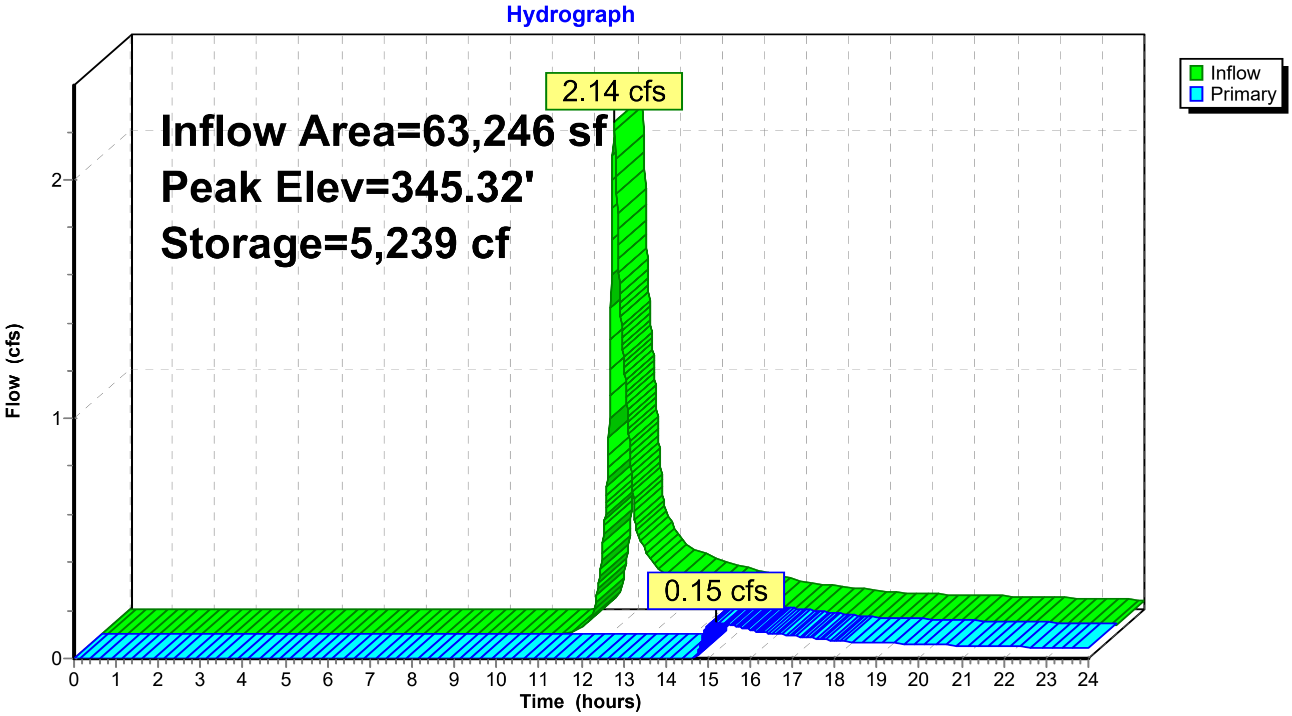
Subcatchment E-4: To Rear Pond



Summary for Pond 3P: Wetland C

```
Inflow Area =         63,246 sf,   6.89% Impervious,  Inflow Depth >   1.45"    for  10-Year event
Inflow      =       2.14 cfs @  12.12 hrs,  Volume=            7,630 cf
Outflow     =       0.15 cfs @  15.19 hrs,  Volume=            2,440 cf,  Atten= 93%,  Lag= 183.8 min
Primary     =       0.15 cfs @  15.19 hrs,  Volume=            2,440 cf
    Routed to Pond 4P : Wetland B

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 345.32' @ 15.19 hrs   Surf.Area= 4,652 sf   Storage= 5,239 cf

Plug-Flow detention time= 379.5 min calculated for 2,440 cf (32% of inflow)
Center-of-Mass det. time= 235.2 min ( 1,104.8 - 869.5 )

Volume        Invert     Avail.Storage   Storage Description
   #1        343.00'          8,932 cf   Custom Stage Data (Prismatic)Listed below (Recalc)

 Elevation        Surf.Area         Inc.Store          Cum.Store
    (feet)          (sq-ft)      (cubic-feet)       (cubic-feet)
    343.00              238                 0                  0
    344.00            1,785             1,012              1,012
    345.00            3,934             2,860              3,871
    346.00            6,187             5,061              8,932

Device    Routing         Invert   Outlet Devices
   #1     Primary        345.30'   20.0' long  x 10.0' breadth Broad-Crested Rectangular Weir
                                   Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60
                                   Coef. (English)  2.49  2.56  2.70  2.69  2.68  2.69  2.67  2.64

Primary OutFlow  Max=0.13 cfs @ 15.19 hrs  HW=345.32'   (Free Discharge)
└─1=Broad-Crested Rectangular Weir (Weir Controls 0.13 cfs @ 0.34 fps)
```

Pond 3P: Wetland C



Summary for Pond 4P: Wetland B

```
Inflow Area =         126,187 sf,   6.67% Impervious,  Inflow Depth >   0.95"    for  10-Year event
Inflow      =       2.29 cfs @  12.09 hrs,  Volume=           10,037 cf
Outflow     =       0.95 cfs @  12.39 hrs,  Volume=            9,274 cf,  Atten= 59%,  Lag= 17.8 min
Primary     =       0.95 cfs @  12.39 hrs,  Volume=            9,274 cf
   Routed to Link 2L : Great Brook

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 345.05' @ 12.39 hrs   Surf.Area= 4,415 sf   Storage= 1,891 cf

Plug-Flow detention time= 70.1 min calculated for 9,274 cf (92% of inflow)
Center-of-Mass det. time= 33.8 min ( 959.3 - 925.5 )

Volume      Invert     Avail.Storage   Storage Description
   #1       344.25'        10,492 cf   Custom Stage Data (Prismatic)Listed below (Recalc)

 Elevation        Surf.Area        Inc.Store        Cum.Store
    (feet)          (sq-ft)     (cubic-feet)     (cubic-feet)
    344.25              563                0                0
    345.00            3,891            1,670            1,670
    346.00           13,752            8,822           10,492

Device  Routing          Invert   Outlet Devices
   #1   Primary         344.59'   18.0"  Round Culvert
                                  L= 107.0'   RCP, mitered to conform to fill,  Ke= 0.700
                                  Inlet / Outlet Invert= 344.59' / 342.78'   S= 0.0169 '/'   Cc= 0.900
                                  n= 0.013,  Flow Area= 1.77 sf

Primary OutFlow  Max=0.95 cfs @ 12.39 hrs  HW=345.05'   (Free Discharge)
└─1=Culvert  (Inlet Controls 0.95 cfs @ 2.04 fps)
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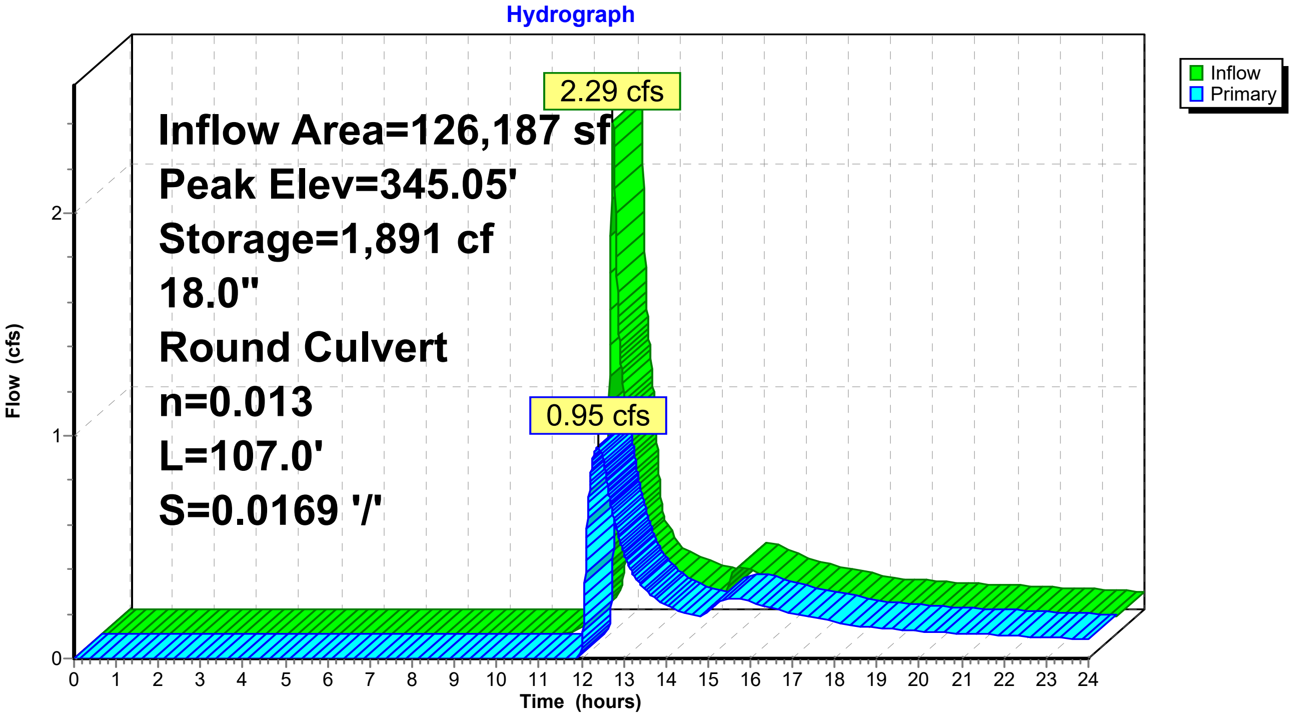
Pond 4P: Wetland B

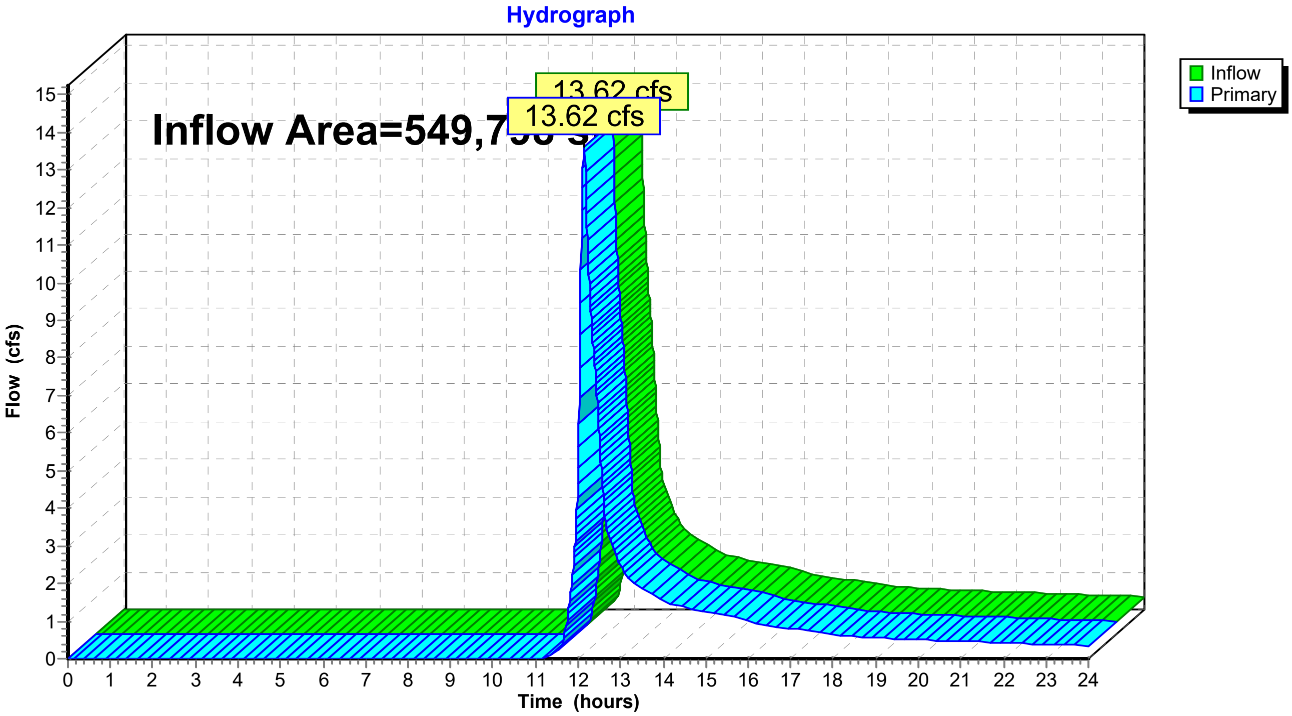


Summary for Link 2L: Great Brook

Inflow Area = 549,798 sf, 2.93% Impervious, Inflow Depth > 1.26" for 10-Year event
Inflow = 13.62 cfs @ 12.14 hrs, Volume= 57,912 cf
Primary = 13.62 cfs @ 12.14 hrs, Volume= 57,912 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 2L: Great Brook



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E-1: To Front Pond Runoff Area=345,377 sf 53.30% Impervious Runoff Depth>3.87"
Flow Length=405' Tc=10.4 min CN=80 Runoff=31.02 cfs 111,477 cf

Subcatchment E-2A: To Wetland C Runoff Area=63,246 sf 6.89% Impervious Runoff Depth>2.16"
Flow Length=314' Tc=7.8 min UI Adjusted CN=62 Runoff=3.33 cfs 11,394 cf

Subcatchment E-2B: To Wetland B Runoff Area=62,941 sf 6.46% Impervious Runoff Depth>2.16"
Flow Length=203' Tc=5.7 min UI Adjusted CN=62 Runoff=3.57 cfs 11,345 cf

Subcatchment E-3: To Great Brook Runoff Area=423,611 sf 1.82% Impervious Runoff Depth>2.07"
Flow Length=353' Tc=8.6 min CN=61 Runoff=20.67 cfs 73,247 cf

Subcatchment E-4: To Rear Pond Runoff Area=226,166 sf 78.70% Impervious Runoff Depth>4.84"
Flow Length=219' Tc=7.2 min CN=89 Runoff=27.13 cfs 91,157 cf

Pond 3P: Wetland C Peak Elev=345.35' Storage=5,375 cf Inflow=3.33 cfs 11,394 cf
Outflow=0.53 cfs 6,194 cf

Pond 4P: Wetland B Peak Elev=345.21' Storage=2,709 cf Inflow=3.57 cfs 17,539 cf
18.0" Round Culvert n=0.013 L=107.0' S=0.0169 '/' Outflow=1.63 cfs 16,718 cf

Link 2L: Great Brook Inflow=21.97 cfs 89,965 cf
Primary=21.97 cfs 89,965 cf

Total Runoff Area = 1,121,341 sf Runoff Volume = 298,621 cf Average Runoff Depth = 3.20"
66.27% Pervious = 743,127 sf 33.73% Impervious = 378,214 sf

Summary for Subcatchment E-1: To Front Pond

[47] Hint: Peak is 699% of capacity of segment #4

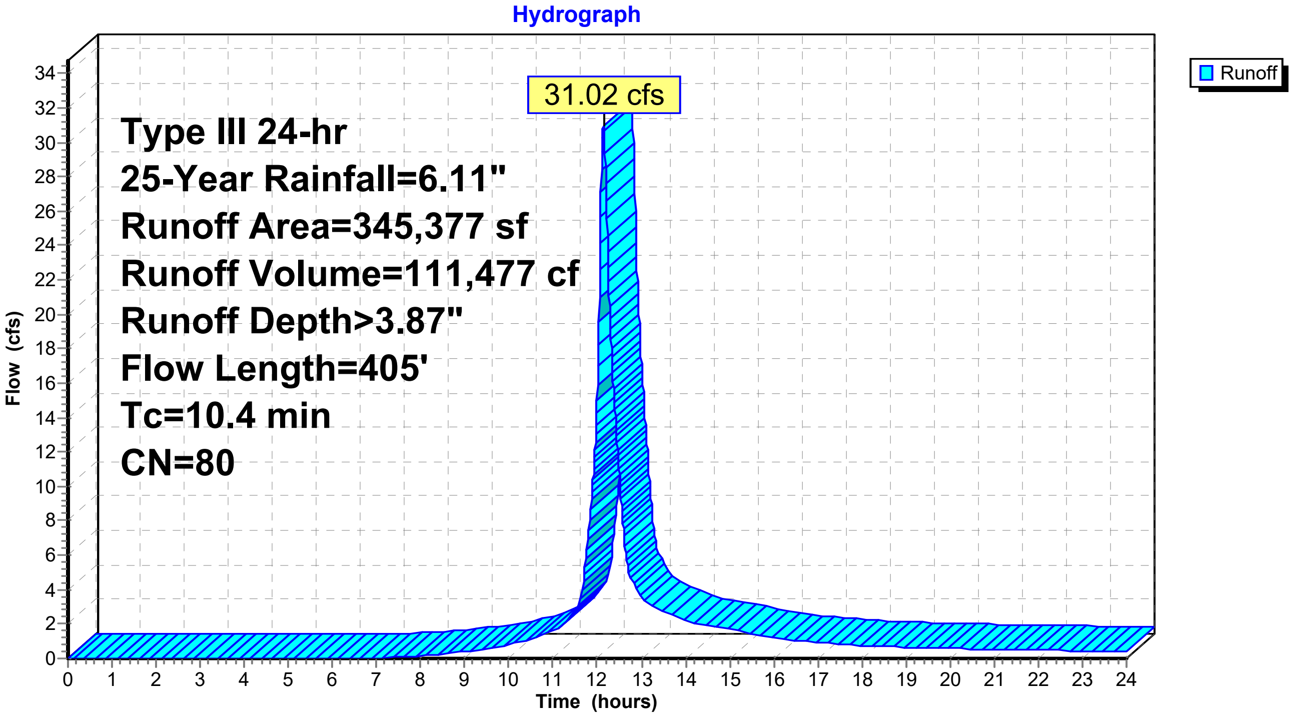
Runoff = 31.02 cfs @ 12.14 hrs, Volume= 111,477 cf, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
22,632	55	Woods, Good, HSG B
138,642	61	>75% Grass cover, Good, HSG B
83,392	98	Paved parking, HSG B
48,095	98	Roofs, HSG B
52,616	98	Water Surface, HSG B
345,377	80	Weighted Average
161,274		46.70% Pervious Area
184,103		53.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	50	0.0060	0.09		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.4	58	0.0190	2.22		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
0.1	20	0.0850	5.92		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
0.5	184	0.0155	5.65	4.44	**Pipe Channel, D-E** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013
0.4	93	0.0699	3.97		**Shallow Concentrated Flow, E-F** Grassed Waterway Kv= 15.0 fps
10.4	405	Total			

Subcatchment E-1: To Front Pond



Summary for Subcatchment E-2A: To Wetland C

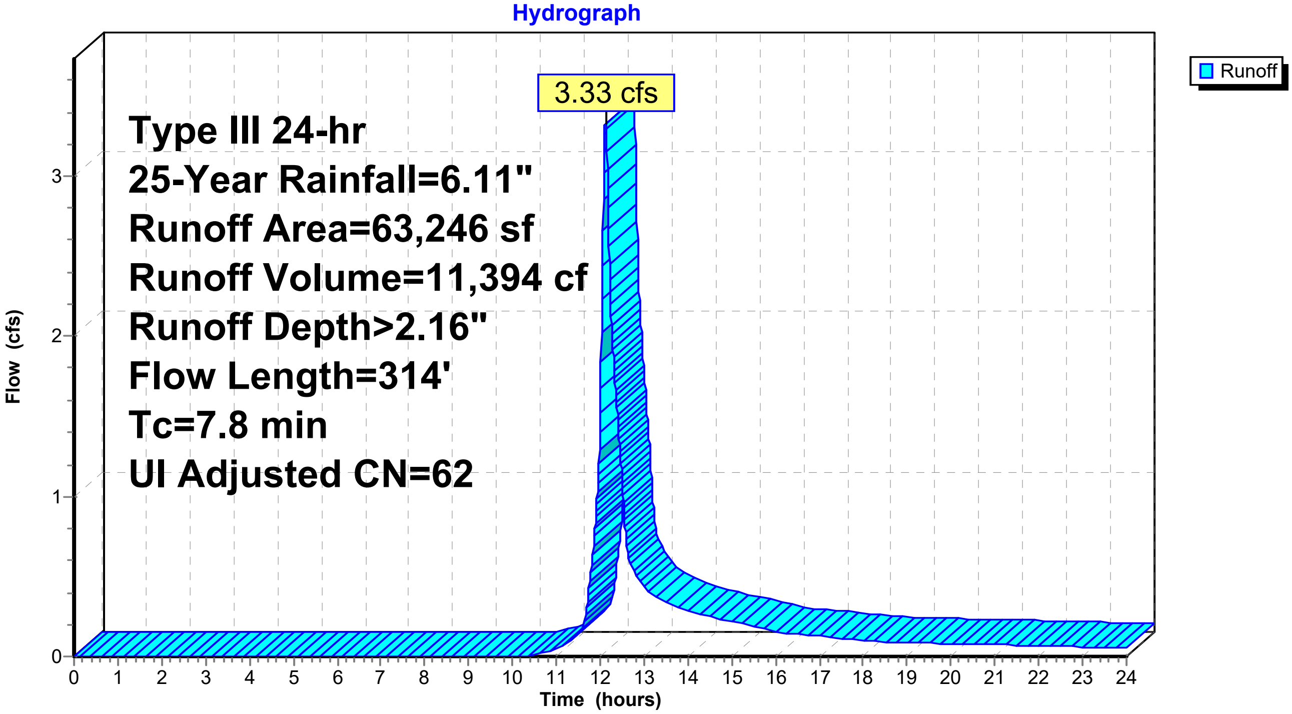
Runoff = 3.33 cfs @ 12.12 hrs, Volume= 11,394 cf, Depth> 2.16"
Routed to Pond 3P : Wetland C

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

	Area (sf)	CN	Adj	Description
	13,064	55		Woods, Good, HSG B
	41,744	61		>75% Grass cover, Good, HSG B
	3,778	98		Unconnected pavement, HSG B
	579	98		Unconnected pavement, HSG B
*	4,081	77		Woods, Good, HSG D Wetlands
	63,246	63	62	Weighted Average, UI Adjusted
	58,889			93.11% Pervious Area
	4,357			6.89% Impervious Area
	4,357			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.1	50	0.0160	0.14		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
1.7	264	0.0257	2.58		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
7.8	314	Total			

Subcatchment E-2A: To Wetland C



Summary for Subcatchment E-2B: To Wetland B

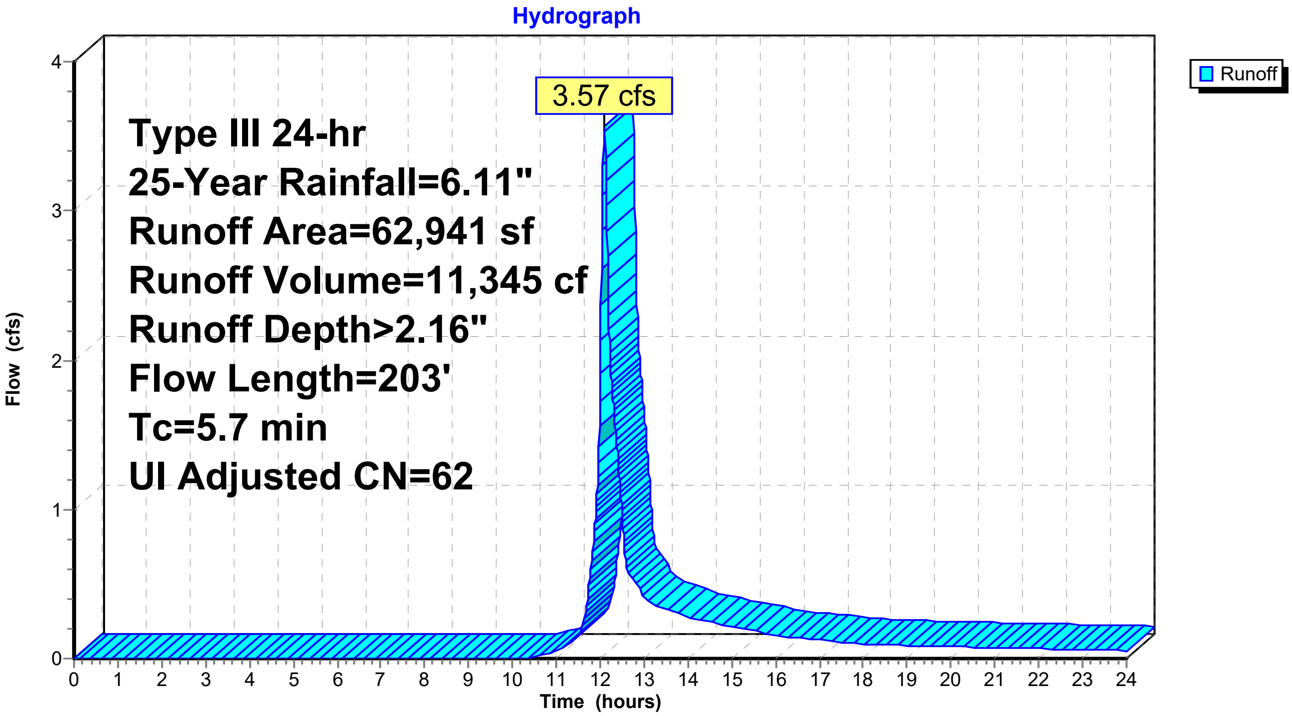
Runoff = 3.57 cfs @ 12.09 hrs, Volume= 11,345 cf, Depth> 2.16"
Routed to Pond 4P : Wetland B

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

	Area (sf)	CN	Adj	Description
	13,824	55		Woods, Good, HSG B
	41,883	61		>75% Grass cover, Good, HSG B
	1,522	98		Unconnected pavement, HSG B
	2,541	98		Unconnected pavement, HSG B
*	3,171	80		>75% Grass cover, Good, HSG D Wetlands
	62,941	63	62	Weighted Average, UI Adjusted
	58,878			93.54% Pervious Area
	4,063			6.46% Impervious Area
	4,063			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	50	0.0320	0.18		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
1.1	153	0.0196	2.25		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
5.7	203	Total			

Subcatchment E-2B: To Wetland B



Summary for Subcatchment E-3: To Great Brook

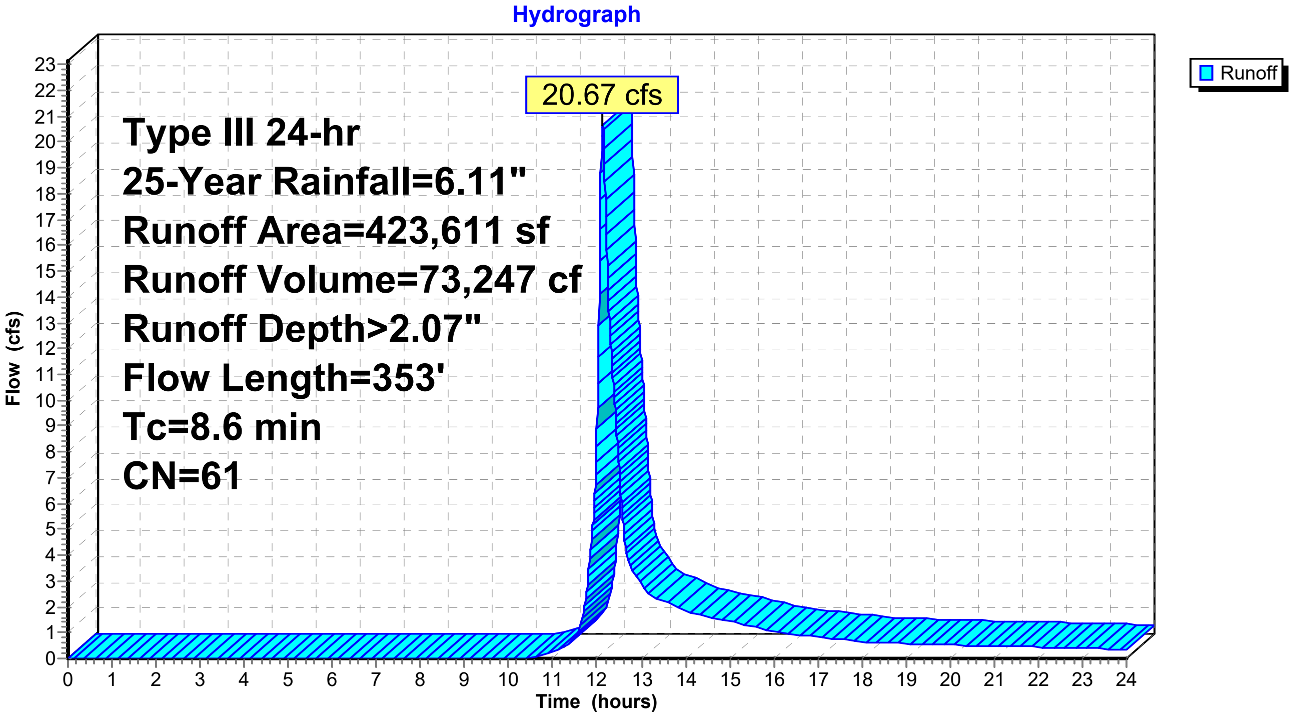
Runoff = 20.67 cfs @ 12.13 hrs, Volume= 73,247 cf, Depth> 2.07"
Routed to Link 2L : Great Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
80,008	55	Woods, Good, HSG B
326,758	61	>75% Grass cover, Good, HSG B
9,139	96	Gravel surface, HSG B
7,562	98	Unconnected pavement, HSG B
144	98	Roofs, HSG B
423,611	61	Weighted Average
415,905		98.18% Pervious Area
7,706		1.82% Impervious Area
7,562		98.13% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.2	57	0.0789	4.52		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
2.8	246	0.0081	1.45		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
8.6	353	Total			

Subcatchment E-3: To Great Brook



Summary for Subcatchment E-4: To Rear Pond

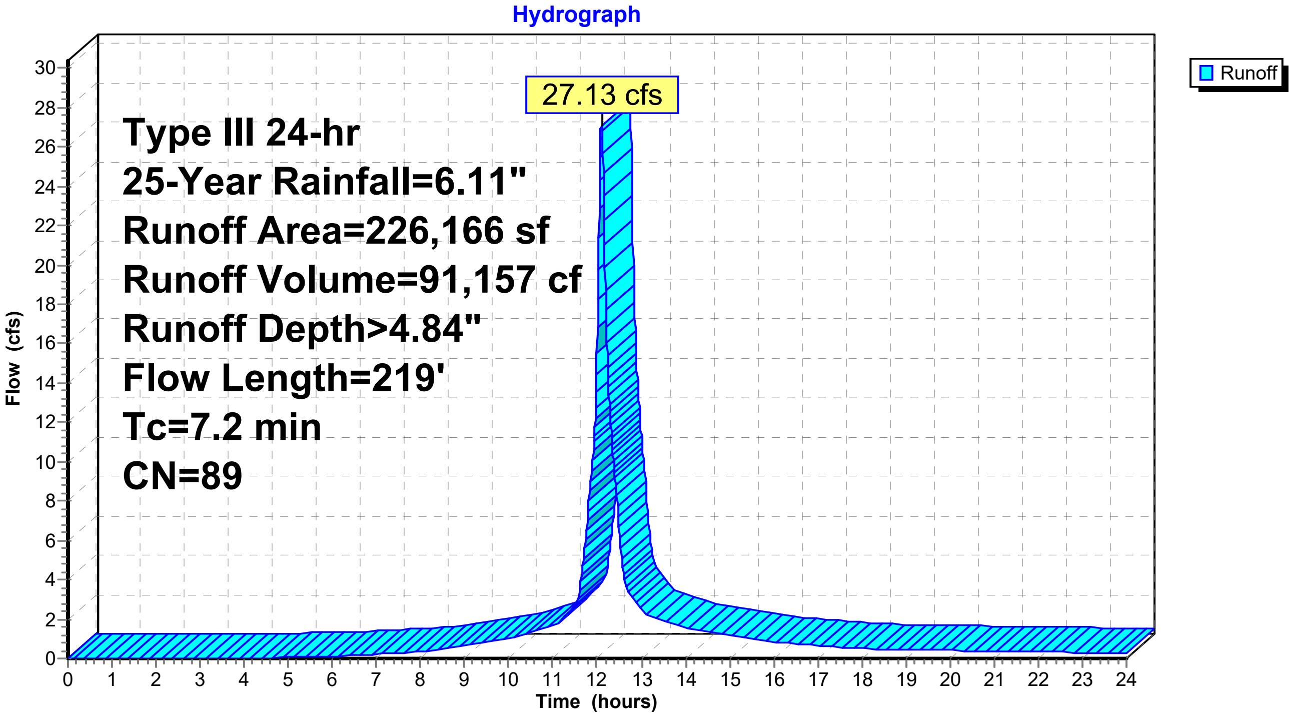
Runoff = 27.13 cfs @ 12.10 hrs, Volume= 91,157 cf, Depth> 4.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
27,154	55	Woods, Good, HSG B
21,027	61	>75% Grass cover, Good, HSG B
127,097	98	Unconnected pavement, HSG B
50,888	98	Water Surface, HSG B
226,166	89	Weighted Average
48,181		21.30% Pervious Area
177,985		78.70% Impervious Area
127,097		71.41% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.0	20	0.2500	8.05		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
1.3	105	0.0067	1.32		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.3	44	0.0364	2.86		**Shallow Concentrated Flow, D-E** Grassed Waterway Kv= 15.0 fps
7.2	219	Total			

Subcatchment E-4: To Rear Pond



Summary for Pond 3P: Wetland C

```
Inflow Area =         63,246 sf,   6.89% Impervious,  Inflow Depth >   2.16"    for  25-Year event
Inflow      =        3.33 cfs @  12.12 hrs,  Volume=           11,394 cf
Outflow     =        0.53 cfs @  12.78 hrs,  Volume=            6,194 cf,  Atten= 84%,  Lag= 39.4 min
Primary     =        0.53 cfs @  12.78 hrs,  Volume=            6,194 cf
   Routed to Pond 4P : Wetland B

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 345.35' @ 12.78 hrs   Surf.Area= 4,717 sf   Storage= 5,375 cf

Plug-Flow detention time= 236.9 min calculated for 6,191 cf (54% of inflow)
Center-of-Mass det. time= 113.5 min ( 970.5 - 857.1 )

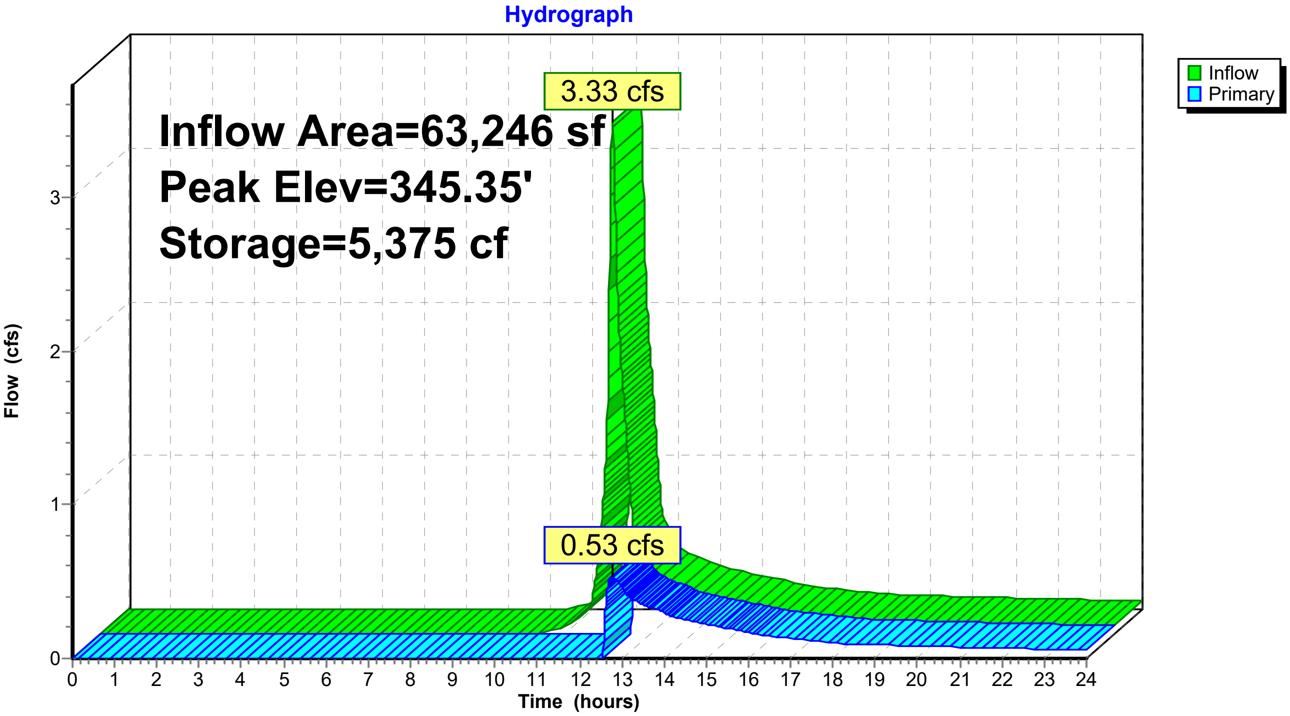
Volume        Invert     Avail.Storage   Storage Description
   #1        343.00'          8,932 cf   Custom Stage Data (Prismatic)Listed below (Recalc)

 Elevation         Surf.Area          Inc.Store          Cum.Store
    (feet)           (sq-ft)        (cubic-feet)       (cubic-feet)
    343.00               238                  0                  0
    344.00             1,785              1,012              1,012
    345.00             3,934              2,860              3,871
    346.00             6,187              5,061              8,932

Device   Routing            Invert   Outlet Devices
   #1    Primary           345.30'   20.0' long  x 10.0' breadth Broad-Crested Rectangular Weir
                                     Head (feet)  0.20  0.40  0.60  0.80  1.00  1.20  1.40  1.60
                                     Coef. (English)  2.49  2.56  2.70  2.69  2.68  2.69  2.67  2.64

Primary OutFlow  Max=0.52 cfs @ 12.78 hrs  HW=345.35'   (Free Discharge)
└─1=Broad-Crested Rectangular Weir (Weir Controls 0.52 cfs @ 0.54 fps)
```

Pond 3P: Wetland C



Summary for Pond 4P: Wetland B

Inflow Area = 126,187 sf, 6.67% Impervious, Inflow Depth > 1.67" for 25-Year event
Inflow = 3.57 cfs @ 12.09 hrs, Volume= 17,539 cf
Outflow = 1.63 cfs @ 12.32 hrs, Volume= 16,718 cf, Atten= 54%, Lag= 13.7 min
Primary = 1.63 cfs @ 12.32 hrs, Volume= 16,718 cf
Routed to Link 2L : Great Brook

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 345.21' @ 12.32 hrs Surf.Area= 5,969 sf Storage= 2,709 cf

Plug-Flow detention time= 49.8 min calculated for 16,711 cf (95% of inflow)
Center-of-Mass det. time= 26.1 min (922.1 - 896.1)

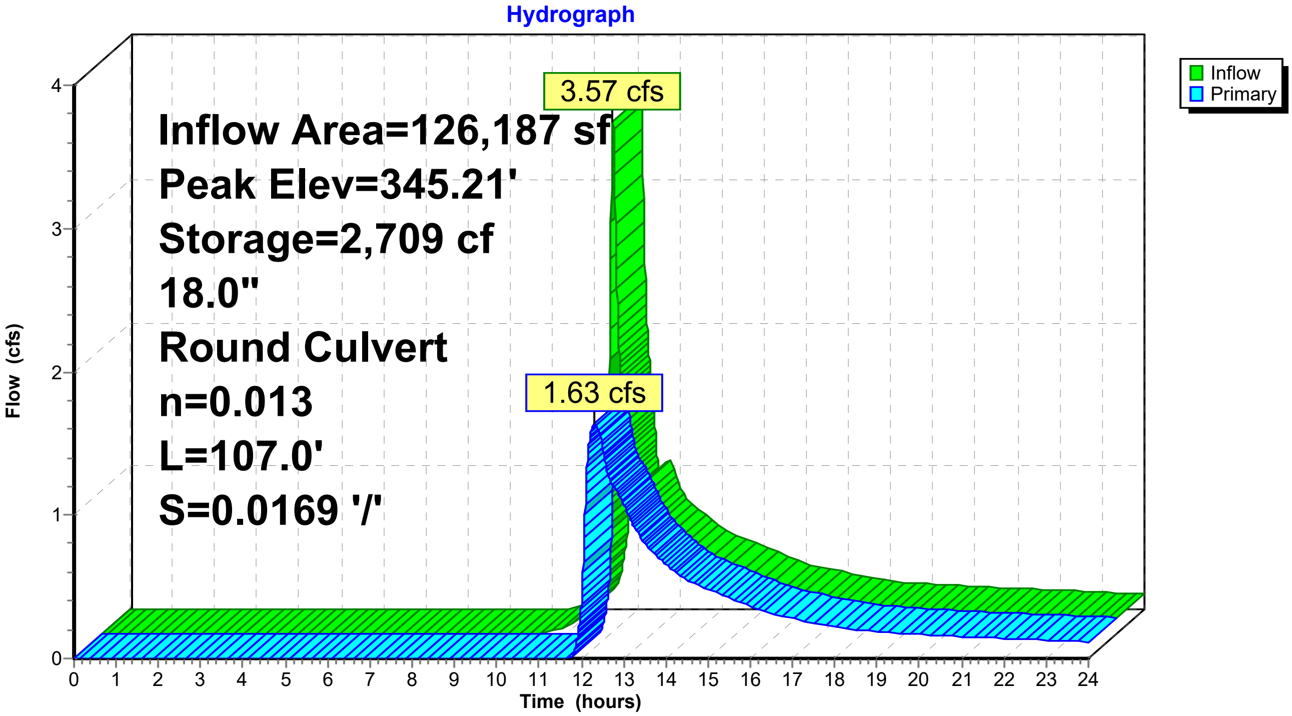
Volume	Invert	Avail.Storage	Storage Description
#1	344.25'	10,492 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
344.25	563	0	0
345.00	3,891	1,670	1,670
346.00	13,752	8,822	10,492

Device	Routing	Invert	Outlet Devices
#1	Primary	344.59'	**18.0" Round Culvert** L= 107.0' RCP, mitered to conform to fill, Ke= 0.700 Inlet / Outlet Invert= 344.59' / 342.78' S= 0.0169 '/' Cc= 0.900 n= 0.013, Flow Area= 1.77 sf

Primary OutFlow Max=1.63 cfs @ 12.32 hrs HW=345.21' (Free Discharge)
↑—**1=Culvert** (Inlet Controls 1.63 cfs @ 2.37 fps)

Pond 4P: Wetland B

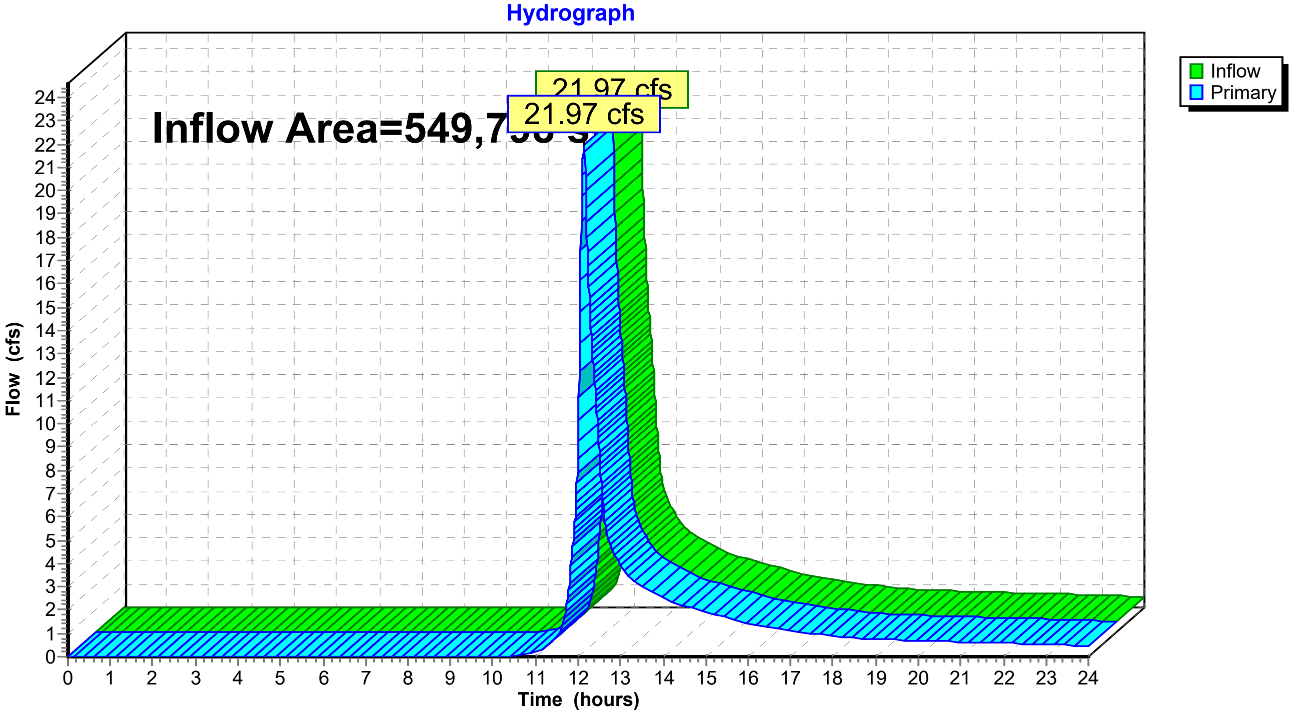


Summary for Link 2L: Great Brook

Inflow Area = 549,798 sf, 2.93% Impervious, Inflow Depth > 1.96" for 25-Year event
Inflow = 21.97 cfs @ 12.13 hrs, Volume= 89,965 cf
Primary = 21.97 cfs @ 12.13 hrs, Volume= 89,965 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 2L: Great Brook



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E-1: To Front Pond Runoff Area=345,377 sf 53.30% Impervious Runoff Depth>5.42"
Flow Length=405' Tc=10.4 min CN=80 Runoff=42.99 cfs 155,956 cf

Subcatchment E-2A: To Wetland C Runoff Area=63,246 sf 6.89% Impervious Runoff Depth>3.39"
Flow Length=314' Tc=7.8 min UI Adjusted CN=62 Runoff=5.36 cfs 17,860 cf

Subcatchment E-2B: To Wetland B Runoff Area=62,941 sf 6.46% Impervious Runoff Depth>3.39"
Flow Length=203' Tc=5.7 min UI Adjusted CN=62 Runoff=5.75 cfs 17,783 cf

Subcatchment E-3: To Great Brook Runoff Area=423,611 sf 1.82% Impervious Runoff Depth>3.28"
Flow Length=353' Tc=8.6 min CN=61 Runoff=33.72 cfs 115,749 cf

Subcatchment E-4: To Rear Pond Runoff Area=226,166 sf 78.70% Impervious Runoff Depth>6.47"
Flow Length=219' Tc=7.2 min CN=89 Runoff=35.73 cfs 122,015 cf

Pond 3P: Wetland C Peak Elev=345.45' Storage=5,885 cf Inflow=5.36 cfs 17,860 cf
Outflow=2.99 cfs 12,651 cf

Pond 4P: Wetland B Peak Elev=345.59' Storage=5,705 cf Inflow=5.78 cfs 30,433 cf
18.0" Round Culvert n=0.013 L=107.0' S=0.0169 '/' Outflow=3.77 cfs 29,529 cf

Link 2L: Great Brook Inflow=36.04 cfs 145,278 cf
Primary=36.04 cfs 145,278 cf

Total Runoff Area = 1,121,341 sf Runoff Volume = 429,363 cf Average Runoff Depth = 4.59"
66.27% Pervious = 743,127 sf 33.73% Impervious = 378,214 sf

Summary for Subcatchment E-1: To Front Pond

[47] Hint: Peak is 969% of capacity of segment #4

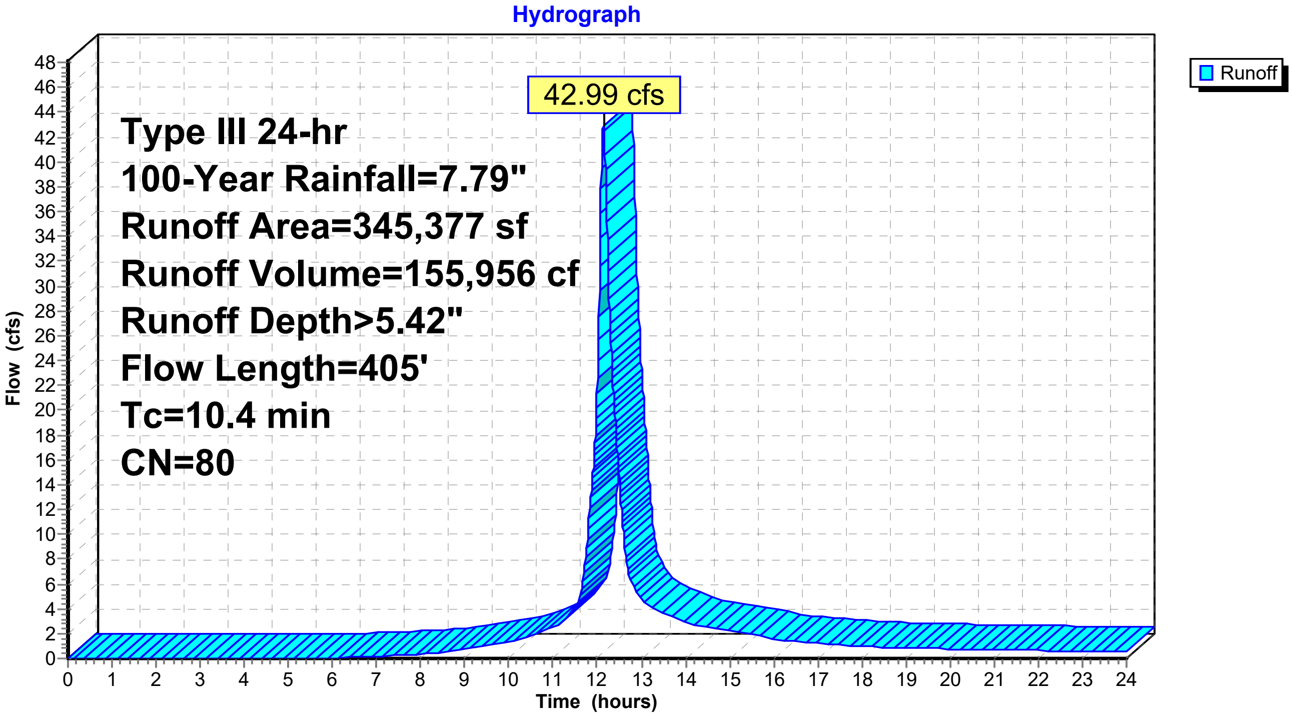
Runoff = 42.99 cfs @ 12.14 hrs, Volume= 155,956 cf, Depth> 5.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

Area (sf)	CN	Description
22,632	55	Woods, Good, HSG B
138,642	61	>75% Grass cover, Good, HSG B
83,392	98	Paved parking, HSG B
48,095	98	Roofs, HSG B
52,616	98	Water Surface, HSG B
345,377	80	Weighted Average
161,274		46.70% Pervious Area
184,103		53.30% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	50	0.0060	0.09		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.4	58	0.0190	2.22		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
0.1	20	0.0850	5.92		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
0.5	184	0.0155	5.65	4.44	**Pipe Channel, D-E** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013
0.4	93	0.0699	3.97		**Shallow Concentrated Flow, E-F** Grassed Waterway Kv= 15.0 fps
10.4	405	Total			

Subcatchment E-1: To Front Pond



Summary for Subcatchment E-2A: To Wetland C

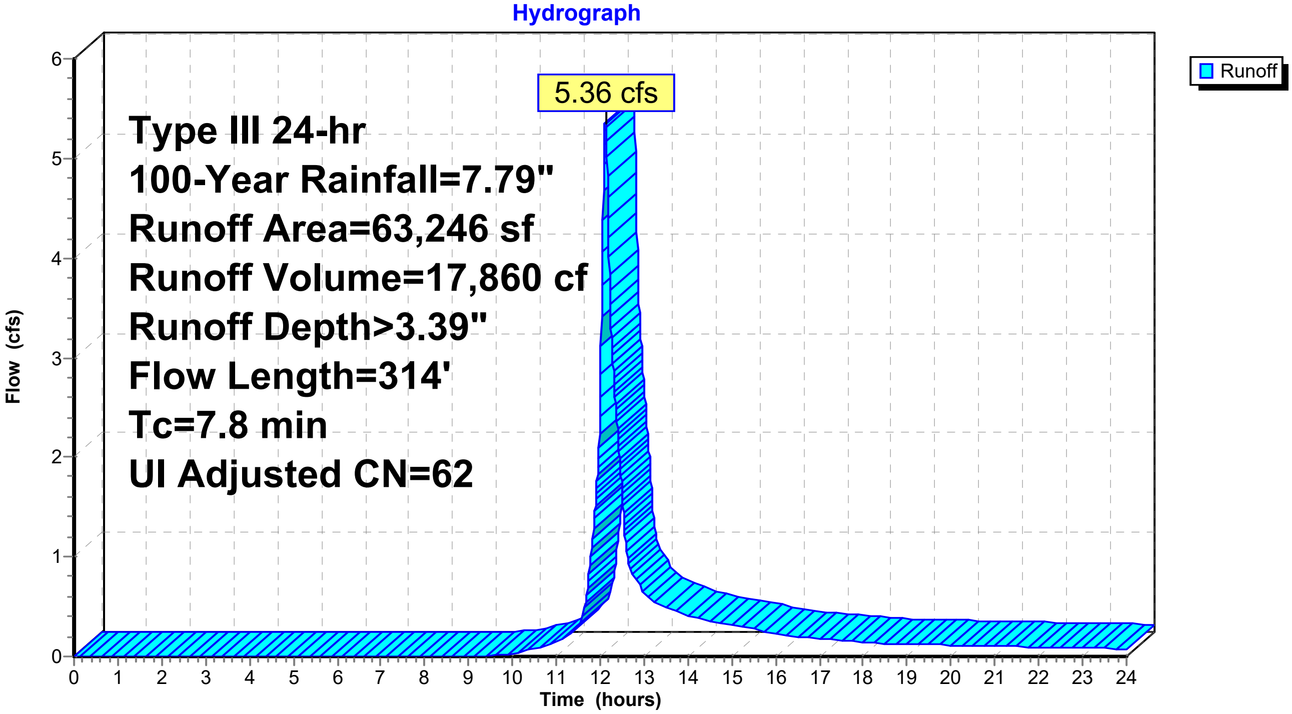
Runoff = 5.36 cfs @ 12.12 hrs, Volume= 17,860 cf, Depth> 3.39"
Routed to Pond 3P : Wetland C

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

	Area (sf)	CN	Adj	Description
	13,064	55		Woods, Good, HSG B
	41,744	61		>75% Grass cover, Good, HSG B
	3,778	98		Unconnected pavement, HSG B
	579	98		Unconnected pavement, HSG B
*	4,081	77		Woods, Good, HSG D Wetlands
	63,246	63	62	Weighted Average, UI Adjusted
	58,889			93.11% Pervious Area
	4,357			6.89% Impervious Area
	4,357			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.1	50	0.0160	0.14		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
1.7	264	0.0257	2.58		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
7.8	314	Total			

Subcatchment E-2A: To Wetland C



Summary for Subcatchment E-2B: To Wetland B

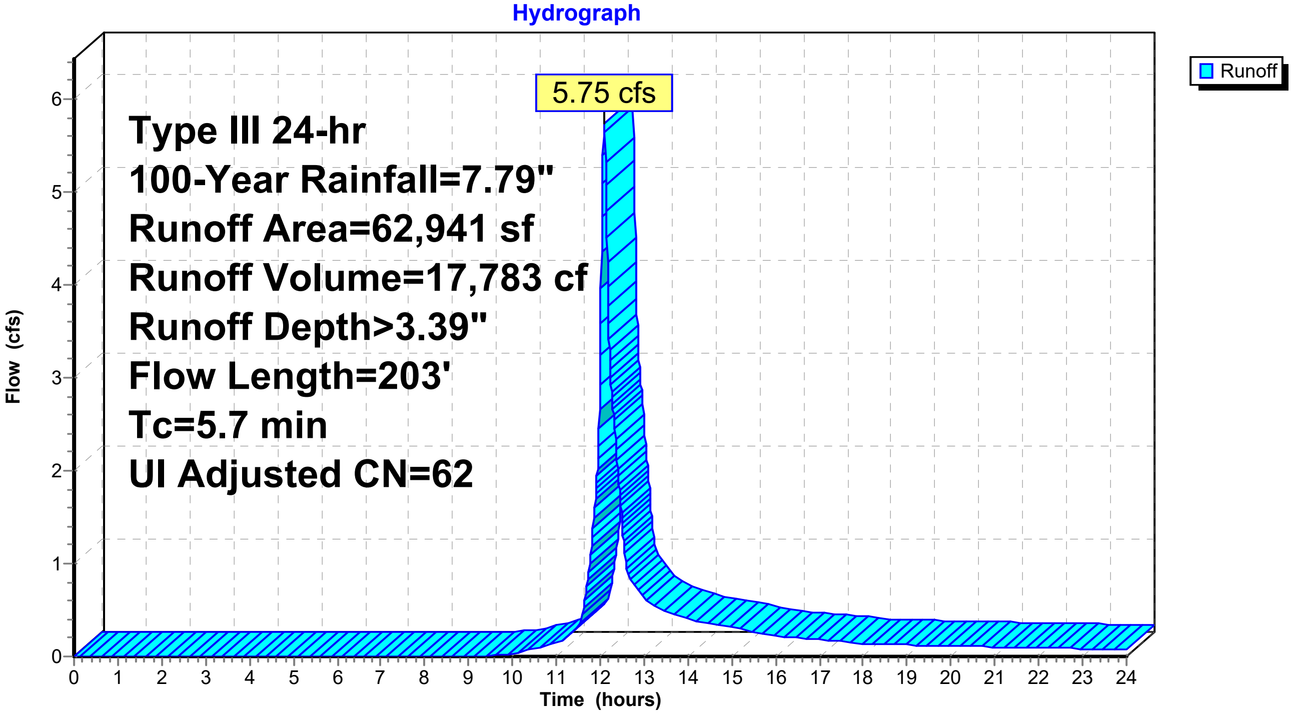
Runoff = 5.75 cfs @ 12.09 hrs, Volume= 17,783 cf, Depth> 3.39"
Routed to Pond 4P : Wetland B

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

	Area (sf)	CN	Adj	Description
	13,824	55		Woods, Good, HSG B
	41,883	61		>75% Grass cover, Good, HSG B
	1,522	98		Unconnected pavement, HSG B
	2,541	98		Unconnected pavement, HSG B
*	3,171	80		>75% Grass cover, Good, HSG D Wetlands
	62,941	63	62	Weighted Average, UI Adjusted
	58,878			93.54% Pervious Area
	4,063			6.46% Impervious Area
	4,063			100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	50	0.0320	0.18		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
1.1	153	0.0196	2.25		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
5.7	203	Total			

Subcatchment E-2B: To Wetland B



Summary for Subcatchment E-3: To Great Brook

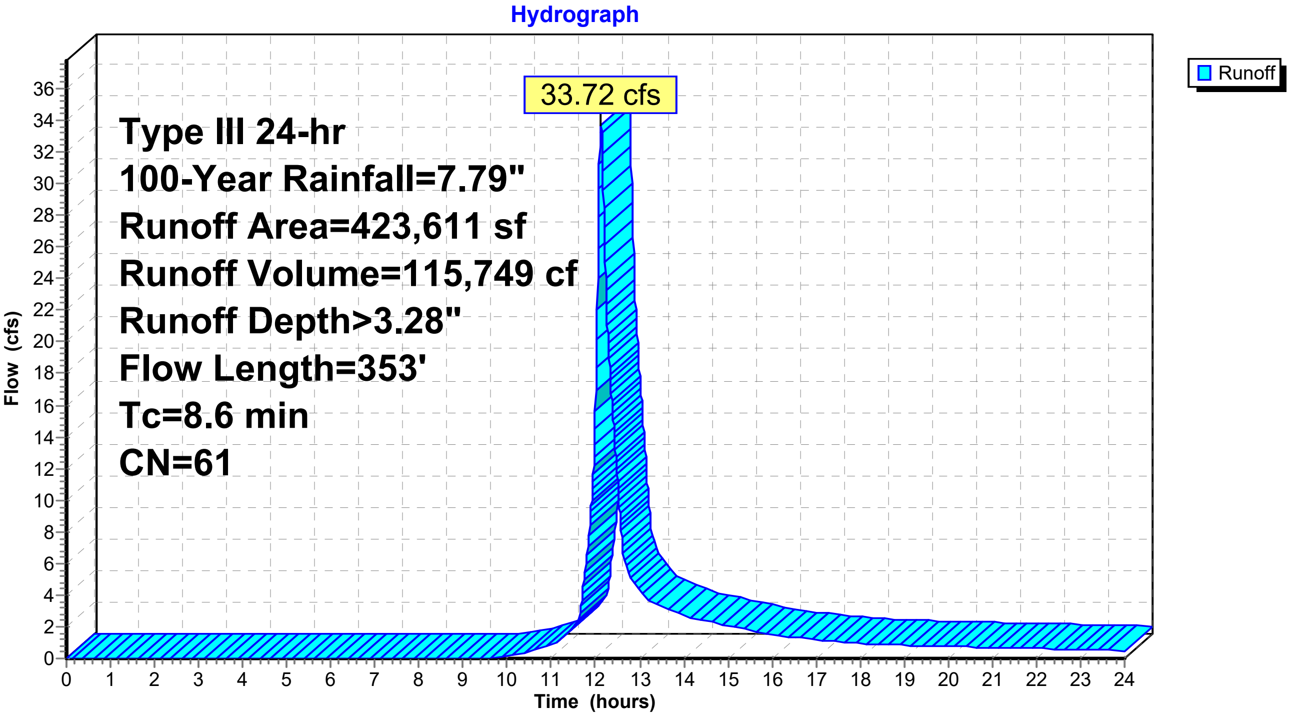
Runoff = 33.72 cfs @ 12.13 hrs, Volume= 115,749 cf, Depth> 3.28"
Routed to Link 2L : Great Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

Area (sf)	CN	Description
80,008	55	Woods, Good, HSG B
326,758	61	>75% Grass cover, Good, HSG B
9,139	96	Gravel surface, HSG B
7,562	98	Unconnected pavement, HSG B
144	98	Roofs, HSG B
423,611	61	Weighted Average
415,905		98.18% Pervious Area
7,706		1.82% Impervious Area
7,562		98.13% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.2	57	0.0789	4.52		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
2.8	246	0.0081	1.45		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
8.6	353	Total			

Subcatchment E-3: To Great Brook



Summary for Subcatchment E-4: To Rear Pond

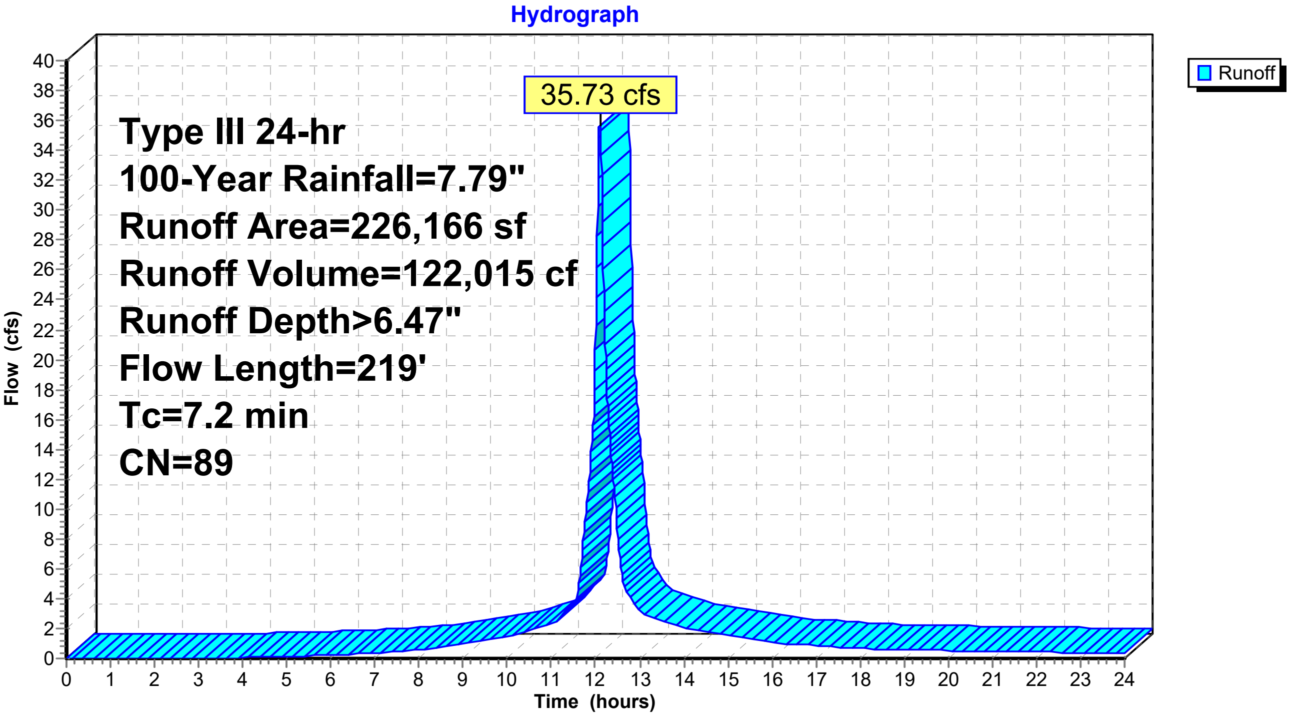
Runoff = 35.73 cfs @ 12.10 hrs, Volume= 122,015 cf, Depth> 6.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

Area (sf)	CN	Description
27,154	55	Woods, Good, HSG B
21,027	61	>75% Grass cover, Good, HSG B
127,097	98	Unconnected pavement, HSG B
50,888	98	Water Surface, HSG B
226,166	89	Weighted Average
48,181		21.30% Pervious Area
177,985		78.70% Impervious Area
127,097		71.41% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.0	20	0.2500	8.05		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
1.3	105	0.0067	1.32		**Shallow Concentrated Flow, C-D** Unpaved Kv= 16.1 fps
0.3	44	0.0364	2.86		**Shallow Concentrated Flow, D-E** Grassed Waterway Kv= 15.0 fps
7.2	219	Total			

Subcatchment E-4: To Rear Pond



Summary for Pond 3P: Wetland C

Inflow Area = 63,246 sf, 6.89% Impervious, Inflow Depth > 3.39" for 100-Year event
Inflow = 5.36 cfs @ 12.12 hrs, Volume= 17,860 cf
Outflow = 2.99 cfs @ 12.28 hrs, Volume= 12,651 cf, Atten= 44%, Lag= 10.2 min
Primary = 2.99 cfs @ 12.28 hrs, Volume= 12,651 cf
Routed to Pond 4P : Wetland B

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 345.45' @ 12.28 hrs Surf.Area= 4,955 sf Storage= 5,885 cf

Plug-Flow detention time= 156.7 min calculated for 12,651 cf (71% of inflow)
Center-of-Mass det. time= 59.0 min (902.7 - 843.7)

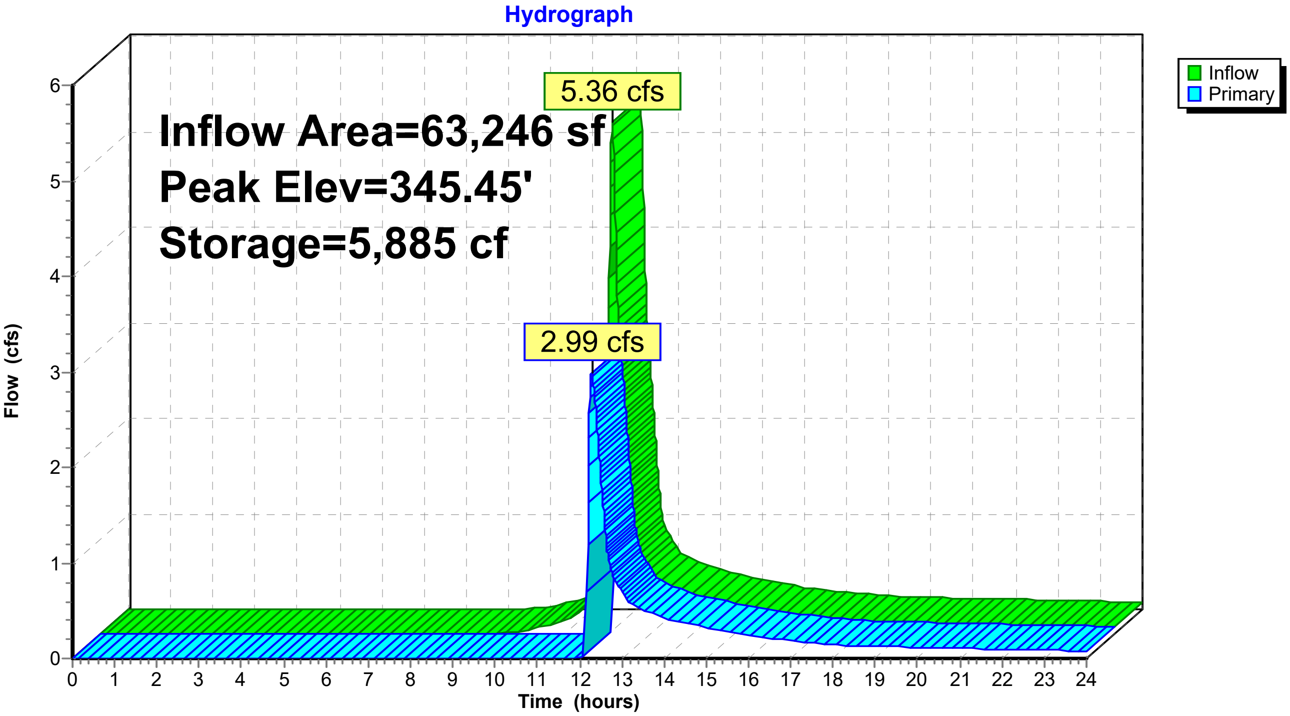
Volume	Invert	Avail.Storage	Storage Description
#1	343.00'	8,932 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
343.00	238	0	0
344.00	1,785	1,012	1,012
345.00	3,934	2,860	3,871
346.00	6,187	5,061	8,932

Device	Routing	Invert	Outlet Devices
#1	Primary	345.30'	**20.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=2.98 cfs @ 12.28 hrs HW=345.45' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 2.98 cfs @ 0.97 fps)

Pond 3P: Wetland C



Summary for Pond 4P: Wetland B

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[81] Warning: Exceeded Pond 3P by 0.24' @ 12.11 hrs

Inflow Area =        126,187 sf,   6.67% Impervious,  Inflow Depth >   2.89"    for  100-Year event
Inflow      =        5.78 cfs @   12.26 hrs,  Volume=          30,433 cf
Outflow     =        3.77 cfs @   12.47 hrs,  Volume=          29,529 cf,  Atten= 35%,  Lag= 12.6 min
Primary     =        3.77 cfs @   12.47 hrs,  Volume=          29,529 cf
    Routed to Link 2L : Great Brook

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 345.59' @ 12.47 hrs   Surf.Area= 9,732 sf   Storage= 5,705 cf

Plug-Flow detention time= 38.8 min calculated for 29,517 cf (97% of inflow)
Center-of-Mass det. time= 22.8 min ( 890.0 - 867.3 )

Volume        Invert     Avail.Storage   Storage Description
   #1        344.25'         10,492 cf   Custom Stage Data (Prismatic)Listed below (Recalc)

 Elevation          Surf.Area          Inc.Store          Cum.Store
    (feet)            (sq-ft)        (cubic-feet)       (cubic-feet)
    344.25                563                  0                  0
    345.00              3,891              1,670              1,670
    346.00             13,752              8,822             10,492

Device   Routing            Invert    Outlet Devices
   #1    Primary           344.59'    18.0"  Round Culvert
                                      L= 107.0'   RCP, mitered to conform to fill,  Ke= 0.700
                                      Inlet / Outlet Invert= 344.59' / 342.78'   S= 0.0169 '/'   Cc= 0.900
                                      n= 0.013,  Flow Area= 1.77 sf

Primary OutFlow  Max=3.77 cfs @ 12.47 hrs  HW=345.59'   (Free Discharge)
└─1=Culvert  (Inlet Controls 3.77 cfs @ 3.01 fps)
```
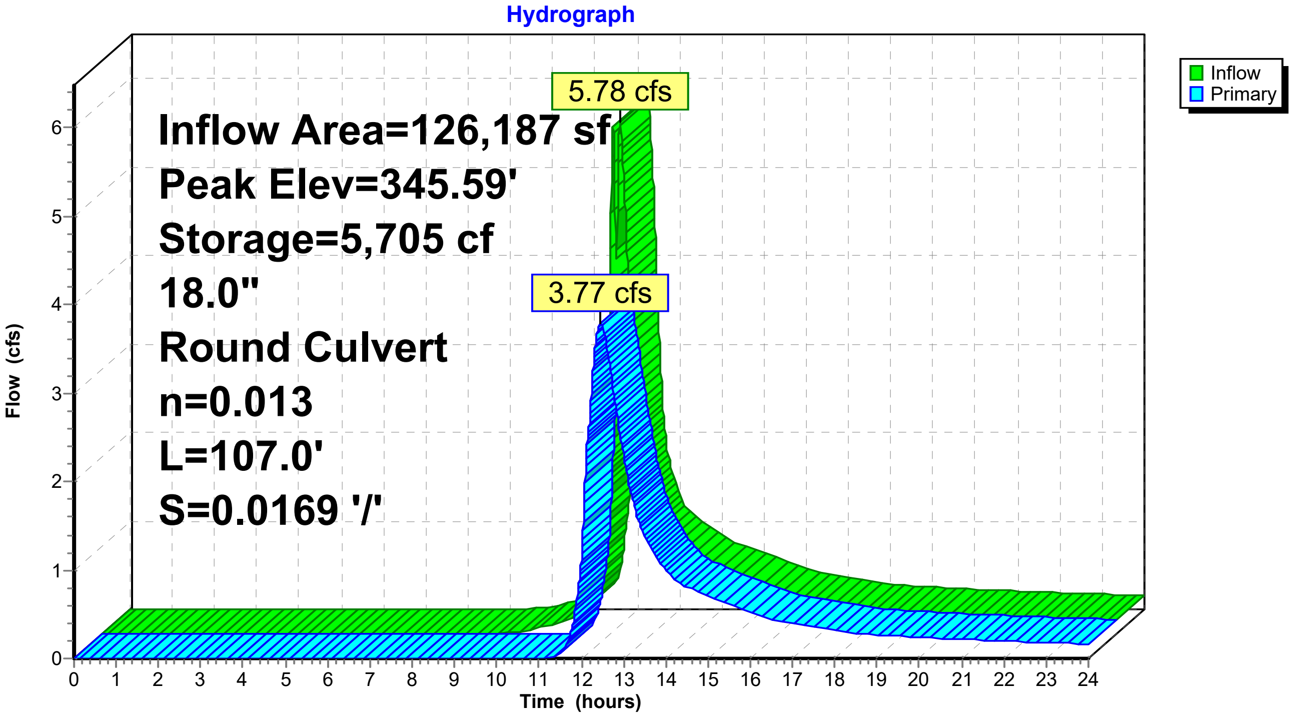

Pond 4P: Wetland B

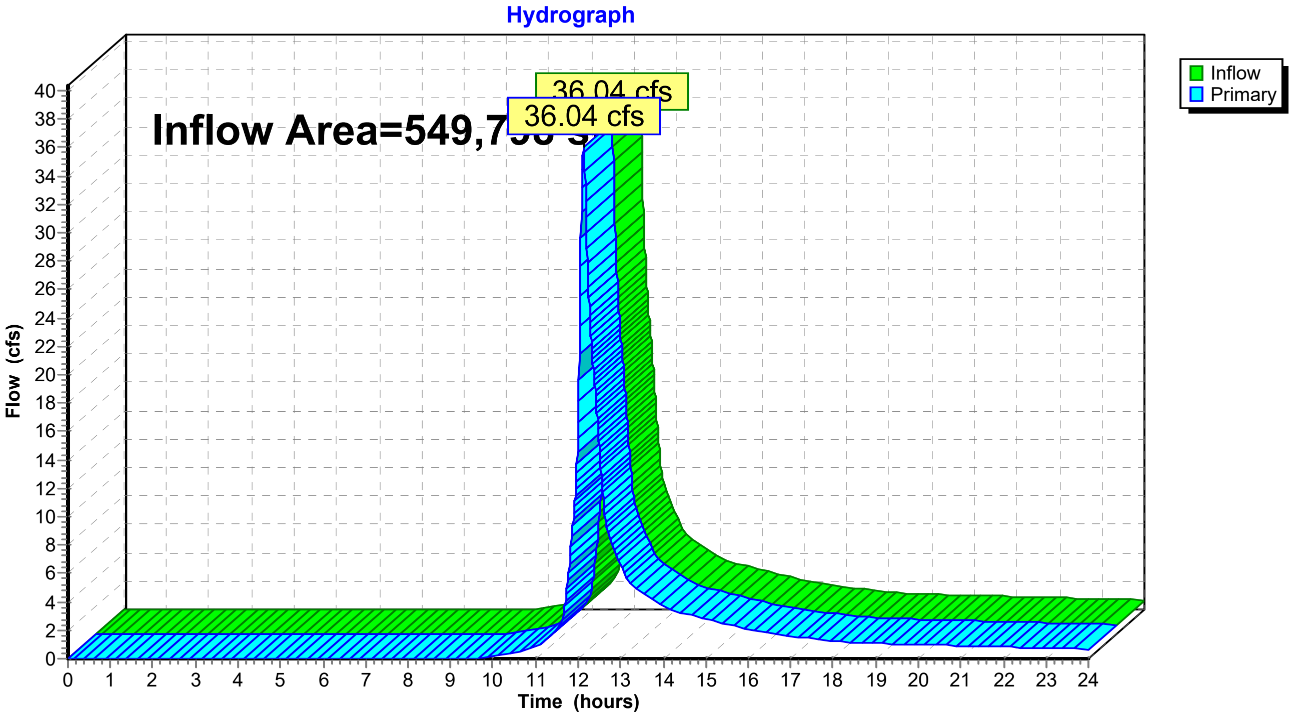


Summary for Link 2L: Great Brook

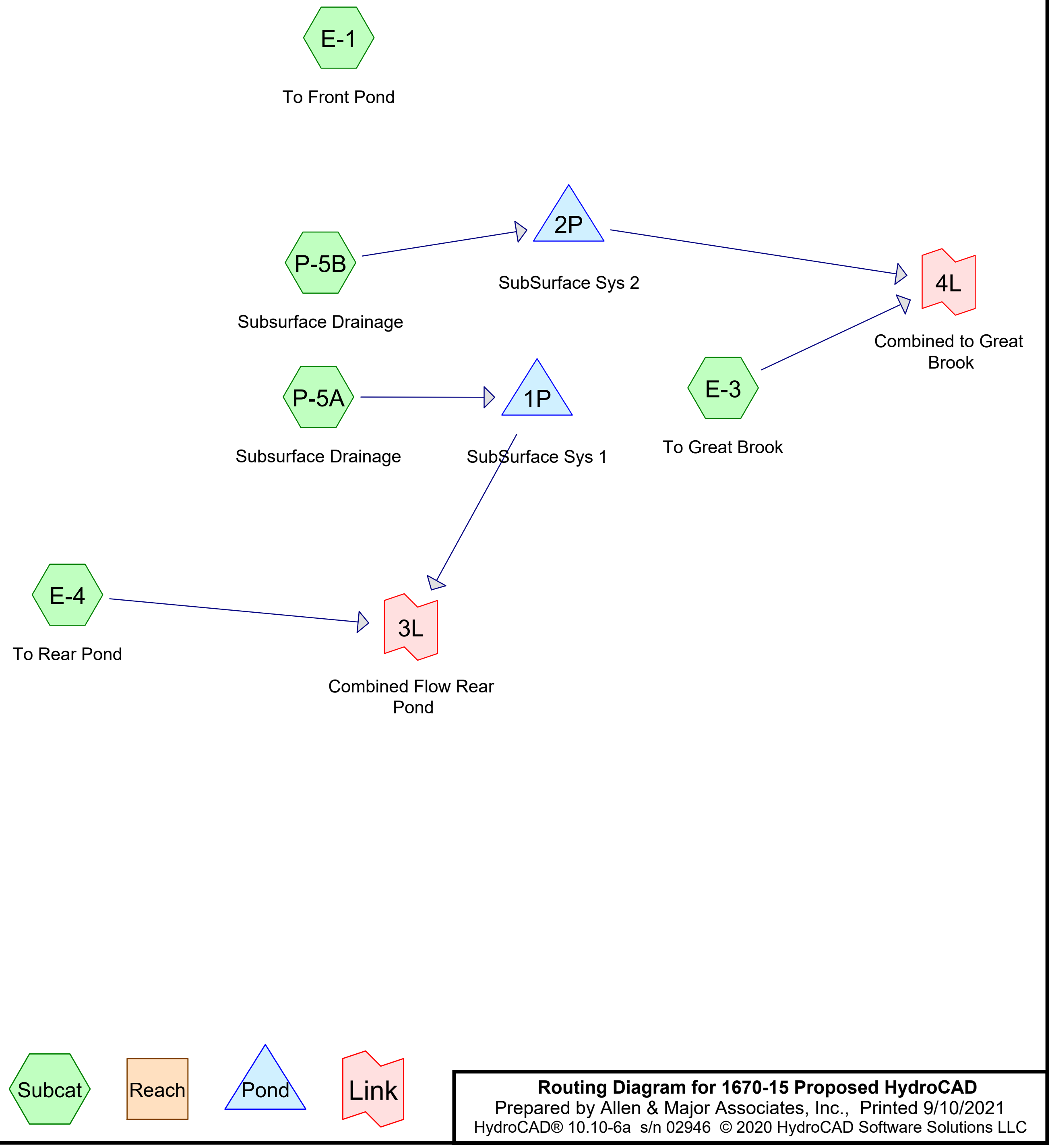
Inflow Area = 549,798 sf, 2.93% Impervious, Inflow Depth > 3.17" for 100-Year event
Inflow = 36.04 cfs @ 12.13 hrs, Volume= 145,278 cf
Primary = 36.04 cfs @ 12.13 hrs, Volume= 145,278 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 2L: Great Brook



POST-DEVELOPMENT



Routing Diagram for 1670-15 Proposed HydroCAD
Prepared by Allen & Major Associates, Inc., Printed 9/10/2021
HydroCAD® 10.10-6a s/n 02946 © 2020 HydroCAD Software Solutions LLC

Project Notes

Rainfall events imported from "NRCS-Rain.txt" for 4092 MA Essex Essex County
Rainfall events imported from "NRCS-Rain.txt" for 4165 MA Manchester Essex County

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	Type III 24-hr		Default	24.00	1	3.27	2
2	10-Year	Type III 24-hr		Default	24.00	1	5.02	2
3	25-Year	Type III 24-hr		Default	24.00	1	6.11	2
4	100-Year	Type III 24-hr		Default	24.00	1	7.79	2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
527,853	61	>75% Grass cover, Good, HSG B (E-1, E-3, E-4, P-5A, P-5B)
7,327	96	Gravel surface, HSG B (E-3)
237,425	98	Paved parking, HSG B (E-1, P-5A, P-5B)
131,980	98	Roofs, HSG B (E-1, E-3, P-5A, P-5B)
8,687	98	Unconnected pavement, HSG B (E-3)
103,504	98	Water Surface, HSG B (E-1, E-4)
102,662	55	Woods, Good, HSG B (E-1, E-3, E-4)
1,119,438	**77**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
1,119,438	HSG B	E-1, E-3, E-4, P-5A, P-5B
0	HSG C	
0	HSG D	
0	Other	
1,119,438		**TOTAL AREA**

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	Sub Num
0	527,853	0	0	0	527,853	>75% Grass cover, Good	
0	7,327	0	0	0	7,327	Gravel surface	
0	237,425	0	0	0	237,425	Paved parking	
0	131,980	0	0	0	131,980	Roofs	
0	8,687	0	0	0	8,687	Unconnected pavement	
0	103,504	0	0	0	103,504	Water Surface	
0	102,662	0	0	0	102,662	Woods, Good	
0	**1,119,438**	**0**	**0**	**0**	**1,119,438**	**TOTAL AREA**	

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	E-1	0.00	0.00	184.0	0.0155	0.013	0.0	12.0	0.0
2	1P	346.75	346.25	50.0	0.0100	0.012	0.0	18.0	0.0
3	2P	338.90	338.40	50.0	0.0100	0.012	0.0	18.0	0.0

Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E-1: To Front Pond Runoff Area=312,214 sf 53.40% Impervious Runoff Depth>1.45"
Flow Length=405' Tc=10.4 min CN=80 Runoff=10.44 cfs 37,793 cf

Subcatchment E-3: To Great Brook Runoff Area=339,925 sf 2.91% Impervious Runoff Depth>0.47"
Flow Length=420' Tc=6.0 min UI Adjusted CN=61 Runoff=2.81 cfs 13,367 cf

Subcatchment E-4: To Rear Pond Runoff Area=121,952 sf 41.73% Impervious Runoff Depth>1.14"
Flow Length=197' Tc=6.3 min CN=75 Runoff=3.56 cfs 11,584 cf

Subcatchment P-5A: Subsurface Drainage Runoff Area=137,534 sf 78.66% Impervious Runoff Depth>2.23"
Tc=6.0 min CN=90 Runoff=8.17 cfs 25,573 cf

Subcatchment P-5B: Subsurface Drainage Runoff Area=207,813 sf 70.21% Impervious Runoff Depth>1.97"
Tc=6.0 min CN=87 Runoff=11.04 cfs 34,198 cf

Pond 1P: SubSurface Sys 1 Peak Elev=348.03' Storage=11,079 cf Inflow=8.17 cfs 25,573 cf
Discarded=0.50 cfs 24,914 cf Primary=0.14 cfs 637 cf Outflow=0.65 cfs 25,551 cf

Pond 2P: SubSurface Sys 2 Peak Elev=339.48' Storage=8,304 cf Inflow=11.04 cfs 34,198 cf
Discarded=2.31 cfs 34,005 cf Primary=0.19 cfs 184 cf Outflow=2.50 cfs 34,189 cf

Link 3L: Combined Flow Rear Pond Inflow=3.56 cfs 12,221 cf
Primary=3.56 cfs 12,221 cf

Link 4L: Combined to Great Brook Inflow=2.81 cfs 13,552 cf
Primary=2.81 cfs 13,552 cf

Total Runoff Area = 1,119,438 sf Runoff Volume = 122,514 cf Average Runoff Depth = 1.31"
56.98% Pervious = 637,842 sf 43.02% Impervious = 481,596 sf

Summary for Subcatchment E-1: To Front Pond

[47] Hint: Peak is 235% of capacity of segment #4

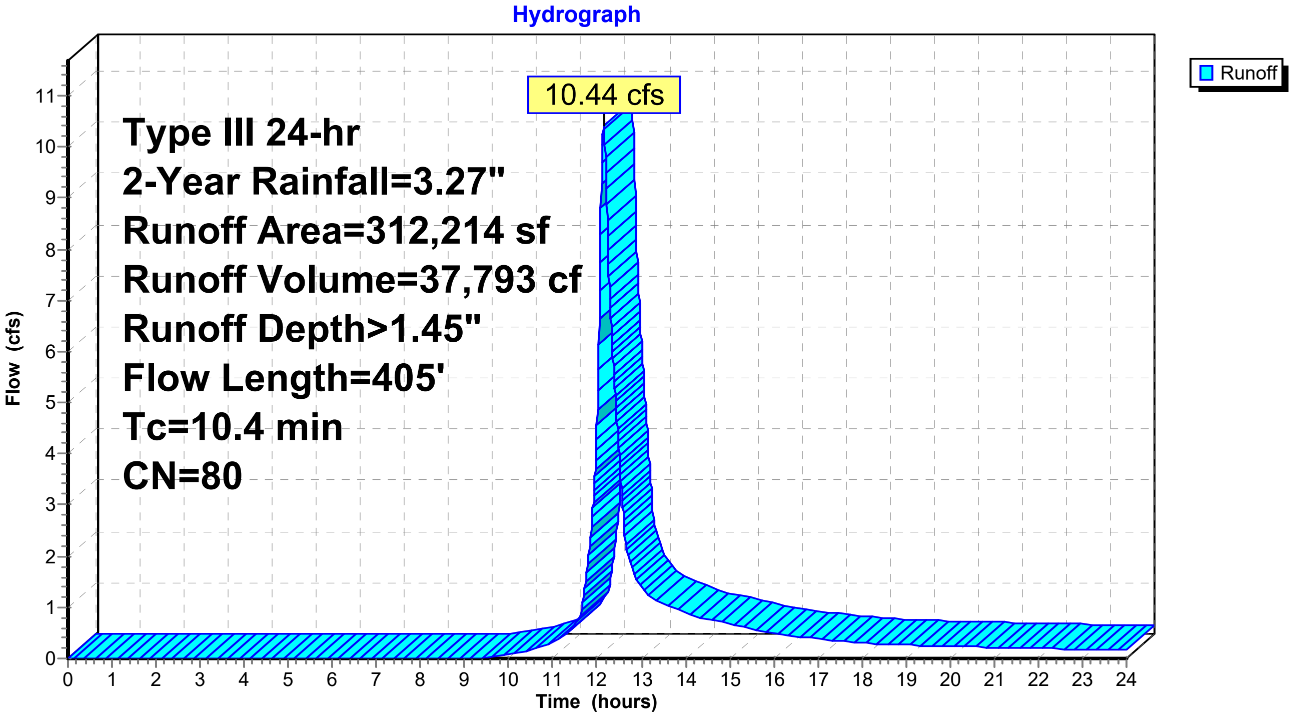
Runoff = 10.44 cfs @ 12.15 hrs, Volume= 37,793 cf, Depth> 1.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

Area (sf)	CN	Description
22,632	55	Woods, Good, HSG B
122,869	61	>75% Grass cover, Good, HSG B
80,603	98	Paved parking, HSG B
33,494	98	Roofs, HSG B
52,616	98	Water Surface, HSG B
312,214	80	Weighted Average
145,501		46.60% Pervious Area
166,713		53.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	50	0.0060	0.09		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.4	58	0.0190	2.22		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
0.1	20	0.0850	5.92		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
0.5	184	0.0155	5.65	4.44	**Pipe Channel, D-E** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013
0.4	93	0.0699	3.97		**Shallow Concentrated Flow, E-F** Grassed Waterway Kv= 15.0 fps
10.4	405	Total			

Subcatchment E-1: To Front Pond



Summary for Subcatchment E-3: To Great Brook

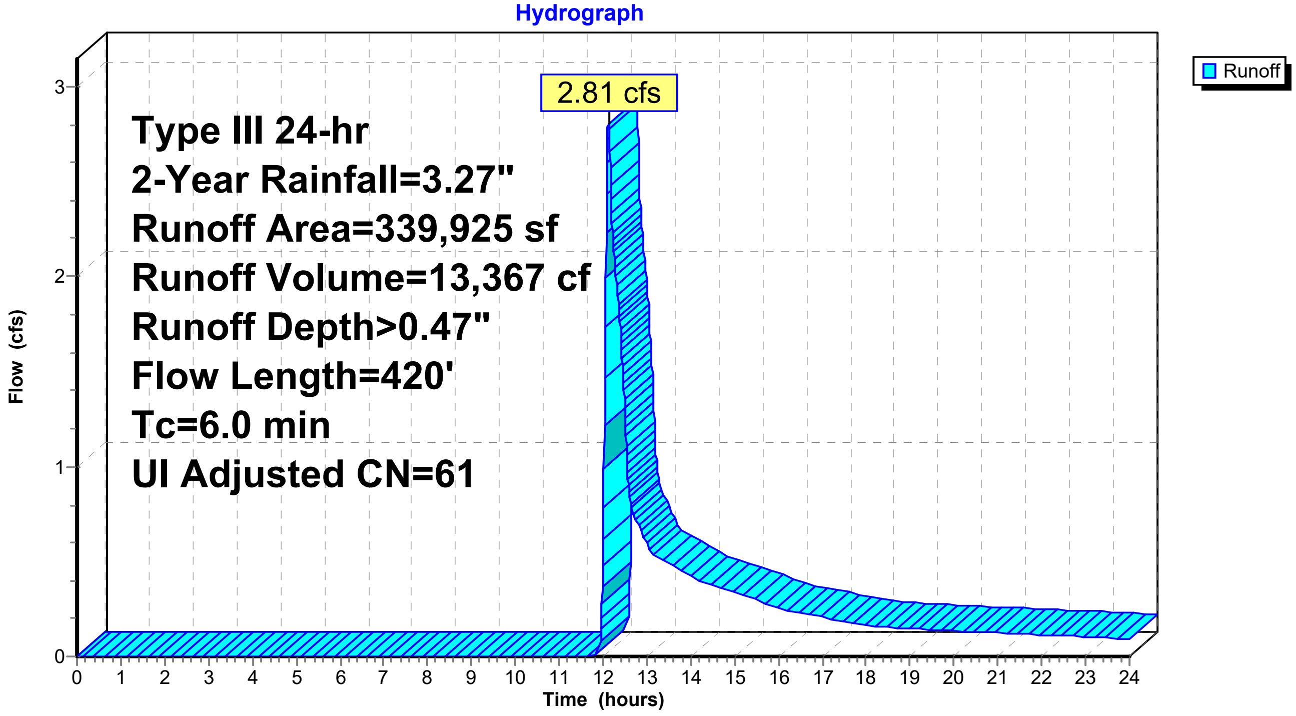
Runoff = 2.81 cfs @ 12.12 hrs, Volume= 13,367 cf, Depth> 0.47"
Routed to Link 4L : Combined to Great Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

Area (sf)	CN	Adj	Description
59,070	55		Woods, Good, HSG B
263,621	61		>75% Grass cover, Good, HSG B
7,327	96		Gravel surface, HSG B
8,687	98		Unconnected pavement, HSG B
1,220	98		Roofs, HSG B
339,925	62	61	Weighted Average, UI Adjusted
330,018			97.09% Pervious Area
9,907			2.91% Impervious Area
8,687			87.69% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	50	0.0600	0.23		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
2.4	370	0.0250	2.55		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
6.0	420	Total			

Subcatchment E-3: To Great Brook



Summary for Subcatchment E-4: To Rear Pond

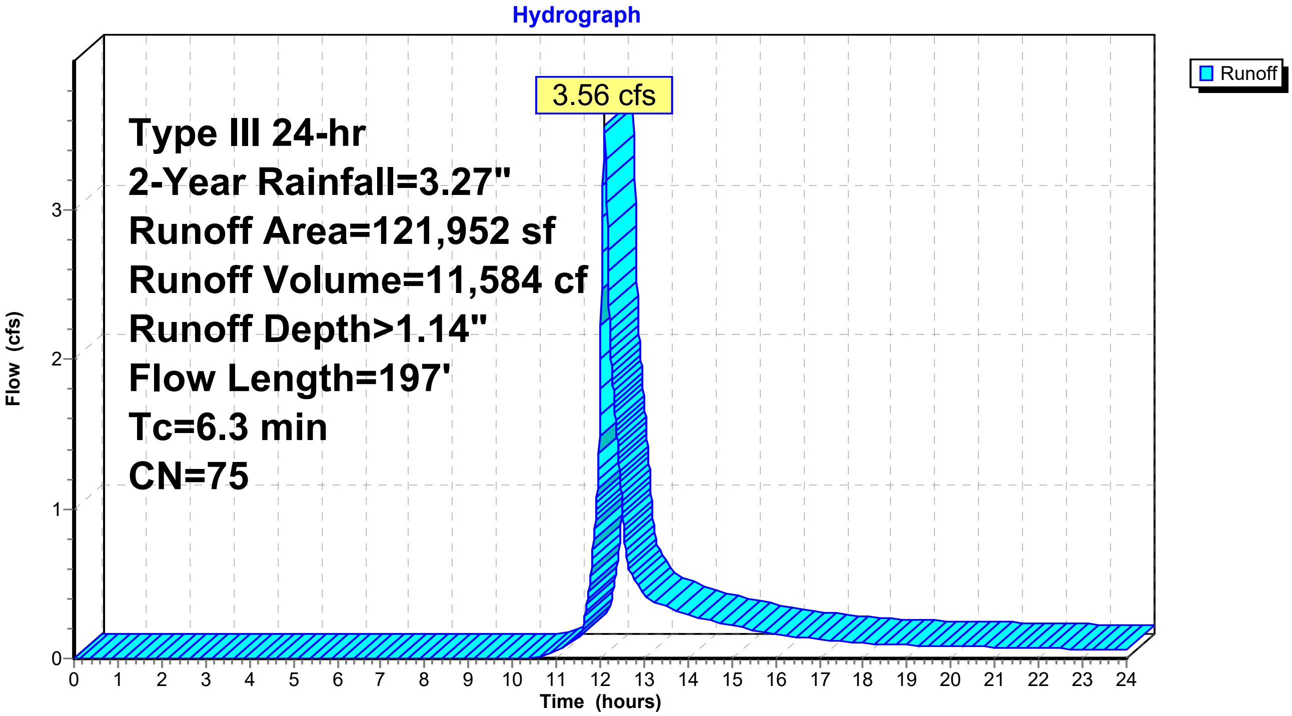
Runoff = 3.56 cfs @ 12.10 hrs, Volume= 11,584 cf, Depth> 1.14"
Routed to Link 3L : Combined Flow Rear Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

Area (sf)	CN	Description
20,960	55	Woods, Good, HSG B
50,104	61	>75% Grass cover, Good, HSG B
50,888	98	Water Surface, HSG B
121,952	75	Weighted Average
71,064		58.27% Pervious Area
50,888		41.73% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.7	147	0.0500	3.60		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
6.3	197	Total			

Subcatchment E-4: To Rear Pond



Summary for Subcatchment P-5A: Subsurface Drainage

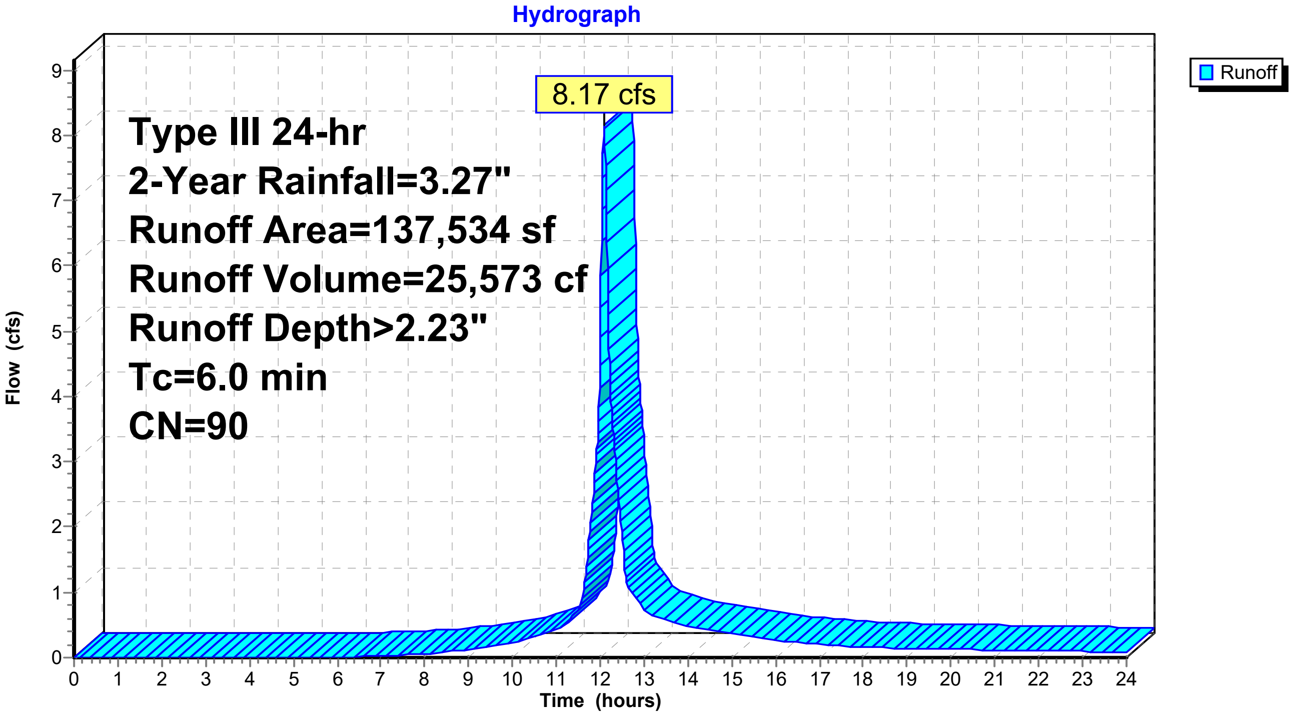
Runoff = 8.17 cfs @ 12.09 hrs, Volume= 25,573 cf, Depth> 2.23"
Routed to Pond 1P : SubSurface Sys 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

Area (sf)	CN	Description
29,348	61	>75% Grass cover, Good, HSG B
34,413	98	Roofs, HSG B
73,773	98	Paved parking, HSG B
137,534	90	Weighted Average
29,348		21.34% Pervious Area
108,186		78.66% Impervious Area

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

Subcatchment P-5A: Subsurface Drainage



Summary for Subcatchment P-5B: Subsurface Drainage

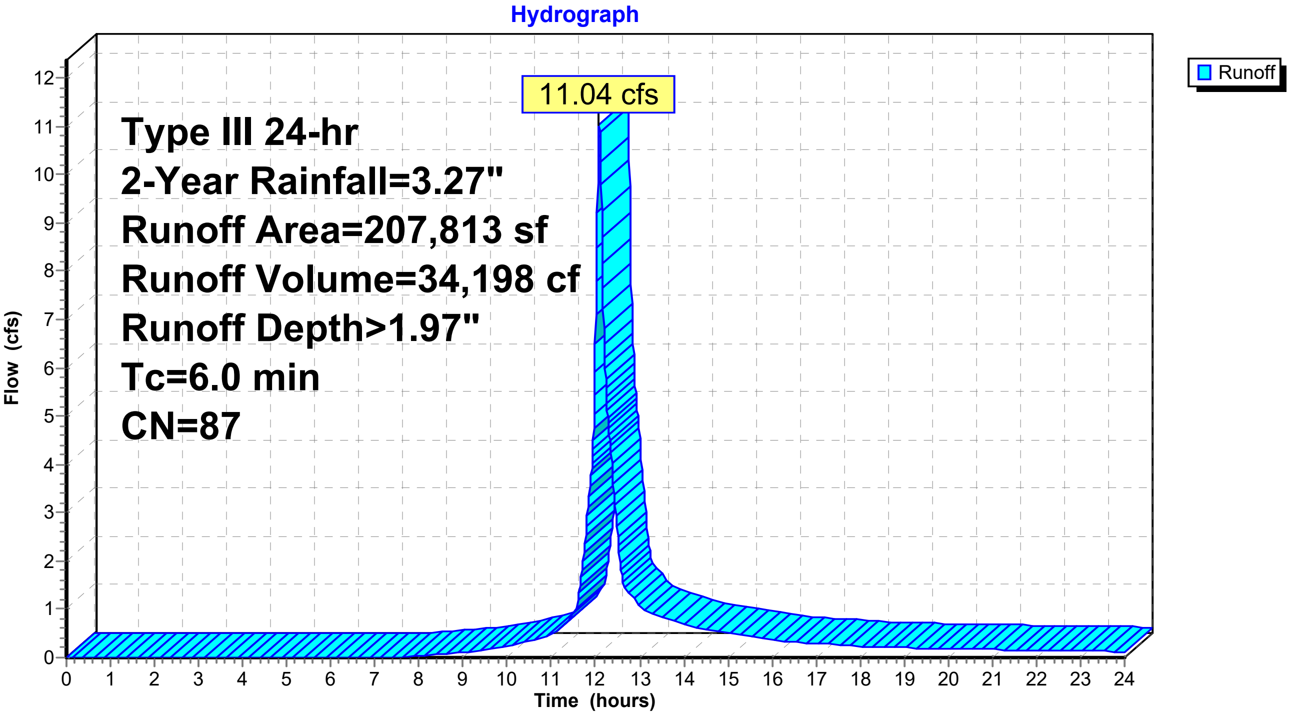
Runoff = 11.04 cfs @ 12.09 hrs, Volume= 34,198 cf, Depth> 1.97"
Routed to Pond 2P : SubSurface Sys 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.27"

Area (sf)	CN	Description
61,911	61	>75% Grass cover, Good, HSG B
62,853	98	Roofs, HSG B
83,049	98	Paved parking, HSG B
207,813	87	Weighted Average
61,911		29.79% Pervious Area
145,902		70.21% Impervious Area

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

Subcatchment P-5B: Subsurface Drainage



Summary for Pond 1P: SubSurface Sys 1

```
Inflow Area =       137,534 sf,  78.66% Impervious,  Inflow Depth >   2.23"    for  2-Year event
Inflow      =       8.17 cfs @   12.09 hrs,  Volume=          25,573 cf
Outflow     =       0.65 cfs @   13.24 hrs,  Volume=          25,551 cf,  Atten= 92%,  Lag= 69.2 min
Discarded   =       0.50 cfs @   11.26 hrs,  Volume=          24,914 cf
Primary     =       0.14 cfs @   13.24 hrs,  Volume=             637 cf
    Routed to Link 3L : Combined Flow Rear Pond

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 348.03' @ 13.24 hrs   Surf.Area= 8,982 sf   Storage= 11,079 cf

Plug-Flow detention time= 191.9 min calculated for 25,551 cf (100% of inflow)
Center-of-Mass det. time= 191.4 min ( 996.8 - 805.4 )

Volume       Invert    Avail.Storage   Storage Description
   #1A      346.25'         7,944 cf   44.25'W x 202.98'L x 3.50'H Field A
                                       31,436 cf Overall - 11,577 cf Embedded = 19,859 cf  x 40.0% Voids
   #2A      346.75'        11,577 cf   ADS_StormTech SC-740 +Cap x 252  Inside #1
                                       Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
                                       Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
                                       252 Chambers in 9 Rows
                           19,521 cf   Total Available Storage

    Storage Group A created with Chamber Wizard

Device   Routing          Invert   Outlet Devices
   #1    Discarded       346.25'   2.410 in/hr Exfiltration over Surface area
   #2    Primary         346.75'   18.0"  Round Culvert X 2.00
                                   L= 50.0'   CPP, square edge headwall,  Ke= 0.500
                                   Inlet / Outlet Invert= 346.75' / 346.25'   S= 0.0100 '/'   Cc= 0.900
                                   n= 0.012,  Flow Area= 1.77 sf
   #3    Primary         347.95'   8.0" Vert. Orifice/Grate X 6.00   C= 0.600
                                   Limited to weir flow at low heads
   #4    Device 2        348.85'   10.0' long  x 0.5' breadth Broad-Crested Rectangular Weir
                                   Head (feet)  0.20  0.40  0.60  0.80  1.00
                                   Coef. (English)  2.80  2.92  3.08  3.30  3.32

Discarded OutFlow  Max=0.50 cfs @ 11.26 hrs  HW=346.29'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.50 cfs)

Primary OutFlow  Max=0.14 cfs @ 13.24 hrs  HW=348.03'   (Free Discharge)
├─2=Culvert  (Passes 0.00 cfs of 11.86 cfs potential flow)
│  └─4=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)
└─3=Orifice/Grate  (Orifice Controls 0.14 cfs @ 0.97 fps)
```

Pond 1P: SubSurface Sys 1 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

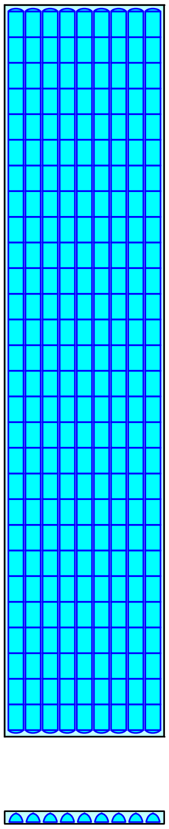
28 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 200.98' Row Length +12.0" End Stone x 2 = 202.98' Base Length
9 Rows x 51.0" Wide + 6.0" Spacing x 8 + 12.0" Side Stone x 2 = 44.25' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

252 Chambers x 45.9 cf = 11,576.9 cf Chamber Storage

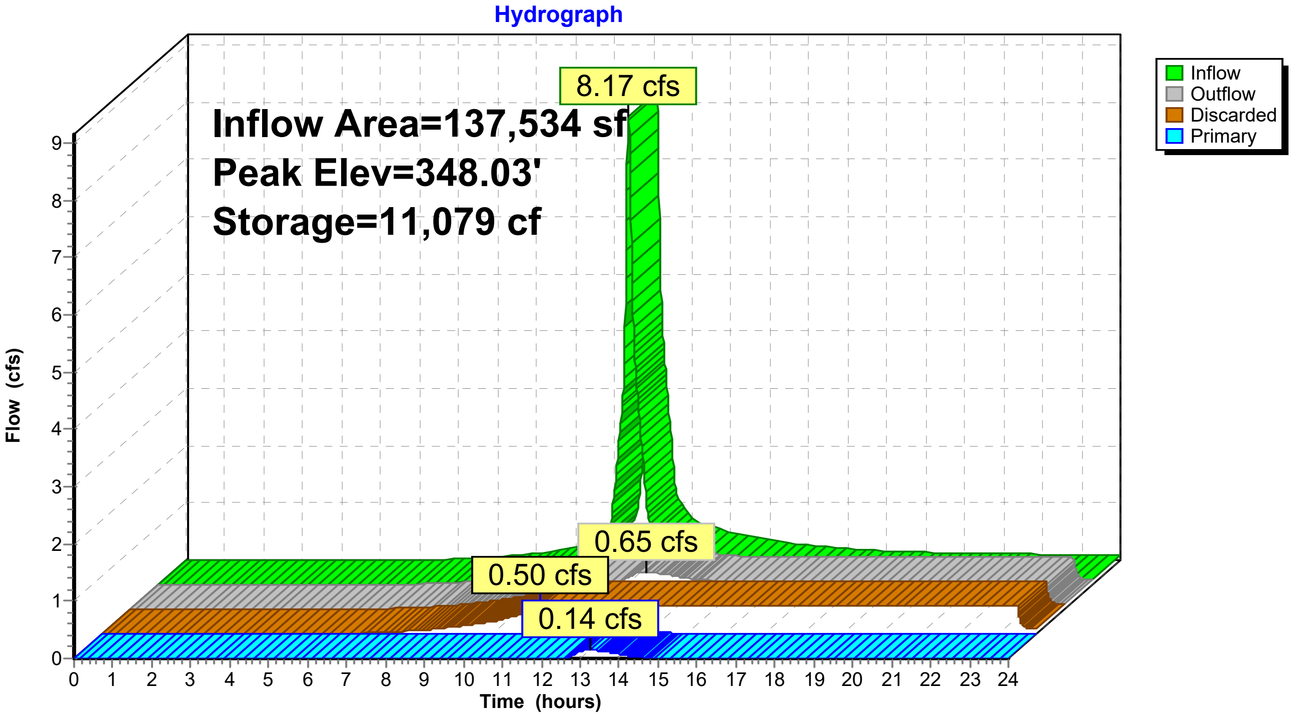
31,436.0 cf Field - 11,576.9 cf Chambers = 19,859.1 cf Stone x 40.0% Voids = 7,943.7 cf Stone Storage

Chamber Storage + Stone Storage = 19,520.5 cf = 0.448 af
Overall Storage Efficiency = 62.1%
Overall System Size = 202.98' x 44.25' x 3.50'

252 Chambers
1,164.3 cy Field
735.5 cy Stone



Pond 1P: SubSurface Sys 1



Summary for Pond 2P: SubSurface Sys 2

```
Inflow Area =         207,813 sf,  70.21% Impervious,  Inflow Depth >   1.97"    for  2-Year event
Inflow      =       11.04 cfs @   12.09 hrs,  Volume=            34,198 cf
Outflow     =        2.50 cfs @   12.51 hrs,  Volume=            34,189 cf,  Atten= 77%,  Lag= 25.0 min
Discarded   =        2.31 cfs @   11.78 hrs,  Volume=            34,005 cf
Primary     =        0.19 cfs @   12.51 hrs,  Volume=               184 cf
    Routed to Link 4L : Combined to Great Brook

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 339.48' @ 12.51 hrs   Surf.Area= 12,084 sf   Storage= 8,304 cf

Plug-Flow detention time= 20.3 min calculated for 34,175 cf (100% of inflow)
Center-of-Mass det. time= 20.1 min ( 837.4 - 817.3 )

Volume      Invert    Avail.Storage   Storage Description
   #1A      338.40'       10,633 cf   87.00'W x 138.90'L x 3.50'H Field A
                                      42,294 cf Overall - 15,711 cf Embedded = 26,583 cf  x 40.0% Voids
   #2A      338.90'       15,711 cf   ADS_StormTech SC-740 +Cap x 342  Inside #1
                                      Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
                                      Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
                                      342 Chambers in 18 Rows
                          26,345 cf   Total Available Storage

    Storage Group A created with Chamber Wizard

Device   Routing          Invert   Outlet Devices
   #1    Discarded        338.40'  8.270 in/hr Exfiltration over Surface area
   #2    Primary          338.90'  18.0"  Round Culvert X 2.00
                                   L= 50.0'   CPP, square edge headwall,  Ke= 0.500
                                   Inlet / Outlet Invert= 338.90' / 338.40'   S= 0.0100 '/'   Cc= 0.900
                                   n= 0.012,  Flow Area= 1.77 sf
   #3    Device 2         339.38'  6.0" Vert. Orifice/Grate X 6.00   C= 0.600
                                   Limited to weir flow at low heads
   #4    Device 2         341.30'  10.0' long  x 0.5' breadth Broad-Crested Rectangular Weir
                                   Head (feet)  0.20  0.40  0.60  0.80  1.00
                                   Coef. (English)  2.80  2.92  3.08  3.30  3.32

Discarded OutFlow  Max=2.31 cfs @ 11.78 hrs  HW=338.44'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 2.31 cfs)

Primary OutFlow  Max=0.19 cfs @ 12.51 hrs  HW=339.48'   (Free Discharge)
└─2=Culvert  (Passes 0.19 cfs of 3.27 cfs potential flow)
   ├─3=Orifice/Grate  (Orifice Controls 0.19 cfs @ 1.08 fps)
   └─4=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)
```

Pond 2P: SubSurface Sys 2 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

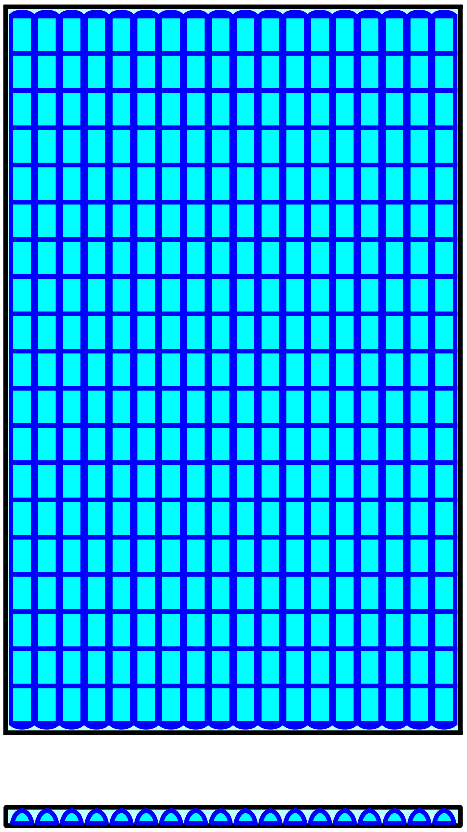
19 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 136.90' Row Length +12.0" End Stone x 2 = 138.90' Base Length
18 Rows x 51.0" Wide + 6.0" Spacing x 17 + 12.0" Side Stone x 2 = 87.00' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

342 Chambers x 45.9 cf = 15,711.5 cf Chamber Storage

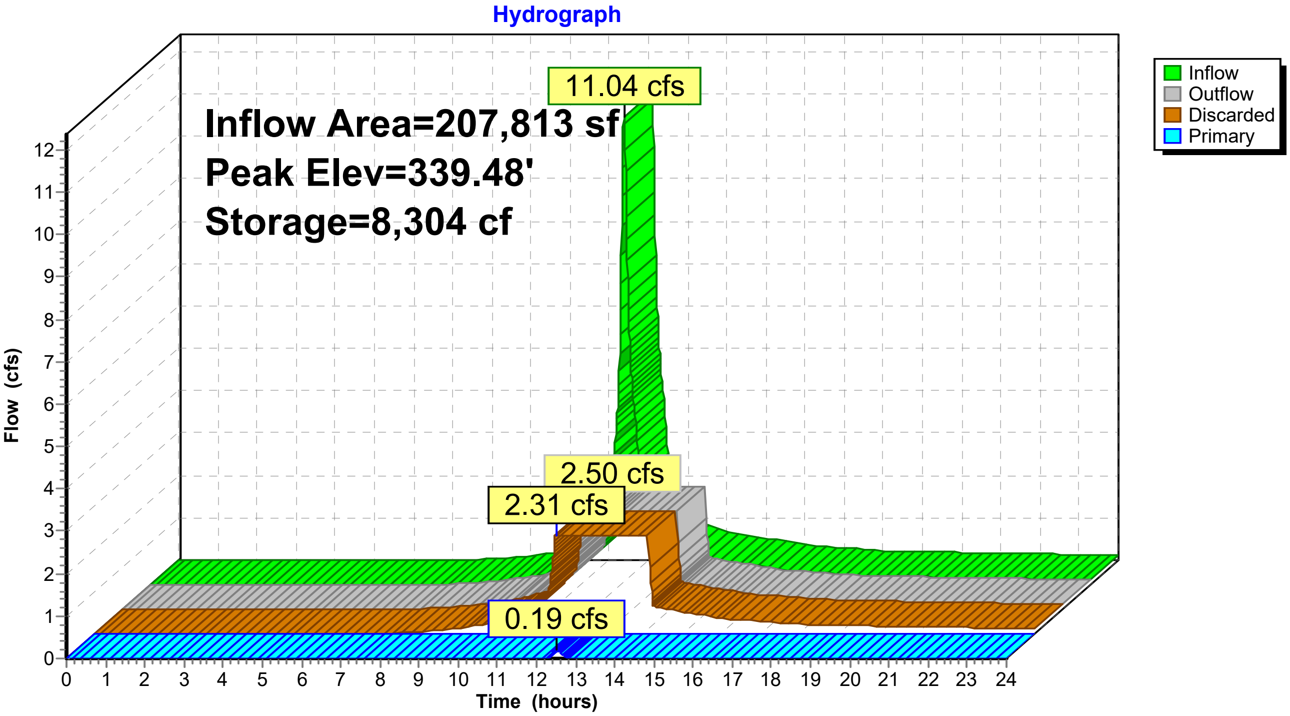
42,294.0 cf Field - 15,711.5 cf Chambers = 26,582.5 cf Stone x 40.0% Voids = 10,633.0 cf Stone Storage

Chamber Storage + Stone Storage = 26,344.5 cf = 0.605 af
Overall Storage Efficiency = 62.3%
Overall System Size = 138.90' x 87.00' x 3.50'

342 Chambers
1,566.4 cy Field
984.5 cy Stone



Pond 2P: SubSurface Sys 2

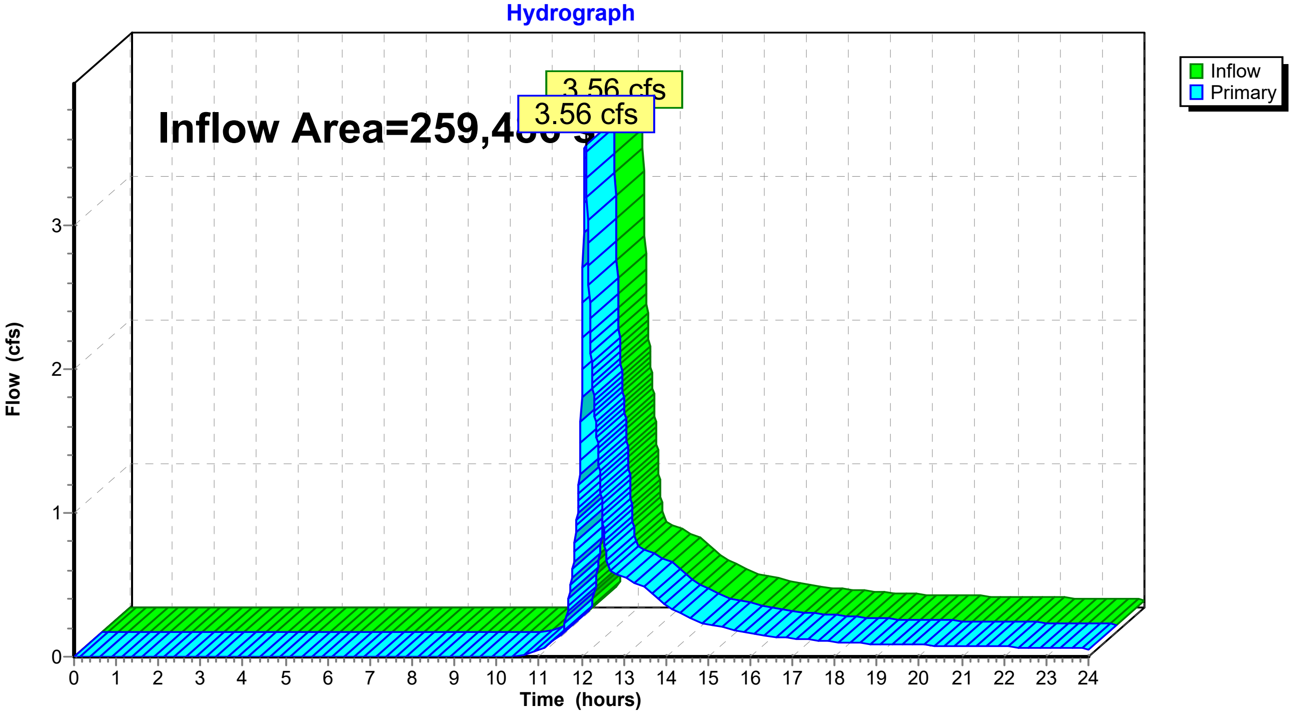


Summary for Link 3L: Combined Flow Rear Pond

Inflow Area = 259,486 sf, 61.30% Impervious, Inflow Depth > 0.57" for 2-Year event
Inflow = 3.56 cfs @ 12.10 hrs, Volume= 12,221 cf
Primary = 3.56 cfs @ 12.10 hrs, Volume= 12,221 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 3L: Combined Flow Rear Pond

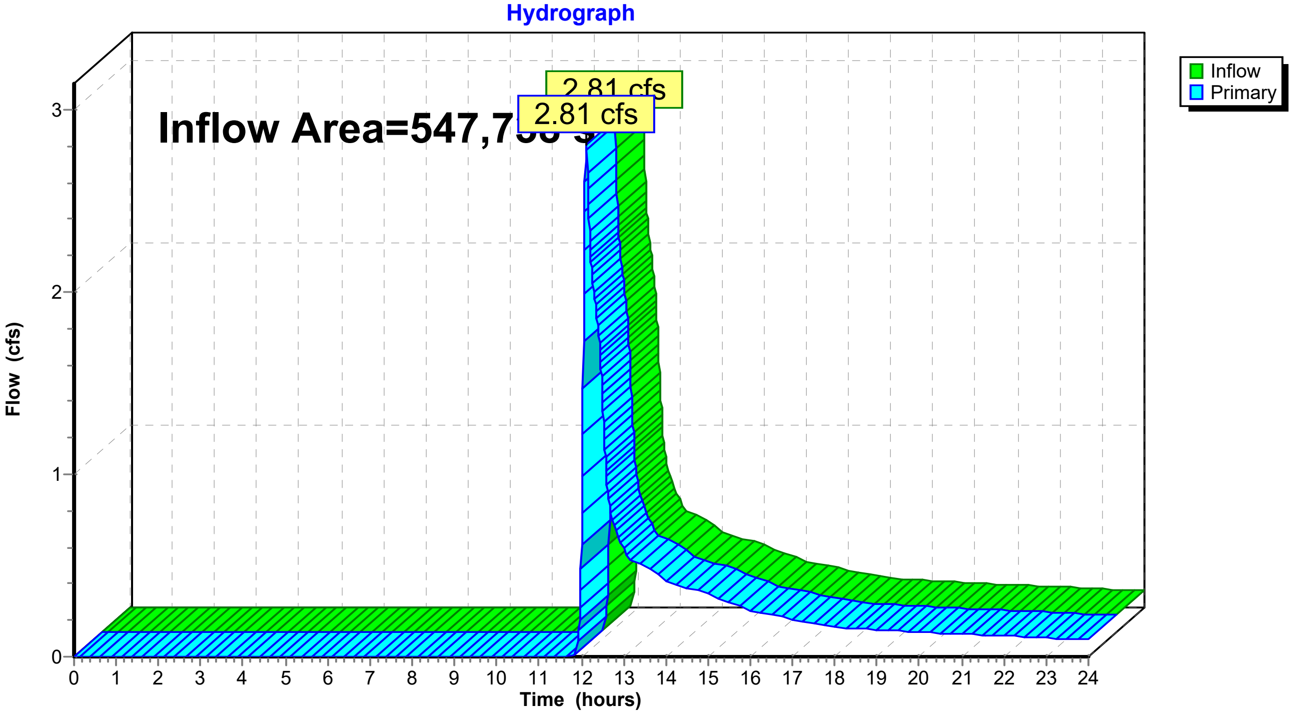


Summary for Link 4L: Combined to Great Brook

Inflow Area = 547,738 sf, 28.45% Impervious, Inflow Depth > 0.30" for 2-Year event
Inflow = 2.81 cfs @ 12.12 hrs, Volume= 13,552 cf
Primary = 2.81 cfs @ 12.12 hrs, Volume= 13,552 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 4L: Combined to Great Brook



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E-1: To Front Pond Runoff Area=312,214 sf 53.40% Impervious Runoff Depth>2.90"
Flow Length=405' Tc=10.4 min CN=80 Runoff=21.10 cfs 75,567 cf

Subcatchment E-3: To Great Brook Runoff Area=339,925 sf 2.91% Impervious Runoff Depth>1.38"
Flow Length=420' Tc=6.0 min UI Adjusted CN=61 Runoff=11.51 cfs 39,059 cf

Subcatchment E-4: To Rear Pond Runoff Area=121,952 sf 41.73% Impervious Runoff Depth>2.46"
Flow Length=197' Tc=6.3 min CN=75 Runoff=7.99 cfs 25,023 cf

Subcatchment P-5A: Subsurface Drainage Runoff Area=137,534 sf 78.66% Impervious Runoff Depth>3.89"
Tc=6.0 min CN=90 Runoff=13.91 cfs 44,606 cf

Subcatchment P-5B: Subsurface Drainage Runoff Area=207,813 sf 70.21% Impervious Runoff Depth>3.58"
Tc=6.0 min CN=87 Runoff=19.69 cfs 62,042 cf

Pond 1P: SubSurface Sys 1 Peak Elev=348.56' Storage=14,396 cf Inflow=13.91 cfs 44,606 cf
Discarded=0.50 cfs 28,265 cf Primary=5.30 cfs 13,633 cf Outflow=5.80 cfs 41,897 cf

Pond 2P: SubSurface Sys 2 Peak Elev=340.20' Storage=15,171 cf Inflow=19.69 cfs 62,042 cf
Discarded=2.31 cfs 50,660 cf Primary=4.30 cfs 11,368 cf Outflow=6.61 cfs 62,028 cf

Link 3L: Combined Flow Rear Pond Inflow=9.68 cfs 38,656 cf
Primary=9.68 cfs 38,656 cf

Link 4L: Combined to Great Brook Inflow=13.33 cfs 50,427 cf
Primary=13.33 cfs 50,427 cf

Total Runoff Area = 1,119,438 sf Runoff Volume = 246,298 cf Average Runoff Depth = 2.64"
56.98% Pervious = 637,842 sf 43.02% Impervious = 481,596 sf

Summary for Subcatchment E-1: To Front Pond

[47] Hint: Peak is 476% of capacity of segment #4

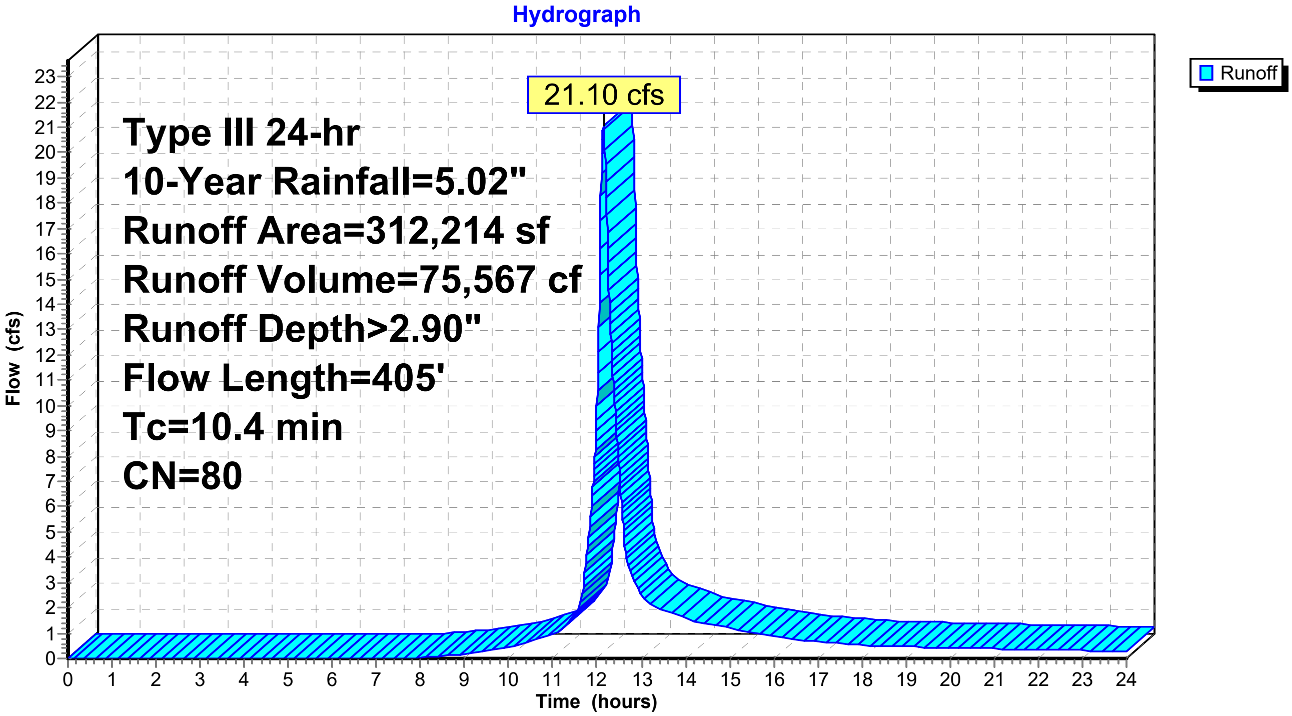
Runoff = 21.10 cfs @ 12.14 hrs, Volume= 75,567 cf, Depth> 2.90"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

Area (sf)	CN	Description
22,632	55	Woods, Good, HSG B
122,869	61	>75% Grass cover, Good, HSG B
80,603	98	Paved parking, HSG B
33,494	98	Roofs, HSG B
52,616	98	Water Surface, HSG B
312,214	80	Weighted Average
145,501		46.60% Pervious Area
166,713		53.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	50	0.0060	0.09		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.4	58	0.0190	2.22		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
0.1	20	0.0850	5.92		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
0.5	184	0.0155	5.65	4.44	**Pipe Channel, D-E** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013
0.4	93	0.0699	3.97		**Shallow Concentrated Flow, E-F** Grassed Waterway Kv= 15.0 fps
10.4	405	Total			

Subcatchment E-1: To Front Pond



Summary for Subcatchment E-3: To Great Brook

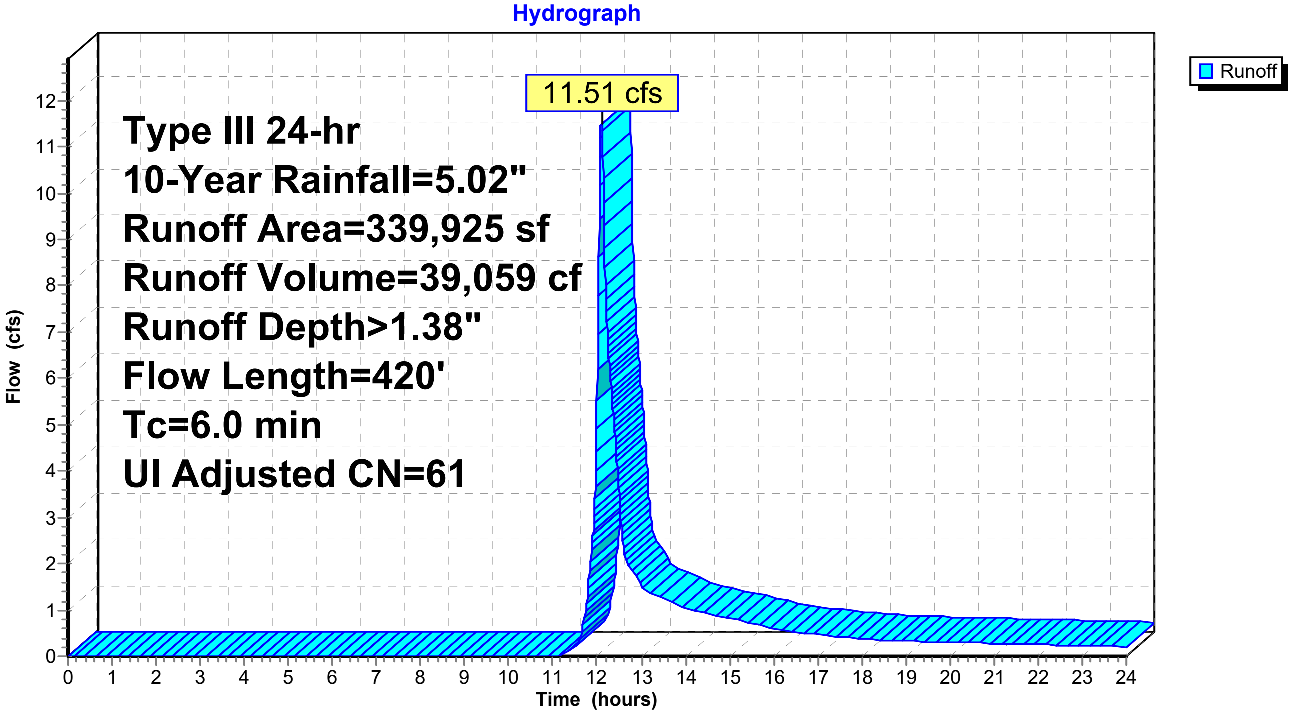
Runoff = 11.51 cfs @ 12.10 hrs, Volume= 39,059 cf, Depth> 1.38"
Routed to Link 4L : Combined to Great Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

Area (sf)	CN	Adj	Description
59,070	55		Woods, Good, HSG B
263,621	61		>75% Grass cover, Good, HSG B
7,327	96		Gravel surface, HSG B
8,687	98		Unconnected pavement, HSG B
1,220	98		Roofs, HSG B
339,925	62	61	Weighted Average, UI Adjusted
330,018			97.09% Pervious Area
9,907			2.91% Impervious Area
8,687			87.69% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	50	0.0600	0.23		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
2.4	370	0.0250	2.55		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
6.0	420	Total			

Subcatchment E-3: To Great Brook



Summary for Subcatchment E-4: To Rear Pond

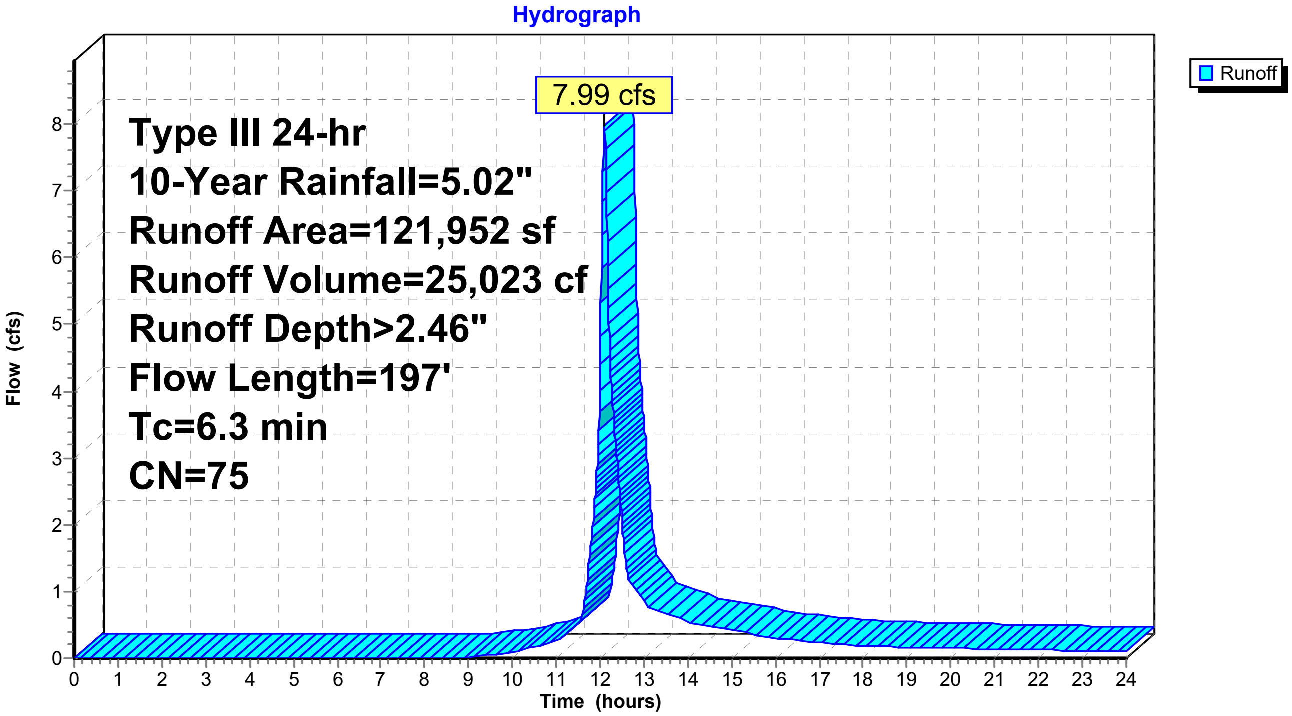
Runoff = 7.99 cfs @ 12.09 hrs, Volume= 25,023 cf, Depth> 2.46"
Routed to Link 3L : Combined Flow Rear Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

Area (sf)	CN	Description
20,960	55	Woods, Good, HSG B
50,104	61	>75% Grass cover, Good, HSG B
50,888	98	Water Surface, HSG B
121,952	75	Weighted Average
71,064		58.27% Pervious Area
50,888		41.73% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.7	147	0.0500	3.60		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
6.3	197	Total			

Subcatchment E-4: To Rear Pond



Summary for Subcatchment P-5A: Subsurface Drainage

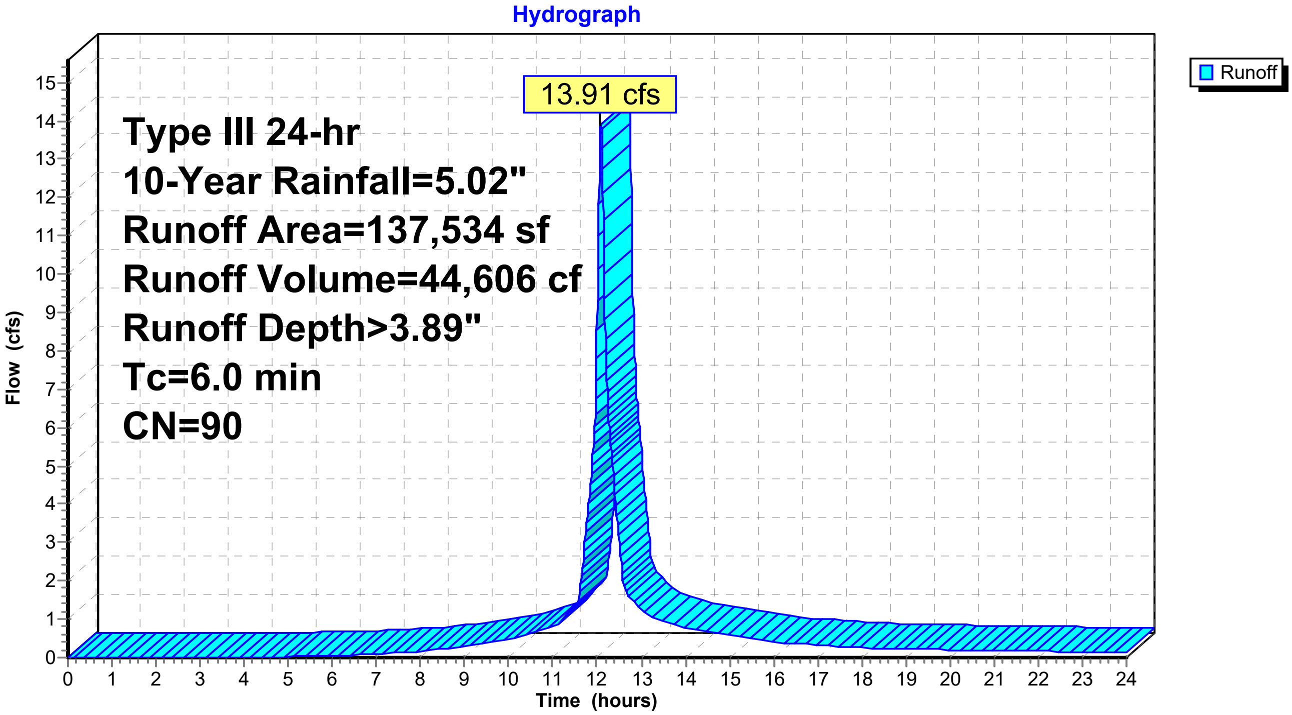
Runoff = 13.91 cfs @ 12.09 hrs, Volume= 44,606 cf, Depth> 3.89"
Routed to Pond 1P : SubSurface Sys 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

Area (sf)	CN	Description
29,348	61	>75% Grass cover, Good, HSG B
34,413	98	Roofs, HSG B
73,773	98	Paved parking, HSG B
137,534	90	Weighted Average
29,348		21.34% Pervious Area
108,186		78.66% Impervious Area

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

Subcatchment P-5A: Subsurface Drainage



Summary for Subcatchment P-5B: Subsurface Drainage

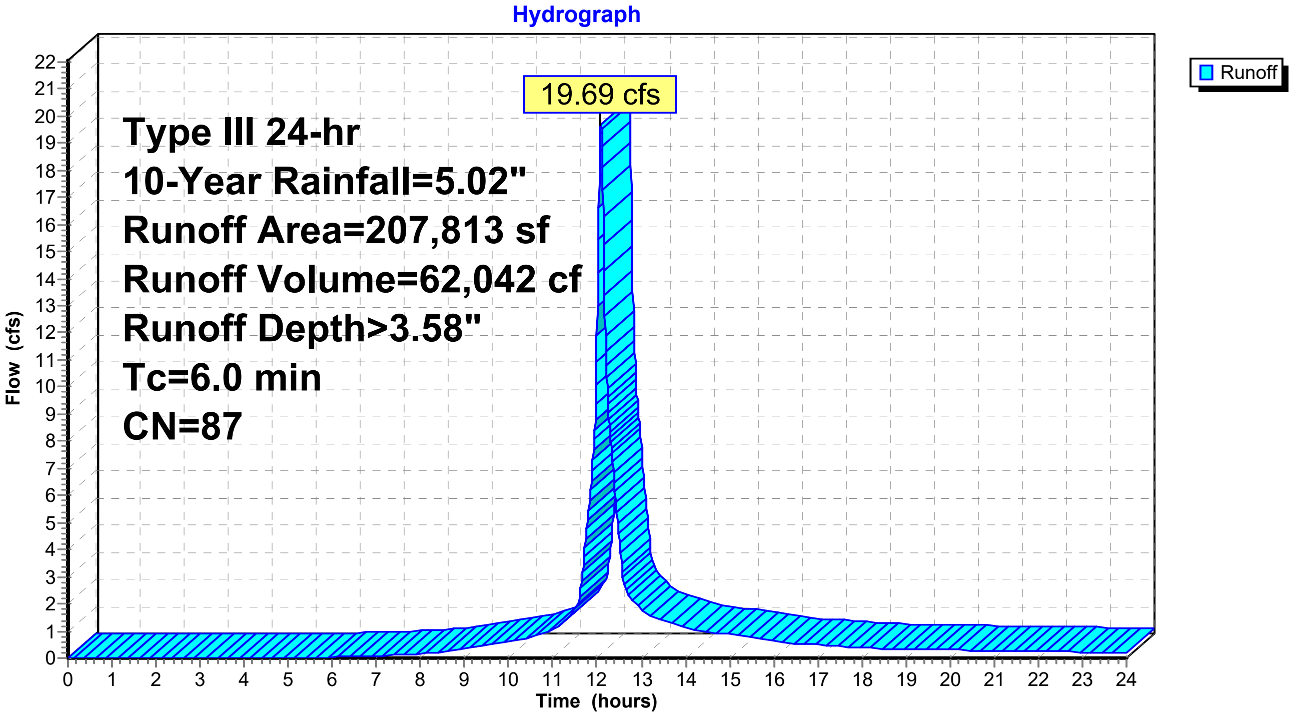
Runoff = 19.69 cfs @ 12.09 hrs, Volume= 62,042 cf, Depth> 3.58"
Routed to Pond 2P : SubSurface Sys 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.02"

Area (sf)	CN	Description
61,911	61	>75% Grass cover, Good, HSG B
62,853	98	Roofs, HSG B
83,049	98	Paved parking, HSG B
207,813	87	Weighted Average
61,911		29.79% Pervious Area
145,902		70.21% Impervious Area

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

Subcatchment P-5B: Subsurface Drainage



Summary for Pond 1P: SubSurface Sys 1

Inflow Area = 137,534 sf, 78.66% Impervious, Inflow Depth > 3.89" for 10-Year event
Inflow = 13.91 cfs @ 12.09 hrs, Volume= 44,606 cf
Outflow = 5.80 cfs @ 12.29 hrs, Volume= 41,897 cf, Atten= 58%, Lag= 12.3 min
Discarded = 0.50 cfs @ 10.17 hrs, Volume= 28,265 cf
Primary = 5.30 cfs @ 12.29 hrs, Volume= 13,633 cf
Routed to Link 3L : Combined Flow Rear Pond

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 348.56' @ 12.29 hrs Surf.Area= 8,982 sf Storage= 14,396 cf

Plug-Flow detention time= 145.2 min calculated for 41,880 cf (94% of inflow)
Center-of-Mass det. time= 112.4 min (902.4 - 790.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	346.25'	7,944 cf	**44.25'W x 202.98'L x 3.50'H Field A** 31,436 cf Overall - 11,577 cf Embedded = 19,859 cf x 40.0% Voids
#2A	346.75'	11,577 cf	**ADS_StormTech SC-740 +Cap** x 252 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 252 Chambers in 9 Rows
		19,521 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	346.25'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	346.75'	**18.0" Round Culvert X 2.00** L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.75' / 346.25' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf
#3	Primary	347.95'	**8.0" Vert. Orifice/Grate X 6.00** C= 0.600 Limited to weir flow at low heads
#4	Device 2	348.85'	**10.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.50 cfs @ 10.17 hrs HW=346.29' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.50 cfs)

Primary OutFlow Max=5.30 cfs @ 12.29 hrs HW=348.56' (Free Discharge)
├—**2=Culvert** (Passes 0.00 cfs of 17.49 cfs potential flow)
│ ↑—**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
└—**3=Orifice/Grate** (Orifice Controls 5.30 cfs @ 2.65 fps)

Pond 1P: SubSurface Sys 1 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

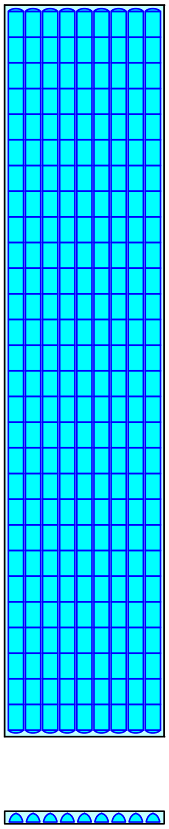
28 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 200.98' Row Length +12.0" End Stone x 2 = 202.98' Base Length
9 Rows x 51.0" Wide + 6.0" Spacing x 8 + 12.0" Side Stone x 2 = 44.25' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

252 Chambers x 45.9 cf = 11,576.9 cf Chamber Storage

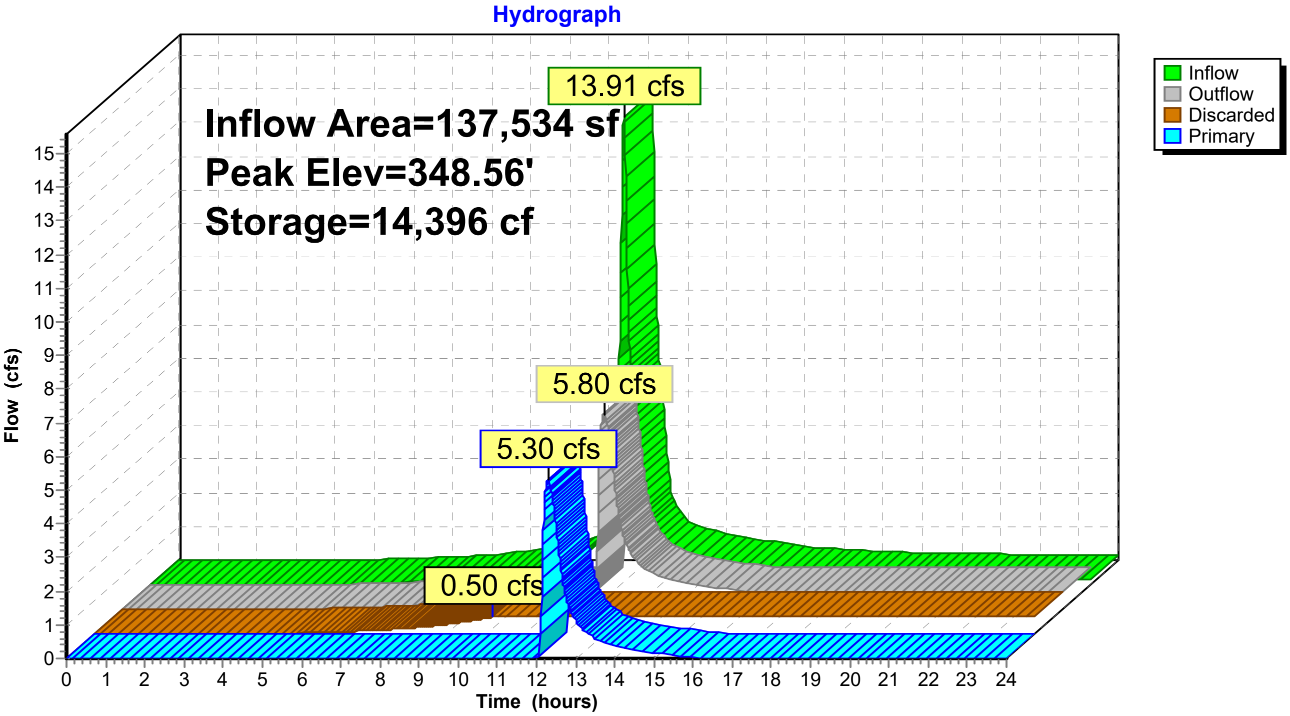
31,436.0 cf Field - 11,576.9 cf Chambers = 19,859.1 cf Stone x 40.0% Voids = 7,943.7 cf Stone Storage

Chamber Storage + Stone Storage = 19,520.5 cf = 0.448 af
Overall Storage Efficiency = 62.1%
Overall System Size = 202.98' x 44.25' x 3.50'

252 Chambers
1,164.3 cy Field
735.5 cy Stone



Pond 1P: SubSurface Sys 1



Summary for Pond 2P: SubSurface Sys 2

```
Inflow Area =       207,813 sf,  70.21% Impervious,  Inflow Depth >   3.58"    for  10-Year event
Inflow      =      19.69 cfs @   12.09 hrs,  Volume=          62,042 cf
Outflow     =       6.61 cfs @   12.38 hrs,  Volume=          62,028 cf,  Atten= 66%,  Lag= 17.5 min
Discarded   =       2.31 cfs @   11.63 hrs,  Volume=          50,660 cf
Primary     =       4.30 cfs @   12.38 hrs,  Volume=          11,368 cf
   Routed to Link 4L : Combined to Great Brook

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 340.20' @ 12.38 hrs   Surf.Area= 12,084 sf   Storage= 15,171 cf

Plug-Flow detention time= 24.4 min calculated for 62,028 cf (100% of inflow)
Center-of-Mass det. time= 24.2 min ( 824.7 - 800.4 )

Volume      Invert    Avail.Storage   Storage Description
   #1A     338.40'        10,633 cf   87.00'W x 138.90'L x 3.50'H Field A
                                      42,294 cf Overall - 15,711 cf Embedded = 26,583 cf  x 40.0% Voids
   #2A     338.90'        15,711 cf   ADS_StormTech SC-740 +Cap x 342  Inside #1
                                      Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
                                      Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
                                      342 Chambers in 18 Rows
                          26,345 cf   Total Available Storage

   Storage Group A created with Chamber Wizard

Device   Routing        Invert   Outlet Devices
   #1    Discarded     338.40'   8.270 in/hr Exfiltration over Surface area
   #2    Primary       338.90'   18.0"  Round Culvert X 2.00
                                 L= 50.0'   CPP, square edge headwall,  Ke= 0.500
                                 Inlet / Outlet Invert= 338.90' / 338.40'   S= 0.0100 '/'   Cc= 0.900
                                 n= 0.012,  Flow Area= 1.77 sf
   #3    Device 2      339.38'   6.0" Vert. Orifice/Grate X 6.00   C= 0.600
                                 Limited to weir flow at low heads
   #4    Device 2      341.30'   10.0' long  x 0.5' breadth Broad-Crested Rectangular Weir
                                 Head (feet)  0.20  0.40  0.60  0.80  1.00
                                 Coef. (English)  2.80  2.92  3.08  3.30  3.32

Discarded OutFlow  Max=2.31 cfs @ 11.63 hrs  HW=338.44'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 2.31 cfs)

Primary OutFlow  Max=4.30 cfs @ 12.38 hrs  HW=340.20'   (Free Discharge)
└─2=Culvert  (Passes 4.30 cfs of 12.16 cfs potential flow)
   ├─3=Orifice/Grate  (Orifice Controls 4.30 cfs @ 3.65 fps)
   └─4=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)
```

Pond 2P: SubSurface Sys 2 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

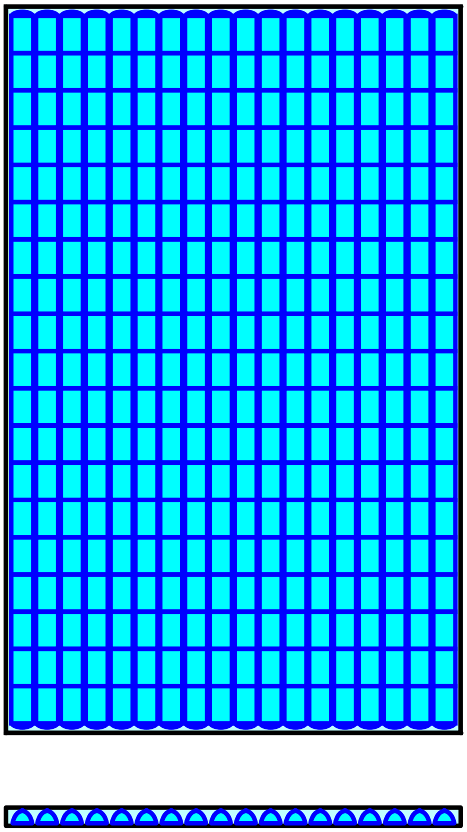
19 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 136.90' Row Length +12.0" End Stone x 2 = 138.90' Base Length
18 Rows x 51.0" Wide + 6.0" Spacing x 17 + 12.0" Side Stone x 2 = 87.00' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

342 Chambers x 45.9 cf = 15,711.5 cf Chamber Storage

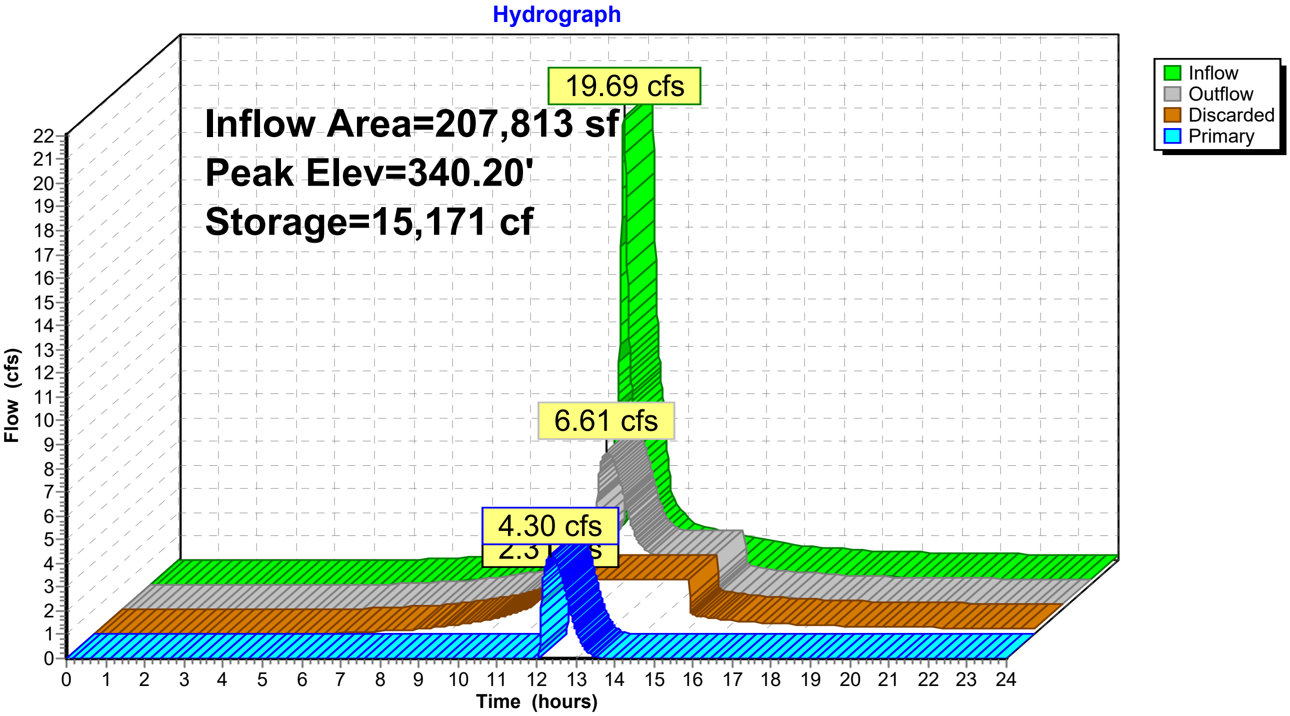
42,294.0 cf Field - 15,711.5 cf Chambers = 26,582.5 cf Stone x 40.0% Voids = 10,633.0 cf Stone Storage

Chamber Storage + Stone Storage = 26,344.5 cf = 0.605 af
Overall Storage Efficiency = 62.3%
Overall System Size = 138.90' x 87.00' x 3.50'

342 Chambers
1,566.4 cy Field
984.5 cy Stone



Pond 2P: SubSurface Sys 2

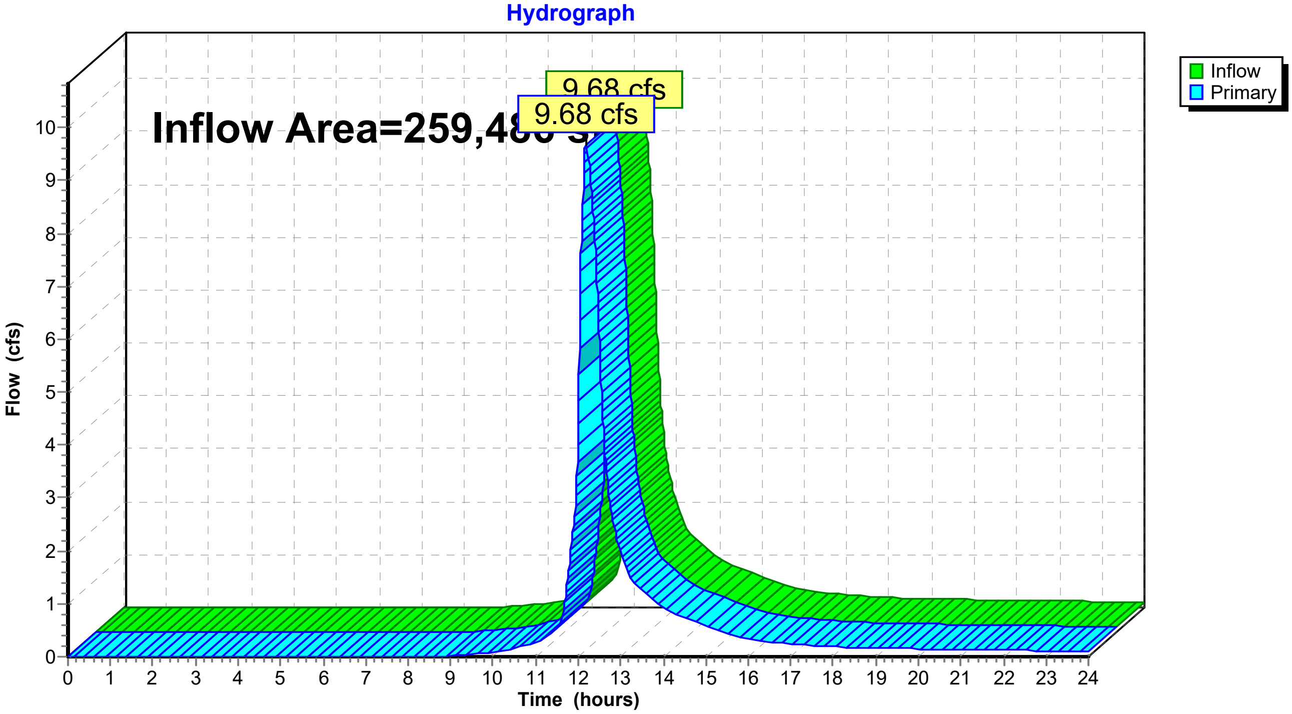


Summary for Link 3L: Combined Flow Rear Pond

Inflow Area =	259,486 sf,	61.30% Impervious,	Inflow Depth > 1.79"	for 10-Year event	
Inflow =	9.68 cfs @	12.18 hrs,	Volume=	38,656 cf	
Primary =	9.68 cfs @	12.18 hrs,	Volume=	38,656 cf,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 3L: Combined Flow Rear Pond

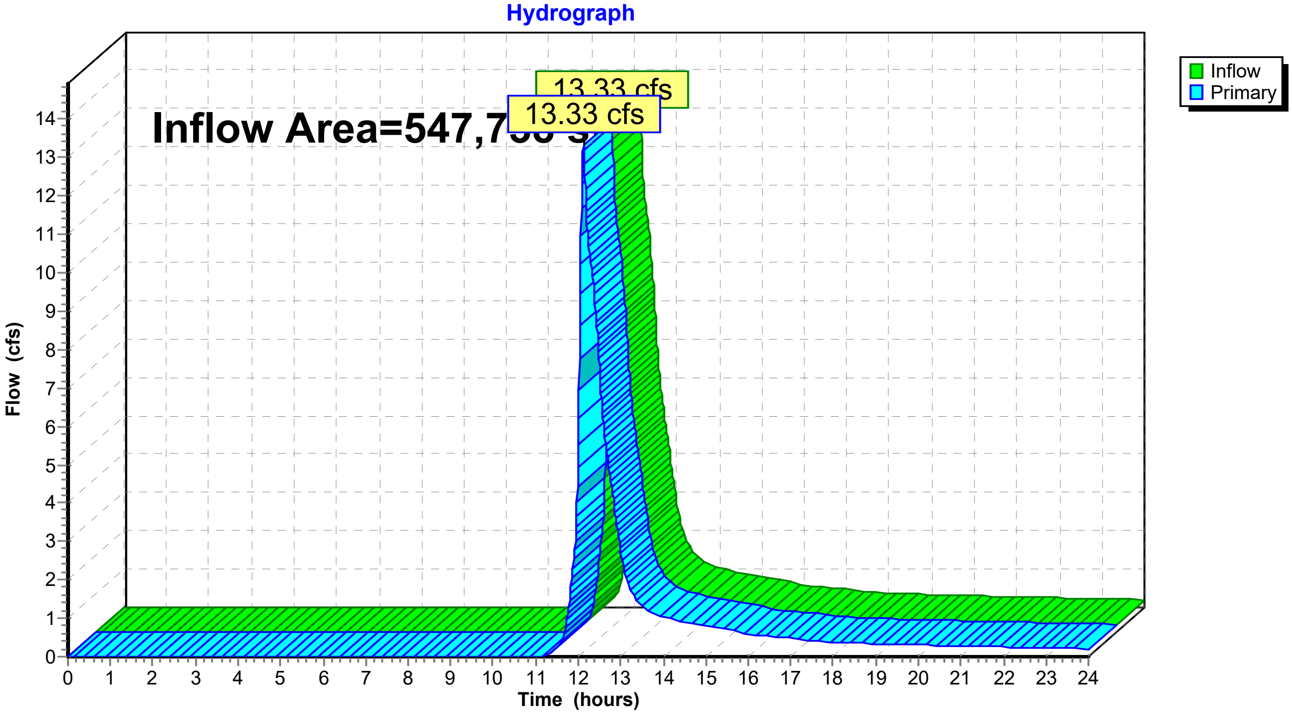


Summary for Link 4L: Combined to Great Brook

```
Inflow Area =         547,738 sf,  28.45% Impervious,  Inflow Depth >   1.10"    for  10-Year event
Inflow      =       13.33 cfs @   12.12 hrs,  Volume=            50,427 cf
Primary     =       13.33 cfs @   12.12 hrs,  Volume=            50,427 cf,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 4L: Combined to Great Brook



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E-1: To Front Pond Runoff Area=312,214 sf 53.40% Impervious Runoff Depth>3.87"
Flow Length=405' Tc=10.4 min CN=80 Runoff=28.04 cfs 100,773 cf

Subcatchment E-3: To Great Brook Runoff Area=339,925 sf 2.91% Impervious Runoff Depth>2.08"
Flow Length=420' Tc=6.0 min UI Adjusted CN=61 Runoff=18.20 cfs 58,818 cf

Subcatchment E-4: To Rear Pond Runoff Area=121,952 sf 41.73% Impervious Runoff Depth>3.37"
Flow Length=197' Tc=6.3 min CN=75 Runoff=10.97 cfs 34,267 cf

Subcatchment P-5A: Subsurface Drainage Runoff Area=137,534 sf 78.66% Impervious Runoff Depth>4.95"
Tc=6.0 min CN=90 Runoff=17.45 cfs 56,717 cf

Subcatchment P-5B: Subsurface Drainage Runoff Area=207,813 sf 70.21% Impervious Runoff Depth>4.62"
Tc=6.0 min CN=87 Runoff=25.09 cfs 79,976 cf

Pond 1P: SubSurface Sys 1 Peak Elev=348.97' Storage=16,616 cf Inflow=17.45 cfs 56,717 cf
Discarded=0.50 cfs 29,626 cf Primary=9.57 cfs 22,832 cf Outflow=10.07 cfs 52,458 cf

Pond 2P: SubSurface Sys 2 Peak Elev=340.78' Storage=20,001 cf Inflow=25.09 cfs 79,976 cf
Discarded=2.31 cfs 59,871 cf Primary=6.08 cfs 20,087 cf Outflow=8.39 cfs 79,958 cf

Link 3L: Combined Flow Rear Pond Inflow=17.44 cfs 57,099 cf
Primary=17.44 cfs 57,099 cf

Link 4L: Combined to Great Brook Inflow=21.97 cfs 78,904 cf
Primary=21.97 cfs 78,904 cf

Total Runoff Area = 1,119,438 sf Runoff Volume = 330,550 cf Average Runoff Depth = 3.54"
56.98% Pervious = 637,842 sf 43.02% Impervious = 481,596 sf

Summary for Subcatchment E-1: To Front Pond

[47] Hint: Peak is 632% of capacity of segment #4

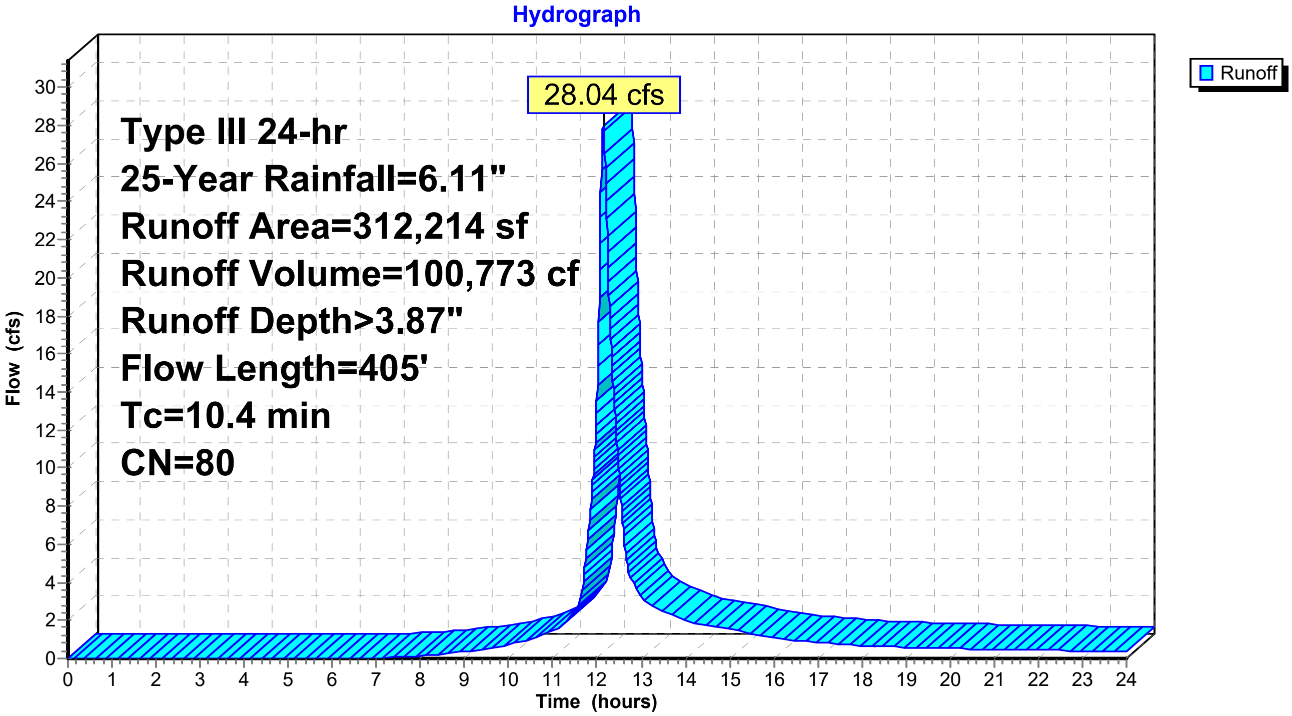
Runoff = 28.04 cfs @ 12.14 hrs, Volume= 100,773 cf, Depth> 3.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
22,632	55	Woods, Good, HSG B
122,869	61	>75% Grass cover, Good, HSG B
80,603	98	Paved parking, HSG B
33,494	98	Roofs, HSG B
52,616	98	Water Surface, HSG B
312,214	80	Weighted Average
145,501		46.60% Pervious Area
166,713		53.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	50	0.0060	0.09		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.4	58	0.0190	2.22		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
0.1	20	0.0850	5.92		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
0.5	184	0.0155	5.65	4.44	**Pipe Channel, D-E** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013
0.4	93	0.0699	3.97		**Shallow Concentrated Flow, E-F** Grassed Waterway Kv= 15.0 fps
10.4	405	Total			

Subcatchment E-1: To Front Pond



Summary for Subcatchment E-3: To Great Brook

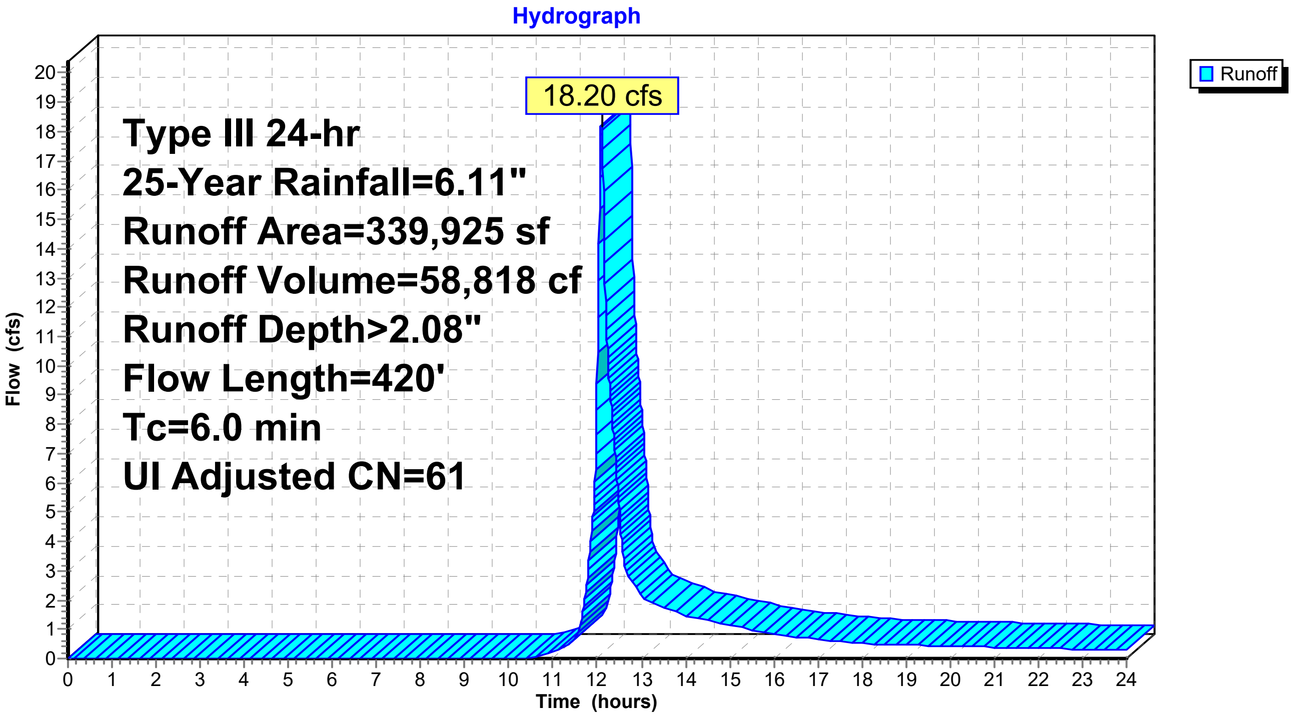
Runoff = 18.20 cfs @ 12.10 hrs, Volume= 58,818 cf, Depth> 2.08"
Routed to Link 4L : Combined to Great Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Adj	Description
59,070	55		Woods, Good, HSG B
263,621	61		>75% Grass cover, Good, HSG B
7,327	96		Gravel surface, HSG B
8,687	98		Unconnected pavement, HSG B
1,220	98		Roofs, HSG B
339,925	62	61	Weighted Average, UI Adjusted
330,018			97.09% Pervious Area
9,907			2.91% Impervious Area
8,687			87.69% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	50	0.0600	0.23		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
2.4	370	0.0250	2.55		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
6.0	420	Total			

Subcatchment E-3: To Great Brook



Summary for Subcatchment E-4: To Rear Pond

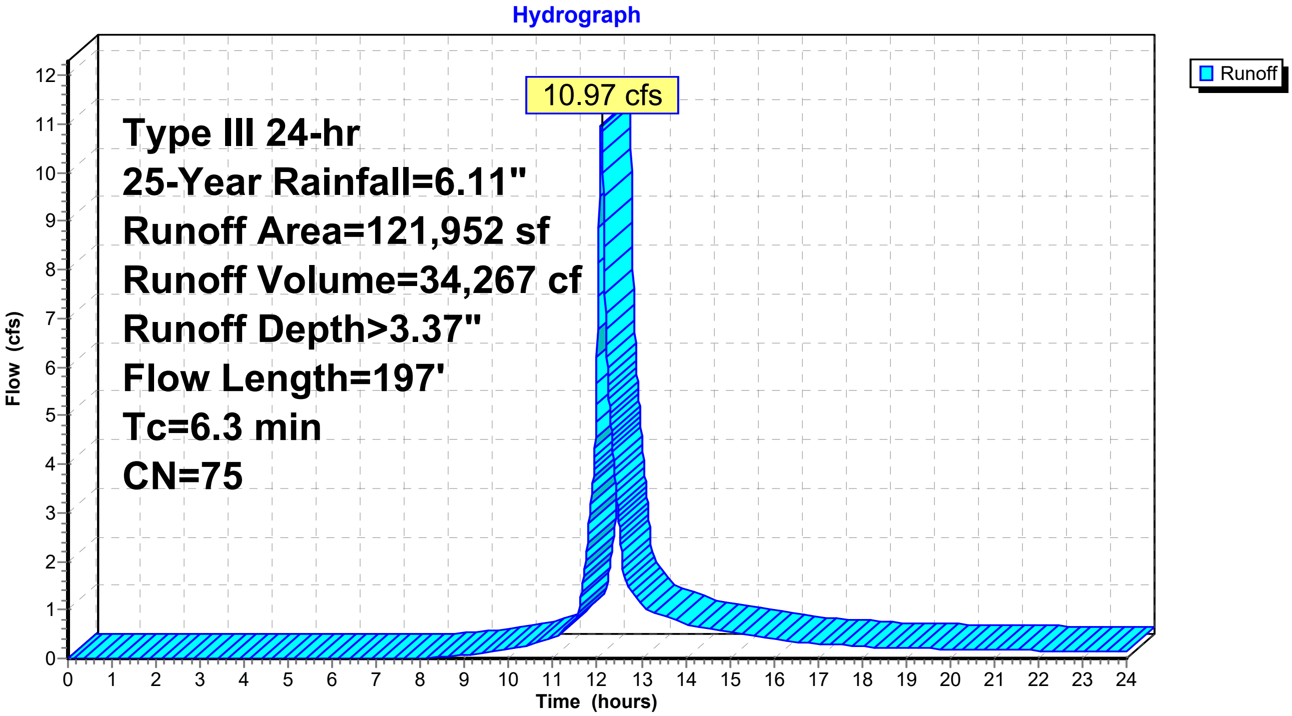
Runoff = 10.97 cfs @ 12.09 hrs, Volume= 34,267 cf, Depth> 3.37"
Routed to Link 3L : Combined Flow Rear Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
20,960	55	Woods, Good, HSG B
50,104	61	>75% Grass cover, Good, HSG B
50,888	98	Water Surface, HSG B
121,952	75	Weighted Average
71,064		58.27% Pervious Area
50,888		41.73% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.7	147	0.0500	3.60		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
6.3	197	Total			

Subcatchment E-4: To Rear Pond



Summary for Subcatchment P-5A: Subsurface Drainage

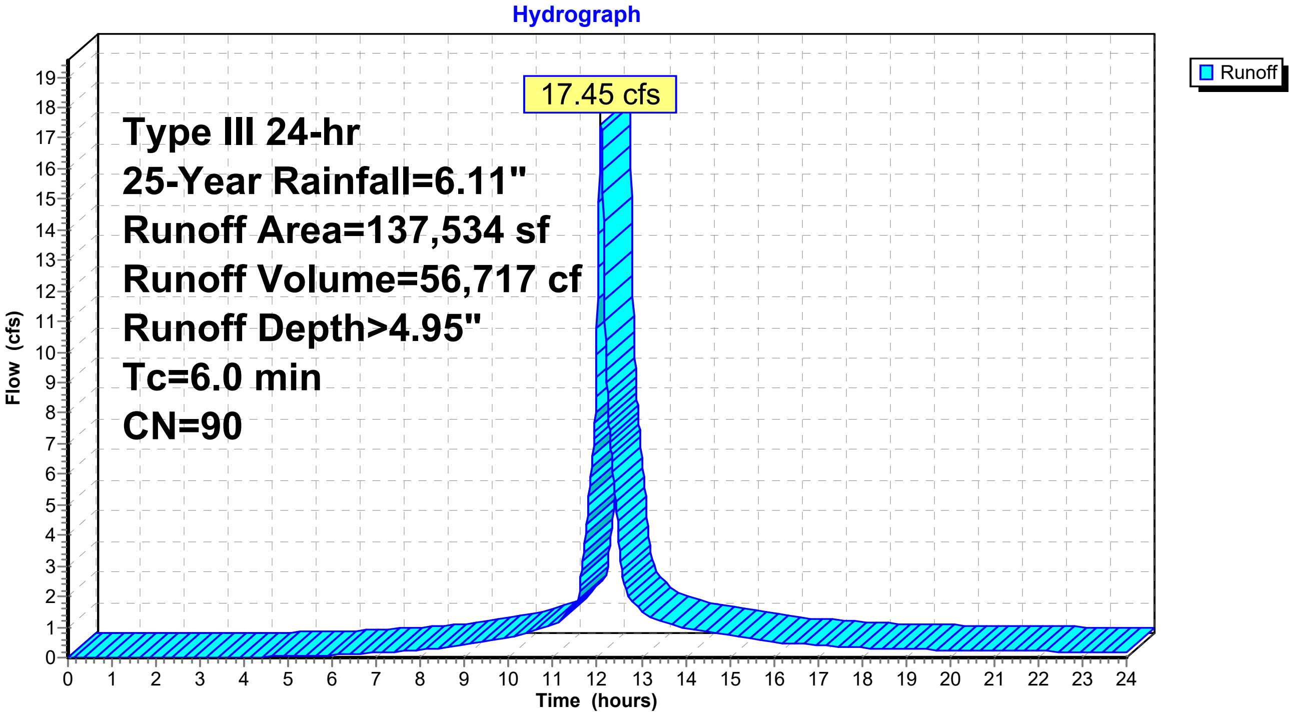
Runoff = 17.45 cfs @ 12.08 hrs, Volume= 56,717 cf, Depth> 4.95"
Routed to Pond 1P : SubSurface Sys 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
29,348	61	>75% Grass cover, Good, HSG B
34,413	98	Roofs, HSG B
73,773	98	Paved parking, HSG B
137,534	90	Weighted Average
29,348		21.34% Pervious Area
108,186		78.66% Impervious Area

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

Subcatchment P-5A: Subsurface Drainage



Summary for Subcatchment P-5B: Subsurface Drainage

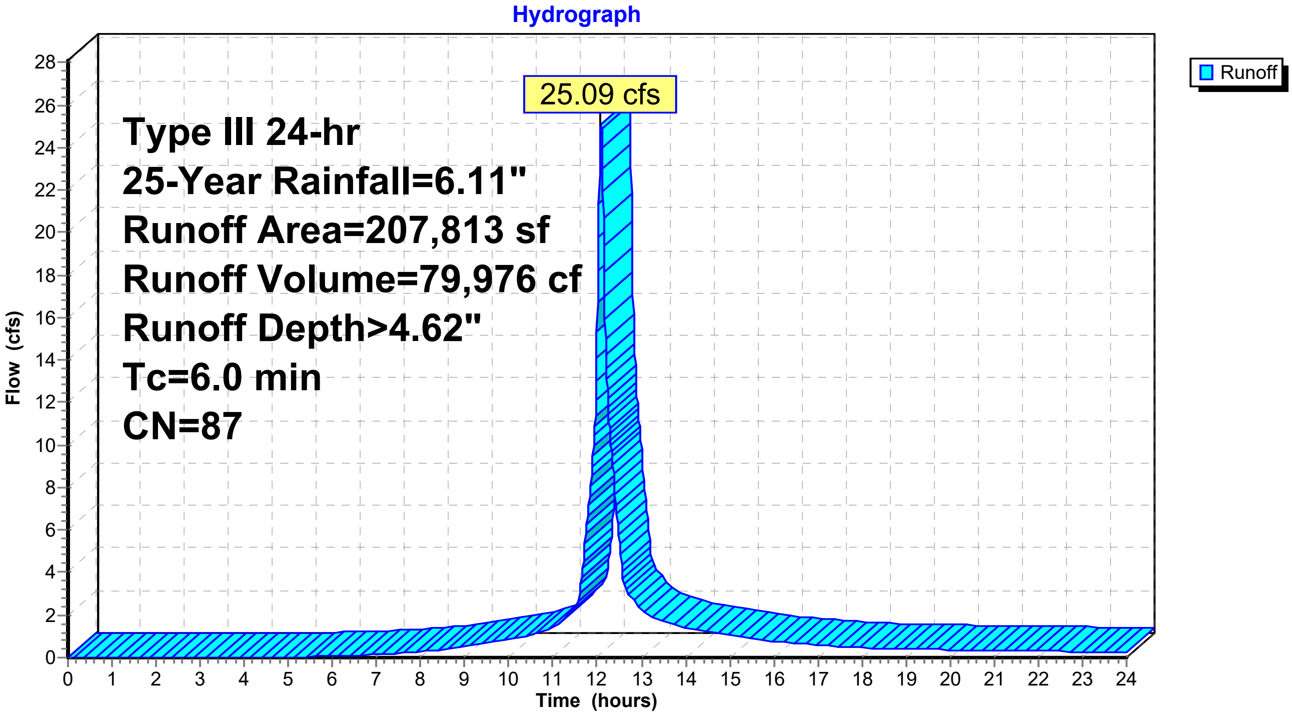
Runoff = 25.09 cfs @ 12.09 hrs, Volume= 79,976 cf, Depth> 4.62"
Routed to Pond 2P : SubSurface Sys 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.11"

Area (sf)	CN	Description
61,911	61	>75% Grass cover, Good, HSG B
62,853	98	Roofs, HSG B
83,049	98	Paved parking, HSG B
207,813	87	Weighted Average
61,911		29.79% Pervious Area
145,902		70.21% Impervious Area

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

Subcatchment P-5B: Subsurface Drainage



Summary for Pond 1P: SubSurface Sys 1

Inflow Area = 137,534 sf, 78.66% Impervious, Inflow Depth > 4.95" for 25-Year event
Inflow = 17.45 cfs @ 12.08 hrs, Volume= 56,717 cf
Outflow = 10.07 cfs @ 12.20 hrs, Volume= 52,458 cf, Atten= 42%, Lag= 6.7 min
Discarded = 0.50 cfs @ 9.43 hrs, Volume= 29,626 cf
Primary = 9.57 cfs @ 12.20 hrs, Volume= 22,832 cf
Routed to Link 3L : Combined Flow Rear Pond

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 348.97' @ 12.20 hrs Surf.Area= 8,982 sf Storage= 16,616 cf

Plug-Flow detention time= 122.8 min calculated for 52,436 cf (92% of inflow)
Center-of-Mass det. time= 83.7 min (867.3 - 783.5)

Volume	Invert	Avail.Storage	Storage Description
#1A	346.25'	7,944 cf	**44.25'W x 202.98'L x 3.50'H Field A** 31,436 cf Overall - 11,577 cf Embedded = 19,859 cf x 40.0% Voids
#2A	346.75'	11,577 cf	**ADS_StormTech SC-740 +Cap** x 252 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 252 Chambers in 9 Rows
		19,521 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	346.25'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	346.75'	**18.0" Round Culvert X 2.00** L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.75' / 346.25' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf
#3	Primary	347.95'	**8.0" Vert. Orifice/Grate X 6.00** C= 0.600 Limited to weir flow at low heads
#4	Device 2	348.85'	**10.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.50 cfs @ 9.43 hrs HW=346.29' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.50 cfs)

Primary OutFlow Max=9.55 cfs @ 12.20 hrs HW=348.97' (Free Discharge)
├—**2=Culvert** (Passes 1.19 cfs of 20.64 cfs potential flow)
│ ↑—**4=Broad-Crested Rectangular Weir** (Weir Controls 1.19 cfs @ 0.98 fps)
└—**3=Orifice/Grate** (Orifice Controls 8.37 cfs @ 3.99 fps)

Pond 1P: SubSurface Sys 1 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

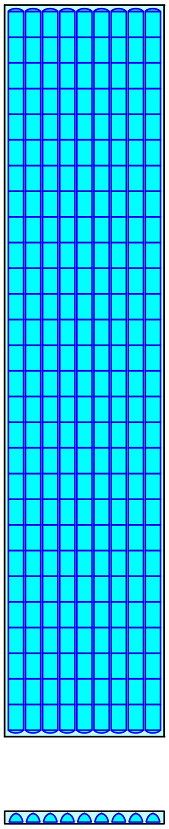
28 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 200.98' Row Length +12.0" End Stone x 2 = 202.98' Base Length
9 Rows x 51.0" Wide + 6.0" Spacing x 8 + 12.0" Side Stone x 2 = 44.25' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

252 Chambers x 45.9 cf = 11,576.9 cf Chamber Storage

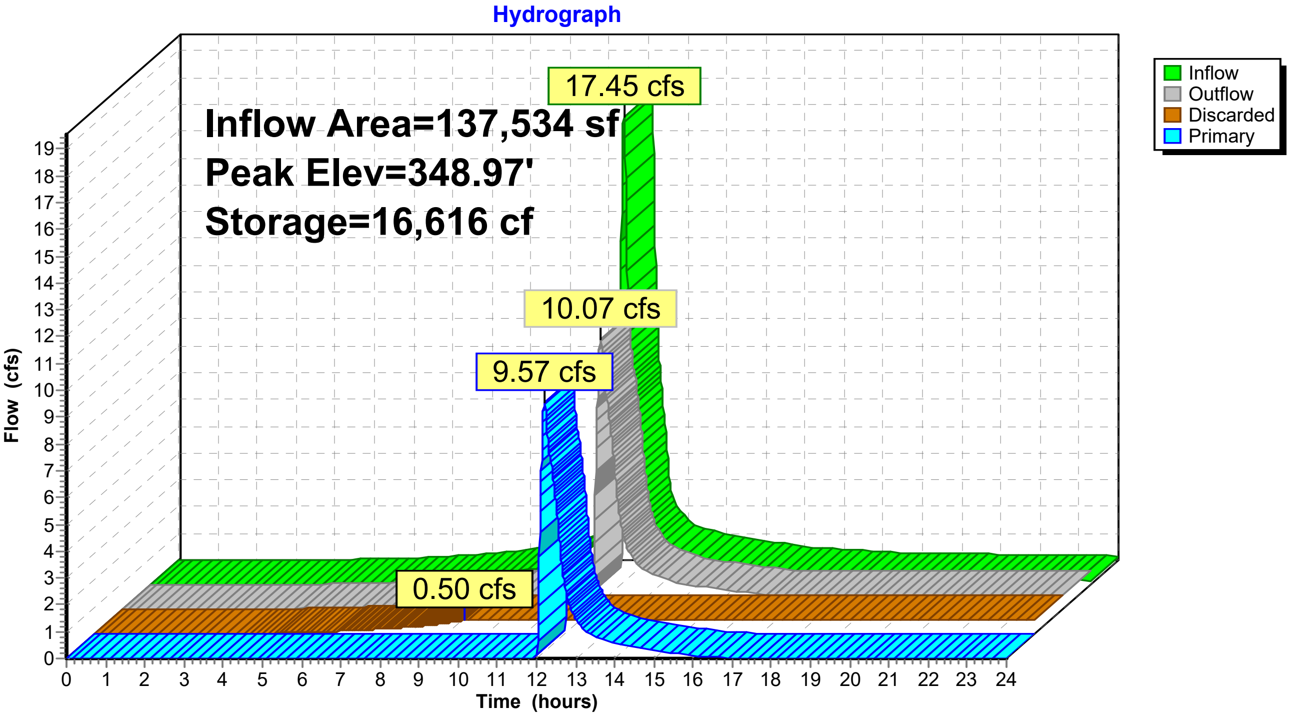
31,436.0 cf Field - 11,576.9 cf Chambers = 19,859.1 cf Stone x 40.0% Voids = 7,943.7 cf Stone Storage

Chamber Storage + Stone Storage = 19,520.5 cf = 0.448 af
Overall Storage Efficiency = 62.1%
Overall System Size = 202.98' x 44.25' x 3.50'

252 Chambers
1,164.3 cy Field
735.5 cy Stone



Pond 1P: SubSurface Sys 1



Summary for Pond 2P: SubSurface Sys 2

```
Inflow Area =       207,813 sf,  70.21% Impervious,  Inflow Depth >   4.62"    for  25-Year event
Inflow      =       25.09 cfs @   12.09 hrs,  Volume=          79,976 cf
Outflow     =        8.39 cfs @   12.37 hrs,  Volume=          79,958 cf,  Atten= 67%,  Lag= 17.4 min
Discarded   =        2.31 cfs @   11.48 hrs,  Volume=          59,871 cf
Primary     =        6.08 cfs @   12.37 hrs,  Volume=          20,087 cf
   Routed to Link 4L : Combined to Great Brook

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 340.78' @ 12.37 hrs   Surf.Area= 12,084 sf   Storage= 20,001 cf

Plug-Flow detention time= 25.7 min calculated for 79,958 cf (100% of inflow)
Center-of-Mass det. time= 25.6 min ( 819.0 - 793.4 )

Volume      Invert    Avail.Storage   Storage Description
  #1A      338.40'        10,633 cf   87.00'W x 138.90'L x 3.50'H Field A
                                      42,294 cf Overall - 15,711 cf Embedded = 26,583 cf  x 40.0% Voids
  #2A      338.90'        15,711 cf   ADS_StormTech SC-740 +Cap x 342  Inside #1
                                      Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
                                      Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
                                      342 Chambers in 18 Rows
                                  
                          26,345 cf   Total Available Storage

   Storage Group A created with Chamber Wizard

Device   Routing         Invert   Outlet Devices
   #1    Discarded      338.40'   8.270 in/hr Exfiltration over Surface area
   #2    Primary        338.90'   18.0"  Round Culvert X 2.00
                                  L= 50.0'   CPP, square edge headwall,  Ke= 0.500
                                  Inlet / Outlet Invert= 338.90' / 338.40'   S= 0.0100 '/'   Cc= 0.900
                                  n= 0.012,  Flow Area= 1.77 sf
   #3    Device 2       339.38'   6.0" Vert. Orifice/Grate X 6.00   C= 0.600
                                  Limited to weir flow at low heads
   #4    Device 2       341.30'   10.0' long  x 0.5' breadth Broad-Crested Rectangular Weir
                                  Head (feet)  0.20  0.40  0.60  0.80  1.00
                                  Coef. (English)  2.80  2.92  3.08  3.30  3.32

Discarded OutFlow  Max=2.31 cfs @ 11.48 hrs  HW=338.44'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 2.31 cfs)

Primary OutFlow  Max=6.08 cfs @ 12.37 hrs  HW=340.78'   (Free Discharge)
└─2=Culvert  (Passes 6.08 cfs of 18.07 cfs potential flow)
   ├─3=Orifice/Grate  (Orifice Controls 6.08 cfs @ 5.16 fps)
   └─4=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)
```

Pond 2P: SubSurface Sys 2 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

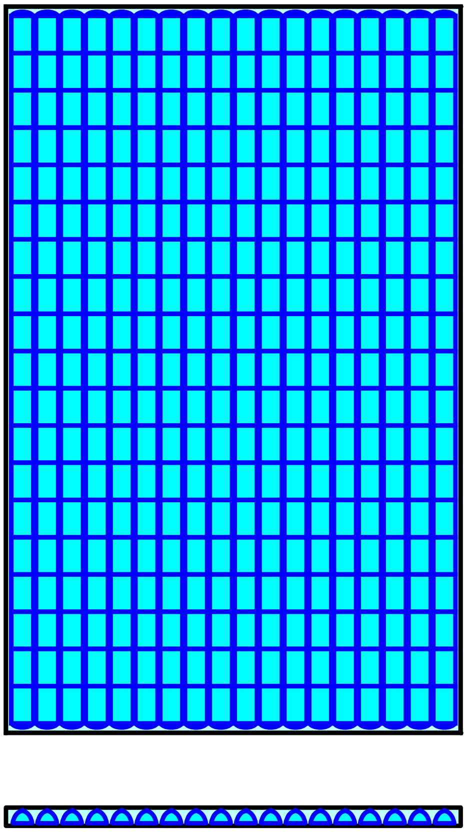
19 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 136.90' Row Length +12.0" End Stone x 2 = 138.90' Base Length
18 Rows x 51.0" Wide + 6.0" Spacing x 17 + 12.0" Side Stone x 2 = 87.00' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

342 Chambers x 45.9 cf = 15,711.5 cf Chamber Storage

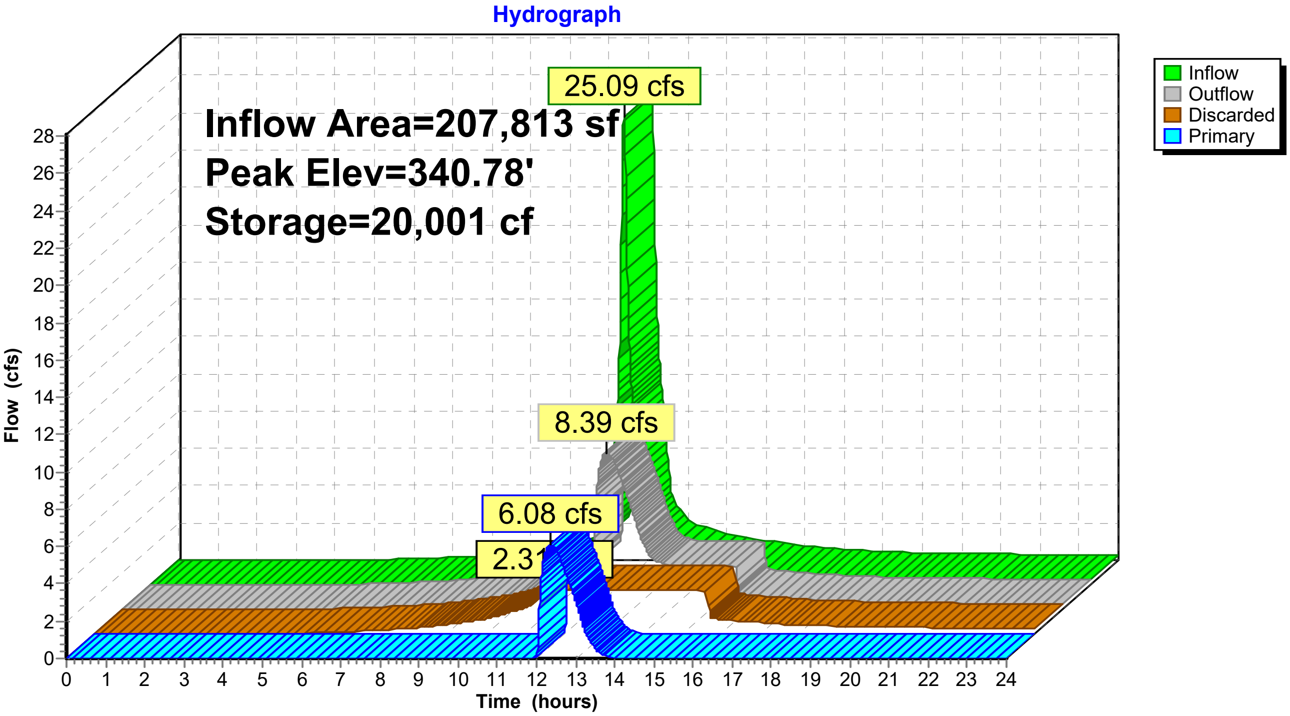
42,294.0 cf Field - 15,711.5 cf Chambers = 26,582.5 cf Stone x 40.0% Voids = 10,633.0 cf Stone Storage

Chamber Storage + Stone Storage = 26,344.5 cf = 0.605 af
Overall Storage Efficiency = 62.3%
Overall System Size = 138.90' x 87.00' x 3.50'

342 Chambers
1,566.4 cy Field
984.5 cy Stone



Pond 2P: SubSurface Sys 2

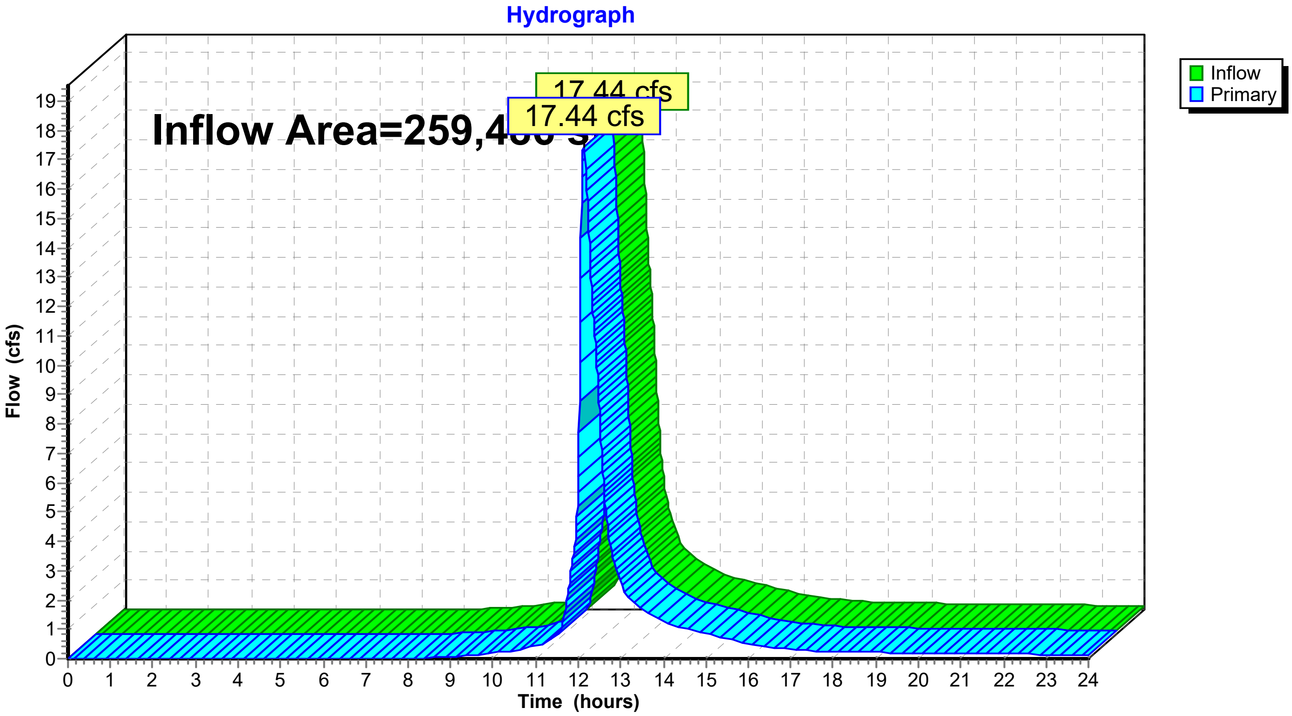


Summary for Link 3L: Combined Flow Rear Pond

Inflow Area = 259,486 sf, 61.30% Impervious, Inflow Depth > 2.64" for 25-Year event
Inflow = 17.44 cfs @ 12.12 hrs, Volume= 57,099 cf
Primary = 17.44 cfs @ 12.12 hrs, Volume= 57,099 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 3L: Combined Flow Rear Pond

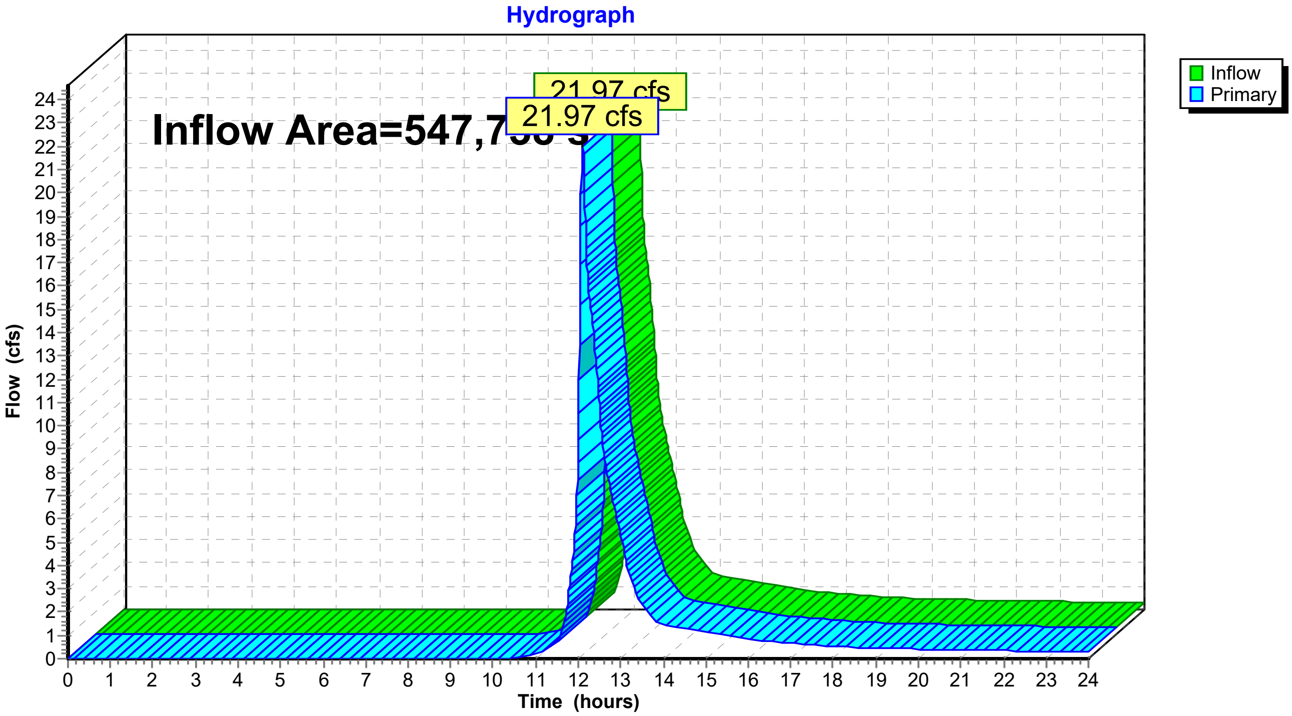


Summary for Link 4L: Combined to Great Brook

Inflow Area = 547,738 sf, 28.45% Impervious, Inflow Depth > 1.73" for 25-Year event
Inflow = 21.97 cfs @ 12.11 hrs, Volume= 78,904 cf
Primary = 21.97 cfs @ 12.11 hrs, Volume= 78,904 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 4L: Combined to Great Brook



Time span=0.00-24.00 hrs, dt=0.01 hrs, 2401 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E-1: To Front Pond Runoff Area=312,214 sf 53.40% Impervious Runoff Depth>5.42"
Flow Length=405' Tc=10.4 min CN=80 Runoff=38.87 cfs 140,981 cf

Subcatchment E-3: To Great Brook Runoff Area=339,925 sf 2.91% Impervious Runoff Depth>3.28"
Flow Length=420' Tc=6.0 min UI Adjusted CN=61 Runoff=29.65 cfs 92,941 cf

Subcatchment E-4: To Rear Pond Runoff Area=121,952 sf 41.73% Impervious Runoff Depth>4.85"
Flow Length=197' Tc=6.3 min CN=75 Runoff=15.72 cfs 49,259 cf

Subcatchment P-5A: Subsurface Drainage Runoff Area=137,534 sf 78.66% Impervious Runoff Depth>6.59"
Tc=6.0 min CN=90 Runoff=22.88 cfs 75,565 cf

Subcatchment P-5B: Subsurface Drainage Runoff Area=207,813 sf 70.21% Impervious Runoff Depth>6.24"
Tc=6.0 min CN=87 Runoff=33.37 cfs 108,058 cf

Pond 1P: SubSurface Sys 1 Peak Elev=349.33' Storage=18,001 cf Inflow=22.88 cfs 75,565 cf
Discarded=0.50 cfs 31,352 cf Primary=20.13 cfs 38,015 cf Outflow=20.63 cfs 69,366 cf

Pond 2P: SubSurface Sys 2 Peak Elev=341.67' Storage=25,238 cf Inflow=33.37 cfs 108,058 cf
Discarded=2.31 cfs 72,570 cf Primary=14.67 cfs 35,465 cf Outflow=16.99 cfs 108,035 cf

Link 3L: Combined Flow Rear Pond Inflow=35.13 cfs 87,274 cf
Primary=35.13 cfs 87,274 cf

Link 4L: Combined to Great Brook Inflow=35.58 cfs 128,405 cf
Primary=35.58 cfs 128,405 cf

Total Runoff Area = 1,119,438 sf Runoff Volume = 466,804 cf Average Runoff Depth = 5.00"
56.98% Pervious = 637,842 sf 43.02% Impervious = 481,596 sf

Summary for Subcatchment E-1: To Front Pond

[47] Hint: Peak is 876% of capacity of segment #4

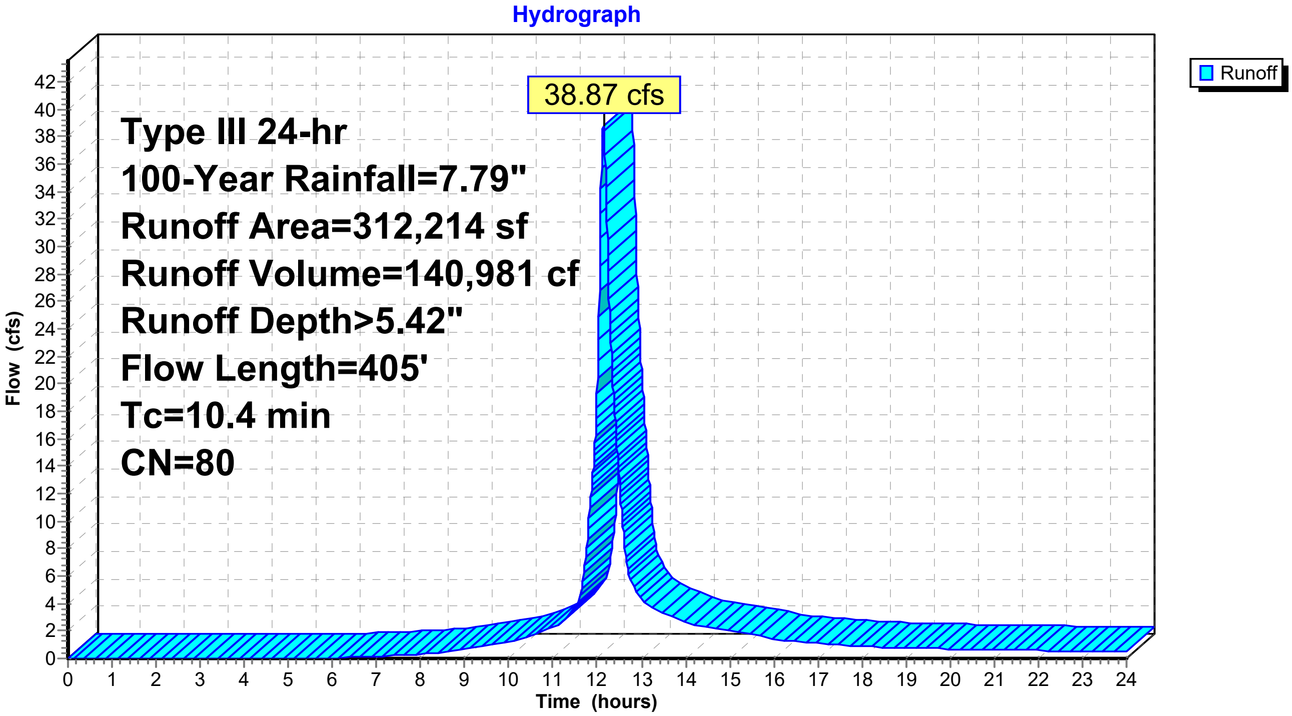
Runoff = 38.87 cfs @ 12.14 hrs, Volume= 140,981 cf, Depth> 5.42"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

Area (sf)	CN	Description
22,632	55	Woods, Good, HSG B
122,869	61	>75% Grass cover, Good, HSG B
80,603	98	Paved parking, HSG B
33,494	98	Roofs, HSG B
52,616	98	Water Surface, HSG B
312,214	80	Weighted Average
145,501		46.60% Pervious Area
166,713		53.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.0	50	0.0060	0.09		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.4	58	0.0190	2.22		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
0.1	20	0.0850	5.92		**Shallow Concentrated Flow, C-D** Paved Kv= 20.3 fps
0.5	184	0.0155	5.65	4.44	**Pipe Channel, D-E** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.013
0.4	93	0.0699	3.97		**Shallow Concentrated Flow, E-F** Grassed Waterway Kv= 15.0 fps
10.4	405	Total			

Subcatchment E-1: To Front Pond



Summary for Subcatchment E-3: To Great Brook

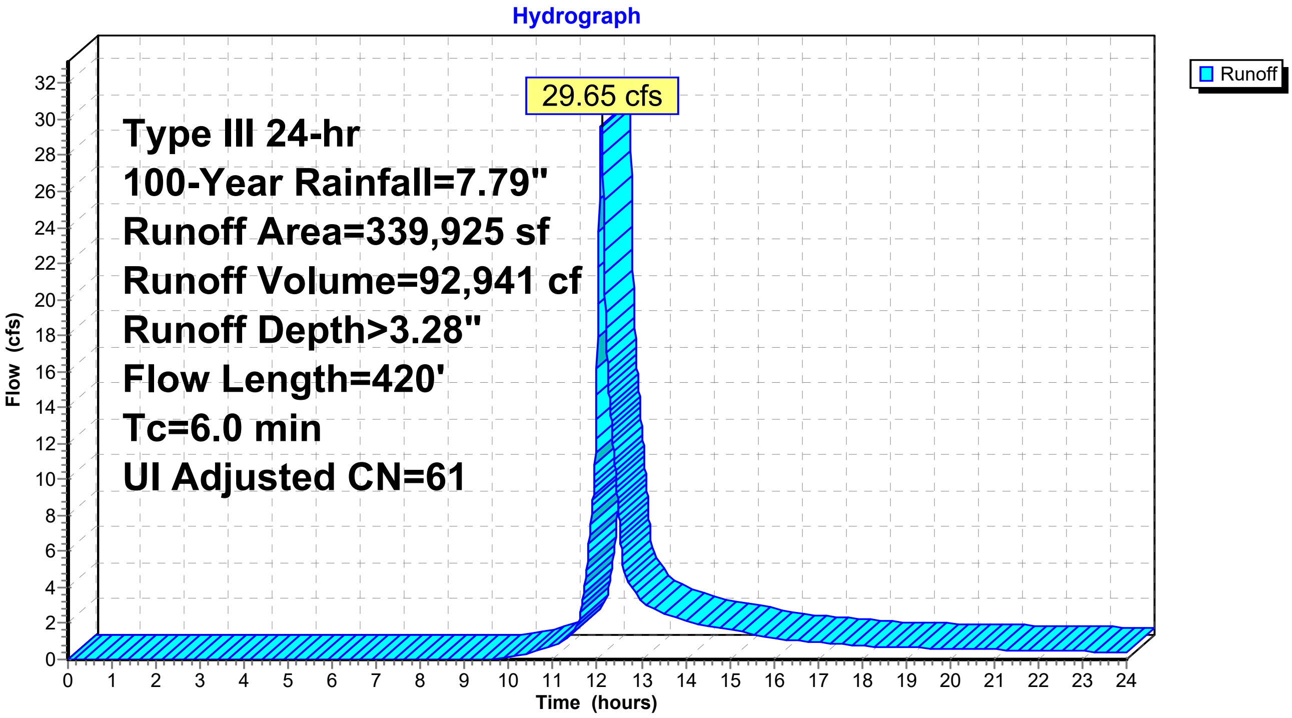
Runoff = 29.65 cfs @ 12.09 hrs, Volume= 92,941 cf, Depth> 3.28"
Routed to Link 4L : Combined to Great Brook

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

Area (sf)	CN	Adj	Description
59,070	55		Woods, Good, HSG B
263,621	61		>75% Grass cover, Good, HSG B
7,327	96		Gravel surface, HSG B
8,687	98		Unconnected pavement, HSG B
1,220	98		Roofs, HSG B
339,925	62	61	Weighted Average, UI Adjusted
330,018			97.09% Pervious Area
9,907			2.91% Impervious Area
8,687			87.69% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
3.6	50	0.0600	0.23		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
2.4	370	0.0250	2.55		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
6.0	420	Total			

Subcatchment E-3: To Great Brook



Summary for Subcatchment E-4: To Rear Pond

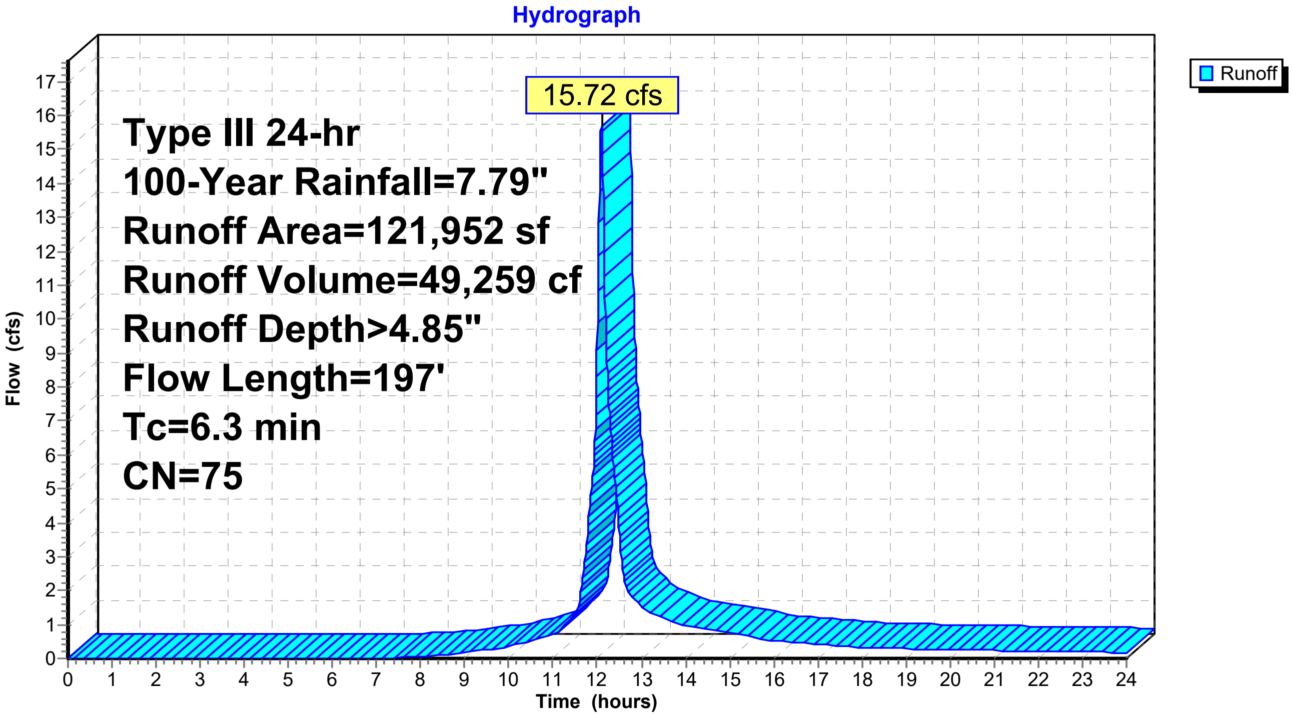
Runoff = 15.72 cfs @ 12.09 hrs, Volume= 49,259 cf, Depth> 4.85"
Routed to Link 3L : Combined Flow Rear Pond

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

Area (sf)	CN	Description
20,960	55	Woods, Good, HSG B
50,104	61	>75% Grass cover, Good, HSG B
50,888	98	Water Surface, HSG B
121,952	75	Weighted Average
71,064		58.27% Pervious Area
50,888		41.73% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.6	50	0.0200	0.15		**Sheet Flow, A-B** Grass: Short n= 0.150 P2= 3.27"
0.7	147	0.0500	3.60		**Shallow Concentrated Flow, B-C** Unpaved Kv= 16.1 fps
6.3	197	Total			

Subcatchment E-4: To Rear Pond



Summary for Subcatchment P-5A: Subsurface Drainage

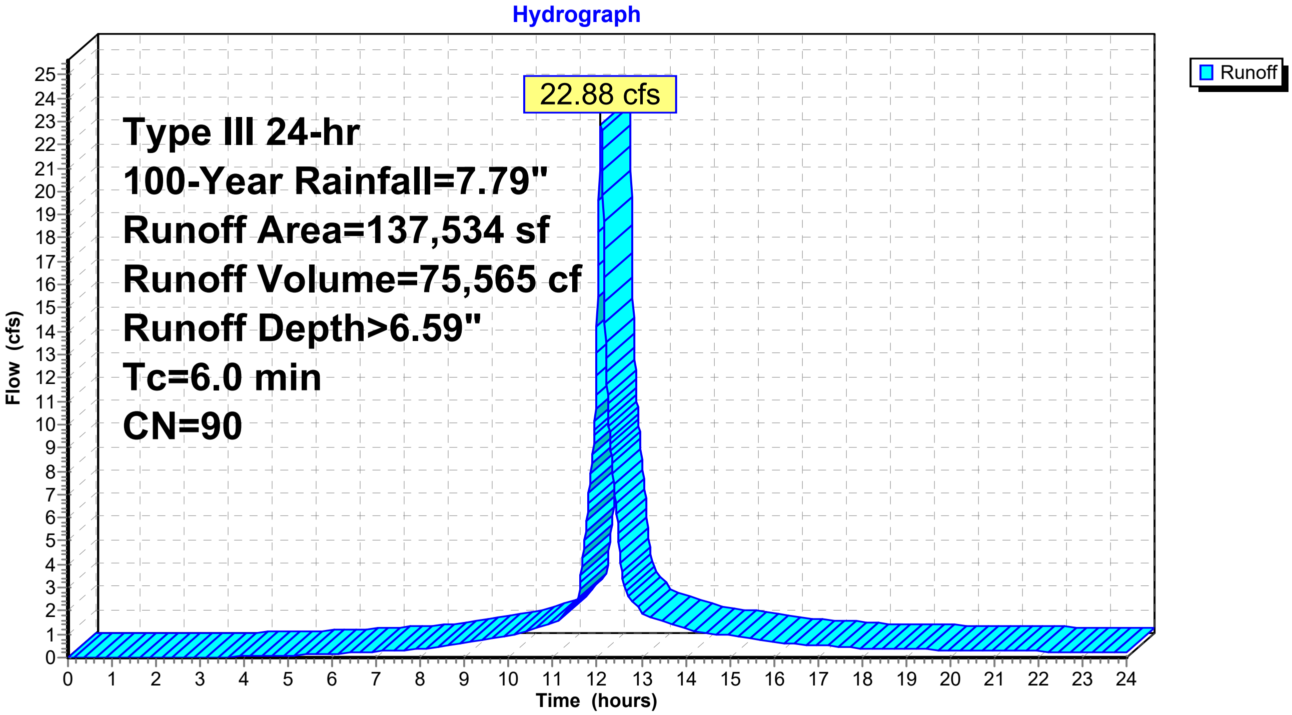
Runoff = 22.88 cfs @ 12.08 hrs, Volume= 75,565 cf, Depth> 6.59"
Routed to Pond 1P : SubSurface Sys 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

Area (sf)	CN	Description
29,348	61	>75% Grass cover, Good, HSG B
34,413	98	Roofs, HSG B
73,773	98	Paved parking, HSG B
137,534	90	Weighted Average
29,348		21.34% Pervious Area
108,186		78.66% Impervious Area

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

Subcatchment P-5A: Subsurface Drainage



Summary for Subcatchment P-5B: Subsurface Drainage

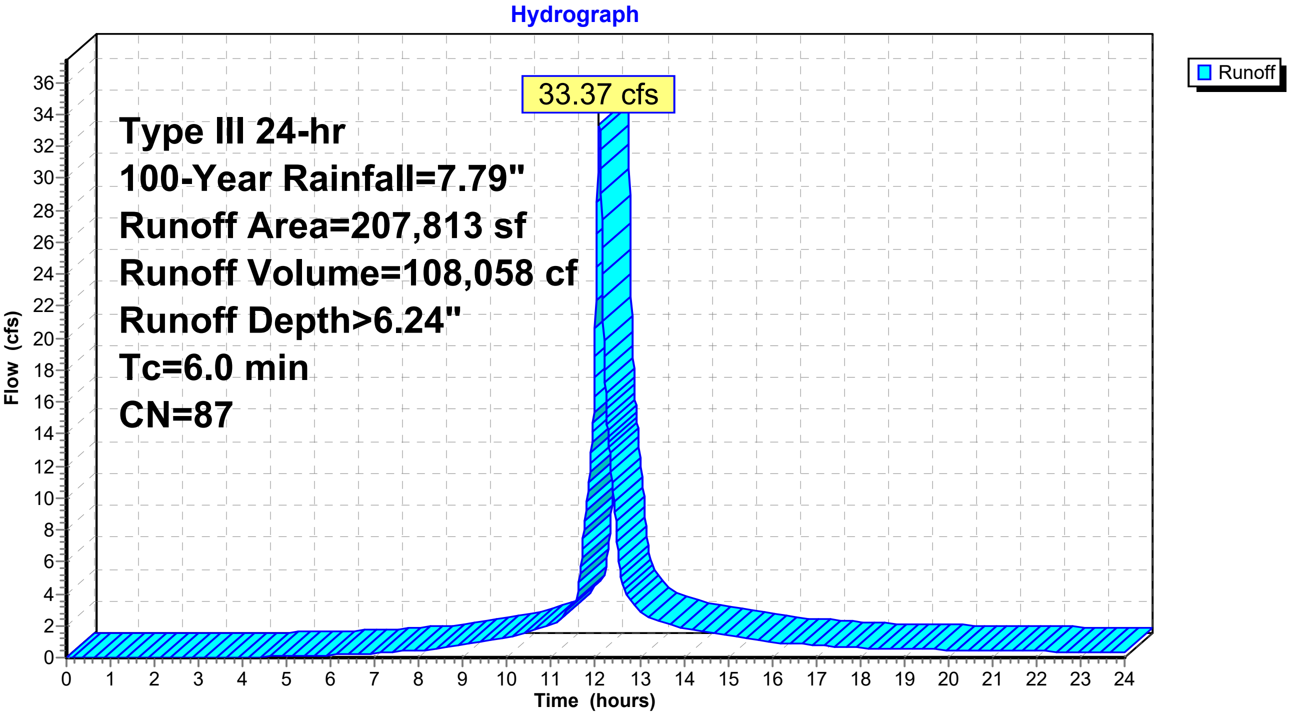
Runoff = 33.37 cfs @ 12.08 hrs, Volume= 108,058 cf, Depth> 6.24"
Routed to Pond 2P : SubSurface Sys 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.79"

Area (sf)	CN	Description
61,911	61	>75% Grass cover, Good, HSG B
62,853	98	Roofs, HSG B
83,049	98	Paved parking, HSG B
207,813	87	Weighted Average
61,911		29.79% Pervious Area
145,902		70.21% Impervious Area

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

Subcatchment P-5B: Subsurface Drainage



Summary for Pond 1P: SubSurface Sys 1

```
Inflow Area =        137,534 sf,  78.66% Impervious,  Inflow Depth >   6.59"    for  100-Year event
Inflow      =       22.88 cfs @  12.08 hrs,  Volume=          75,565 cf
Outflow     =       20.63 cfs @  12.12 hrs,  Volume=          69,366 cf,  Atten= 10%,  Lag= 2.3 min
Discarded  =         0.50 cfs @   8.61 hrs,  Volume=          31,352 cf
Primary     =       20.13 cfs @  12.12 hrs,  Volume=          38,015 cf
    Routed to Link 3L : Combined Flow Rear Pond
```

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 349.33' @ 12.12 hrs Surf.Area= 8,982 sf Storage= 18,001 cf

Plug-Flow detention time= 99.6 min calculated for 69,337 cf (92% of inflow)
Center-of-Mass det. time= 57.7 min (833.8 - 776.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	346.25'	7,944 cf	**44.25'W x 202.98'L x 3.50'H Field A** 31,436 cf Overall - 11,577 cf Embedded = 19,859 cf x 40.0% Voids
#2A	346.75'	11,577 cf	**ADS_StormTech SC-740 +Cap** x 252 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 252 Chambers in 9 Rows
		19,521 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	346.25'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	346.75'	**18.0" Round Culvert X 2.00** L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.75' / 346.25' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf
#3	Primary	347.95'	**8.0" Vert. Orifice/Grate X 6.00** C= 0.600 Limited to weir flow at low heads
#4	Device 2	348.85'	**10.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

```
Discarded OutFlow  Max=0.50 cfs @ 8.61 hrs  HW=346.29'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 0.50 cfs)

Primary OutFlow  Max=20.08 cfs @ 12.12 hrs  HW=349.33'   (Free Discharge)
├─2=Culvert  (Passes 9.79 cfs of 23.00 cfs potential flow)
│  └─4=Broad-Crested Rectangular Weir (Weir Controls 9.79 cfs @ 2.06 fps)
└─3=Orifice/Grate  (Orifice Controls 10.30 cfs @ 4.92 fps)
```

Pond 1P: SubSurface Sys 1 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

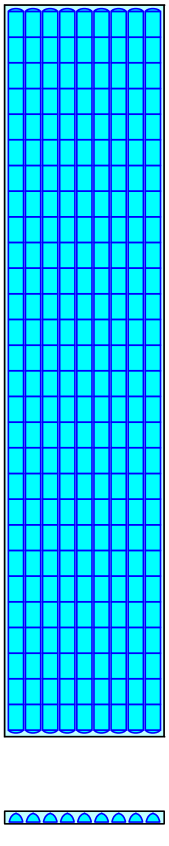
28 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 200.98' Row Length +12.0" End Stone x 2 = 202.98' Base Length
9 Rows x 51.0" Wide + 6.0" Spacing x 8 + 12.0" Side Stone x 2 = 44.25' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

252 Chambers x 45.9 cf = 11,576.9 cf Chamber Storage

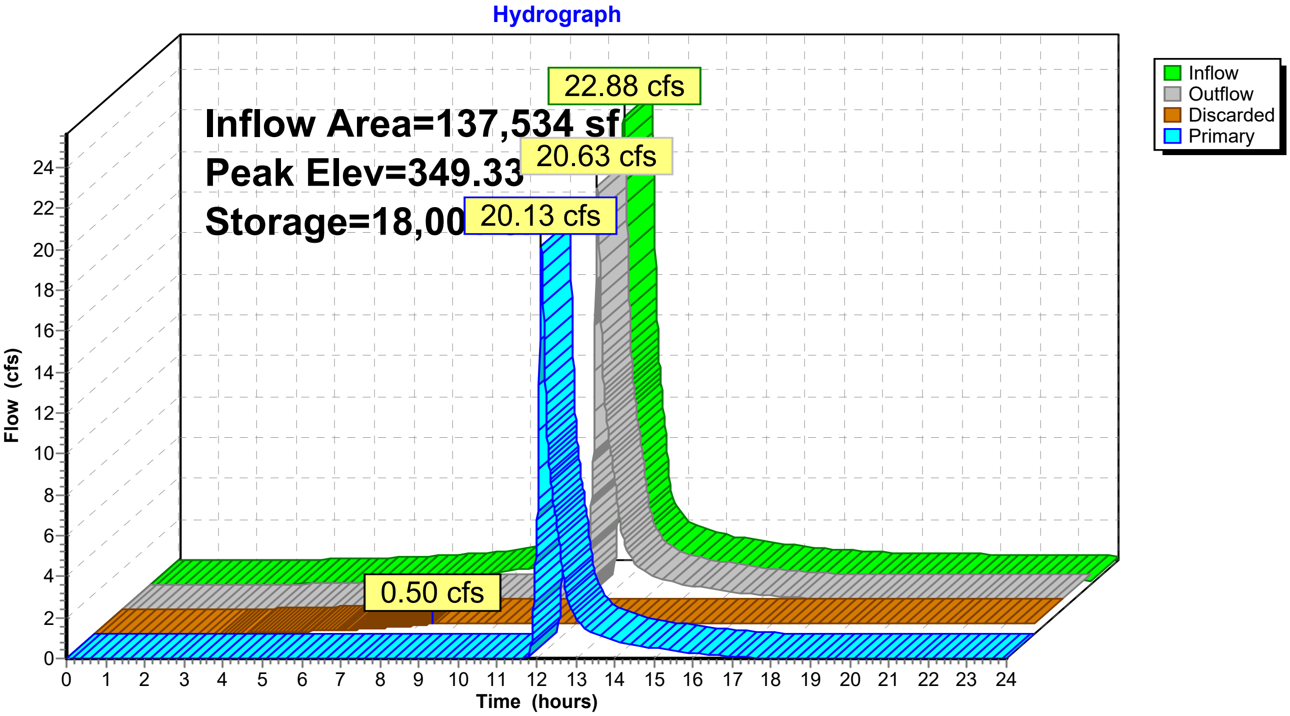
31,436.0 cf Field - 11,576.9 cf Chambers = 19,859.1 cf Stone x 40.0% Voids = 7,943.7 cf Stone Storage

Chamber Storage + Stone Storage = 19,520.5 cf = 0.448 af
Overall Storage Efficiency = 62.1%
Overall System Size = 202.98' x 44.25' x 3.50'

252 Chambers
1,164.3 cy Field
735.5 cy Stone



Pond 1P: SubSurface Sys 1



Summary for Pond 2P: SubSurface Sys 2

```
Inflow Area =        207,813 sf,  70.21% Impervious,  Inflow Depth >   6.24"    for  100-Year event
Inflow      =      33.37 cfs @   12.08 hrs,  Volume=         108,058 cf
Outflow     =      16.99 cfs @   12.22 hrs,  Volume=         108,035 cf,  Atten= 49%,  Lag= 8.4 min
Discarded   =       2.31 cfs @   11.18 hrs,  Volume=          72,570 cf
Primary     =      14.67 cfs @   12.22 hrs,  Volume=          35,465 cf
    Routed to Link 4L : Combined to Great Brook

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs
Peak Elev= 341.67' @ 12.22 hrs   Surf.Area= 12,084 sf   Storage= 25,238 cf

Plug-Flow detention time= 26.0 min calculated for 107,990 cf (100% of inflow)
Center-of-Mass det. time= 25.8 min ( 811.1 - 785.2 )

Volume      Invert    Avail.Storage   Storage Description
   #1A     338.40'        10,633 cf   87.00'W x 138.90'L x 3.50'H Field A
                                      42,294 cf Overall - 15,711 cf Embedded = 26,583 cf  x 40.0% Voids
   #2A     338.90'        15,711 cf   ADS_StormTech SC-740 +Cap x 342  Inside #1
                                      Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
                                      Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
                                      342 Chambers in 18 Rows
                          26,345 cf   Total Available Storage

    Storage Group A created with Chamber Wizard

Device   Routing          Invert   Outlet Devices
   #1    Discarded       338.40'   8.270 in/hr Exfiltration over Surface area
   #2    Primary         338.90'   18.0"  Round Culvert X 2.00
                                   L= 50.0'   CPP, square edge headwall,  Ke= 0.500
                                   Inlet / Outlet Invert= 338.90' / 338.40'   S= 0.0100 '/'   Cc= 0.900
                                   n= 0.012,  Flow Area= 1.77 sf
   #3    Device 2        339.38'   6.0" Vert. Orifice/Grate X 6.00   C= 0.600
                                   Limited to weir flow at low heads
   #4    Device 2        341.30'   10.0' long  x 0.5' breadth Broad-Crested Rectangular Weir
                                   Head (feet)  0.20  0.40  0.60  0.80  1.00
                                   Coef. (English)  2.80  2.92  3.08  3.30  3.32

Discarded OutFlow Max=2.31 cfs @ 11.18 hrs  HW=338.44'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 2.31 cfs)

Primary OutFlow Max=14.64 cfs @ 12.22 hrs  HW=341.67'   (Free Discharge)
└─2=Culvert  (Passes 14.64 cfs of 24.19 cfs potential flow)
    ├─3=Orifice/Grate  (Orifice Controls 8.10 cfs @ 6.88 fps)
    └─4=Broad-Crested Rectangular Weir (Weir Controls 6.54 cfs @ 1.77 fps)
```

Pond 2P: SubSurface Sys 2 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

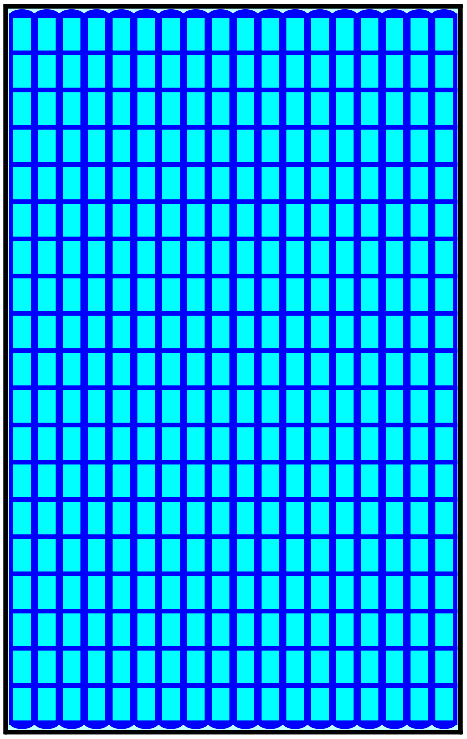
19 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 136.90' Row Length +12.0" End Stone x 2 = 138.90' Base Length
18 Rows x 51.0" Wide + 6.0" Spacing x 17 + 12.0" Side Stone x 2 = 87.00' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

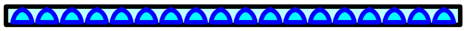
342 Chambers x 45.9 cf = 15,711.5 cf Chamber Storage

42,294.0 cf Field - 15,711.5 cf Chambers = 26,582.5 cf Stone x 40.0% Voids = 10,633.0 cf Stone Storage

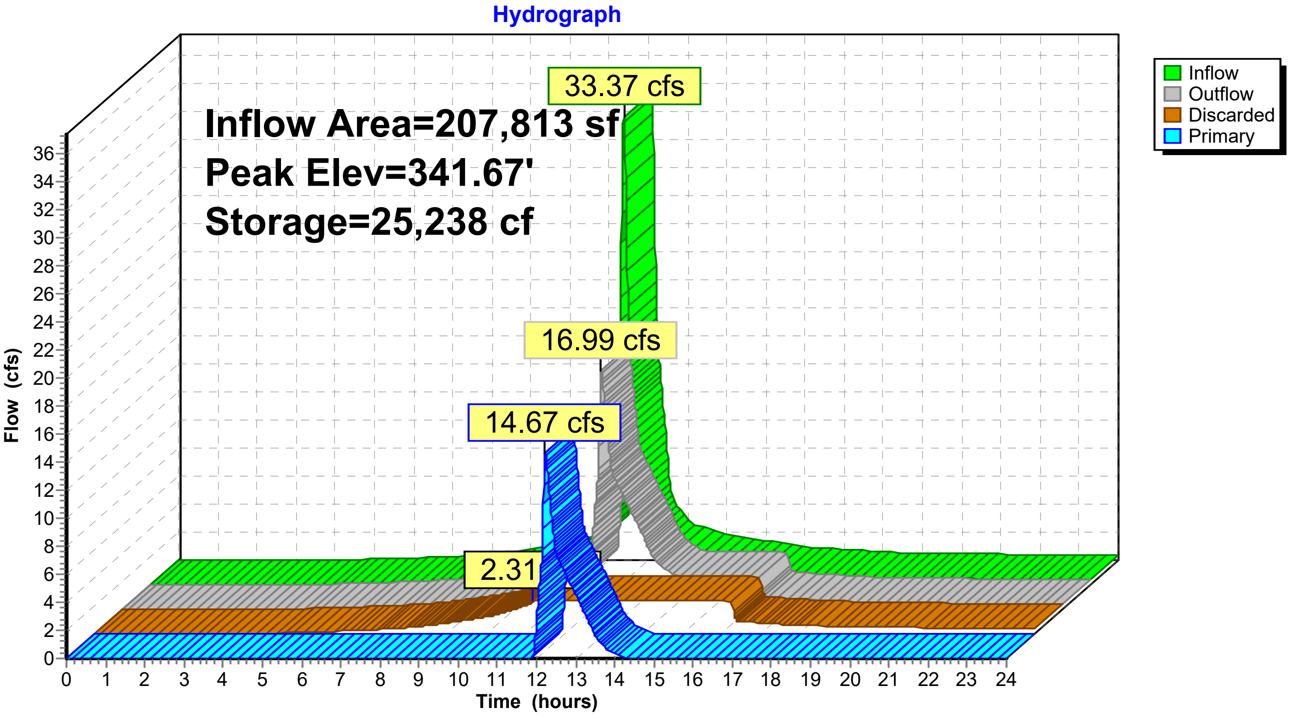
Chamber Storage + Stone Storage = 26,344.5 cf = 0.605 af
Overall Storage Efficiency = 62.3%
Overall System Size = 138.90' x 87.00' x 3.50'

342 Chambers
1,566.4 cy Field
984.5 cy Stone





Pond 2P: SubSurface Sys 2

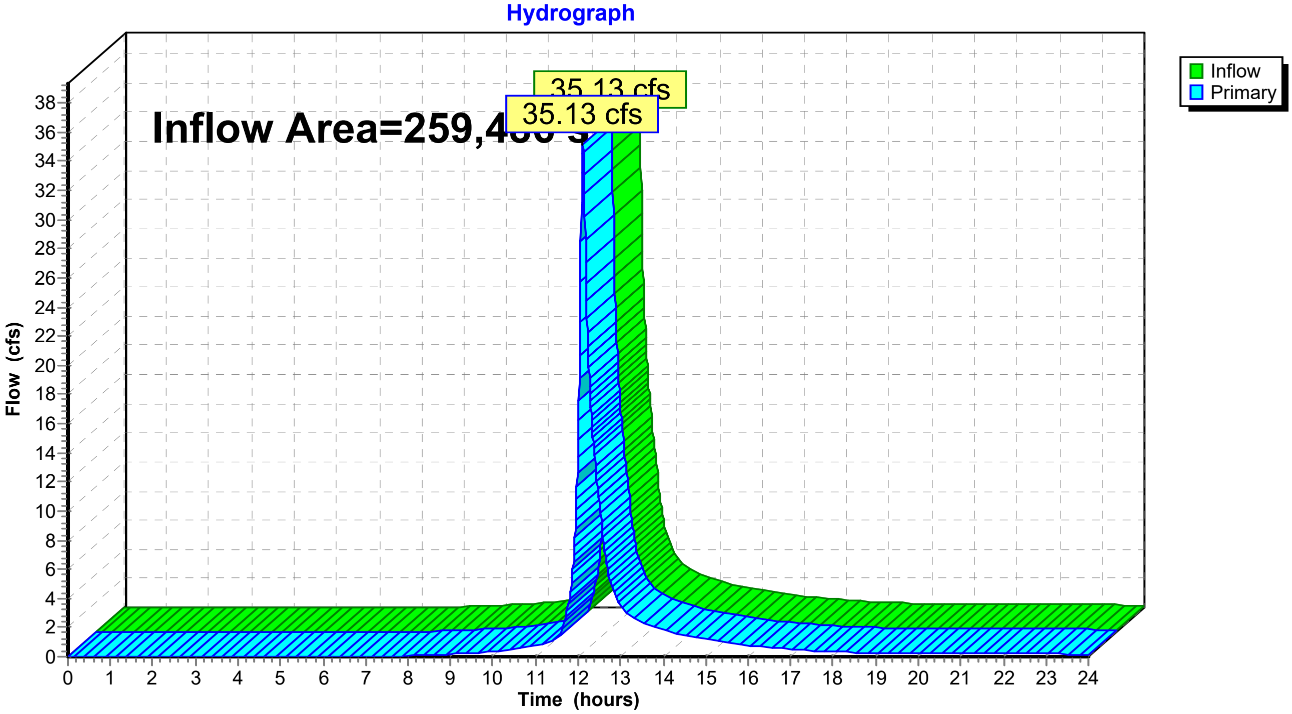


Summary for Link 3L: Combined Flow Rear Pond

Inflow Area =	259,486 sf,	61.30% Impervious,	Inflow Depth > 4.04"	for 100-Year event	
Inflow =	35.13 cfs @	12.11 hrs,	Volume=	87,274 cf	
Primary =	35.13 cfs @	12.11 hrs,	Volume=	87,274 cf,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 3L: Combined Flow Rear Pond

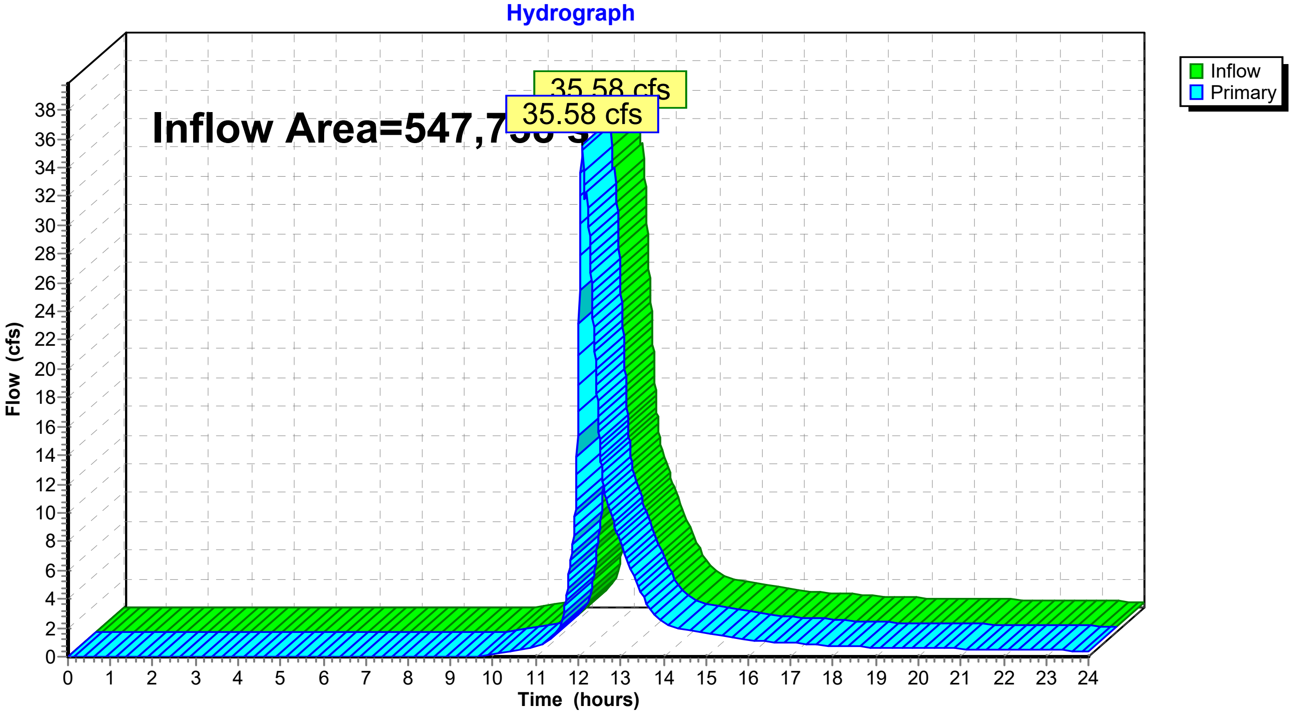


Summary for Link 4L: Combined to Great Brook

Inflow Area = 547,738 sf, 28.45% Impervious, Inflow Depth > 2.81" for 100-Year event
Inflow = 35.58 cfs @ 12.10 hrs, Volume= 128,405 cf
Primary = 35.58 cfs @ 12.10 hrs, Volume= 128,405 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Link 4L: Combined to Great Brook



SIMPLE DYNAMIC METHOD HYDROCAD MODEL

The Required Recharge Volume was done in accordance with the Massachusetts Stormwater Handbook, Volume 3 Chapter 1 – Documenting Compliance with the Massachusetts Stormwater Management Standards for the Simple Dynamic Method.

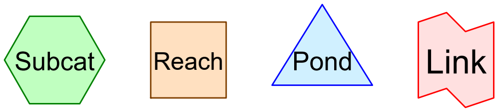
To size an infiltration BMP using the "Simple Dynamic" Method, applicants may also use a computer model based on TR-20 as described below. As more fully set forth below, this computer model assumes that the Required Water Quality Volume is entering the infiltration BMP during the peak two hours of the storm and that runoff is being discharged from the BMP during the same two hour period at the Rawls Rate. This contemporaneous exfiltration allows a proponent to reduce the size of the infiltration BMP.

a. *Use Equation 1 (Rv=F x impervious area) to determine the Required Recharge Volume*
b. *Select a 24-hour rainfall event that generates the Required Recharge Volume during the peak 2 hours. Use only the Site's impervious drainage area and the default NRCS Initial Abstraction of 0.2S and Type III storm. Set the storm duration for 24 hours, but use a start time of 11 hours and an end time of 13 hours. This creates a truncated hydrograph where most of the rainfall typical of a 24-hour Type III Storm occurs in just 2 hours. Selecting the correct precipitation depth is an iterative process. Various precipitation depths must be tested to determine which depth generates the Required Recharge Volume, using the Win TR-20 method (or other software based on TR-20). Each precipitation depth evaluated generates a runoff hydrograph. The area under the hydrograph is a volume. The correct result is achieved when the volume under the inflow hydrograph equals the Required Recharge Volume.*
c. *Using the resulting inflow hydrograph, choose an appropriate exfiltration structure with an appropriate bottom area and storage volume.*[1]
d. *Use recharge system bottom as maximum infiltrative surface area. Do not use sidewalls.*[2]
e. *Assume stormwater exfiltrates from the device over the peak 2-hour period of the rainfall event determined in step b above*
f. *Set exfiltration rates no higher than the Rawls Rates for the corresponding soil at the specific location where infiltration is proposed (see Table 2.3.3).*
g. *Assume exfiltration rate is constant.*
h. *Using the computer model, confirm adequate Storage Volume.*
i. *Go to STEP 5 to confirm that the bottom of the proposed infiltration BMP is large enough to ensure that the practice will drain completely in 72 hours or less. For purposes of the STEP 5 evaluation, assume the exfiltration rates are no higher than the Rawls Rates*

---

[1] An applicant may have to select several different size infiltration structures before s/he identifies a structure that is adequately sized.

[2] If the recharge system includes stone or other media, remember that the effective storage volume only includes the voids between the stone or other media.



Routing Diagram for 1670-15 Proposed HydroCAD - Simple Dynamic Test
Prepared by Allen & Major Associates, Inc., Printed 9/13/2021
HydroCAD® 10.10-6a s/n 02946 © 2020 HydroCAD Software Solutions LLC

Project Notes

Rainfall events imported from "NRCS-Rain.txt" for 4092 MA Essex Essex County
Rainfall events imported from "NRCS-Rain.txt" for 4165 MA Manchester Essex County

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	wqv	Type III 24-hr		Default	24.00	1	2.08	2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
57,049	98	Imp Area - Half from Front (P-5B)
57,049	98	Imp Surface - half from front (P-5A)
145,902	98	Impervious Areas (P-5B)
108,186	98	Impervious Surfaces (P-5A)
368,186	**98**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
0	HSG C	
0	HSG D	
368,186	Other	P-5A, P-5B
368,186		**TOTAL AREA**

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	S N
0	0	0	0	57,049	57,049	Imp Area - Half from Front	
0	0	0	0	57,049	57,049	Imp Surface - half from front	
0	0	0	0	145,902	145,902	Impervious Areas	
0	0	0	0	108,186	108,186	Impervious Surfaces	
0	**0**	**0**	**0**	**368,186**	**368,186**	**TOTAL AREA**	

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	1P	346.75	346.25	50.0	0.0100	0.012	0.0	18.0	0.0
2	2P	338.90	338.40	50.0	0.0100	0.012	0.0	18.0	0.0

Time span=11.00-13.00 hrs, dt=0.01 hrs, 201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment P-5A: Rear Site Runoff Area=165,235 sf 100.00% Impervious Runoff Depth>1.00"
Tc=6.0 min CN=98 Runoff=7.54 cfs 13,802 cf

Subcatchment P-5B: Front Site Runoff Area=202,951 sf 100.00% Impervious Runoff Depth>1.00"
Tc=6.0 min CN=98 Runoff=9.26 cfs 16,953 cf

Pond 1P: SubSurface Sys 1 Peak Elev=347.91' Storage=10,279 cf Inflow=7.54 cfs 13,802 cf
Discarded=0.50 cfs 3,521 cf Primary=0.00 cfs 0 cf Outflow=0.50 cfs 3,521 cf

Pond 2P: SubSurface Sys 2 Peak Elev=339.27' Storage=6,148 cf Inflow=9.26 cfs 16,953 cf
Discarded=2.31 cfs 13,073 cf Primary=0.00 cfs 0 cf Outflow=2.31 cfs 13,073 cf

Total Runoff Area = 368,186 sf Runoff Volume = 30,755 cf Average Runoff Depth = 1.00"
0.00% Pervious = 0 sf 100.00% Impervious = 368,186 sf

Summary for Subcatchment P-5A: Rear Site

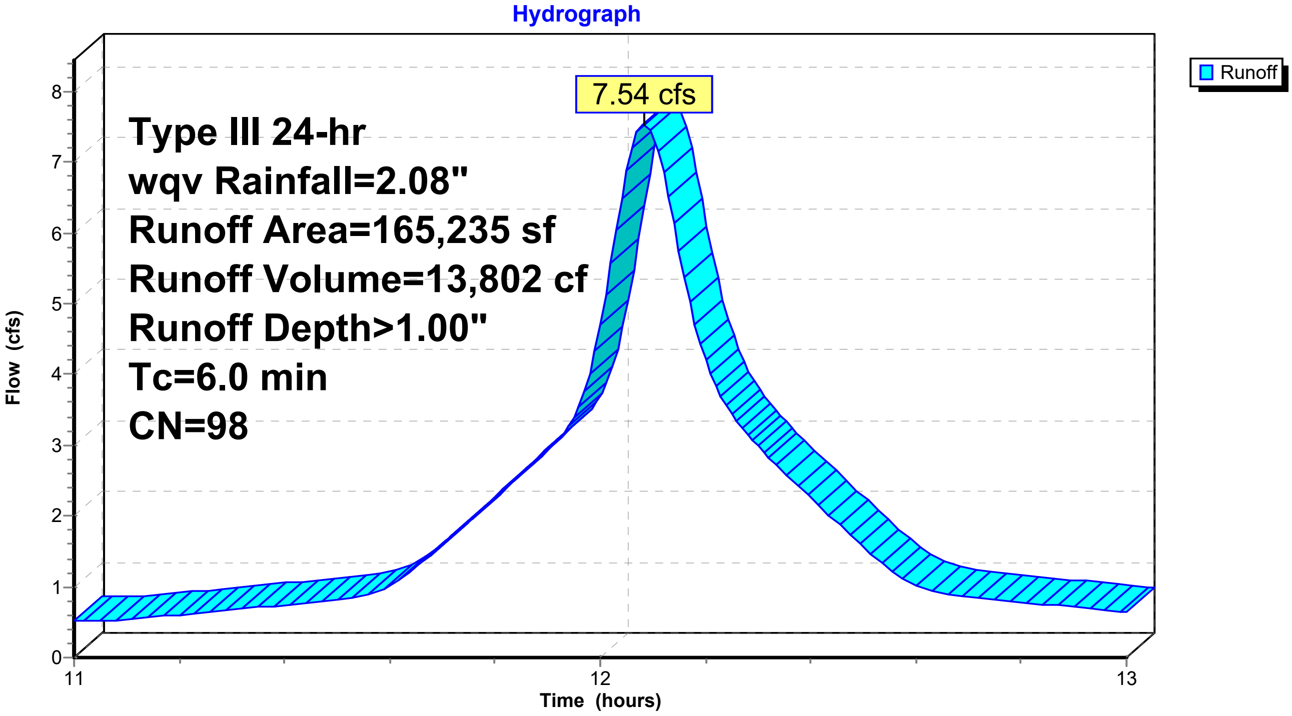
Runoff = 7.54 cfs @ 12.08 hrs, Volume= 13,802 cf, Depth> 1.00"
Routed to Pond 1P : SubSurface Sys 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 11.00-13.00 hrs, dt= 0.01 hrs
Type III 24-hr wqv Rainfall=2.08"

	Area (sf)	CN	Description
*	108,186	98	Impervious Surfaces
*	57,049	98	Imp Surface - half from front
	165,235	98	Weighted Average
	165,235		100.00% Impervious Area

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

Subcatchment P-5A: Rear Site



Summary for Subcatchment P-5B: Front Site

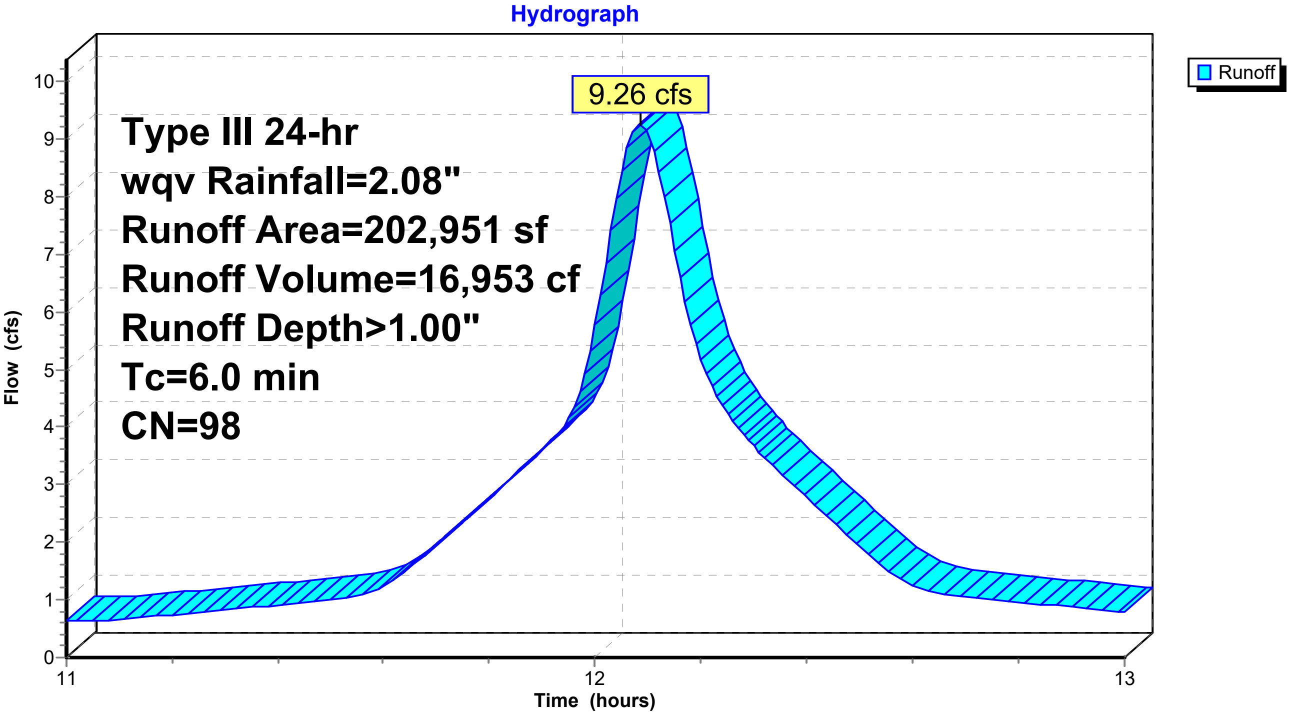
Runoff = 9.26 cfs @ 12.08 hrs, Volume= 16,953 cf, Depth> 1.00"
Routed to Pond 2P : SubSurface Sys 2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 11.00-13.00 hrs, dt= 0.01 hrs
Type III 24-hr wqv Rainfall=2.08"

	Area (sf)	CN	Description
*	145,902	98	Impervious Areas
*	57,049	98	Imp Area - Half from Front
	202,951	98	Weighted Average
	202,951		100.00% Impervious Area

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

Subcatchment P-5B: Front Site



Summary for Pond 1P: SubSurface Sys 1

[82] Warning: Early inflow requires earlier time span

Inflow Area = 165,235 sf,100.00% Impervious, Inflow Depth > 1.00" for wqv event
Inflow = 7.54 cfs @ 12.08 hrs, Volume= 13,802 cf
Outflow = 0.50 cfs @ 11.17 hrs, Volume= 3,521 cf, Atten= 93%, Lag= 0.0 min
Discarded = 0.50 cfs @ 11.17 hrs, Volume= 3,521 cf
Primary = 0.00 cfs @ 11.00 hrs, Volume= 0 cf
Routed to nonexistent node 3L

Routing by Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.01 hrs
Peak Elev= 347.91' @ 13.00 hrs Surf.Area= 8,982 sf Storage= 10,279 cf

Plug-Flow detention time= 26.6 min calculated for 3,495 cf (25% of inflow)
Center-of-Mass det. time= (not calculated: outflow precedes inflow)

Volume	Invert	Avail.Storage	Storage Description
#1A	346.25'	7,944 cf	**44.25'W x 202.98'L x 3.50'H Field A** 31,436 cf Overall - 11,577 cf Embedded = 19,859 cf x 40.0% Voids
#2A	346.75'	11,577 cf	**ADS_StormTech SC-740 +Cap** x 252 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 252 Chambers in 9 Rows
		19,521 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	346.25'	**2.410 in/hr Exfiltration over Surface area**
#2	Primary	346.75'	**18.0" Round Culvert X 2.00** L= 50.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.75' / 346.25' S= 0.0100 '/' Cc= 0.900 n= 0.012, Flow Area= 1.77 sf
#3	Primary	347.95'	**8.0" Vert. Orifice/Grate X 6.00** C= 0.600 Limited to weir flow at low heads
#4	Device 2	348.85'	**10.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.50 cfs @ 11.17 hrs HW=346.29' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.50 cfs)

Primary OutFlow Max=0.00 cfs @ 11.00 hrs HW=346.25' (Free Discharge)
├─**2=Culvert** (Controls 0.00 cfs)
│ └─**4=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)
└─**3=Orifice/Grate** (Controls 0.00 cfs)

Pond 1P: SubSurface Sys 1 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

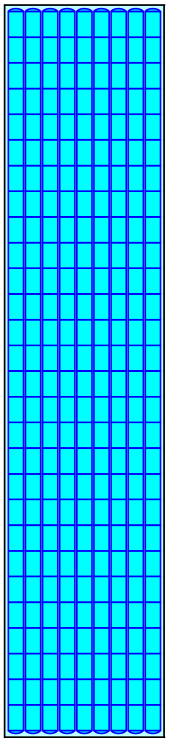
28 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 200.98' Row Length +12.0" End Stone x 2 = 202.98' Base Length
9 Rows x 51.0" Wide + 6.0" Spacing x 8 + 12.0" Side Stone x 2 = 44.25' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

252 Chambers x 45.9 cf = 11,576.9 cf Chamber Storage

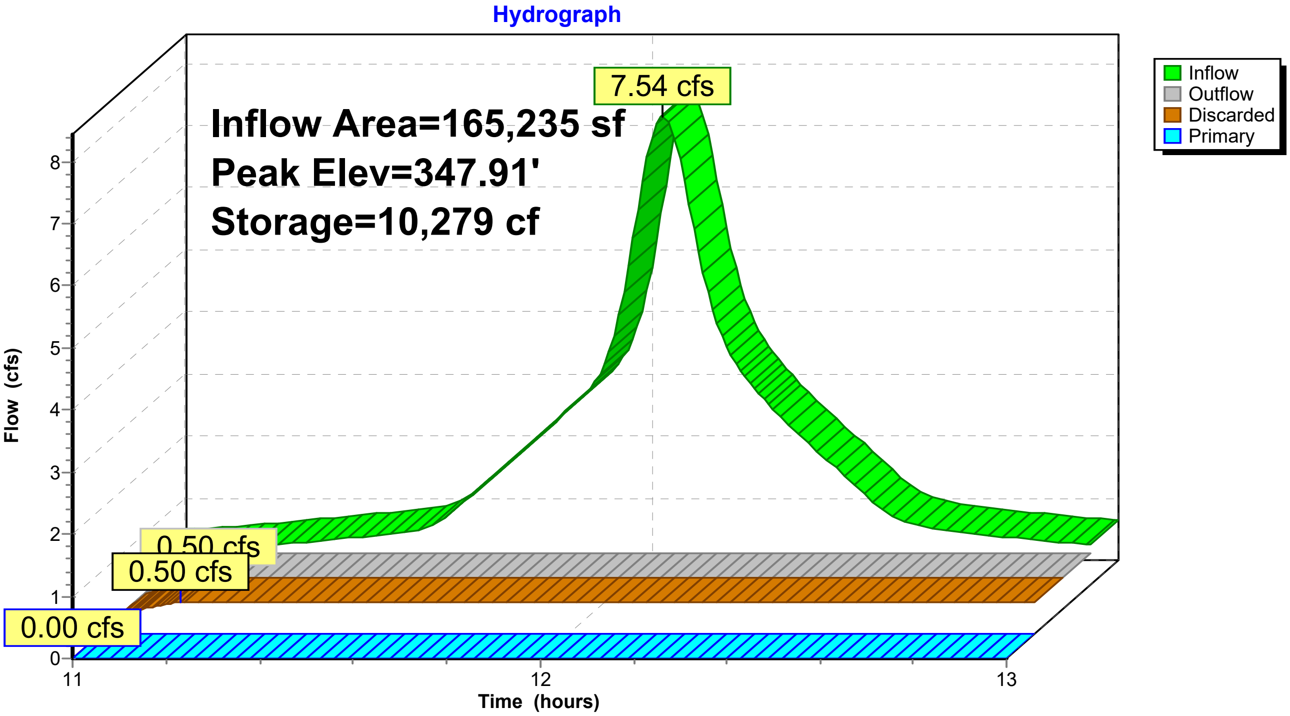
31,436.0 cf Field - 11,576.9 cf Chambers = 19,859.1 cf Stone x 40.0% Voids = 7,943.7 cf Stone Storage

Chamber Storage + Stone Storage = 19,520.5 cf = 0.448 af
Overall Storage Efficiency = 62.1%
Overall System Size = 202.98' x 44.25' x 3.50'

252 Chambers
1,164.3 cy Field
735.5 cy Stone



Pond 1P: SubSurface Sys 1



Summary for Pond 2P: SubSurface Sys 2

```
[82] Warning: Early inflow requires earlier time span

Inflow Area =         202,951 sf,100.00% Impervious,  Inflow Depth >   1.00"    for  wqv event
Inflow      =        9.26 cfs @   12.08 hrs,  Volume=            16,953 cf
Outflow     =        2.31 cfs @   11.77 hrs,  Volume=            13,073 cf,  Atten= 75%,  Lag= 0.0 min
Discarded  =         2.31 cfs @   11.77 hrs,  Volume=            13,073 cf
Primary     =        0.00 cfs @   11.00 hrs,  Volume=                 0 cf
    Routed to nonexistent node 4L

Routing by Stor-Ind method, Time Span= 11.00-13.00 hrs, dt= 0.01 hrs
Peak Elev= 339.27' @ 12.45 hrs   Surf.Area= 12,084 sf   Storage= 6,148 cf

Plug-Flow detention time= 15.8 min calculated for 12,999 cf (77% of inflow)
Center-of-Mass det. time= 7.2 min ( 731.5 - 724.4 )

Volume        Invert    Avail.Storage   Storage Description
   #1A       338.40'        10,633 cf   87.00'W x 138.90'L x 3.50'H Field A
                                        42,294 cf Overall - 15,711 cf Embedded = 26,583 cf  x 40.0% Voids
   #2A       338.90'        15,711 cf   ADS_StormTech SC-740 +Cap x 342  Inside #1
                                        Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
                                        Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
                                        342 Chambers in 18 Rows
                            26,345 cf   Total Available Storage

    Storage Group A created with Chamber Wizard

Device   Routing           Invert   Outlet Devices
   #1    Discarded        338.40'   8.270 in/hr Exfiltration over Surface area
   #2    Primary          338.90'   18.0"  Round Culvert X 2.00
                                    L= 50.0'   CPP, square edge headwall,  Ke= 0.500
                                    Inlet / Outlet Invert= 338.90' / 338.40'   S= 0.0100 '/'   Cc= 0.900
                                    n= 0.012,  Flow Area= 1.77 sf
   #3    Device 2         339.38'   8.0" Vert. Orifice/Grate X 6.00   C= 0.600
                                    Limited to weir flow at low heads
   #4    Device 2         341.30'   10.0' long  x 0.5' breadth Broad-Crested Rectangular Weir
                                    Head (feet)  0.20  0.40  0.60  0.80  1.00
                                    Coef. (English)  2.80  2.92  3.08  3.30  3.32

Discarded OutFlow  Max=2.31 cfs @ 11.77 hrs  HW=338.44'   (Free Discharge)
└─1=Exfiltration  (Exfiltration Controls 2.31 cfs)

Primary OutFlow  Max=0.00 cfs @ 11.00 hrs  HW=338.40'   (Free Discharge)
└─2=Culvert  ( Controls 0.00 cfs)
   ├─3=Orifice/Grate  ( Controls 0.00 cfs)
   └─4=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)
```

Pond 2P: SubSurface Sys 2 - Chamber Wizard Field A

Chamber Model = ADS_StormTech SC-740 +Cap (ADS StormTech® SC-740 with cap length)
Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap

51.0" Wide + 6.0" Spacing = 57.0" C-C Row Spacing

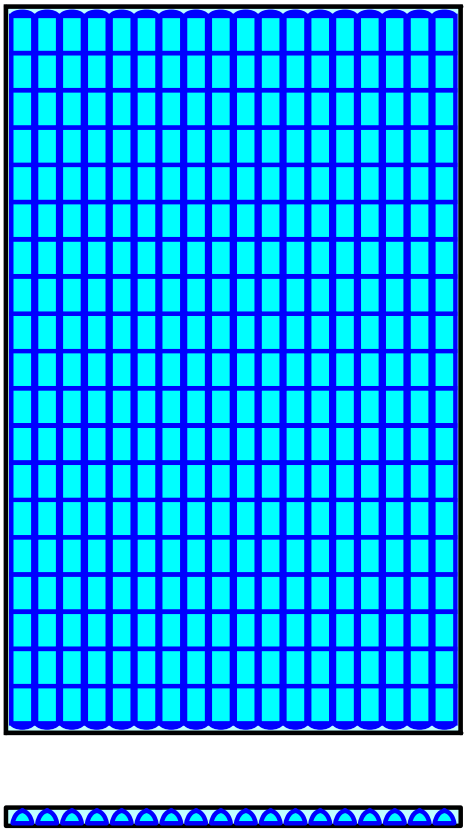
19 Chambers/Row x 7.12' Long +0.81' Cap Length x 2 = 136.90' Row Length +12.0" End Stone x 2 = 138.90' Base Length
18 Rows x 51.0" Wide + 6.0" Spacing x 17 + 12.0" Side Stone x 2 = 87.00' Base Width
6.0" Stone Base + 30.0" Chamber Height + 6.0" Stone Cover = 3.50' Field Height

342 Chambers x 45.9 cf = 15,711.5 cf Chamber Storage

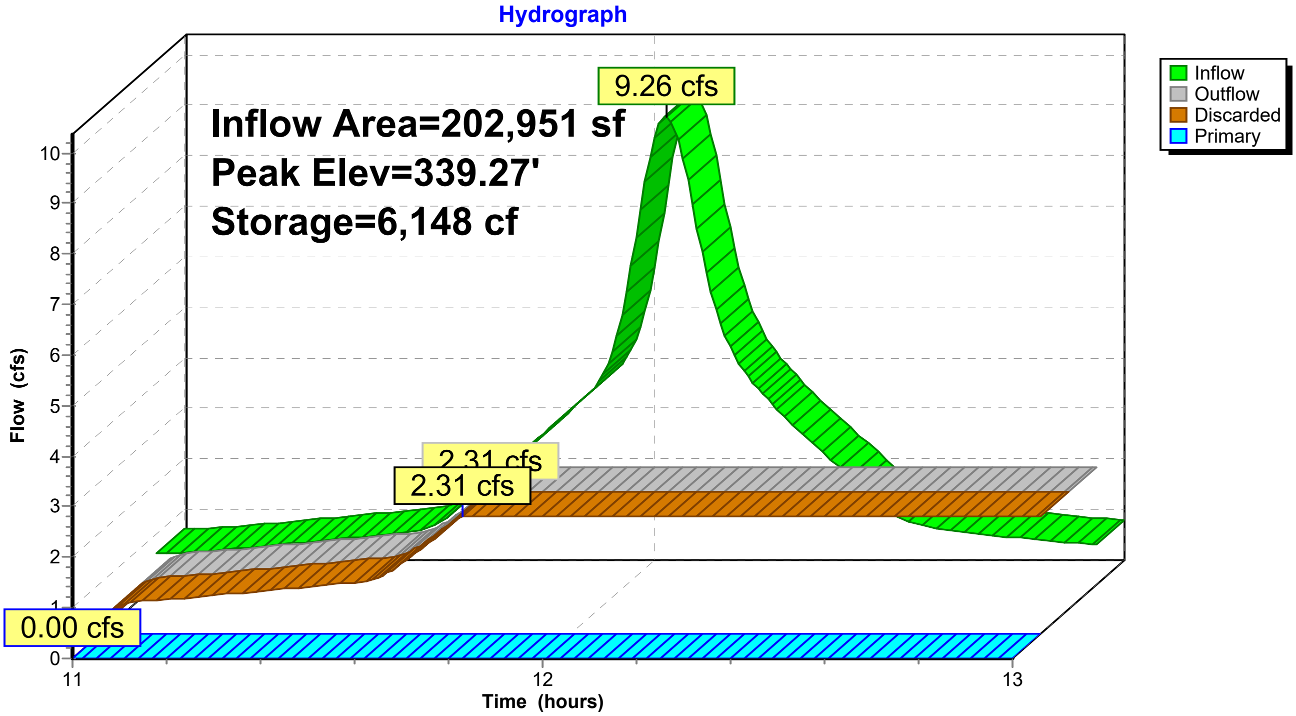
42,294.0 cf Field - 15,711.5 cf Chambers = 26,582.5 cf Stone x 40.0% Voids = 10,633.0 cf Stone Storage

Chamber Storage + Stone Storage = 26,344.5 cf = 0.605 af
Overall Storage Efficiency = 62.3%
Overall System Size = 138.90' x 87.00' x 3.50'

342 Chambers
1,566.4 cy Field
984.5 cy Stone



Pond 2P: SubSurface Sys 2



APPENDIX H

SUPPORTING INFORMATION

ILLICIT DISCHARGE STATEMENT

Project: Multi-Family Residential Development
ALTA Nashoba Valley
580 Main Street
Bolton, MA

Date: September 10, 2021

The stormwater management system proposed shall not be connected to the wastewater management system and shall not be contaminated by contact with process wastes, raw materials, toxic pollutants, hazardous substances, oil, or grease per Massachusetts DEP stormwater standard 10.

Engineer:
Allen & Major Associates, Inc.
10 Main Street
Lakeville, MA 02347

______________________________ ______________________________
Print Name Signature

Owner:
Limited Dividend Affiliate of
WP East Acquisitions, LLC
91 Hartwell Avenue
Lexington, MA 02421

______________________________ ______________________________
Print Name Signature

PIPE SIZING

ALLEN & MAJOR
ASSOCIATES, INC.

DESIGN YEAR: 25.00
K= 230.00 B= 30

Title ***Stormwater Conveyance Sizing (25 YEAR STORM)***
Project ***Multi-Family Development - Bolton, MA***
Date 09-10-2021
A&M Project Number: 1670-15

Minimum Slope:	0.005	
Minimum Size:	12.000	inch
Rainfall Intensity (in/hr):	6.389	(25 year storm)
Manning's n:	0.012	HDPE
Manning's n:	0.013	RCP
Min. Velocity:	2.000	fps
Max. Velocity:	12.000	fps

From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Time of Peak Flow (days hh:mm)	Max Flow Velocity (ft/sec)	Travel Time (min)	Design Flow Capacity (cfs)	Max Flow / Design Flow Ratio	Max Flow Depth (ft)	Reported Condition
To Sub-Surface System No. 1																
PCB 14A	PDMH 14	85.2	349.69	349.26	0.50	CIRCULAR	12	0.012	0.66	0 00:06	4.08	0.35	2.73	0.24	0.33	OK
PCB 14B	PDMH 14	7.2	349.30	349.26	0.50	CIRCULAR	12	0.012	0.93	0 00:06	3.15	0.04	2.74	0.34	0.40	OK
PDMH 14	PDMH 15	106.7	349.26	348.73	0.50	CIRCULAR	12	0.012	1.55	0 00:06	3.64	0.49	2.73	0.57	0.54	OK
PCB 15A	PDMH 15	8.2	348.77	348.73	0.50	CIRCULAR	12	0.012	0.87	0 00:06	3.09	0.04	2.73	0.32	0.39	OK
GA ROOF	PDMH 15	10.9	349.34	349.23	1.00	CIRCULAR	6	0.012	0.41	0 00:06	3.32	0.05	0.61	0.67	0.30	OK
PDMH 15	PDMH 16	96.6	348.63	348.15	0.50	CIRCULAR	15	0.012	2.74	0 00:06	4.18	0.39	4.95	0.55	0.66	OK
PCB 16A	PDMH 16	13.4	348.53	348.40	1.00	CIRCULAR	12	0.012	0.97	0 00:06	4.10	0.05	3.86	0.25	0.34	OK
PDMH 16	PDMH 17	93.4	348.15	347.68	0.50	CIRCULAR	15	0.012	3.64	0 00:06	4.45	0.35	4.95	0.74	0.80	OK
PCB 17A	PDMH 17	3.1	348.21	348.18	0.98	CIRCULAR	12	0.012	1.01	0 00:06	4.12	0.01	3.83	0.26	0.35	OK
PDMH 17	PDMH 18	58.3	347.68	347.39	0.50	CIRCULAR	18	0.012	4.54	0 00:06	4.69	0.21	8.02	0.57	0.81	OK
B3 ROOF	PDMH 18	56.0	348.66	348.38	0.50	CIRCULAR	12	0.012	1.76	0 00:06	4.89	0.19	2.73	0.65	0.58	OK
PCB 18A	PDMH 18	5.4	348.41	348.38	0.50	CIRCULAR	12	0.012	0.36	0 00:06	2.41	0.04	2.73	0.13	0.24	OK
PCB 18B	PDMH 18	103.9	348.90	348.38	0.50	CIRCULAR	12	0.012	1.12	0 00:06	4.76	0.36	2.73	0.41	0.44	OK
PDMH 18	PDMH 19	94.7	347.39	347.10	0.31	CIRCULAR	24	0.012	7.59	0 00:06	4.47	0.35	13.59	0.56	1.07	OK
PCB 19A	PDMH 19	15.7	348.18	348.10	0.50	CIRCULAR	12	0.012	0.76	0 00:06	2.97	0.09	2.72	0.28	0.36	OK
PDMH 19	PDMH 20	93.5	347.10	346.79	0.33	CIRCULAR	24	0.012	8.24	0 00:07	4.69	0.33	14.09	0.59	1.10	OK
PDMH 20	PDMH 20A	6.4	346.79	346.77	0.33	CIRCULAR	24	0.012	9.19	0 00:07	4.75	0.02	14.00	0.66	1.18	OK
PCB 20A	PDMH 20	28.1	347.93	347.79	0.50	CIRCULAR	12	0.012	1.08	0 00:06	3.29	0.14	2.73	0.40	0.44	OK
PDMH 20A	IR 1A	3.2	346.77	346.76	0.35	CIRCULAR	24	0.012	9.19	0 00:07	4.86	0.01	14.41	0.64	1.16	OK
PCB 21A	PDMH 21	37.5	347.70	347.51	0.50	CIRCULAR	12	0.012	1.69	0 00:06	3.71	0.17	2.73	0.62	0.57	OK
PDMH 21	IR 1C	5.1	346.79	346.76	0.50	CIRCULAR	24	0.012	1.68	0 00:06	3.50	0.02	17.33	0.10	0.42	OK
PCB 11B	PDMH 11	118.7	348.37	347.78	0.50	CIRCULAR	12	0.012	0.94	0 00:06	4.82	0.41	2.73	0.34	0.40	OK
PCB 11A	PDMH 11	9.1	347.82	347.78	0.50	CIRCULAR	12	0.012	0.75	0 00:06	2.97	0.05	2.73	0.28	0.36	OK
PDMH 11	PDMH 12	103.8	347.78	347.26	0.50	CIRCULAR	12	0.012	1.65	0 00:06	3.68	0.47	2.73	0.60	0.56	OK
PDMH 12	PDMH 13	107.8	347.26	346.92	0.32	CIRCULAR	15	0.012	1.63	0 00:07	3.10	0.58	3.93	0.41	0.56	OK
PDMH 13	IR 1D	4.8	346.80	346.76	0.83	CIRCULAR	24	0.012	1.63	0 00:07	4.15	0.02	22.36	0.07	0.36	OK
POCS 1A	PFES 1A	17.0	346.75	346.58	1.00	CIRCULAR	18	0.012	4.79	0 00:00	6.16	0.05	11.38	0.42	0.68	OK
POCS 1B	PFES 1B	14.9	346.75	346.60	1.00	CIRCULAR	18	0.012	4.79	0 00:00	6.16	0.04	11.38	0.42	0.68	OK
To Sub-Surface System No. 2																
PAD 3	PAD 3B	135.7	347.28	346.60	0.50	CIRCULAR	12	0.012	0.20	0 00:06	3.72	0.61	2.73	0.07	0.18	OK

ALLEN & MAJOR
ASSOCIATES, INC.

DESIGN YEAR: **25.00**
K= 230.00 B= 30

Title ***Stormwater Conveyance Sizing (25 YEAR STORM)***
Project ***Multi-Family Development - Bolton, MA***
Date 09-10-2021
A&M Project Number: 1670-15

Minimum Slope: 0.005
Minimum Size: 12.000 inch
Rainfall Intensity (in/hr): 6.389 (25 year storm)
Manning's n: 0.012 HDPE
Manning's n: 0.013 RCP
Min. Velocity: 2.000 fps
Max. Velocity: 12.000 fps

From (Inlet) Node	**To (Outlet) Node**	**Length (ft)**	**Inlet Invert Elevation (ft)**	**Outlet Invert Elevation (ft)**	**Average Slope (%)**	**Pipe Shape**	**Pipe Diameter or Height (inches)**	**Manning's Roughness**	**Peak Flow (cfs)**	**Time of Peak Flow (days hh:mm)**	**Max Flow Velocity (ft/sec)**	**Travel Time (min)**	**Design Flow Capacity (cfs)**	**Max Flow / Design Flow Ratio**	**Max Flow Depth (ft)**	**Reported Condition**
PAD 3B	PDMH 3	61.3	346.50	346.19	0.50	CIRCULAR	12	0.012	0.33	0 00:06	2.36	0.43	2.73	0.12	0.23	OK
GB ROOF	PDMH 3	34.9	348.19	347.24	2.70	CIRCULAR	6	0.012	0.40	0 00:06	5.32	0.11	1.00	0.40	0.22	OK
PCB 3A	PDMH 3	6.3	346.50	346.44	1.00	CIRCULAR	12	0.012	1.09	0 00:06	4.22	0.02	3.86	0.28	0.36	OK
C1 ROOF	C1 WYE	31.9	346.64	346.00	2.01	CIRCULAR	6	0.012	0.29	0 00:06	4.41	0.12	0.86	0.33	0.20	OK
PDMH 3	PDMH 4	165.3	346.09	344.44	1.00	CIRCULAR	12	0.012	1.74	0 00:06	4.85	0.57	3.86	0.45	0.47	OK
PCB 4A	PDMH 4	4.2	345.50	345.46	1.00	CIRCULAR	12	0.012	1.77	0 00:06	4.81	0.01	3.86	0.46	0.47	OK
B1 ROOF	PDMH 4	50.4	347.05	344.29	5.48	CIRCULAR	12	0.012	3.66	0 00:06	10.93	0.08	9.04	0.41	0.44	OK
PDMH 4	PDMH 5	224.1	343.94	341.70	1.00	CIRCULAR	18	0.012	6.92	0 00:06	6.86	0.54	11.38	0.61	0.84	OK
B2C ROOF	PDMH 5	48.8	343.99	343.50	1.00	CIRCULAR	12	0.012	1.79	0 00:06	5.69	0.14	3.86	0.46	0.48	OK
PCB 5A	PDMH 5	3.4	342.27	342.20	1.99	CIRCULAR	12	0.012	2.39	0 00:06	6.71	0.01	5.45	0.44	0.46	OK
PDMH 5	PDMH 6	79.9	341.60	340.00	2.00	CIRCULAR	18	0.012	10.87	0 00:06	9.79	0.14	16.10	0.68	0.90	OK
PCB 6A	PDMH 6	13.0	340.57	340.50	0.50	CIRCULAR	12	0.012	1.02	0 00:06	3.23	0.07	2.73	0.38	0.42	OK
PDMH 6	PDMH 7	76.2	339.32	338.94	0.50	CIRCULAR	24	0.012	11.82	0 00:06	5.96	0.21	17.33	0.68	1.21	OK
PDMH 7	PDMH 7A	2.3	338.94	338.92	0.49	CIRCULAR	24	0.012	13.12	0 00:06	6.01	0.01	17.13	0.77	1.31	OK
PCB 7A	PDMH 7	3.1	340.00	339.94	2.01	CIRCULAR	12	0.012	1.43	0 00:06	5.86	0.01	5.47	0.26	0.35	OK
PDMH 7A	IR 2A	2.8	338.92	338.91	0.50	CIRCULAR	24	0.012	13.12	0 00:06	6.06	0.01	17.32	0.76	1.30	OK
PCB 10B	PDMH 10	8.3	344.08	344.00	1.00	CIRCULAR	12	0.012	0.53	0 00:06	3.45	0.04	3.86	0.14	0.25	OK
PCB 10A	PDMH 10	27.1	344.27	344.00	1.00	CIRCULAR	12	0.012	0.59	0 00:06	3.62	0.12	3.86	0.15	0.26	OK
PDMH 10	PDMH 9	147.8	343.27	340.31	2.00	CIRCULAR	12	0.012	2.87	0 00:06	7.11	0.35	5.46	0.53	0.51	OK
B2B ROOF	PDMH 9	39.1	340.51	340.31	0.50	CIRCULAR	12	0.012	0.00	0 00:00	0.00		2.73	0.00	0.00	OK
B2A ROOF	PDMH 10	30.0	344.60	344.00	2.00	CIRCULAR	12	0.012	1.80	0 00:06	6.27	0.08	5.46	0.33	0.40	OK
PCB 9A	PDMH 9	8.4	340.35	340.31	0.50	CIRCULAR	12	0.012	1.52	0 00:06	3.58	0.04	2.73	0.56	0.53	OK
PDMH 9	PDMH 8	62.1	340.06	339.69	0.60	CIRCULAR	15	0.012	4.32	0 00:06	4.93	0.21	5.40	0.80	0.85	OK
PDMH 8	PDMH 8A	1.5	339.44	339.43	0.53	CIRCULAR	18	0.012	5.85	0 00:06	5.09	0	8.30	0.70	0.93	OK
PCB 8A	PDMH 8	4.2	339.98	339.94	0.99	CIRCULAR	12	0.012	1.61	0 00:06	4.68	0.02	3.84	0.42	0.45	OK
PDMH 8A	IR 2B	3.4	338.93	338.91	0.50	CIRCULAR	24	0.012	5.85	0 00:06	4.99	0.01	17.41	0.34	0.80	OK
GC ROOF	PINF 2C	16.4	339.58	339.25	2.00	CIRCULAR	6	0.012	0.29	0 00:06	3.94	0.07	0.86	0.33	0.20	OK
POCS 2A	PFES 2A	35.1	338.90	338.55	1.00	CIRCULAR	18	0.012	3.04	0 00:01	5.45	0.11	11.38	0.27	0.53	OK
POCS 2B	PFES 2B	25.3	338.91	338.65	1.04	CIRCULAR	18	0.012	3.04	0 00:01	5.53	0.08	11.60	0.26	0.52	OK

To Existing Collection System																
ECB-1C	ECB 1A	38.0	348.29	346.69	4.21	CIRCULAR	12	0.012	0.10	0 00:06	3.89	0.16	7.92	0.01	0.08	OK

AutoDesk Storm and Sanitary Analysis 2019

ALLEN & MAJOR
ASSOCIATES, INC.

DESIGN YEAR: 25.00
K= 230.00 B= 30

Title ***Stormwater Conveyance Sizing (25 YEAR STORM)***
Project ***Multi-Family Development - Bolton, MA***
Date 09-10-2021
A&M Project Number: 1670-15

Minimum Slope: 0.005
Minimum Size: 12.000 inch
Rainfall Intensity (in/hr): 6.389 (25 year storm)
Manning's n: 0.012 HDPE
Manning's n: 0.013 RCP
Min. Velocity: 2.000 fps
Max. Velocity: 12.000 fps

From (Inlet) Node	**To (Outlet) Node**	**Length (ft)**	**Inlet Invert Elevation (ft)**	**Outlet Invert Elevation (ft)**	**Average Slope (%)**	**Pipe Shape**	**Pipe Diameter or Height (inches)**	**Manning's Roughness**	**Peak Flow (cfs)**	**Time of Peak Flow (days hh:mm)**	**Max Flow Velocity (ft/sec)**	**Travel Time (min)**	**Design Flow Capacity (cfs)**	**Max Flow / Design Flow Ratio**	**Max Flow Depth (ft)**	**Reported Condition**
ECB 1A	PDMH 1	35.8	346.50	346.14	1.00	CIRCULAR	12	0.012	1.63	0 00:06	4.72	0.13	3.86	0.42	0.45	OK
PCB 1B	PDMH 1	19.1	346.33	346.14	1.00	CIRCULAR	12	0.012	0.65	0 00:06	3.66	0.09	3.86	0.17	0.28	OK
M ROOF	PDMH 1	71.4	348.07	346.64	2.00	CIRCULAR	6	0.012	0.11	0 00:06	4.35	0.27	0.86	0.13	0.12	OK
PDMH 1	PDMH 2	152.4	345.89	345.13	0.50	CIRCULAR	15	0.012	2.32	0 00:06	4.05	0.63	4.95	0.47	0.60	OK
C2 ROOF	C2 WYE	7.4	346.65	346.50	2.00	CIRCULAR	6	0.012	0.46	0 00:06	4.45	0.03	0.86	0.53	0.26	OK
PCB 2A	PDMH 2	10.1	345.60	345.50	1.00	CIRCULAR	12	0.012	0.36	0 00:06	3.09	0.05	3.86	0.09	0.21	OK
PDMH 2	EDMH	105.6	345.00	344.47	0.50	CIRCULAR	15	0.012	2.63	0 00:07	4.14	0.43	4.95	0.53	0.65	OK

ALLEN & MAJOR
ASSOCIATES, INC.

Title *Stormwater Conveyance Sizing (25 YEAR STORM)*
Project *Multi-Family Development - Canton, MA*
Date 09-10-2021
A&M Project Number: 1670-15

Watershed	Drainage Node ID	Area (acres)	Weighted Runoff Coefficient	Accumulated Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Rainfall Intensity (inches/hr)	Time of Concentration (days hh:mm:ss)
1	PCB 14A	0.14	0.7500	0.64	0.48	0.67	6.389	0 00:06:00
2	PCB 14B	0.19	0.7700	0.64	0.49	0.94	6.389	0 00:06:00
3	PCB 15A	0.18	0.7600	0.64	0.49	0.87	6.389	0 00:06:00
4	PCB 16A	0.21	0.7300	0.64	0.47	0.98	6.389	0 00:06:00
5	PCB 17A	0.23	0.6900	0.64	0.44	1.01	6.389	0 00:06:00
6	PCB 18A	0.07	0.8100	0.64	0.52	0.36	6.389	0 00:06:00
7	PCB 11B	0.22	0.6900	0.64	0.44	0.97	6.389	0 00:06:00
8	PCB 11A	0.16	0.7400	0.64	0.47	0.76	6.389	0 00:06:00
9	PCB 18B	0.25	0.7200	0.64	0.46	1.15	6.389	0 00:06:00
10	PCB 19A	0.17	0.7000	0.64	0.45	0.76	6.389	0 00:06:00
11	PCB 20A	0.23	0.7400	0.64	0.47	1.09	6.389	0 00:06:00
12	PCB 21A	0.35	0.7600	0.64	0.49	1.70	6.389	0 00:06:00
13	GA ROOF	0.07	0.9000	0.64	0.58	0.41	6.389	0 00:06:00
14	B3 ROOF	0.31	0.9000	0.64	0.58	1.78	6.389	0 00:06:00
16	PCB 3A	0.23	0.7400	0.64	0.47	1.09	6.389	0 00:06:00
17	PCB 4A	0.39	0.7100	0.64	0.45	1.77	6.389	0 00:06:00
18	PCB 5A	0.52	0.7200	0.64	0.46	2.39	6.389	0 00:06:00
19	PCB 6A	0.24	0.6700	0.64	0.43	1.03	6.389	0 00:06:00
20	PCB 7A	0.28	0.8000	0.64	0.51	1.43	6.389	0 00:06:00
21	PCB 8A	0.32	0.7900	0.64	0.51	1.62	6.389	0 00:06:00
22	PCB 9A	0.34	0.7000	0.64	0.45	1.52	6.389	0 00:06:00
23	PCB 10A	0.14	0.6600	0.64	0.42	0.59	6.389	0 00:06:00
24	PCB 10B	0.13	0.6400	0.64	0.41	0.53	6.389	0 00:06:00
25	GB ROOF	0.07	0.9000	0.64	0.58	0.40	6.389	0 00:06:00
26	C1 ROOF	0.05	0.9000	0.64	0.58	0.29	6.389	0 00:06:00
27	B1 ROOF	0.64	0.9000	0.64	0.58	3.68	6.389	0 00:06:00
28	B2A ROOF	0.32	0.9000	0.64	0.58	1.81	6.389	0 00:06:00
28	B2C ROOF	0.32	0.9000	0.64	0.58	1.81	6.389	0 00:06:00
29	GC ROOF	0.05	0.9000	0.64	0.58	0.29	6.389	0 00:06:00
30	ECB 1A	0.35	0.6900	0.64	0.44	1.54	6.389	0 00:06:00
31	PCB 1B	0.13	0.7900	0.64	0.51	0.66	6.389	0 00:06:00
32	M ROOF	0.02	0.9000	0.64	0.58	0.12	6.389	0 00:06:00
33	C2 ROOF	0.08	0.9000	0.64	0.58	0.46	6.389	0 00:06:00
34	PCB 2A	0.08	0.7100	0.64	0.45	0.36	6.389	0 00:06:00
36	PAD 3	0.11	0.3000	0.64	0.19	0.21	6.389	0 00:06:00
37	PAD 3B	0.07	0.3000	0.64	0.19	0.13	6.389	0 00:06:00
38	ECB-1C	0.05	0.3000	0.64	0.19	0.10	6.389	0 00:06:00

ALLEN & MAJOR ASSOCIATES, INC.

DESIGN YEAR: **100.00**
K= 290.00 B= 31

Title ***Stormwater Conveyance Sizing (100 YEAR STORM)***
Project ***Multi-Family Development - Bolton, MA***
Date 09-10-2021
A&M Project Number: 1670-15

Minimum Slope:	0.005	
Minimum Size:	12.000	inch
Rainfall Intensity (in/hr):	7.840	(100 year storm)
Manning's n:	0.012	HDPE
Manning's n:	0.013	RCP
Min. Velocity:	2.000	fps
Max. Velocity:	12.000	fps

From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Time of Peak Flow (days hh:mm)	Max Flow Velocity (ft/sec)	Travel Time (min)	Design Flow Capacity (cfs)	Max Flow / Design Flow Ratio	Max Flow Depth (ft)	Reported Condition
To Sub-Surface System No. 1																
PCB 14A	PDMH 14	85.20	349.69	349.26	0.5000	CIRCULAR	12.000	0.0120	0.80	0 00:06	4.32	0.33	2.73	0.29	0.37	OK
PCB 14B	PDMH 14	7.16	349.30	349.26	0.5000	CIRCULAR	12.000	0.0120	1.15	0 00:06	3.33	0.04	2.74	0.42	0.45	OK
PDMH 14	PDMH 15	106.66	349.26	348.73	0.5000	CIRCULAR	12.000	0.0120	1.89	0 00:06	3.81	0.47	2.73	0.69	0.61	OK
PCB 15A	PDMH 15	8.22	348.77	348.73	0.5000	CIRCULAR	12.000	0.0120	1.07	0 00:06	3.27	0.04	2.73	0.39	0.44	OK
GA ROOF	PDMH 15	10.85	349.34	349.23	1.0000	CIRCULAR	6.000	0.0120	0.50	0 00:06	3.46	0.05	0.61	0.82	0.35	OK
PDMH 15	PDMH 16	96.64	348.63	348.15	0.5000	CIRCULAR	15.000	0.0120	3.36	0 00:06	4.38	0.37	4.95	0.68	0.76	OK
PCB 16A	PDMH 16	13.37	348.53	348.40	1.0000	CIRCULAR	12.000	0.0120	1.20	0 00:06	4.35	0.05	3.86	0.31	0.38	OK
PDMH 16	PDMH 17	93.42	348.15	347.68	0.5000	CIRCULAR	15.000	0.0120	4.46	0 00:06	4.62	0.34	4.95	0.90	0.93	OK
PCB 17A	PDMH 17	3.05	348.21	348.18	0.9800	CIRCULAR	12.000	0.0120	1.24	0 00:06	4.35	0.01	3.83	0.32	0.39	OK
PDMH 17	PDMH 18	58.34	347.68	347.39	0.5000	CIRCULAR	18.000	0.0120	5.57	0 00:06	4.91	0.20	8.02	0.69	0.92	OK
B3 ROOF	PDMH 18	55.99	348.66	348.38	0.5000	CIRCULAR	12.000	0.0120	2.16	0 00:06	5.10	0.18	2.73	0.79	0.67	OK
PCB 18A	PDMH 18	5.40	348.41	348.38	0.5000	CIRCULAR	12.000	0.0120	0.44	0 00:06	2.56	0.04	2.73	0.16	0.27	OK
PCB 18B	PDMH 18	103.86	348.90	348.38	0.5000	CIRCULAR	12.000	0.0120	1.37	0 00:06	4.93	0.35	2.73	0.50	0.50	OK
PDMH 18	PDMH 19	94.66	347.39	347.10	0.3100	CIRCULAR	24.000	0.0120	9.35	0 00:06	4.70	0.34	13.59	0.69	1.22	OK
PCB 19A	PDMH 19	15.67	348.18	348.10	0.5000	CIRCULAR	12.000	0.0120	0.93	0 00:06	3.14	0.08	2.72	0.34	0.40	OK
PDMH 19	PDMH 20	93.50	347.10	346.79	0.3300	CIRCULAR	24.000	0.0120	10.16	0 00:07	4.92	0.32	14.09	0.72	1.26	OK
PDMH 20	PDMH 20A	6.43	346.79	346.77	0.3300	CIRCULAR	24.000	0.0120	11.32	0 00:07	4.96	0.02	14.00	0.81	1.36	OK
PCB 20A	PDMH 20	28.14	347.93	347.79	0.5000	CIRCULAR	12.000	0.0120	1.32	0 00:06	3.46	0.14	2.73	0.48	0.49	OK
PDMH 20A	IR 1A	3.18	346.77	346.76	0.3500	CIRCULAR	24.000	0.0120	11.32	0 00:07	5.08	0.01	14.41	0.79	1.34	OK
PCB 21A	PDMH 21	37.45	347.70	347.51	0.5000	CIRCULAR	12.000	0.0120	2.07	0 00:06	3.85	0.16	2.73	0.76	0.65	OK
PDMH 21	IR 1C	5.12	346.79	346.76	0.5000	CIRCULAR	24.000	0.0120	2.07	0 00:06	3.71	0.02	17.33	0.12	0.47	OK
PCB 11B	PDMH 11	118.72	348.37	347.78	0.5000	CIRCULAR	12.000	0.0120	1.15	0 00:06	4.95	0.40	2.73	0.42	0.45	OK
PCB 11A	PDMH 11	9.07	347.82	347.78	0.5000	CIRCULAR	12.000	0.0120	0.92	0 00:06	3.14	0.05	2.73	0.34	0.40	OK
PDMH 11	PDMH 12	103.82	347.78	347.26	0.5000	CIRCULAR	12.000	0.0120	2.03	0 00:06	3.86	0.45	2.73	0.74	0.64	OK
PDMH 12	PDMH 13	107.75	347.26	346.92	0.3200	CIRCULAR	15.000	0.0120	2.00	0 00:07	3.27	0.55	3.93	0.51	0.63	OK
PDMH 13	IR 1D	4.81	346.80	346.76	0.8300	CIRCULAR	24.000	0.0120	2.00	0 00:07	4.41	0.02	22.36	0.09	0.40	OK
POCS 1A	PFES 1A	16.95	346.75	346.58	1.0000	CIRCULAR	18.000	0.0120	10.07	0 00:00	7.27	0.04	11.38	0.88	1.10	OK
POCS 1B	PFES 1B	14.85	346.75	346.60	1.0000	CIRCULAR	18.000	0.0120	10.07	0 00:00	7.27	0.03	11.38	0.88	1.10	OK

To Sub-Surface System No. 2																
PAD 3	PAD 3B	135.66	347.28	346.60	0.5000	CIRCULAR	12.000	0.0120	0.25	0 00:06	3.89	0.58	2.73	0.09	0.20	OK

AutoDesk Storm and Sanitary Analysis 2019

ALLEN & MAJOR
ASSOCIATES, INC.

DESIGN YEAR: **100.00**
K= 290.00 B= 31

Title ***Stormwater Conveyance Sizing (100 YEAR STORM)***
Project ***Multi-Family Development - Bolton, MA***
Date 09-10-2021
A&M Project Number: 1670-15

Minimum Slope: 0.005
Minimum Size: 12.000 inch
Rainfall Intensity (in/hr): 7.840 (100 year storm)
Manning's n: 0.012 HDPE
Manning's n: 0.013 RCP
Min. Velocity: 2.000 fps
Max. Velocity: 12.000 fps

From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Time of Peak Flow (days hh:mm)	Max Flow Velocity (ft/sec)	Travel Time (min)	Design Flow Capacity (cfs)	Max Flow / Design Flow Ratio	Max Flow Depth (ft)	Reported Condition
PAD 3B	PDMH 3	61.30	346.50	346.19	0.5000	CIRCULAR	12.000	0.0120	0.40	0 00:06	2.50	0.41	2.73	0.15	0.26	OK
GB ROOF	PDMH 3	34.92	348.19	347.24	2.7000	CIRCULAR	6.000	0.0120	0.49	0 00:06	5.58	0.10	1.00	0.49	0.25	OK
PCB 3A	PDMH 3	6.28	346.50	346.44	1.0000	CIRCULAR	12.000	0.0120	1.33	0 00:06	4.46	0.02	3.86	0.35	0.41	OK
C1 ROOF	C1 WYE	31.90	346.64	346.00	2.0100	CIRCULAR	6.000	0.0120	0.35	0 00:06	4.62	0.12	0.86	0.41	0.22	OK
PDMH 3	PDMH 4	165.32	346.09	344.44	1.0000	CIRCULAR	12.000	0.0120	2.14	0 00:06	5.11	0.54	3.86	0.55	0.53	OK
PCB 4A	PDMH 4	4.15	345.50	345.46	1.0000	CIRCULAR	12.000	0.0120	2.17	0 00:06	5.06	0.01	3.86	0.56	0.54	OK
B1 ROOF	PDMH 4	50.40	347.05	344.29	5.4800	CIRCULAR	12.000	0.0120	4.49	0 00:06	11.51	0.07	9.04	0.50	0.50	OK
PDMH 4	PDMH 5	224.08	343.94	341.70	1.0000	CIRCULAR	18.000	0.0120	8.52	0 00:06	7.19	0.52	11.38	0.75	0.96	OK
B2C ROOF	PDMH 5	48.77	343.99	343.50	1.0000	CIRCULAR	12.000	0.0120	2.21	0 00:06	6.02	0.14	3.86	0.57	0.54	OK
PCB 5A	PDMH 5	3.41	342.27	342.20	1.9900	CIRCULAR	12.000	0.0120	2.93	0 00:06	7.06	0.01	5.45	0.54	0.52	OK
PDMH 5	PDMH 6	79.93	341.60	340.00	2.0000	CIRCULAR	18.000	0.0120	13.38	0 00:06	10.21	0.13	16.10	0.83	1.04	OK
PCB 6A	PDMH 6	13.02	340.57	340.50	0.5000	CIRCULAR	12.000	0.0120	1.26	0 00:06	3.41	0.06	2.73	0.46	0.48	OK
PDMH 6	PDMH 7	76.19	339.32	338.94	0.5000	CIRCULAR	24.000	0.0120	14.54	0 00:06	6.21	0.20	17.33	0.84	1.40	OK
PDMH 7	PDMH 7A	2.25	338.94	338.92	0.4900	CIRCULAR	24.000	0.0120	16.14	0 00:06	6.20	0.01	17.13	0.94	1.55	OK
PCB 7A	PDMH 7	3.09	340.00	339.94	2.0100	CIRCULAR	12.000	0.0120	1.76	0 00:06	6.19	0.01	5.47	0.32	0.39	OK
PDMH 7A	IR 2A	2.80	338.92	338.91	0.5000	CIRCULAR	24.000	0.0120	16.14	0 00:06	6.26	0.01	17.32	0.93	1.53	OK
PCB 10B	PDMH 10	8.28	344.08	344.00	1.0000	CIRCULAR	12.000	0.0120	0.65	0 00:06	3.65	0.04	3.86	0.17	0.28	OK
PCB 10A	PDMH 10	27.12	344.27	344.00	1.0000	CIRCULAR	12.000	0.0120	0.72	0 00:06	3.77	0.12	3.86	0.19	0.29	OK
B2A ROOF	PDMH 10	29.99	344.60	344.00	2.0000	CIRCULAR	12.000	0.0120	2.21	0 00:06	6.60	0.08	5.46	0.41	0.44	OK
PDMH 10	PDMH 9	147.77	343.27	340.31	2.0000	CIRCULAR	12.000	0.0120	3.53	0 00:06	7.47	0.33	5.46	0.65	0.58	OK
B2B ROOF	PDMH 9	39.10	340.51	340.31	0.5000	CIRCULAR	12.000	0.0120	0.00	0 00:00	0.00		2.73	0.00	0.00	OK
PCB 9A	PDMH 9	8.37	340.35	340.31	0.5000	CIRCULAR	12.000	0.0120	1.86	0 00:06	3.75	0.04	2.73	0.68	0.60	OK
PDMH 9	PDMH 8	62.10	340.06	339.69	0.6000	CIRCULAR	15.000	0.0120	5.31	0 00:06	5.08	0.20	5.40	0.98	1.00	OK
PDMH 8	PDMH 8A	1.50	339.44	339.43	0.5300	CIRCULAR	18.000	0.0120	7.18	0 00:06	5.28	0.00	8.30	0.86	1.08	OK
PCB 8A	PDMH 8	4.24	339.98	339.94	0.9900	CIRCULAR	12.000	0.0120	1.98	0 00:06	4.93	0.01	3.84	0.51	0.51	OK
PDMH 8A	IR 2B	3.37	338.93	338.91	0.5000	CIRCULAR	24.000	0.0120	7.18	0 00:06	5.28	0.01	17.41	0.41	0.89	OK
GC ROOF	PINF 2C	16.37	339.58	339.25	2.0000	CIRCULAR	6.000	0.0120	0.35	0 00:06	4.17	0.07	0.86	0.41	0.22	OK
POCS 2A	PFES 2A	35.06	338.90	338.55	1.0000	CIRCULAR	18.000	0.0120	7.33	0 00:01	6.84	0.09	11.38	0.64	0.88	OK
POCS 2B	PFES 2B	25.34	338.91	338.65	1.0400	CIRCULAR	18.000	0.0120	7.33	0 00:01	6.94	0.06	11.60	0.63	0.87	OK

To Existing Collection System

ECB-1C	ECB 1A	37.98	348.29	346.69	4.2100	CIRCULAR	12.000	0.0120	0.12	0 00:06	4.01	0.16	7.92	0.01	0.08	OK

AutoDesk Storm and Sanitary Analysis 2019

ALLEN & MAJOR
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DESIGN YEAR: **100.00**
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A&M Project Number: 1670-15

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From (Inlet) Node	To (Outlet) Node	Length (ft)	Inlet Invert Elevation (ft)	Outlet Invert Elevation (ft)	Average Slope (%)	Pipe Shape	Pipe Diameter or Height (inches)	Manning's Roughness	Peak Flow (cfs)	Time of Peak Flow (days hh:mm)	Max Flow Velocity (ft/sec)	Travel Time (min)	Design Flow Capacity (cfs)	Max Flow / Design Flow Ratio	Max Flow Depth (ft)	Reported Condition
ECB 1A	PDMH 1	35.80	346.50	346.14	1.0000	CIRCULAR	12.000	0.0120	2.00	0 00:06	4.98	0.12	3.86	0.52	0.51	OK
PCB 1B	PDMH 1	19.13	346.33	346.14	1.0000	CIRCULAR	12.000	0.0120	0.80	0 00:06	3.88	0.08	3.86	0.21	0.31	OK
M ROOF	PDMH 1	71.40	348.07	346.64	2.0000	CIRCULAR	6.000	0.0120	0.14	0 00:06	4.59	0.26	0.86	0.16	0.14	OK
PDMH 1	PDMH 2	152.42	345.89	345.13	0.5000	CIRCULAR	15.000	0.0120	2.86	0 00:06	4.27	0.59	4.95	0.58	0.68	OK
C2 ROOF	C2 WYE	7.41	346.65	346.50	2.0000	CIRCULAR	6.000	0.0120	0.56	0 00:06	4.67	0.03	0.86	0.65	0.30	OK
PCB 2A	PDMH 2	10.11	345.60	345.50	1.0000	CIRCULAR	12.000	0.0120	0.44	0 00:06	3.27	0.05	3.86	0.11	0.23	OK
PDMH 2	EDMH	105.59	345.00	344.47	0.5000	CIRCULAR	15.000	0.0120	3.25	0 00:06	4.35	0.40	4.95	0.66	0.74	OK

ALLEN & MAJOR
ASSOCIATES, INC.

Title *Stormwater Conveyance Sizing (100 YEAR STORM)*
Project *Multi-Family Development - Bolton, MA*
Date 09-10-2021
A&M Project Number: 1670-15

Watershed	Drainage Node ID	Area (acres)	Weighted Runoff Coefficient	Accumulated Precipitation (inches)	Total Runoff (inches)	Peak Runoff (cfs)	Rainfall Intensity (inches/hr)	Time of Concentration (days hh:mm:ss)
1	PCB 14A	0.14	0.7500	0.78	0.59	0.82	7.838	0 00:06:00
2	PCB 14B	0.19	0.7700	0.78	0.60	1.15	7.838	0 00:06:00
3	PCB 15A	0.18	0.7600	0.78	0.60	1.07	7.838	0 00:06:00
4	PCB 16A	0.21	0.7300	0.78	0.57	1.20	7.838	0 00:06:00
5	PCB 17A	0.23	0.6900	0.78	0.54	1.24	7.838	0 00:06:00
6	PCB 18A	0.07	0.8100	0.78	0.64	0.44	7.838	0 00:06:00
7	PCB 11B	0.22	0.6900	0.78	0.54	1.19	7.838	0 00:06:00
8	PCB 11A	0.16	0.7400	0.78	0.58	0.93	7.838	0 00:06:00
9	PCB 18B	64	0.7200	0.78	0.56	1.41	7.838	0 00:06:00
10	PCB 19A	64	0.7000	0.78	0.55	0.93	7.838	0 00:06:00
11	PCB 20A	64	0.7400	0.78	0.58	1.33	7.838	0 00:06:00
12	PCB 21A	64	0.7600	0.78	0.60	2.09	7.838	0 00:06:00
13	GA ROOF	64	0.9000	0.78	0.71	0.50	7.838	0 00:06:00
14	B3 ROOF	64	0.9000	0.78	0.71	2.19	7.838	0 00:06:00
16	PCB 3A	64	0.7400	0.78	0.58	1.33	7.838	0 00:06:00
17	PCB 4A	64	0.7100	0.78	0.56	2.17	7.838	0 00:06:00
18	PCB 5A	64	0.7200	0.78	0.56	2.93	7.838	0 00:06:00
19	PCB 6A	64	0.6700	0.78	0.53	1.26	7.838	0 00:06:00
20	PCB 7A	64	0.8000	0.78	0.63	1.76	7.838	0 00:06:00
21	PCB 8A	64	0.7900	0.78	0.62	1.98	7.838	0 00:06:00
22	PCB 9A	64	0.7000	0.78	0.55	1.87	7.838	0 00:06:00
23	PCB 10A	64	0.6600	0.78	0.52	0.72	7.838	0 00:06:00
24	PCB 10B	64	0.6400	0.78	0.50	0.65	7.838	0 00:06:00
25	GB ROOF	64	0.9000	0.78	0.71	0.49	7.838	0 00:06:00
26	C1 ROOF	64	0.9000	0.78	0.71	0.35	7.838	0 00:06:00
27	B1 ROOF	64	0.9000	0.78	0.71	4.52	7.838	0 00:06:00
28	B2A ROOF	64	0.9000	0.78	0.71	2.22	7.838	0 00:06:00
28	B2C ROOF	64	0.9000	0.78	0.71	2.22	7.838	0 00:06:00
29	GC ROOF	64	0.9000	0.78	0.71	0.35	7.838	0 00:06:00
30	ECB 1A	64	0.6900	0.78	0.54	1.89	7.838	0 00:06:00
31	PCB 1B	64	0.7900	0.78	0.62	0.81	7.838	0 00:06:00
32	M ROOF	64	0.9000	0.78	0.71	0.14	7.838	0 00:06:00
33	C2 ROOF	64	0.9000	0.78	0.71	0.56	7.838	0 00:06:00
34	PCB 2A	64	0.7100	0.78	0.56	0.45	7.838	0 00:06:00
36	PAD 3	64	0.3000	0.78	0.24	0.26	7.838	0 00:06:00
37	PAD 3B	64	0.3000	0.78	0.24	0.17	7.838	0 00:06:00
38	ECB-1C	64	0.3000	0.78	0.24	0.12	7.838	0 00:06:00

SOIL INFORMATION

United States
Department of
Agriculture

Natural
Resources
Conservation
Service

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

Custom Soil Resource Report for Worcester County, Massachusetts, Northeastern Part

January 20, 2021

Preface

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

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

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

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

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

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

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or a part of an individual's income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require

Contents

How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

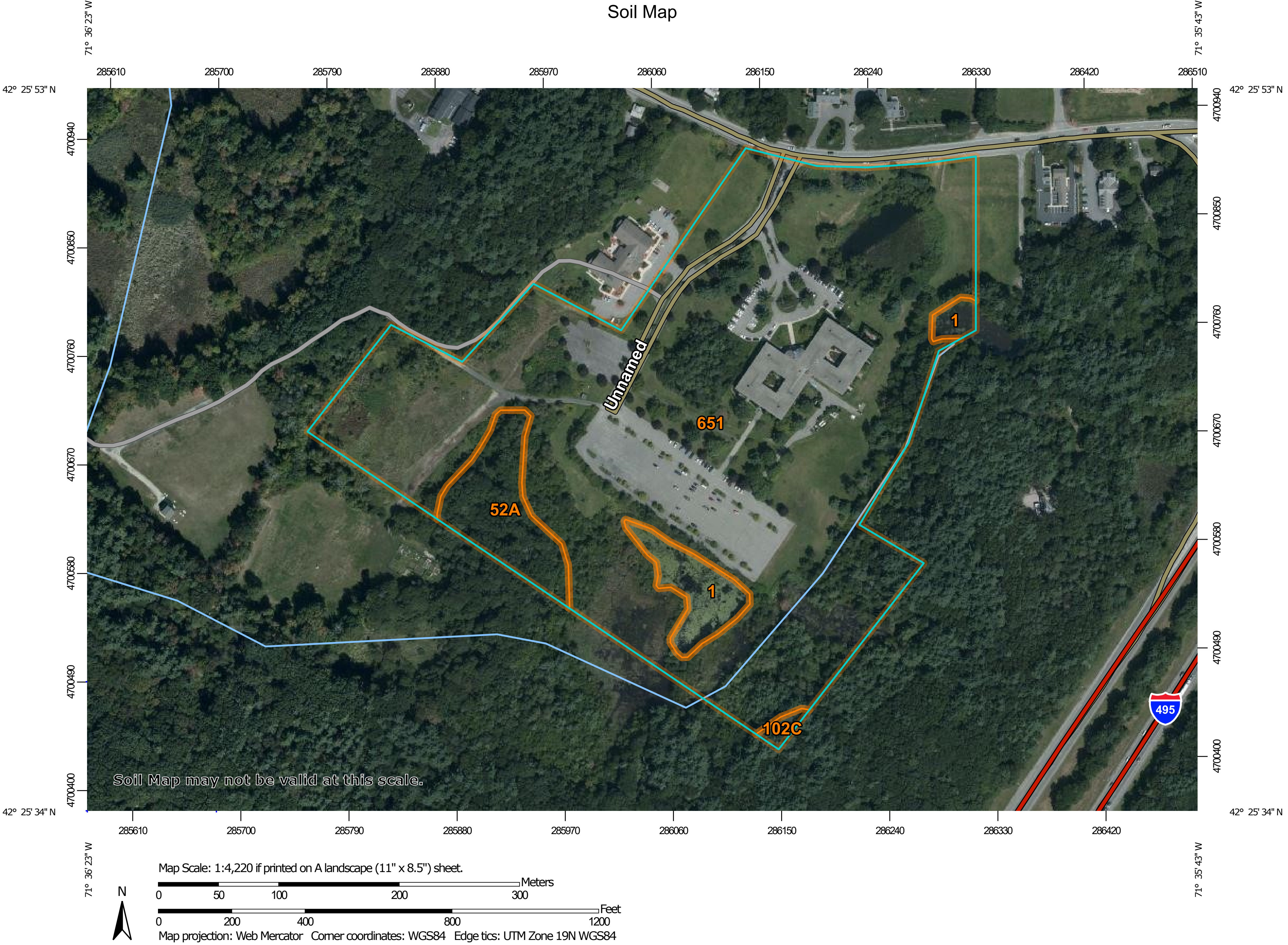
Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can predict with a fairly high degree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

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Soil Map

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

Custom Soil Resource Report
Soil Map



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:20,000.

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

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

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

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

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

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

Soil Survey Area: Worcester County, Massachusetts, Northeastern Part
Survey Area Data: Version 15, Jun 10, 2020

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

Date(s) aerial images were photographed: Aug 12, 2019—Sep 29, 2019

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background

MAP LEGEND	MAP INFORMATION
	imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	1.4	3.7%
52A	Freetown muck, 0 to 1 percent slopes	2.0	5.5%
102C	Chatfield-Hollis-Rock outcrop complex, 0 to 15 percent slopes	0.2	0.4%
651	Udorthents, smoothed	33.1	90.4%
Totals for Area of Interest		**36.6**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

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

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

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

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

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

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

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

Worcester County, Massachusetts, Northeastern Part

1—Water

Map Unit Setting

National map unit symbol: w3qb
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 45 to 50 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Water: 100 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

52A—Freetown muck, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2t2q9
Elevation: 0 to 1,110 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Freetown and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Freetown

Setting

Landform: Depressions, kettles, swamps, bogs, marshes, depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Highly decomposed organic material

Typical profile

Oe - 0 to 2 inches: mucky peat
Oa - 2 to 79 inches: muck

Properties and qualities

Slope: 0 to 1 percent
Surface area covered with cobbles, stones or boulders: 0.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)

Depth to water table: About 0 to 6 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water capacity: Very high (about 19.2 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 5w
Hydrologic Soil Group: B/D
Ecological site: F144AY043MA - Acidic Organic Wetlands
Hydric soil rating: Yes

Minor Components

Swansea

Percent of map unit: 5 percent
Landform: Swamps, bogs, marshes, depressions, depressions, kettles
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Scarboro

Percent of map unit: 5 percent
Landform: Depressions, drainageways
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope, tread, dip
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Whitman

Percent of map unit: 5 percent
Landform: Drainageways, depressions
Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

102C—Chatfield-Hollis-Rock outcrop complex, 0 to 15 percent slopes

Map Unit Setting

National map unit symbol: 2w69g
Elevation: 0 to 1,540 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Chatfield, extremely stony, and similar soils: 39 percent
Hollis, extremely stony, and similar soils: 26 percent
Rock outcrop: 17 percent
Minor components: 18 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Chatfield, Extremely Stony

Setting

Landform: Hills, ridges
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Crest, side slope, nose slope
Down-slope shape: Convex
Across-slope shape: Linear, convex
Parent material: Coarse-loamy melt-out till derived from granite, gneiss, and/or schist

Typical profile

Oi - 0 to 1 inches: slightly decomposed plant material
A - 1 to 2 inches: fine sandy loam
Bw - 2 to 30 inches: gravelly fine sandy loam
2R - 30 to 40 inches: bedrock

Properties and qualities

Slope: 0 to 15 percent
Surface area covered with cobbles, stones or boulders: 9.0 percent
Depth to restrictive feature: 20 to 41 inches to lithic bedrock
Drainage class: Well drained
Runoff class: High
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water capacity: Low (about 4.3 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: B
Ecological site: F144AY034CT - Well Drained Till Uplands
Hydric soil rating: No

Description of Hollis, Extremely Stony

Setting

Landform: Ridges, hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Nose slope, crest, side slope
Down-slope shape: Convex
Across-slope shape: Linear, convex
Parent material: Coarse-loamy melt-out till derived from granite, gneiss, and/or schist

Typical profile

Oi - 0 to 2 inches: slightly decomposed plant material
A - 2 to 7 inches: gravelly fine sandy loam
Bw - 7 to 16 inches: gravelly fine sandy loam
2R - 16 to 26 inches: bedrock

Properties and qualities

Slope: 0 to 15 percent
Surface area covered with cobbles, stones or boulders: 9.0 percent
Depth to restrictive feature: 8 to 23 inches to lithic bedrock
Drainage class: Somewhat excessively drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water capacity: Very low (about 2.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: F144AY033MA - Shallow Dry Till Uplands
Hydric soil rating: No

Description of Rock Outcrop

Setting

Parent material: Igneous and metamorphic rock

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: 0 inches to lithic bedrock
Runoff class: Very high

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D
Hydric soil rating: No

Minor Components

Charlton, extremely stony

Percent of map unit: 12 percent
Landform: Ridges, hills
Landform position (two-dimensional): Backslope, shoulder, summit
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Hydric soil rating: No

Sutton, extremely stony

Percent of map unit: 3 percent
Landform: Hills, ground moraines

Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Paxton, extremely stony

Percent of map unit: 2 percent
Landform: Drumlins, hills, ground moraines
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex, linear
Across-slope shape: Linear, convex
Hydric soil rating: No

Leicester, extremely stony

Percent of map unit: 1 percent
Landform: Drainageways, depressions, hills, ground moraines
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear, concave
Across-slope shape: Concave
Hydric soil rating: Yes

651—Udorthents, smoothed

Map Unit Setting

National map unit symbol: w3q6
Elevation: 180 to 1,020 feet
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 45 to 50 degrees F
Frost-free period: 145 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 80 percent
Urban land: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Setting

Parent material: Made land over firm loamy basal till

Properties and qualities

Slope: 0 to 3 percent
Depth to restrictive feature: More than 80 inches
Depth to water table: More than 80 inches

Frequency of flooding: None
Frequency of ponding: None

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RAINFALL DATA

NOAA Atlas 14, Volume 10, Version 3
Location name: Bolton, Massachusetts, USA*
Latitude: 42.4295°, Longitude: -71.5989°
Elevation: 337.73 ft**
* source: ESRI Maps
** source: USGS

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_&_aerials

PF tabular

PDS-based point precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	**0.341** (0.263-0.431)	**0.403** (0.310-0.510)	**0.504** (0.387-0.640)	**0.588** (0.449-0.751)	**0.703** (0.521-0.936)	**0.791** (0.574-1.07)	**0.882** (0.622-1.24)	**0.982** (0.660-1.42)	**1.12** (0.728-1.67)	**1.24** (0.783-1.88)
10-min	**0.483** (0.373-0.611)	**0.571** (0.440-0.723)	**0.715** (0.548-0.908)	**0.833** (0.636-1.07)	**0.997** (0.738-1.33)	**1.12** (0.813-1.52)	**1.25** (0.881-1.76)	**1.39** (0.935-2.00)	**1.59** (1.03-2.37)	**1.75** (1.11-2.66)
15-min	**0.568** (0.438-0.719)	**0.672** (0.517-0.850)	**0.841** (0.646-1.07)	**0.980** (0.748-1.25)	**1.17** (0.868-1.56)	**1.32** (0.957-1.79)	**1.47** (1.04-2.06)	**1.64** (1.10-2.36)	**1.87** (1.21-2.79)	**2.06** (1.30-3.13)
30-min	**0.768** (0.592-0.971)	**0.907** (0.698-1.15)	**1.13** (0.871-1.44)	**1.32** (1.01-1.69)	**1.58** (1.17-2.11)	**1.78** (1.29-2.41)	**1.98** (1.40-2.79)	**2.21** (1.48-3.18)	**2.52** (1.63-3.76)	**2.78** (1.76-4.22)
60-min	**0.967** (0.745-1.22)	**1.14** (0.879-1.45)	**1.43** (1.10-1.81)	**1.67** (1.27-2.13)	**1.99** (1.48-2.65)	**2.24** (1.63-3.04)	**2.50** (1.76-3.51)	**2.78** (1.87-4.00)	**3.18** (2.06-4.73)	**3.50** (2.21-5.31)
2-hr	**1.21** (0.943-1.52)	**1.45** (1.13-1.83)	**1.85** (1.43-2.33)	**2.18** (1.68-2.76)	**2.63** (1.97-3.48)	**2.97** (2.18-4.02)	**3.33** (2.38-4.68)	**3.74** (2.53-5.35)	**4.36** (2.83-6.44)	**4.87** (3.09-7.34)
3-hr	**1.39** (1.09-1.74)	**1.68** (1.31-2.10)	**2.15** (1.67-2.70)	**2.54** (1.97-3.21)	**3.08** (2.31-4.07)	**3.48** (2.57-4.70)	**3.91** (2.81-5.49)	**4.42** (2.99-6.29)	**5.18** (3.37-7.62)	**5.82** (3.70-8.73)
6-hr	**1.77** (1.40-2.20)	**2.15** (1.69-2.67)	**2.77** (2.17-3.45)	**3.28** (2.56-4.11)	**3.99** (3.02-5.23)	**4.51** (3.35-6.05)	**5.07** (3.67-7.08)	**5.75** (3.90-8.12)	**6.76** (4.42-9.88)	**7.63** (4.87-11.4)
12-hr	**2.25** (1.79-2.77)	**2.73** (2.17-3.36)	**3.51** (2.78-4.33)	**4.15** (3.27-5.16)	**5.04** (3.85-6.56)	**5.70** (4.26-7.58)	**6.41** (4.67-8.87)	**7.26** (4.95-10.2)	**8.53** (5.59-12.4)	**9.61** (6.15-14.2)
24-hr	**2.69** (2.16-3.28)	**3.27** (2.62-3.99)	**4.23** (3.38-5.18)	**5.02** (3.99-6.18)	**6.11** (4.70-7.88)	**6.91** (5.21-9.13)	**7.79** (5.71-10.7)	**8.84** (6.06-12.3)	**10.4** (6.87-15.0)	**11.8** (7.58-17.3)
2-day	**3.00** (2.43-3.63)	**3.70** (2.99-4.47)	**4.83** (3.90-5.87)	**5.77** (4.63-7.05)	**7.07** (5.49-9.07)	**8.02** (6.11-10.5)	**9.07** (6.72-12.4)	**10.4** (7.13-14.3)	**12.4** (8.16-17.6)	**14.1** (9.07-20.4)
3-day	**3.26** (2.65-3.92)	**4.00** (3.26-4.83)	**5.22** (4.24-6.32)	**6.24** (5.03-7.58)	**7.63** (5.95-9.75)	**8.66** (6.62-11.3)	**9.78** (7.27-13.3)	**11.2** (7.71-15.3)	**13.3** (8.82-18.9)	**15.2** (9.80-21.9)
4-day	**3.50** (2.87-4.20)	**4.28** (3.50-5.14)	**5.56** (4.52-6.69)	**6.61** (5.35-8.01)	**8.06** (6.31-10.3)	**9.14** (7.00-11.9)	**10.3** (7.67-14.0)	**11.7** (8.13-16.1)	**14.0** (9.25-19.7)	**15.9** (10.3-22.8)
7-day	**4.20** (3.47-5.01)	**5.04** (4.14-6.01)	**6.39** (5.24-7.65)	**7.52** (6.13-9.05)	**9.07** (7.13-11.4)	**10.2** (7.86-13.2)	**11.5** (8.54-15.4)	**12.9** (9.00-17.6)	**15.2** (10.1-21.3)	**17.1** (11.1-24.4)
10-day	**4.89** (4.05-5.80)	**5.75** (4.75-6.83)	**7.15** (5.89-8.53)	**8.32** (6.81-9.97)	**9.93** (7.83-12.4)	**11.1** (8.57-14.2)	**12.4** (9.24-16.5)	**13.9** (9.69-18.8)	**16.1** (10.7-22.4)	**17.9** (11.6-25.4)
20-day	**6.94** (5.80-8.16)	**7.86** (6.56-9.26)	**9.37** (7.79-11.1)	**10.6** (8.77-12.6)	**12.3** (9.79-15.2)	**13.7** (10.6-17.2)	**15.0** (11.1-19.5)	**16.4** (11.5-22.0)	**18.4** (12.3-25.4)	**19.9** (13.0-28.1)
30-day	**8.64** (7.27-10.1)	**9.61** (8.07-11.3)	**11.2** (9.35-13.2)	**12.5** (10.4-14.8)	**14.3** (11.4-17.5)	**15.7** (12.2-19.5)	**17.1** (12.7-21.9)	**18.4** (13.0-24.5)	**20.2** (13.6-27.8)	**21.6** (14.1-30.3)
45-day	**10.8** (9.10-12.5)	**11.8** (9.94-13.7)	**13.4** (11.3-15.7)	**14.8** (12.4-17.4)	**16.7** (13.4-20.3)	**18.2** (14.1-22.5)	**19.6** (14.6-24.9)	**21.0** (14.9-27.7)	**22.6** (15.3-30.9)	**23.7** (15.5-33.2)
60-day	**12.5** (10.6-14.5)	**13.6** (11.5-15.8)	**15.3** (12.9-17.9)	**16.7** (14.0-19.6)	**18.7** (15.0-22.6)	**20.3** (15.8-24.9)	**21.8** (16.2-27.5)	**23.1** (16.4-30.4)	**24.6** (16.7-33.5)	**25.6** (16.8-35.7)

[1] 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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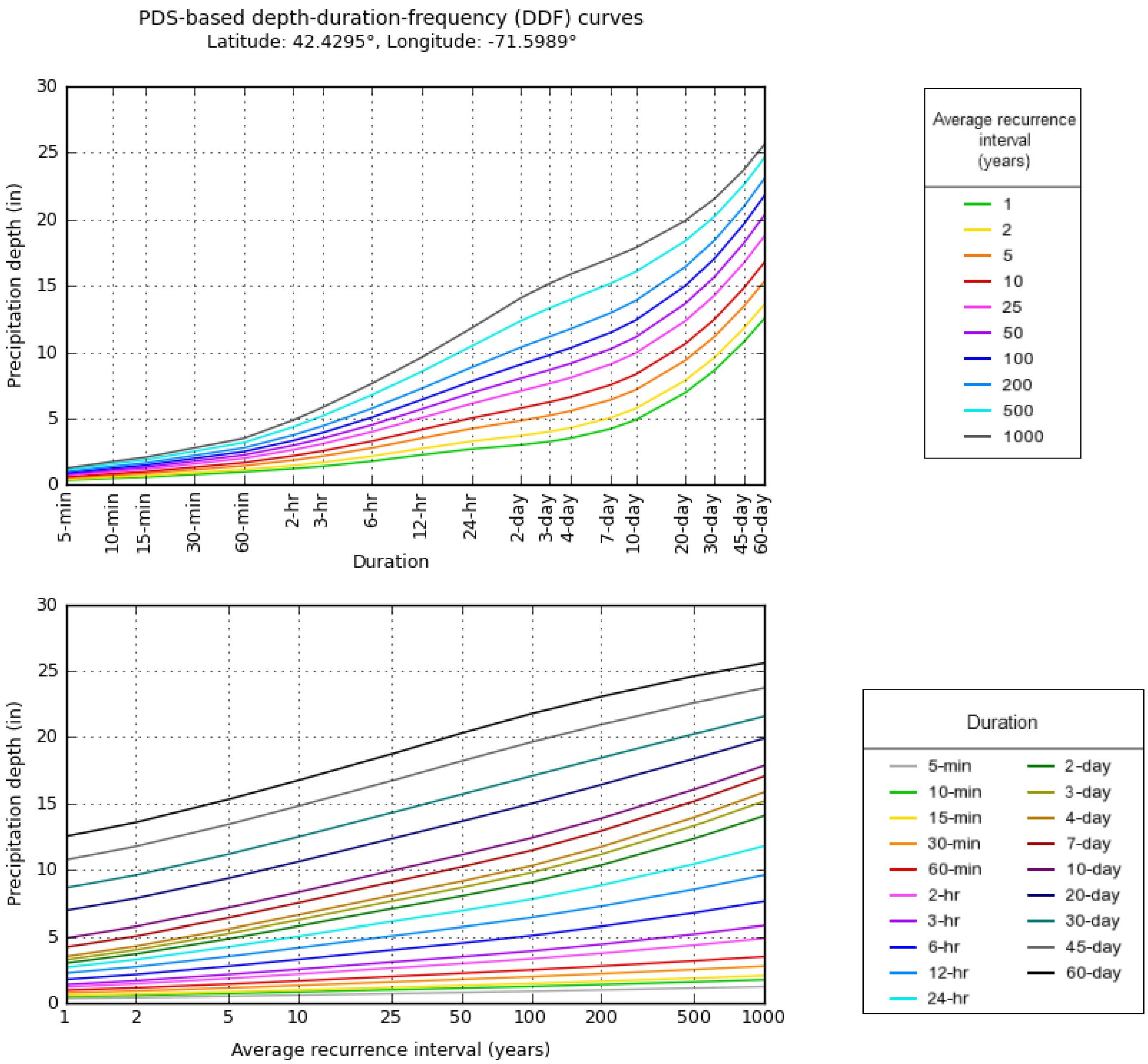
PF graphical



NOAA Atlas 14, Volume 10, Version 3

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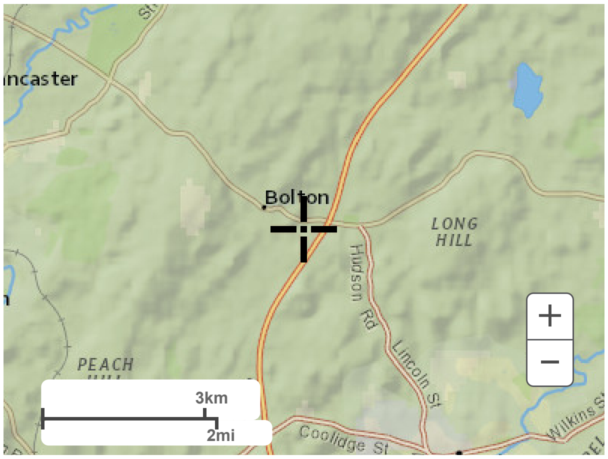
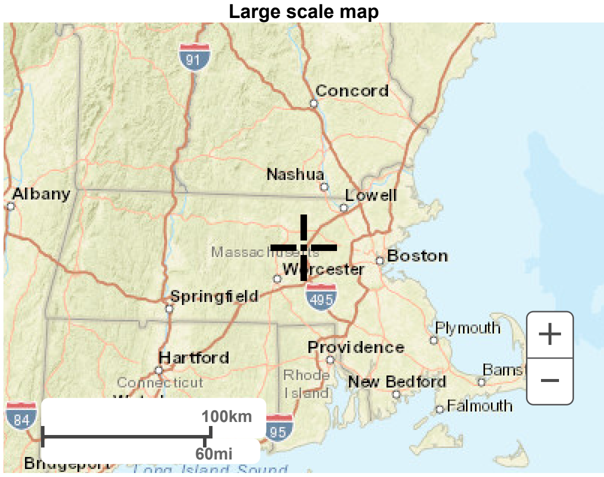
Maps & aerials

Small scale terrain

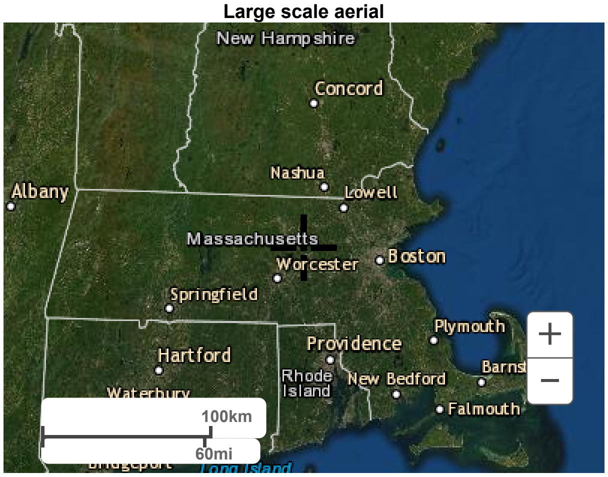


Large scale terrain

Large scale map



Large scale aerial



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US Department of Commerce
National Oceanic and Atmospheric Administration
National Weather Service
National Water Center
1325 East West Highway
Silver Spring, MD 20910
Questions?: HDSC.Questions@noaa.gov

Disclaimer

WATER QUALITY SIZING (CONTECH)

Project: **Alta Nashoba Valley**
Location: **Bolton, MA**
Prepared For: **Allen & Major / Paul Matos**

Purpose: To calculate the water quality flow rate (WQF) over a given site area. In this situation the WQF is derived from the first 1" of runoff from the contributing impervious surface.

Reference: Massachusetts Dept. of Environmental Protection Wetlands Program / United States Department of Agriculture Natural Resources Conservation Service TR-55 Manual

Procedure: Determine unit peak discharge using Figure 1 or 2. Figure 2 is in tabular form so is preferred. Using the tc, read the unit peak discharge (qu) from Figure 1 or Table in Figure 2. qu is expressed in the following units: cfs/mi^2/watershed inches (csm/in).

Compute Q Rate using the following equation:

$$Q = (qu)\ (A)\ (WQV)$$

where:

Q = flow rate associated with first 1" of runoff
qu = the unit peak discharge, in csm/in.
A = impervious surface drainage area (in square miles)
WQV = water quality volume in watershed inches (1" in this case)

Structure Name	Impv. (acres)	A (miles^2)	t_c (min)	t_c (hr)	WQV (in)	qu (csm/in.)	Q (cfs)
PDMH 2	0.65	0.0010156	6.0	0.100	1.00	774.00	0.79
PDMH 7	2.25	0.0035156	6.0	0.100	1.00	774.00	2.72
PDMH 8	0.96	0.0015000	6.0	0.100	1.00	774.00	1.16
PDMH 12	0.26	0.0004109	6.0	0.100	1.00	774.00	0.32
PDMH 20	1.59	0.0024844	6.0	0.100	1.00	774.00	1.92
PCB 21A	0.27	0.0004172	6.0	0.100	1.00	774.00	0.32

Brief Stormceptor Sizing Report - PCB 21A

Project Information & Location			
Project Name	Alta Nashoba Valley	**Project Number**	688805
City	Bolton	**State/ Province**	Massachusetts
Country	United States of America	**Date**	9/10/2021
Designer Information		**EOR Information (optional)**	
Name	Jim Lyons	**Name**	Paul Matos
Company	Contech ES	**Company**	Allen & Major
Phone #	413-246-5151	**Phone #**	508-923-1010
Email	jlyons@conteches.com	**Email**	pmatos@allenmajor.com

Stormwater Treatment Recommendation

The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	PCB 21A
Target TSS Removal (%)	80
TSS Removal (%) Provided	92
Recommended Stormceptor Model	STC 450i

The recommended Stormceptor Model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

Stormceptor Sizing Summary	
Stormceptor Model	**% TSS Removal Provided**
STC 450i	92
STC 900	96
STC 1200	96
STC 1800	96
STC 2400	97
STC 3600	98
STC 4800	98
STC 6000	98
STC 7200	99
STC 11000	99
STC 13000	99
STC 16000	99

Sizing Details

Drainage Area

Total Area (acres)	0.35
Imperviousness %	76.0

Rainfall

Station Name	EAST BRIMFIELD LAKE
State/Province	Massachusetts
Station ID #	2107
Years of Records	45
Latitude	42°7'0"N
Longitude	72°8'0"W

Water Quality Objective

TSS Removal (%)	80.0
Runoff Volume Capture (%)	
Oil Spill Capture Volume (Gal)	
Peak Conveyed Flow Rate (CFS)	
Water Quality Flow Rate (CFS)	0.32

Up Stream Storage

Storage (ac-ft)	Discharge (cfs)
0.000	0.000

Up Stream Flow Diversion

Max. Flow to Stormceptor (cfs)	

Particle Size Distribution (PSD)
The selected PSD defines TSS removal

OK-110

Particle Diameter (microns)	Distribution %	Specific Gravity
1.0	0.0	2.65
53.0	3.0	2.65
75.0	15.0	2.65
88.0	25.0	2.65
106.0	41.0	2.65
125.0	15.0	2.65
150.0	1.0	2.65
212.0	0.0	2.65

Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
- For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

For Stormceptor Specifications and Drawings Please Visit:
https://www.conteches.com/technical-guides/search?filter=1WBC0O5EYX

Brief Stormceptor Sizing Report - PDMH 12

Project Information & Location			
Project Name	Alta Nashoba Valley	**Project Number**	688805
City	Bolton	**State/ Province**	Massachusetts
Country	United States of America	**Date**	9/10/2021
Designer Information		**EOR Information (optional)**	
Name	Jim Lyons	**Name**	Paul Matos
Company	Contech ES	**Company**	Allen & Major
Phone #	413-246-5151	**Phone #**	508-923-1010
Email	jlyons@conteches.com	**Email**	pmatos@allenmajor.com

Stormwater Treatment Recommendation

The recommended Stormceptor Model(s) which achieve or exceed the user defined water quality objective for each site within the project are listed in the below Sizing Summary table.

Site Name	PDMH 12
Target TSS Removal (%)	80
TSS Removal (%) Provided	92
Recommended Stormceptor Model	STC 450i

The recommended Stormceptor Model achieves the water quality objectives based on the selected inputs, historical rainfall records and selected particle size distribution.

Stormceptor Sizing Summary	
Stormceptor Model	**% TSS Removal Provided**
STC 450i	92
STC 900	96
STC 1200	96
STC 1800	96
STC 2400	97
STC 3600	98
STC 4800	98
STC 6000	98
STC 7200	99
STC 11000	99
STC 13000	99
STC 16000	99

Sizing Details

Drainage Area

Total Area (acres)	0.38
Imperviousness %	69.0

Rainfall

Station Name	EAST BRIMFIELD LAKE
State/Province	Massachusetts
Station ID #	2107
Years of Records	45
Latitude	42°7'0"N
Longitude	72°8'0"W

Water Quality Objective

TSS Removal (%)	80.0
Runoff Volume Capture (%)	
Oil Spill Capture Volume (Gal)	
Peak Conveyed Flow Rate (CFS)	
Water Quality Flow Rate (CFS)	0.32

Up Stream Storage

Storage (ac-ft)	Discharge (cfs)
0.000	0.000

Up Stream Flow Diversion

Max. Flow to Stormceptor (cfs)	

Particle Size Distribution (PSD)
The selected PSD defines TSS removal

OK-110

Particle Diameter (microns)	Distribution %	Specific Gravity
1.0	0.0	2.65
53.0	3.0	2.65
75.0	15.0	2.65
88.0	25.0	2.65
106.0	41.0	2.65
125.0	15.0	2.65
150.0	1.0	2.65
212.0	0.0	2.65

Notes

- Stormceptor performance estimates are based on simulations using PCSWMM for Stormceptor, which uses the EPA Rainfall and Runoff modules.
- Design estimates listed are only representative of specific project requirements based on total suspended solids (TSS) removal defined by the selected PSD, and based on stable site conditions only, after construction is completed.
- For submerged applications or sites specific to spill control, please contact your local Stormceptor representative for further design assistance.

For Stormceptor Specifications and Drawings Please Visit:
https://www.conteches.com/technical-guides/search?filter=1WBC0O5EYX

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

ALTA NASHOBA VALLEY
BOLTON, MA

Area	0.65 ac	Unit Site Designation	PDMH 2
Weighted C	0.9	Rainfall Station #	71
t_c	6 min		
CDS Model	2015-4	CDS Treatment Capacity	1.4 cfs

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Cumulative Rainfall Volume	Total Flowrate (cfs)	Treated Flowrate (cfs)	Incremental Removal (%)
0.08	37.6%	37.6%	0.05	0.05	37.5
0.16	22.6%	60.2%	0.09	0.09	22.2
0.24	11.9%	72.1%	0.14	0.14	11.5
0.32	7.6%	79.7%	0.19	0.19	7.2
0.40	4.3%	84.1%	0.23	0.23	4.1
0.48	2.3%	86.4%	0.28	0.28	2.2
0.56	1.8%	88.2%	0.33	0.33	1.6
0.64	1.4%	89.6%	0.37	0.37	1.2
0.72	0.9%	90.4%	0.42	0.42	0.8
0.80	1.2%	91.6%	0.47	0.47	1.0
0.88	1.5%	93.1%	0.51	0.51	1.2
0.96	0.9%	94.0%	0.56	0.56	0.8
1.04	0.4%	94.4%	0.61	0.61	0.3
1.12	0.4%	94.8%	0.66	0.66	0.3
1.20	0.6%	95.4%	0.70	0.70	0.4
1.28	0.3%	95.7%	0.75	0.75	0.2
1.36	0.2%	95.9%	0.80	0.80	0.1
1.44	0.9%	96.7%	0.84	0.84	0.6
1.52	0.6%	97.3%	0.89	0.89	0.4
1.60	0.4%	97.7%	0.94	0.94	0.3
1.80	0.2%	97.9%	1.05	1.05	0.1
					94.7

Removal Efficiency Adjustment[2] =	0.0%
Predicted % Annual Rainfall Treated =	98.8%
Predicted Net Annual Load Removal Efficiency =	**94.7%**

1 - Based on 13 years of 15 minute precipitation data for Station 0666, Birch Hill Dam, Worcester County, MA
2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

CDS ESTIMATED NET ANNUAL SOLIDS LOAD REDUCTION BASED ON THE RATIONAL RAINFALL METHOD

ALTA NASHOBA VALLEY
BOLTON, MA

Area	**0.96 ac**	Unit Site Designation	**PDMH 8**
Weighted C	**0.9**	Rainfall Station #	**71**
t_c	**6 min**		
CDS Model	**2015-4**	CDS Treatment Capacity	**1.4 cfs**

Rainfall Intensity[1] (in/hr)	**Percent Rainfall Volume[1]**	**Cumulative Rainfall Volume**	**Total Flowrate (cfs)**	**Treated Flowrate (cfs)**	**Incremental Removal (%)**
0.08	37.6%	37.6%	0.07	0.07	37.2
0.16	22.6%	60.2%	0.14	0.14	21.9
0.24	11.9%	72.1%	0.21	0.21	11.2
0.32	7.6%	79.7%	0.28	0.28	7.0
0.40	4.3%	84.1%	0.35	0.35	3.9
0.48	2.3%	86.4%	0.41	0.41	2.0
0.56	1.8%	88.2%	0.48	0.48	1.5
0.64	1.4%	89.6%	0.55	0.55	1.1
0.72	0.9%	90.4%	0.62	0.62	0.7
0.80	1.2%	91.6%	0.69	0.69	0.9
0.88	1.5%	93.1%	0.76	0.76	1.1
0.96	0.9%	94.0%	0.83	0.83	0.7
1.04	0.4%	94.4%	0.90	0.90	0.3
1.12	0.4%	94.8%	0.97	0.97	0.3
1.20	0.6%	95.4%	1.04	1.04	0.4
1.28	0.3%	95.7%	1.11	1.11	0.2
1.36	0.2%	95.9%	1.18	1.18	0.1
1.44	0.9%	96.7%	1.24	1.24	0.5
1.52	0.6%	97.3%	1.31	1.31	0.3
1.60	0.4%	97.7%	1.38	1.38	0.2
1.80	0.2%	97.9%	1.56	1.40	0.1
					92.1

Removal Efficiency Adjustment[2] = 0.0%

Predicted % Annual Rainfall Treated = 98.6%

Predicted Net Annual Load Removal Efficiency = 92.1%

1 - Based on 13 years of 15 minute precipitation data for Station 0666, Birch Hill Dam, Worcester County, MA

2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

Estimated Net Annual Solids Load Reduction
Based on the Rational Rainfall Method

CONTECH ENGINEERED SOLUTIONS

CASCADE separator™

ALTA NASHOBA VALLEY
BOLTON, MA
PDMH 7

AREA	2.25	acres	CASCADE MODEL	CS-5
WEIGHTED C	0.95			
TC	6.00	minutes	RAINFALL STATION	71

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Hydraulic Loading Rate (gpm/ft2)	Removal Efficiency (%)	Incremental Removal (%)
0.08	37.6%	3.91	100.0	37.6
0.16	22.6%	7.82	100.0	22.6
0.24	11.9%	11.73	100.0	11.9
0.32	7.6%	15.64	97.2	7.4
0.40	4.3%	19.54	93.5	4.1
0.48	2.3%	23.45	89.9	2.1
0.56	1.8%	27.36	86.2	1.5
0.64	1.4%	31.27	82.5	1.1
0.72	0.9%	35.18	78.8	0.7
0.80	1.2%	39.09	75.2	0.9
0.88	1.5%	43.00	71.5	1.1
0.96	0.9%	46.91	67.8	0.6
1.04	0.4%	50.81	64.1	0.2
1.12	0.4%	54.72	60.5	0.2
1.20	0.6%	58.63	56.8	0.3
1.28	0.3%	62.54	53.1	0.2
1.36	0.2%	66.45	49.4	0.1
1.44	0.9%	70.36	45.8	0.4
1.52	0.6%	74.27	42.1	0.2
1.60	0.4%	78.18	38.4	0.2
1.80	0.2%	80.01	33.4	0.1
2.00	0.9%	80.01	30.0	0.3
				93.8

Removal Efficiency Adjustment[2] = 0.0%

Predicted % Annual Rainfall Treated = 98.6%

Predicted Net Annual Load Removal Efficiency = 93.8%

[1] - Based on 13 years of 15 minute precipitation data for Station 0666, Birch Hill Dam, Worcester County, MA

[2] - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

Estimated Net Annual Solids Load Reduction
Based on the Rational Rainfall Method

CONTECH ENGINEERED SOLUTIONS

CASCADE separator™

ALTA NASHOBA VALLEY
BOLTON, MA
PDMH 20

AREA	1.59	acres	CASCADE MODEL	CS-4
WEIGHTED C	0.95			
TC	6.00	minutes	RAINFALL STATION	71

Rainfall Intensity[1] (in/hr)	Percent Rainfall Volume[1]	Hydraulic Loading Rate (gpm/ft2)	Removal Efficiency (%)	Incremental Removal (%)
0.08	37.6%	4.32	100.0	37.6
0.16	22.6%	8.63	100.0	22.6
0.24	11.9%	12.95	99.7	11.9
0.32	7.6%	17.26	95.7	7.3
0.40	4.3%	21.58	91.6	4.0
0.48	2.3%	25.90	87.6	2.1
0.56	1.8%	30.21	83.5	1.5
0.64	1.4%	34.53	79.4	1.1
0.72	0.9%	38.84	75.4	0.7
0.80	1.2%	43.16	71.3	0.8
0.88	1.5%	47.48	67.3	1.0
0.96	0.9%	51.79	63.2	0.6
1.04	0.4%	56.11	59.2	0.2
1.12	0.4%	60.42	55.1	0.2
1.20	0.6%	64.74	51.0	0.3
1.28	0.3%	69.06	47.0	0.1
1.36	0.2%	73.37	42.9	0.1
1.44	0.9%	76.08	39.6	0.3
1.52	0.6%	76.08	37.5	0.2
1.60	0.4%	76.08	35.6	0.1
1.80	0.2%	76.08	31.6	0.1
2.00	0.9%	76.08	28.5	0.3
				93.0
			Removal Efficiency Adjustment[2] =	0.0%
			Predicted % Annual Rainfall Treated =	98.4%
			Predicted Net Annual Load Removal Efficiency =	93.0%

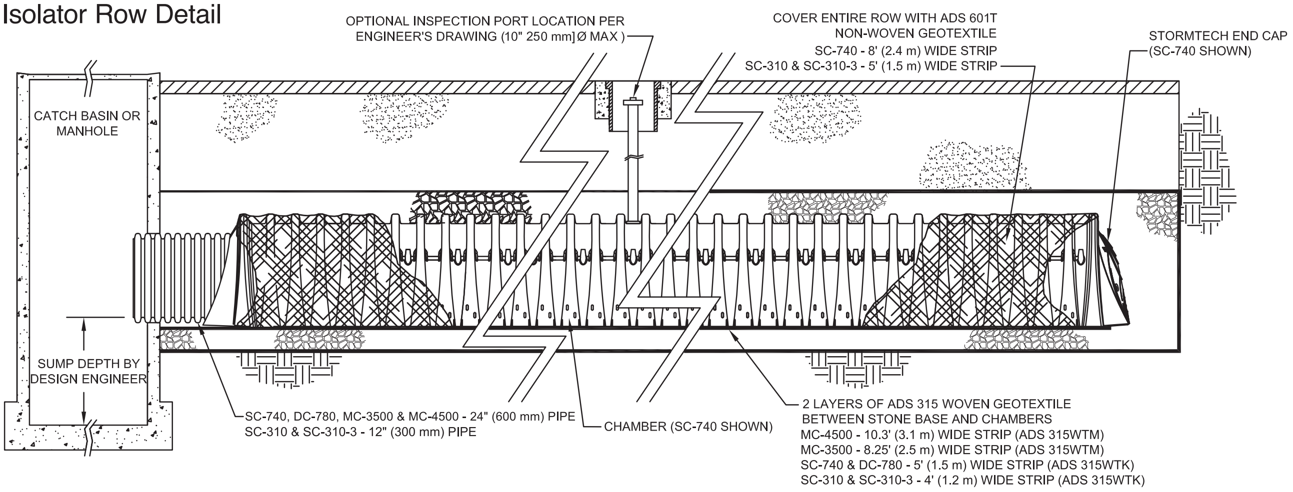
1 - Based on 13 years of 15 minute precipitation data for Station 0666, Birch Hill Dam, Worcester County, MA

2 - Reduction due to use of 60-minute data for a site that has a time of concentration less than 30-minutes.

StormTech and Stormwater Quality

StormTech's patented Isolator® Row is a row of chambers wrapped in a geotextile which filters the stormwater trapping pollutants in the row. The Isolator Row provides a way to inspect and maintain the system.

Isolator Row Detail



Note: For many applications, the non-woven geotextile over the DC-780, MC-3500 and MC-4500 Isolator Row chambers can be eliminated or substituted with the AASHTO Class 1 woven geotextile. Contact your StormTech representative for assistance.

Isolator Row Field Verification Testing at the University of New Hampshire Stormwater Center

- Lab and field (TARP tier II protocol) tested.
- Removal efficiencies for TSS have improved as the filter cake has built up on the bottom fabric of the Isolator Row.
- Current data shows a TSS removal efficiency which exceeds 80%.

Removal Efficiency Results:

- Total Suspended Solids = 80%
- Phosphorous = 49%
- Total Petroleum Hydrocarbons = 90%
- Zinc = 53%

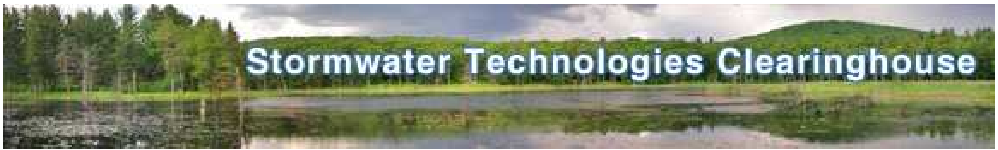
This system achieves a removal efficiency of 80% for TSS which meets most municipal recommended levels for water quality treatment.

Inspection and Maintenance

The Isolator Row can be inspected through the upstream manhole or optional inspection port.

Maintenance is easily accomplished with the JetVac process.

The frequency of inspection and maintenance varies by location. Contact StormTech for assistance with inspection and maintenance scheduling.



Performance Evaluation

Back to Profile

StormTech Isolator Row :: A product from STORMTECH LLC ::

Performance information: (This product was evaluated in at least one third-party study. See MASTEP Evaluation Summary.)

The StormTech Isolator Row was tested several times at a laboratory at Tennessee Tech University and also in the field by the UNH Stormwater Center (initially reported on in 2008, expanded and updated in a 2010 report). UNH analyzed runoff from a 9 acre parking lot for TSS, TPH, nitrogen as nitrate (DIN), TZn, and TP. Samples were collected during 23 events (13.2” rainfall) from 2007- 2009. The following pollutants were monitored, with results obtained: TSS (81% Efficiency Ratio (ER), 69% mean Removal Efficiency (RE), 83% median RE); SSC (only 5 storms monitored (94% ER, 93% mean RE, 91% median RE); Zinc (61% ER, 60% mean RE, 57% median RE); Total Phosphorus (53% ER, 29% mean RE, 33% median RE); Dissolved Inorganic Nitrogen(-74% ER, -97% mean RE, -80% median RE); Total Petroleum Hydrocarbons (79% ER, 81% mean RE, 91% median RE). A full scale StormTech SC-740 isolator Row was tested in the laboratory at Tennessee Tech University. Three different influent mixes were used in the testing including a SIL-CO-SIL 106, SIL-CO-SIL250 and US Silica OK-110. The SIL-CO-SIL106 had a median particle size of 22 microns and was tested at a hydraulic loading rate of 3.2gpm/ft2 of filter area. The SIL-CO-SIL 250 had a median particle size of 45 microns and was tested at 3.2 and 1.7 gpm/ft2 of filter area. The OK-110 influent slurry had a median particle size of 110 microns and was tested at rates up to 4.8 and 8.1 gpm/ft2 in the four and two chamber configurations. Five runs were done with the SIL-CO-SIL 106 influent at 3.2gpm/ft2 (125% of treatment operating rate). One run was done with the SIL-CO-SIL 250 slurry at each of the two hydraulic loading rates (3.2, 1.7gpm/ft2-62.5% of treatment operating rate). Each run lasted 15 detention times, allowing 3 detention times prior to collecting samples. OK-110 tests were run for 11 treatment flows from 44.9-539gpm (0.1-1.2cfs) or hydraulic loading rates of 0.4-4.8gpm/ft2 with a four chamber Isolator row. They also ran tests with a two chamber model at 0.4, 1.0, and 1.2 cfs, up to a hydraulic loading rate of 8.1gpm/ft2. Results of SIL-CO-SIL 106 runs show an average influent of 270 +/-59mg/l (range 139-361mg/l). This influent was higher than expected and due to recirculation of sediments that were not trapped in the filter sock at the outlet. Average removal efficiency was 60% across all samples but average removal by sample number (1-5) shows that removal efficiency decreased with increasing detention time from 66% at sample 1 to 58% at sample 5. Results for the SIL-CO-SIL 250 test at 3.2gpm/ft2 an average removal of 71%. Recirculation in these tests would have reduced the D50 below 45microns in the influent but a PSD was not done as it was with the SIL-CO-SIL 106 influent mix. Results for SIL-CO-SIL 250 at 1.7gpm/ft2 found an average removal of 88%. Compared to the demonstrated results for the SIL-CO-SIL106, these values appear reasonable since higher removal efficiencies are expected when the particle size distribution is greater. Results from OK-110 testing demonstrated an average removal of 99.14% from discrete samples and 98.06% from the grab samples across all flow rates tested.

Pollutants addressed	Manufacturer's Removal Efficiency claim	Minimum particle size	Tested removal efficiency (*)	Test Data Status (**)	Notes
Suspended sediment concentration	60-95%	-	60-95 %	2	average removal for all rates and influent types from Tenn Tech studies verified by NJCAT
Total suspended solids	66%	-	69-83 %	2	UNH Stormwater Center field studies, removal efficiency and efficiency ratio methods.
Zinc	50%	-	57-61 %	2	UNH Stormwater Center field studies, removal efficiency and efficiency ratio methods.
Hydrocarbons	78%	-	79-91 %	2	UNH Stormwater Center field studies, removal efficiency and efficiency ratio methods.
Total Phosphorus	37%	-	29-53 %	2	UNH Stormwater Center field studies, removal efficiency and efficiency ratio methods.

***** - Pollution removal efficiency evaluated by MASTEP staff based on review of available performance evaluation reports.

****** - **1** = sufficient credible data to be able to evaluate pollution removal efficiency claims. **2** = sound field or laboratory performance studies exist for this technology. Some caveats exist regarding use of the study information. **3** = performance studies with some scientific merit exist for this technology. Significant caveats exist regarding use of the study information. **4** = There is insufficient reliable data available to evaluate the performance of this technology. **0** = data review not yet conducted.

Test reports: (click on link to view a summary of a test, click on disk icon to download the full report)

Title	Author/ Agency	Date	TARP compliancy	Test protocol compliancy	Documents
Hydraulic Performance and Sediment Trap Efficiency for the StormTech SC-740 Isolator Row	Andrew Christensen and Vince Neary	02/23/2005	No	-	Hydraulic_Perf_Sed_Trap_Eff_StormTech_Isolator.pdf
PERFORMANCE EVALUATION OF SEDIMENT REMOVAL EFFICIENCY STORMTECH ISOLATOR ROW	Vincent Neary	10/20/2006	No	-	Tenn Tech Oct 2006 Report.pdf
NJCAT Technology Verification of the StormTech Isolotor Row	-	08/01/2007	No	-	NJCAT_Verification_StormTech_081507finalbdapprov-doc1.pdf
FINAL REPORT ON FIELD VERIFICATION TESTING OF THE STORMTECH ISOLATOR ROW TREATMENT UNIT	University of New Hampshire Stormwater Center	06/01/2008	No	The UNHSC QAPP was designed tobsubstantially comply with TARP and TAPE guidelines	UNHSC_StormTech Isolator Row_Final Report_6_08.pdf
Performance Evaluation Report of the StormTech Isolator Row Treatment Unit	Roseen et al	09/01/2010	No	TARP and TAPE	UNHSC_Stormtech PER_9_9_10-Final.pdf

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MA DEP

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This project has been financed with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under an s. 319 competitive grant. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

APPENDIX I

OPERATION & MAINTENANCE PLAN

ALLEN & MAJOR
ASSOCIATES, INC.

OPERATION & MAINTENANCE PLAN

Multi-Family Development
580 Main Street Bolton, MA

Prepared: September 10, 2021

Site Locus

CLIENT:
Limited Dividend Affiliate of
WP East Acquisitions, LLC
91 Hartwell Avenue
Lexington, MA 02421

PREPARED BY:
Allen & Major Associates, Inc.
10 Main Street
Lakeville, Massachusetts 02347

allenmajor.com

OPERATION & MAINTENANCE PLAN

Multi-Family Development
580 Main Street Bolton, MA

PROPONENT:
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ISSUED:
September 10, 2021

REVISED:
-

A&M PROJECT NO.:
1670-15

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SECTION 1.0

OPERATIONS & MAINTENANCE PLAN

1.1 INTRODUCTION

In accordance with the standards set forth by the Stormwater Management Policy issued by the Massachusetts Department of Environmental Protection (MassDEP), Allen & Major Associates, Inc. has prepared the following Operations & Maintenance (O&M) Plan for the proposed stormwater management system for the Multi-Family Development located at 580 Main Street in Bolton, MA.

This plan focuses on post construction maintenance of the on-site drainage system. Operation and Maintenance (O&M) practices discussed below are recommendations made by the Design Engineer based on available reference material on Best Management Practices (BMP's) and experience. The property owner is responsible for implementation of the plan, and is encouraged to revise / supplement this plan accordingly based on actual site conditions.

The plan is broken down into two major sections. The first section describes the long-term pollution prevention measures (Long Term Pollution Prevention Plan). The second section is a post-construction operation and maintenance plan designed to address the long-term maintenance needs of the stormwater management system (Long Term Maintenance Plan).

1.2 NOTIFICATION PROCEDURES FOR CHANGE OF RESPONSIBILITY FOR O&M

The Stormwater Management System (SMS) for this project is owned by a Limited Dividend Affiliate of WP East Acquisitions, LLC (owner). The owner shall be legally responsible for the long-term operation and maintenance of this SMS as outlined in this Operation and Maintenance Plan.

The owner shall submit an annual summary report and the completed Operation & Maintenance Schedule & Checklist to the Conservation Commission (via email or print copy), highlighting inspection and maintenance activities including performances of BMPs. Should ownership of the SMS change, the owner will continue to be responsible until the succeeding owner shall notify the Commission that the succeeding owner has assumed such responsibility. Upon subsequent transfers, the responsibility shall continue to be that of transferring owner until the transferee owner notifies the Commission of its assumption of responsibility.

In the event the SMS will serve multiple lots/owners, such as the subdivision of the existing parcel or creation of lease areas, the owner(s) shall establish an association on other legally enforceable arrangements under which the association or a single party shall have legal responsibility for the operation and maintenance of the entire SMS. The legal instrument creating such responsibility shall be recorded with the Registry of Deeds and promptly following its recording, a copy thereof shall be furnished to the Commission.

1.3 CONTACT INFORMATION

Stormwater Management System Owner:

Limited Dividend Affiliate of
WP East Acquisitions, LLC
91 Hartwell Avenue
Lexington, MA 02421
Phone: TBD

Emergency Contact Information:

Limited Dividend Affiliate of WP East Acquisitions, LLC (Owner/Operator)	Phone: TBD
Bolton Department of Public Works	Phone: 978-779-6402
Bolton Fire Department (non-emergency line)	Phone: 978-779-2203
MassDEP Emergency Response	Phone: (888) 304-1133
Clean Harbors Inc (24-Hour Line)	Phone: (800) 645-8265

1.4 CONSTRUCTION PERIOD

1. Call Digsafe: 1-888-344-7233
2. Schedule a meeting with the various Town Departments, Design Engineer and Owner at least three (3) days prior to start of construction.
3. Install Erosion Control measures (construction entrance, wattles, straw bales, silt fence, silt sac, etc.) as shown on the Plans prepared by A&M. If required, by any special conditions, the Town shall review the installation of erosion control measures prior to the start of any site demolition work. Install Construction fencing if determined to be necessary at the commencement of construction.
4. All erosion and sedimentation controls shall be in accordance with MassDEP's Erosion and Sedimentation Control guidelines revised through May 2003 and the USDA SCS Erosion and Sedimentation Control in site development dated September 1983.
5. Site access shall be achieved only from the designated construction entrances.
6. Cut and clear trees in construction areas only (within the limit of work; see plans).
7. Stockpiles of materials subject to erosion shall be stabilized with erosion control matting or temporary seeding whenever practicable, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased.

8. Install silt sacks and straw bales around each drain inlet prior to any demolition and or construction activities.
9. All erosion control measures shall be inspected weekly and after every rainfall event. Records of these inspections shall be kept on-site for review.
10. All erosion control measures shall be maintained, repaired, or replaced as required or at the direction of the owner's engineer or the Town's representative.
11. Sediment accumulation up-gradient of the straw bales, silt fence, and stone check dams greater than 6" in depth shall be removed and disposed of in accordance with all applicable regulations.
12. If it appears that sediment is exiting the site, silt sacks shall be installed in all catch basins adjacent to the site. Sediment accumulation on all adjacent catch basin inlets shall be removed and the silt sack replaced if torn or damaged.
13. Install stone check dam on-site during construction as needed. Refer to the erosion control details. Temporary sediment basins combined with stone check damns shall be installed on-site during construction to control and collect runoff from upland areas of this site during demolition and construction activities.
14. The contractor shall comply with the Sedimentation and Erosion Control Notes as shown on the Site Development Plans and Specifications.
15. The stabilized construction entrances shall be inspected weekly and records of inspections kept. The entrances shall be maintained by adding additional clean, angular, durable stone to remove the soil from the construction vehicle's tires when exiting the site. If soil is still leaving the site via the construction vehicle tires, adjacent roadways shall be kept clean by street sweeping.
16. Dust pollution shall be controlled using on-site water trucks and/or an approved soil stabilization product.
17. During demolition and construction activities, Status Reports on compliance with this O&M Document shall be submitted weekly. The report shall document any deficiencies and corrective actions taken by the applicant.
18. No overuse, over-compaction, or storage of materials shall occur within any areas defined as stormwater infiltration to prevent the incidental compaction of soils. The areas are to be constructed as soon as possible and protected from construction traffic. NO CONSTRUCTION WATERS are to be emptied into an infiltration system. An allowance may be accommodated for a temporary excavation of soils within the infiltration basin for collection and handling of construction water, but the entirety of the debris is to be removed in order to achieve the grades as shown on the construction drawings.

19. The entire drainage system, including but not limited to catch basin, manholes, piping, water quality structures and infiltration system should be cleaned prior to turnover to the Owner.

1.5 LONG-TERM POLLUTION PREVENTION PLAN

Standard #4 from the MassDEP Stormwater Management Handbook requires that a Long-Term Pollution Prevention Plan (LTPPP) be prepared and incorporated as part of the Operation and Maintenance Plan of the Stormwater Management System. The purpose of the LTPPP is to identify potential sources of pollution that may affect the quality of stormwater discharges, and to describe the implementation of practices to reduce the pollutants in stormwater discharges. The following items describe the source control and proper procedures of the LTPPP.

- **Housekeeping**
  The existing development has been designed to maintain a high level of water quality treatment for all stormwater discharge to the wetland areas. An Operation and Maintenance (O&M) plan has been prepared and is included in this section of the report. The owner (or its designee) is responsible for adherence to the O&M plan in a strict and complete manner.

- **Storing of Materials & Water Products**
  The trash and waste program for the site includes exterior dumpsters. There is a trash contractor used to pick up the waste material in the dumpsters. The stormwater drainage system has water quality inlets designed to capture trash and debris.

- **Vehicle Washing**
  Outdoor vehicle washing has the potential to result in high loads of nutrients, metals, and hydrocarbons during dry weather conditions, as the detergent-rich water used to wash the grime off the vehicle enters the stormwater drainage system. The existing development does not include any designated vehicle washing areas, nor is it expected that any vehicle washing will take place on-site.

- **Spill Prevention & Response**
  Sources of potential spill hazards include vehicle fluids, liquid fuels, pesticides, paints, solvents, and liquid cleaning products. The majority of the spill hazards would likely occur within the buildings and would not enter the stormwater drainage system. However, there are spill hazards from vehicle fluids or liquid fuels located outside of the buildings. These exterior spill hazards have the potential to enter the stormwater drainage system and are to be addressed as follows:

1. Spill hazards of pesticides, paints, and solvents shall be remediated using the Manufacturers' recommended spill cleanup protocol.
2. Vehicle fluids and liquid fuel spill shall be remediated according to the local and state regulations governing fuel spills.
3. The owner shall have the following equipment and materials on hand to address a spill clean-up: brooms, dust pans, mops, rags, gloves, absorptive material, sand, sawdust, plastic and metal trash containers.
4. All spills shall be cleaned up immediately after discovery.
5. Spills of toxic or hazardous material shall be reported, regardless of size, to the Massachusetts Department of Environmental Protection at (888) 304-1333.
6. Should a spill occur, the pollution prevention plan will be adjusted to include measures to prevent another spill of a similar nature. A description of the spill, along with the causes and cleanup measures will be included in the updated pollution prevention plan.

- **Maintenance of Lawns, Gardens, and Other Landscaped Areas**
  It should be recognized that this is a general guideline towards achieving high quality and well-groomed landscaped areas. The grounds staff/landscape contractor must recognize the shortcomings of a general maintenance plan such as this, and modify and/or augment it based on weekly, monthly, and yearly observations. In order to assure the highest quality conditions, the staff must also recognize and appreciate the need to be aware of the constantly changing conditions of the landscaping and be able to respond to them on a proactive basis. No trees shall be planted over the drain lines or recharge area, and that only shallow rooted plants and shrubs will be allowed.

  - **Fertilizer**

    Maintenance practices should be aimed at reducing environmental, mechanical and pest stresses to promote healthy and vigorous growth. When necessary, pest outbreaks should be treated with the most sensitive control measure available. Synthetic chemical controls should be used only as a last resort to organic and biological control methods. Fertilizer, synthetic chemical controls and pest management applications (when necessary) shall be performed only by licensed applicators in accordance with the manufacturer's label instructions when environmental conditions are conducive to controlled product application.

Only slow-release organic fertilizers should be used in the planting and mulch areas to limit the amount of nutrients that could enter downstream resource areas. Fertilization of the planting and mulch areas will be performed within manufacturers labeling instructions and shall not exceed an NPK ration of 1:1:1 (i.e. Triple 10 fertilizer mix), considered a low nitrogen mixture. Fertilizers approved for the use under this O&M Plan are as follows:

Type:	LESCO® 28-0-12 (Lawn Fertilizer)
	MERIT® 0.2 Plus Turf Fertilizer
	MOMENTUM™ Force Weed & Feed

- **Suggested Aeration Program**

  In-season aeration of lawn areas is good cultural practice, and is recommended whenever feasible. It should be accomplished with a solid thin tine aeration method to reduce disruption to the use of the area. The depth of solid tine aeration is similar to core type, but should be performed when the soil is somewhat drier for a greater overall effect.

  Depending on the intensity of use, it can be expected that all landscaped lawn areas will need aeration to reduce compaction at least once per year. The first operation should occur in late May following the spring season. Methods of reducing compaction will vary based on the nature of the compaction. Compaction on newly established landscaped areas is generally limited to the top 2-3" and can be alleviated using hollow core or thin tine aeration methods.

  The spring aeration should consist of two passes at opposite directions with 1/4" hollow core tines penetrating 3-5" into the soil profile. Aeration should occur when the soil is moist but not saturated. The soil cores should be shattered in place and dragged or swept back into the turf to control thatch. If desired the cores may also be removed and the area top-dressed with sand or sandy loam. If the area drains on average too slowly, the topdressing should contain a higher percentage of sand. If it is draining on average too quickly, the top dressing should contain a higher percentage of soil and organic matter.

- **Landscape Maintenance Program Practices**:
  - **Lawn**
    1. Mow a minimum of once a week in spring, to a height of 2” to 2 1/2” high. Mowing should be frequent enough so that no more than 1/3 of grass blade is removed at each mowing. The top growth supports the roots; the shorter the grass is cute, the less

the roots will grow. Short cutting also dries out the soil and encourages weeds to germinate.

2. Mow approximately once every two weeks from July 1st to August 15th depending on lawn growth.
3. Mow on a ten-day cycle in fall, when growth is stimulated by cooler nights and increased moisture.
4. Do not remove grass clippings after mowing.
5. Keep mower blades sharp to prevent ragged cuts on grass leaves, which cause a brownish appearance and increase the chance for disease to enter a leaf.

- **Shrubs**
  1. Mulch not more than 3″ depth with shredded pine or fir bark.
  2. Hand prune annually, immediately after blooming, to remove 1/3 of the above-ground biomass (older stems). Stem removals are to occur within 6″ of the ground to open up shrub and maintain two-year wood (the blooming wood).
  3. Hand-prune evergreen shrubs only as needed to remove dead and damaged wood and to maintain the naturalistic form of the shrub. Never mechanically shear evergreen shrubs.
- **Trees**
  1. Provide aftercare of new tree plantings for the first three years.
  2. Do not fertilize trees, it artificially stimulates them (unless tree health warrants).
  3. Water once a week for the first year; twice a month for the second; once a month for the third year.
  4. Prune trees on a four-year cycle.
- **Invasive Species**
  1. Inform the Conservation Commission Agent prior to the removal of invasive species proposed either through hand work or through chemical removal.

- **Storage and Use of Herbicides and Pesticides**
  Integrated Pest Management is the combination of all methods (of pest control) which may prevent, reduce, suppress, eliminate, or repel an insect population. The main requirements necessary to support any pest population are food, shelter and

water, and any upset of the balance of these will assist in controlling a pest population. Scientific pest management is the knowledgeable use of all pest control methods (sanitation, mechanical, chemical) to benefit mankind's health, welfare, comfort, property and food. A Pest Management Professional (PMP) should be retained who is licensed with the Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs, Department of Agricultural Resources.

The site manager will be provided with approved bulletin before entering into or renewing an agreement to apply pesticides for the control of indoor household or structural pests, refer to 333 CMR 13.08.

Before beginning each application, the applicator must post a Department approved notice on all of the entrances to the treated room or area. The applicator must leave such notices posted after the application. The notice will be posted at conspicuous point(s) of access to the area treated. The location and number of signs will be determined by the configuration of the area to be treated based on the applicator’s best judgment. It is intended to give sufficient notice so that no one comes into an area being treated unaware that the applicator is working and pesticides are being applied. However, if the contracting entity does not want the signs posted, he/she may sign a Department approved waiver indicating this.

The applicator or employer will provide to any person upon their request the following information on previously conducted applications:

1. Name and phone number of pest control company;
2. Date and time of the application;
3. Name and license number of the applicator;
4. Target pests; and
5. Name and EPA Registration Number of pesticide products applied.

- **Pet Waste Management**
  The owner’s landscape crew (or designee) shall remove any obvious pet waste that has been left behind by pet owners within the development. The pet waste shall be disposed of in accordance with local and state regulations.

- **Operations and Management of Septic Systems**
  The private on-site wastewater treatment systems shall be inspected in accordance with the special conditions from the groundwater discharge permit issues by MassDEP.

- **Management of Deicing Chemicals and Snow**
  Snow will be stockpiled on site until the accumulated snow becomes a hazard to the daily operations of the site. It will be the responsibility of the snow removal contractor to properly dispose of transported snow according to MassDEP, Bureau of Resource Protection – Snow Disposal Guideline #BRPG01-01, governing the proper disposal of snow. It will be the responsibility of the snow removal contractor to follow these guidelines and all applicable laws and regulations

  The owner's maintenance staff (or its designee) will be responsible for the clearing of the sidewalk and building entrances. The owner may be required to use a de-icing agent such as potassium chloride to maintain a safe walking surface. If used, the de-icing agent for the walkways and building entrances will be kept within the storage rooms located within the building. If used, de-icing agents will not be stored outside. The owner's maintenance staff will limit the application of sand.

1.6 LONG-TERM MAINTENANCE PLAN – FACILITIES DESCRIPTION

A maintenance log will be kept (i.e. report) summarizing inspections, maintenance, and any corrective actions taken. The log will include the date on which each inspection or maintenance task was performed, a description of the inspection findings or maintenance completed, and the name of the inspector or maintenance personnel performing the task. If a maintenance task requires the clean-out of any sediments or debris, the location where the sediment and debris was disposed after removal will be indicated. The log will be made accessible to department staff and a copy provided to the department upon request.

The following is a description of the Stormwater Management System for the project site.

- **Stormwater Collection System – On-Site**: The stormwater collection system is comprised of deep sump hooded catch basins, Contech CDS 2015-4 water quality structures, Stormtech Isolator Row, a sub-surface infiltration system consisting of Stormtech SC-740 Chambers, wet basin, a closed gravity pipe network and several outlet control structures.
  The stormwater runoff from the building rooftops are collected using roof drains. The stormwater is conveyed to the discharge locations using internal building plumbing and external roof leaders. The building rooftop runoff discharges to one of several sub-surface infiltration systems.

1.7 INSPECTION AND MAINTENANCE FREQUENCY AND CORRECTIVE MEASURES

In accordance with MA DEP Stormwater Handbook: Volume 2, Chapter 2; the following areas, facilities, and measures will be inspected and the identified deficiencies will be corrected. Clean-out must include the removal and legal disposal of any accumulated sediments, trash, and debris. In any and all cases, operations, inspections, and maintenance activities shall utilize best practical measures to avoid and minimize impacts to wetland resource areas outside the footprint of the SMS.

Attached is an Operation and Maintenance Plan (OM-1) illustrating the location of the following SMS components that will require continuing inspection as outlined in the document:

- *Street Sweeping*
- *Deep Sump Hooded Catch Basin*
- *Contech CDS 2015-4 Water Quality Structures*
- *Stormtech Isolator Row*
- *Sub-Surface Infiltration Systems (Stormtech SC-740 Chambers)*
- *Pipe Ends*
- *Wet Basin*
- *Snow Storage (as outlined on plan)*

1.8 STRUCTURAL PRETREATMENT BMPS

Regular maintenance of these BMPs is especially critical because they typically receive the highest concentration of suspended solids during the first flush of a storm event.

Deep Sump Catch Basins:

Deep sump catch basins, also known as oil and grease or hooded catch basins, are underground retention systems designed to remove trash, debris, and coarse sediment from stormwater runoff, and serve as temporary spill containment devices for floatables such as oils and greases.

Regular maintenance is essential. Deep sump catch basins remain effective by removing pollutants only if they are cleaned out frequently. One study found that once 50% of the sump volume is filled, the catch basin is not able to retain additional sediments.

Inspect or clean deep sump catch basins at least four times per year and at the end of the foliage and snow-removal seasons. Sediments must also be removed four times per year or whenever the depths of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin.

Clamshell buckets are typically used to remove sediment in Massachusetts. However, vacuum trucks are preferable, because they remove more trapped sediment and supernatant than clamshells. Vacuuming is also a speedier process and is less likely to snap the cast iron hood within the deep sump catch basin.

Always consider the safety of the staff cleaning deep sump catch basins. Cleaning a deep sump catch basin within a road with active traffic or even within a parking lot is dangerous, and a police detail may be necessary to safeguard workers.

Although catch basin debris often contains concentrations of oil and hazardous materials, such as petroleum hydrocarbons and metals, MassDEP classifies them as solid waste. Unless there is evidence that they have been contaminated by a spill or other means, MassDEP does not routinely require catch basin cleanings to be tested before disposal. Contaminated catch basin cleanings must be evaluated in accordance with the Hazardous Waste Regulations, 310 CMR 30.000, and handled as hazardous waste.

In the absence of evidence of contamination, catch basin cleanings may be taken to a landfill or other facility permitted by MassDEP to accept solid waste, without any prior approval by MassDEP. However, some landfills require catch basin cleanings to be tested before they are accepted.

With prior MassDEP approval, catch basin cleanings may be used as grading and shaping materials at landfills undergoing closure (see Revised Guidelines for Determining Closure Activities at Inactive Unlined Landfill Sites) or as daily cover at active landfills. MassDEP also encourages the beneficial reuse of catch basin cleanings whenever possible. A Beneficial Reuse Determination is required for such use.

MassDEP regulations prohibit landfills from accepting materials that contain free-draining liquids. One way to remove liquids is to use a hydraulic lift truck during cleaning operations so that the material can be decanted at the site. After loading material from several catch basins into a truck, elevate the truck so that any free-draining liquid can flow back into the structure. If there is no free water in the truck, the material may be deemed to be sufficiently dry. Otherwise catch basin cleanings must undergo a Paint Filter Liquids Test. Go to www.Mass.gov/dep/recycle/laws/cafacts.doc for information on all of the MassDEP requirements pertaining to the disposal of catch basin cleanings

Contech CDS 2015-4 450i Water Quality Structure:

Regular maintenance is essential. Inspect or clean water quality structure at least twice per year (e.g. spring & fall) and snow-removal seasons. Sediments must also be removed whenever the depths of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin. Please refer to the Stormceptor STC Operation and Maintenance Guide attached hereafter.

Vacuum trucks are preferable, because they remove more trapped sediment and supernatant than clamshells. Vacuuming is also a speedier process and is less likely to snap the cast iron hood within the deep sump catch basin.

Always consider the safety of the staff cleaning the structure. Cleaning structures within a road with active traffic or even within a parking lot is dangerous, and a police detail may be necessary to safeguard workers.

Although debris often contains concentrations of oil and hazardous materials, such as petroleum hydrocarbons and metals, MassDEP classifies them as solid waste. Unless there is evidence that they have been contaminated by a spill or other means, MassDEP does not routinely require catch basin cleanings to be tested before disposal. Contaminated catch basin cleanings must be evaluated in accordance with the Hazardous Waste Regulations, 310 CMR 30.000, and handled as hazardous waste.

In the absence of evidence of contamination, catch basin cleanings may be taken to a landfill or other facility permitted by MassDEP to accept solid waste, without any prior approval by MassDEP. However, some landfills require catch basin cleanings to be tested before they are accepted.

With prior MassDEP approval, catch basin cleanings may be used as grading and shaping materials at landfills undergoing closure (see Revised Guidelines for Determining Closure Activities at Inactive Unlined Landfill Sites) or as daily cover at active landfills. MassDEP also encourages the beneficial reuse of catch basin cleanings whenever possible. A Beneficial Reuse Determination is required for such use.

MassDEP regulations prohibit landfills from accepting materials that contain free-draining liquids. One way to remove liquids is to use a hydraulic lift truck during cleaning operations so that the material can be decanted at the site. After loading material from several catch basins into a truck, elevate the truck so that any free-draining liquid can flow back into the structure. If there is no free water in the truck, the material may be deemed to be sufficiently dry. Otherwise catch basin cleanings must undergo a Paint Filter Liquids Test. Go to www.Mass.gov/dep/recycle/laws/cafacts.doc for information on all of the MassDEP requirements pertaining to the disposal of catch basin cleanings.

1.9 TREATMENT BMPS

Stormtech Isolator Row:

Stormtech's Isolator Row is an isolated row of chambers wrapped in geotextile fabric which filters the stormwater, trapping pollutants in the row before entering the adjacent chambers. The Isolator Row inspection/maintenance should be done in accordance with the manufacturer's guidelines and documentation. A copy is attached hereafter.

Wet Basins:

Wet basins use a permanent pool of water as the primary mechanism to treat stormwater. The pool allows sediments to settle (including fine sediments) and removes soluble pollutants. Wet basins must have additional dry storage capacity to control peak discharge rates. Wet basins have a moderate to high capacity to remove most urban pollutants, depending on how large the volume of the permanent pool is in relation to the runoff from the surrounding watershed.

Inspect wet basins at least once per year to ensure they are operating as designed. Inspect the outlet structure for evidence of clogging or excessive outflow releases. Potential problems to check include: subsidence, erosion, cracking or tree growth on the embankment, damage to the emergency spillway, sediment accumulation around the outlet, inadequacy of the inlet/outlet channel erosion control measures, change in the condition of the pilot channel, erosion within the basin and banks, and the emergence of invasive species. During inspections, note any changes to the wet basin or the contributing watershed area because these may affect basin performance. At least twice a year, mow the upper-stage, side slopes, embankment and emergency spillway. At this time, also check the sediment in the forebay for accumulated material, sediment, trash, and debris and remove it. Remove sediment from the basin as necessary, and at least once every 10 years.

1.10 CONVEYANCE BMPS

Grass Swale:

Grass Drainage Channels should be inspected within the first three months after construction to ensure proper vegetation is established; thereafter, Inspect 2 times per year (preferably in Spring and Fall) to ensure they are working in their intended fashion and that they are free of sediment and debris. Remove any obstructions to flow, including accumulated sediments and debris and vegetated growth. Repair any erosion of the ditch lining. Vegetated ditches will be mowed at least annually or otherwise maintained to control the growth of woody vegetation and maintain flow capacity. Any woody vegetation growing through riprap linings must also be removed. Repair any slumping side slopes as soon as practicable and correct any erosion of the channel's bottom or side slopes.

1.11 INFILTRATION BMPS

Subsurface Structures:

Subsurface structures are underground systems that capture runoff, and gradually infiltrate it into the groundwater through rock and gravel.

Because subsurface structures are installed underground, they are extremely difficult to maintain. Inspect inlets at least twice a year. Remove any debris that might clog the system. Include mosquito controls in the Operation and Maintenance Plan.

Inspect outlet from subsurface structures to adjacent resource area for signs of scour and sediment accumulation at least twice annually. Remove sediment accumulation and add rip rap as necessary to prevent scour.

1.12 OTHER BMPS AND ACCESSORIES:

Outlet Control Structures:

Outlets of BMPs are devices that control the flow of stormwater out of the BMP to the conveyance system.

Inspect outlet structures twice per year. Remove any accumulated sediment and debris that could prevent flow at the outlet structure.

Culverts:

Inspect culverts 2 times per year (preferably in Spring and Fall) to ensure that the culverts are working in their intended fashion and that they are free of debris. Remove any obstructions to flow; remove accumulated sediments and debris at the inlet, at the outlet, and within the conduit and repair any erosion damage at the culvert’s inlet and outlet.

Rip Rap and Level Spreaders:

Inspect twice per year for erosion, debris accumulation, and unwanted vegetation. Erosion areas shall be stabilized and sediment, debris, and woody vegetation will be removed.

Vegetated Areas:

Inspect slopes and embankments early in the growing season to identify active or potential erosion problems. Replant bare areas or areas with sparse growth. Where rill erosion is evident, armor the area with an appropriate lining or divert the erosive flows to on-site areas able to withstand the concentrated flows.

Roadway and Parking Surfaces:

Clear accumulations of winter sand in parking lots and along roadways at least once a year, preferably in the spring. Accumulations on pavement may be removed by pavement sweeping. Accumulations of sand along road shoulders may be removed by grading excess sand to the pavement edge and removing it manually or by a front-end loader.

Mosquito Control Plan:

MA Stormwater Handbook; Volume 2, Chapter 5 (Attached)

Both above ground and underground stormwater BMPs have the potential to serve as mosquito breeding areas. Good design, proper operation and maintenance, and treatment with larvicides can minimize this potential.

1.13 SUPPLEMENTAL INFORMATION

PROPOSED OPERATIONS AND MAINTENANCE LOG FORM

Based on site specific stormwater management system asset list. At a minimum, fields should be provided for:

- Date of inspection
- Name of inspector
- Condition of each BMP, including components such as:
    - Pretreatment devices
    - Vegetation
    - Other safety devices
    - Control structures
    - Embankments, slopes, and safety benches
    - Inlet and outlet channels and structures
    - Underground drainage
    - Sediment and debris accumulation in storage and forebay areas (including catch basins)
    - Any nonstructural practices
    - Any other item that could affect the proper function of the stormwater management system
- Description of the need for maintenance
- Description of maintenance performed

APPENDIX A

SUPPLEMENT INFORMATION

SNOW DISPOSAL GUIDANCE

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

One Winter Street Boston, MA 02108 • 617-292-5500

Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

Massachusetts Department of Environmental Protection
Bureau of Water Resources
Snow Disposal Guidance

Effective Date: December 23, 2019

Applicability: Applies to all federal, state, regional and local agencies, as well as to private businesses.

Supersedes: Bureau of Resource Protection (BRP) Snow Disposal Guideline No. BRPG97-1 issued December 12, 1997 and BRPG01-01 issued March 8, 2001; Bureau of Water Resources (BWR) snow disposal guidance issued December 21, 2015 and December 12, 2018.

Approved by: Kathleen Baskin, Assistant Commissioner, Bureau of Water Resources

PURPOSE: To provide guidelines to all government agencies and private businesses regarding snow disposal site selection, site preparation and maintenance, and emergency snow disposal options that are protective of wetlands, drinking water, and water bodies, and are acceptable to the Massachusetts Department of Environmental Protection (MassDEP), Bureau of Water Resources.

APPLICABILITY: These Guidelines are issued by MassDEP's Bureau of Water Resources on behalf of all Bureau Programs (including Drinking Water Supply, Wetlands and Waterways, Wastewater Management, and Watershed Planning and Permitting). They apply to all federal agencies, state agencies, state authorities, municipal agencies and private businesses disposing of snow in the Commonwealth of Massachusetts.

INTRODUCTION

Finding a place to dispose of collected snow poses a challenge to municipalities and businesses as they clear roads, parking lots, bridges, and sidewalks. While MassDEP is aware of the threats to public safety caused by snow, collected snow that is contaminated with road salt, sand, litter, and automotive pollutants such as oil also threatens public health and the environment.

As snow melts, road salt, sand, litter, and other pollutants are transported into surface water or through the soil where they may eventually reach the groundwater. Road salt and other pollutants can contaminate water supplies and are toxic to aquatic life at certain levels. Sand washed into waterbodies can create sand bars or fill in wetlands and ponds, impacting aquatic life, causing flooding, and affecting our use of these resources.

There are several steps that communities can take to minimize the impacts of snow disposal on public health and the environment. These steps will help communities avoid the costs of a contaminated water supply, degraded waterbodies, and flooding. Everything that occurs on the land has the potential to impact the Commonwealth's water resources. Given the authority of local government over the use of the land, municipal officials and staff have a critically important role to play in protecting our water resources.

The purpose of these guidelines is to help federal agencies, state agencies, state authorities, municipalities and businesses select, prepare, and maintain appropriate snow disposal sites before the snow begins to accumulate through the winter. Following these guidelines and obtaining the necessary approvals may also help municipalities in cases when seeking reimbursement for snow disposal costs from the Federal Emergency Management Agency is possible.

RECOMMENDED GUIDELINES

These snow disposal guidelines address: (1) site selection; (2) site preparation and maintenance; and (3) emergency snow disposal.

1. SITE SELECTION

The key to selecting effective snow disposal sites is to locate them adjacent to or on pervious surfaces in upland areas or upland locations on impervious surfaces away from water resources and drinking water wells. At these locations, the snow meltwater can filter into the soil, leaving behind sand and debris which can be removed in the spring. The following conditions should be followed:

- Within water supply Zone A and Zone II, avoid storage or disposal of snow and ice containing deicing chemicals that has been collected from streets located outside these zones. Municipalities may have a water supply protection land use control that prohibits the disposal of snow and ice containing deicing chemicals from outside the Zone A and Zone II, subject to the Massachusetts Drinking Water Regulations at 310 CMR 22.20C and 310 CMR 22.21(2).
- Avoid storage or disposal of snow or ice in Interim Wellhead Protection Areas (IWPA) of public water supply wells, and within 75 feet of a private well, where road salt may contaminate water supplies.
- Avoid dumping snow into any waterbody, including rivers, the ocean, reservoirs, ponds, or wetlands. In addition to water quality impacts and flooding, snow disposed of in open water can cause navigational hazards when it freezes into ice blocks.
- Avoid dumping snow on MassDEP-designated high and medium-yield aquifers where it may contaminate groundwater.
- Avoid dumping snow in sanitary landfills and gravel pits. Snow meltwater will create more contaminated leachate in landfills posing a greater risk to groundwater, and in gravel pits, there is little opportunity for pollutants to be filtered out of the meltwater because groundwater is close to the land surface.

- Avoid disposing of snow on top of storm drain catch basins or in stormwater drainage systems including detention basins, swales or ditches. Snow combined with sand and debris may block a stormwater drainage system, causing localized flooding. A high volume of sand, sediment, and litter released from melting snow also may be quickly transported through the system into surface water.

Recommended Site Selection Procedures

It is important that the municipal Department of Public Works or Highway Department, Conservation Commission, and Board of Health work together to select appropriate snow disposal sites. The following steps should be taken:

- Estimate how much snow disposal capacity may be needed for the season so that an adequate number of disposal sites can be selected and prepared.
- Identify sites that could potentially be used for snow disposal, such as municipal open space (e.g., parking lots or parks).
- Select sites located in upland locations that are not likely to impact sensitive environmental resources first.
- If more storage space is still needed, prioritize the sites with the least environmental impact (using the site selection criteria, and local or MassGIS maps as a guide).

Snow Disposal Mapping Assistance

MassDEP has an online mapping tool to assist in identifying possible locations to potentially dispose of snow. MassDEP encourages municipalities to use this tool to identify possible snow disposal options. The tool identifies wetland resource areas, public drinking water supplies and other sensitive locations where snow should not be disposed. The tool may be accessed through the Internet at the following web address: **https://maps.env.state.ma.us/dep/arcgis/js/templates/PSF/**.

2. SITE PREPARATION AND MAINTENANCE

In addition to carefully selecting disposal sites before the winter begins, it is important to prepare and maintain these sites to maximize their effectiveness. The following maintenance measures should be undertaken for all snow disposal sites:

- A silt fence or equivalent barrier should be placed securely on the downgradient side of the snow disposal site.
- Wherever possible maintain a 50-foot vegetated buffer between the disposal site and adjacent waterbodies to filter pollutants from the meltwater.
- Clear debris from the site prior to using the site for snow disposal.
- Clear debris from the site and properly dispose of it at the end of the snow season, and no later than May 15.

3. SNOW DISPOSAL APPROVALS

Proper snow disposal may be undertaken through one of the following approval procedures:

- Routine snow disposal – Minimal, if any, administrative review is required in these cases when upland and pervious snow disposal locations or upland locations on impervious surfaces that have functioning and maintained stormwater management systems have been identified, mapped, and used for snow disposal following ordinary snowfalls. Use of upland and pervious snow disposal sites avoids wetland resource areas and allows snow meltwater to recharge groundwater and will help filter pollutants, sand, and other debris. This process will address the majority of snow removal efforts until an entity exhausts all available upland snow disposal sites. The location and mapping of snow disposal sites will help facilitate each entity's routine snow management efforts.
- Emergency Certifications – If an entity demonstrates that there is no remaining capacity at upland snow disposal locations, local conservation commissions may issue an Emergency Certification under the Massachusetts Wetlands Protection regulations to authorize snow disposal in buffer zones to wetlands, certain open water areas, and certain wetland resource areas (i.e. within flood plains). Emergency Certifications can only be issued at the request of a public agency or by order of a public agency for the protection of the health or safety of citizens, and are limited to those activities necessary to abate the emergency. See 310 CMR 10.06(1)-(4). Use the following guidelines in these emergency situations:
    - Dispose of snow in open water with adequate flow and mixing to prevent ice dams from forming.
    - Do not dispose of snow in salt marshes, vegetated wetlands, certified vernal pools, shellfish beds, mudflats, drinking water reservoirs and their tributaries, Zone IIs or IWPAs of public water supply wells, Outstanding Resource Waters, or Areas of Critical Environmental Concern.
    - Do not dispose of snow where trucks may cause shoreline damage or erosion.
    - Consult with the municipal Conservation Commission to ensure that snow disposal in open water complies with local ordinances and bylaws.

- Severe Weather Emergency Declarations – In the event of a large-scale severe weather event, MassDEP may issue a broader Emergency Declaration under the Wetlands Protection Act which allows federal agencies, state agencies, state authorities, municipalities, and businesses greater flexibility in snow disposal practices. Emergency Declarations typically authorize greater snow disposal options while protecting especially sensitive resources such as public drinking water supplies, vernal pools, land containing shellfish, FEMA designated floodways, coastal dunes, and salt marsh. In the event of severe winter storm emergencies, the snow disposal site maps created by municipalities will enable MassDEP and the Massachusetts Emergency Management Agency (MEMA) in helping communities identify appropriate snow disposal locations.

  If upland disposal sites have been exhausted, the Emergency Declaration issued by MassDEP allows for snow disposal near water bodies. In these situations, a buffer of at least 50 feet, preferably vegetated, should still be maintained between the site and the waterbody. Furthermore, it is essential that the other guidelines for preparing and maintaining snow disposal sites be followed to minimize the threat to adjacent waterbodies.

Under extraordinary conditions, when all land-based snow disposal options are exhausted, the Emergency Declaration issued by MassDEP may allow disposal of snow in certain waterbodies under certain conditions. ***A federal agency, state agency, state authority, municipality or business seeking to dispose of snow in a waterbody should take the following steps***:

- Call the emergency contact phone number [(888) 304-1133)] and notify the MEMA of the municipality's intent.
- MEMA will ask for some information about where the requested disposal will take place.
- MEMA will confirm that the disposal is consistent with MassDEP's Severe Weather Emergency Declaration and these guidelines and is therefore approved.

During declared statewide snow emergency events, MassDEP's website will also highlight the emergency contact phone number [(888) 304-1133)] for authorizations and inquiries. For further non-emergency information about this Guidance you may contact your MassDEP Regional Office Service Center:

Northeast Regional Office, Wilmington, 978-694-3246
Southeast Regional Office, Lakeville, 508-946-2714
Central Regional Office, Worcester, 508-792-7650
Western Regional Office, Springfield, 413-755-2114

MOSQUITO CONTROL

Chapter 5
Miscellaneous Stormwater Topics

Mosquito Control in Stormwater Management Practices

Both aboveground and underground stormwater BMPs have the potential to serve as mosquito breeding areas. Good design, proper operation and maintenance and treatment with larvicides can minimize this potential.

EPA recommends that stormwater treatment practices dewater within 3 days (72 hours) to reduce the number of mosquitoes that mature to adults, since the aquatic stage of many mosquito species is 7 to 10 days. Massachusetts has had a 72-hour dewatering rule in its Stormwater Management Standards since 1996. The 2008 technical specifications for BMPs set forth in Volume 2, Chapter 2 of the Massachusetts Stormwater Handbook also concur with this practice by requiring that all stormwater practices designed to drain do so within 72 hours.

Some stormwater practices are designed to include permanent wet pools. These practices – if maintained properly – can limit mosquito breeding by providing habitat for mosquito predators. Additional measures that can be taken to reduce mosquito populations include increasing water circulation, attracting mosquito predators by adding suitable habitat, and applying larvicides.

The Massachusetts State Reclamation and Mosquito Control Board (SRMCB), through the Massachusetts Mosquito Control Districts, can undertake further mosquito control actions specifically for the purpose of mosquito control pursuant to Massachusetts General Law Chapter 252. The Mosquito Control Board, http://www.mass.gov/agr/mosquito/, describes mosquito control methods and is in the process of developing guidance documents that describe Best Management Practices for mosquito control projects.

The SRMCB and Mosquito Control Districts are not responsible for operating and maintaining stormwater BMPs to reduce mosquito populations. The owners of property that construct the stormwater BMPs or municipalities that "accept" them through local subdivision approval are responsible for their maintenance.[1] The SRMCB is composed of officials from MassDEP, Department of Agricultural Resources, and Department of Conservation and Recreation. The nine (9) Mosquito Control Districts overseen by the SRMCB are located throughout Massachusetts, covering 176 municipalities.

Construction Period Best Management Practices for Mosquito Control

To minimize mosquito breeding during construction, it is essential that the following actions be taken to minimize the creation of standing pools by taking the following actions:

- ***Minimize Land Disturbance:*** Minimizing land disturbance reduces the likelihood of mosquito breeding by reducing silt in runoff that will cause construction period controls to clog and retain standing pools of water for more than 72 hours.
- ***Catch Basin inlets:*** Inspect and refresh filter fabric, hay bales, filter socks or stone dams on a regular basis to ensure that any stormwater ponded at the inlet drains within 8 hours after precipitation stops. Shorter periods may be necessary to avoid hydroplaning in roads

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[1] MassDEP and MassHighway understand that the numerous stormwater BMPs along state highways pose a unique challenge. To address this challenge, the 2004 MassHighway Stormwater Handbook will provide additional information on appropriate operation and maintenance practices for mosquito control when the Handbook is revised to reflect the 2008 changes to the Stormwater Management Standards..

caused by water ponded at the catch basin inlet. Treat catch basin sumps with larvicides such as *Bacillus sphaericus* (*Bs*) using a licensed pesticide applicator.

- ***Check Dams:*** If temporary check dams are used during the construction period to lag peak rate of runoff or pond runoff for exfiltration, inspect and repair the check dams on a regular basis to ensure that any stormwater ponded behind the check dam drains within 72 hours.
- ***Design construction period sediment traps*** to dewater within 72 hours after precipitation. Because these traps are subject to high silt loads and tend to clog, treat them with the larvicide *Bs* after it rains from June through October, until the first frost occurs.
- ***Construction period open conveyances:*** When temporary manmade ditches are used for channelizing construction period runoff, inspect them on a regular basis to remove any accumulated sediment to restore flow capacity to the temporary ditch.
- ***Revegetating Disturbed Surfaces:*** Revegetating disturbed surfaces reduces sediment in runoff that will cause construction period controls to clog and retain standing pools of water for greater than 72 hours.
- ***Sediment fences/hay bale barriers:*** When inspections find standing pools of water beyond the 24-hour period after a storm, take action to restore barrier to its normal function.

<u>Post-Construction Stormwater Treatment Practices</u>

- Mosquito control begins with the environmentally sensitive site design. Environmentally sensitive site design that minimizes impervious surfaces reduces the amount of stormwater runoff. Disconnecting runoff using the LID Site Design credits outlined in the Massachusetts Stormwater Handbook reduces the amount of stormwater that must be conveyed to a treatment practice. Utilizing green roofs minimizes runoff from smaller storms. Storage media must be designed to dewater within 72 hours after precipitation.
- Mosquito control continues with the selection of structural stormwater BMPs that are unlikely to become breeding grounds for mosquitoes, such as:
  - ***Bioretention Areas/Rain Gardens/Sand Filter:*** These practices tend not to result in mosquito breeding. If any level spreaders, weirs or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
  - ***Infiltration Trenches:*** This practice tends not to result in mosquito breeding. If any level spreaders, weirs, or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
- Another mosquito control strategy is to select BMPs that can become habitats for mosquito predators, such as:
  - ***Constructed Stormwater Wetlands:*** Habitat features can be incorporated in constructed stormwater wetlands to attract dragonflies, amphibians, turtles, birds, bats, and other natural predators of mosquitoes.
  - ***Wet Basins:*** Wet basins can be designed to incorporate fish habitat features, such as deep pools. Introduce fish in consultation with Massachusetts Division of Fisheries and Wildlife. Vegetation within wet basins designed as fish habitat must be properly managed to ensure that vegetation does not overtake the habitat. Proper design to ensure that no low circulation or “dead” zones are created may reduce the potential for mosquito breeding. Introducing bubblers may increase water circulation in the wet basin.

Effective mosquito controls require proponents to design structural BMPs to prevent ponding and facilitate maintenance and, if necessary, the application of larvicides. Examples of such design practices include the following:

- ***Basins:*** Provide perimeter access around wet basins, extended dry detention basins and dry detention basins for both larviciding and routine maintenance. Control vegetation to ensure that access pathways stay open.
- ***BMPs without a permanent pool of water:*** All structural BMPs that do not rely on a permanent pool of water must drain and completely dewater within 72 hours after precipitation. This includes dry detention basins, extended dry detention basins, infiltration basins, and dry water quality swales. Use underdrains at extended dry detention basins to drain the small pools that form due to accumulation of silts. Wallace indicates that extended dry extended detention basins may breed more mosquitoes than wet basins. It is, therefore, imperative to design outlets from extended dry detention basins to completely dewater within the 72-hour period.
- ***Energy Dissipators and Flow Spreaders:*** Currier and Moeller, 2000 indicate that shallow recesses in energy dissipators and flow spreaders trap water where mosquitoes breed. Set the riprap in grout to reduce the shallow recesses and minimize mosquito breeding.
- ***Outlet control structures:*** Debris trapped in small orifices or on trash racks of outlet control structures such as multiple stage outlet risers may clog the orifices or the trash rack, causing a standing pool of water. Optimize the orifice size or trash rack mesh size to provide required peak rate attenuation/water quality detention/retention time while minimizing clogging.
- ***Rain Barrels and Cisterns:*** Seal lids to reduce the likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over inlets. The cistern system should be designed to ensure that all collected water is drained into it within 72 hours.
- ***Subsurface Structures, Deep Sump Catch Basins, Oil Grit Separators, and Leaching Catch Basins:*** Seal all manhole covers to reduce likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over the outlet (CALTRANS 2004).

The Operation and Maintenance Plan should provide for mosquito prevention and control.

- ***Check dams:*** Inspect permanent check dams on the schedule set forth in the O&M Plan. Inspect check dams 72 hours after storms for standing water ponding behind the dam. Take corrective action if standing water is found.
- ***Cisterns:*** Apply *Bs* larvicide in the cistern if any evidence of mosquitoes is found. The Operation and Maintenance Plan shall specify how often larvicides should be applied to waters in the cistern.
- ***Water quality swales:*** Remove and properly dispose of any accumulated sediment as scheduled in the Operation and Maintenance Plan.
- ***Larvicide Treatment:*** The Operation and Maintenance Plan must include measures to minimize mosquito breeding, including larviciding.
- The party identified in the Operation and Maintenance Plan as responsible for maintenance shall see that larvicides are applied as necessary to the following stormwater treatment practices: catch basins, oil/grit separators, wet basins, wet water quality swales, dry extended detention basins, infiltration basins, and constructed stormwater wetlands. The Operation and Maintenance Plan must ensure that all larvicides are applied by a licensed pesticide applicator and in compliance with all pesticide label requirements.
- The Operation and Maintenance Plan should identify the appropriate larvicide and the time and method of application. For example, *Bacillus sphaericus (Bs*), the preferred

larvicide for stormwater BMPs, should be hand-broadcast.[2] Alternatively, Altosid, a Methopren product, may be used. Because some practices are designed to dewater between storms, such as dry extended detention and infiltration basins, the Operation and Maintenance Plan should provide that larviciding must be conducted during or immediately after wet weather, when the detention or infiltration basin has a standing pool of water, unless a product is used that can withstand extended dry periods.

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[2] *Bacillus thuringienis israelensis* or *Bti* is usually applied by helicopter to wetlands and floodplains

Roads and Stormwater BMPs

In general, the stormwater BMPs used for land development projects can also be used for new roadways and roadway improvement projects. However, for improvement of existing roads, there are often constraints that limit the choice of BMP. These constraints derive from the linear configuration of the road, the limited area within the existing right-of-way, the structural and safety requirements attendant to good roadway design, and the long-term maintainability of the roadway drainage systems. The MassHighway Handbook provides strategies for dealing with the constraints associated with providing stormwater BMPs for roadway redevelopment projects.

Roadway design can minimize impacts caused by stormwater. Reducing roadway width reduces the total and peak volume of runoff. Designing a road with country drainage (no road shoulders or curbs) disconnects roadway runoff. Disconnection of roadway runoff is eligible for the Low Impact Site Design Credit provided the drainage is disconnected in accordance with specifications outlined in Volume 3.

Like other parties, municipalities that work within wetlands jurisdictional areas and adjacent buffer zones must design and implement structural stormwater best management practices in accordance with the Stormwater Management Standards and the Stormwater Management Handbook. In addition, in municipalities and areas where state agencies operate stormwater systems, the DPWs (or other town or state agencies) must meet the “good housekeeping“ requirement of the municipality’s or agency's MS4 permit.

MassHighway has taken stormwater management one step further by working with MassDEP to develop the MassHighway Storm Water Handbook for Highways and Bridges. The purpose of the MassHighway Handbook is to provide guidance for persons involved in the design, permitting, review and implementation of state highway projects, especially those involving existing roadways where physical constraints often limit the stormwater management options available. These constraints, like those common to redevelopment sites, may make it difficult to comply precisely with the requirements of the Stormwater Management Standards and the Massachusetts Stormwater Handbook.[3] In response to these constraints, MassDEP and MHD developed specific design, permitting, review and implementation practices that meet the unique challenges of providing environmental protection for existing state roads. The information in the MassHighway Handbook may also aid in the planning and design of projects to build new highways and to add lanes to existing highways, since they may face similar difficulties in meeting the requirements of the Stormwater Management Standards.

Although it is very useful, the MassHighway Handbook does not allow MassHighway projects to proceed without individual review and approval by the issuing authority when subject to the Wetlands Protection Act Regulations, 310 CMR 10.00, or the 401 Water Quality Certification Regulations, 314 CMR 9.00. For example, MassHighway must provide a Conservation Commission with a project-specific Operation and Maintenance Plan in accordance with Standard 9 that documents how the project’s post-construction BMPs will be operated and maintained.[4]

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[3] The 2004 MassHighway Handbook outlines standardized methods for dealing with these constraints as they apply to highway redevelopment projects. MassDEP and MassHighway intend to work together to provide guidance for add a lane projects when the 2004 Handbook is revised to reflect the 2008 changes to the Stormwater Management Standards.

[4] The general permit for municipal separate storm sewer systems (the MS4 Permit) requires MassHighway to develop and implement procedures for the proper operation and maintenance of stormwater BMPs. To

Some municipalities have asked if the MassHighway Handbook governs municipal road projects. The answer is no.[5] The MassHighway Handbook was developed in response to the unique problems and challenges arising out of the management of the state highway system. Like other project proponents, cities and towns planning road or other projects in areas subject to jurisdiction under the Wetlands Protection Act must design and implement LID, non-structural and structural best management practices in accordance with the Stormwater Management Standards and the Massachusetts Stormwater Handbook.

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avoid duplication of effort, MassHighway may be able rely on the same procedures to fulfill the operation and maintenance requirements of Standard 9 and the MS 4 Permit.

[5] Although the MassHighway Handbook does not govern municipal road projects, cities and towns may find some of the information presented in the Handbook useful.

OPERATION & MAINTENANCE SUMMARY TABLE

OPERATION AND MAINTENANCE PLAN SCHEDULE **Date:**

ALLEN & MAJOR
ASSOCIATES, INC.

Project: Multi-Family Development
Project Address: 580 Main Street Bolton, MA

Responsible for O&M Plan: WP East Acquisitions, LLC
Address: 91 Hartwell Avenue Lexington, MA 02421
Phone:

All information within table is derived from Massachussetts Stormwater Handbook: Volume 2, Chapter 2

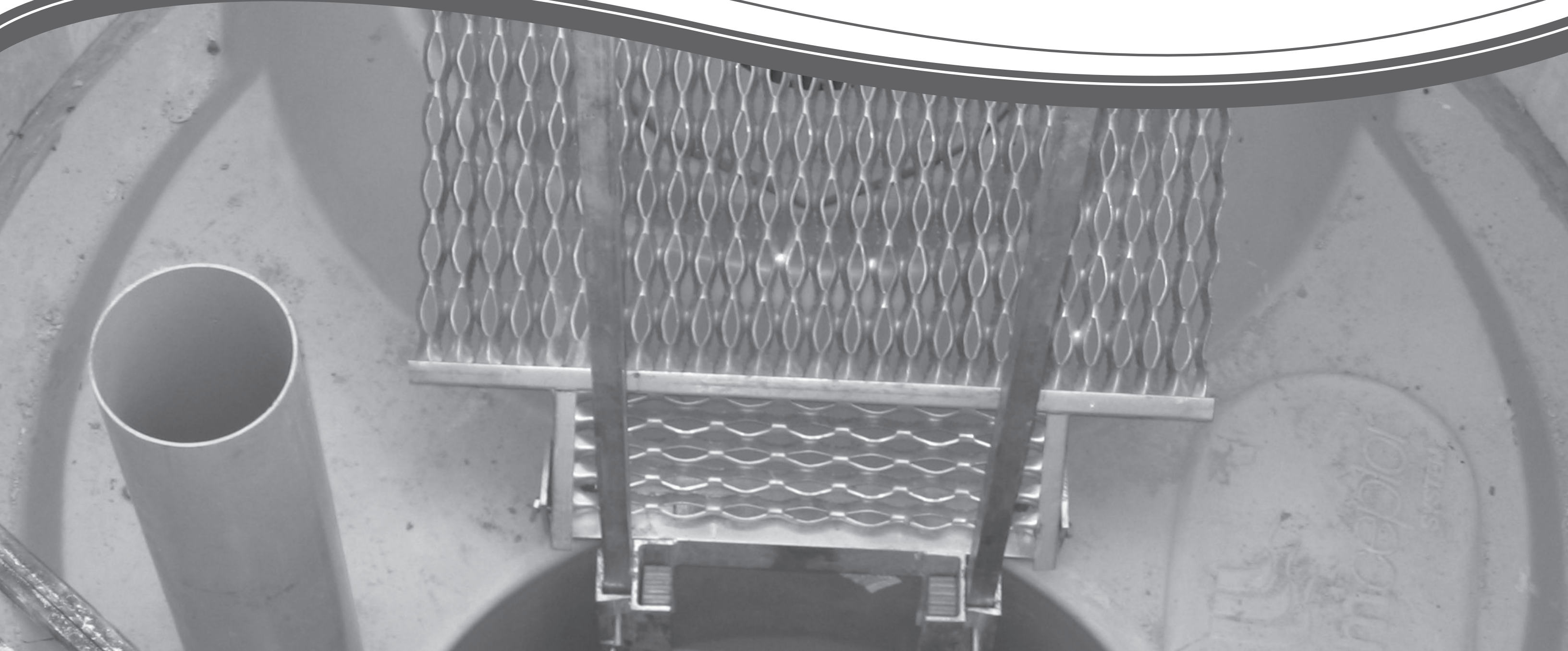
BMP CATEGORY	BMP OR MAINTENANCE ACTIVITY	SCHEDULE/ FREQUENCY	NOTES	ESTIMATED ANNUAL MAINTENANCE COST	INSPECTION PERFORMED	
					DATE:	BY:
STRUCTURAL PRETREATMENT BMPs	DEEP SUMP HOODED CATCH BASIN	Twice per year.	Inspect and clean catch basin units whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin.	$1,000		
	PROPRIETARY SEPARATORS	In accordance with manufacturers requirements, but no less than twice a year following installation and once a year thereafter.	Remove sediment and other trapped pollutants at frequency or level specified by manufacturer.	$1,000		
TREATMENT BMP'S	PROPRIETARY STORMTECH ISOLATOR ROW	Twice per year minimum; follow manufacturer's schedule	Inspect for standing water, sediment, trash and debris and clogging. Inspect to determine if system drains in 72 hours once a year during wet season after a large storm.	$1,000		
	WET BASIN	Twice per year.	Inspect wet basins to ensure they are operating as designed. Mow the upper stage, side slopes, embankments and emergency spillway. Check the sediment forebay for accumulated sediment, trash, debris and remove it. Remove sediment from the basin as necessary and at least once evry 10 yrs.	$1,000		
CONVEYANCE BMPs	GRASS SWALE	Remove sediment annually. Mow once a month during growing season. Repair erosion no less than once per year.	Remove sediment from forebay and grass channel, mow, repair areas of erosion and revegetate.	$500		
INFILTRATION BMPs	SUBSURFACE STRUCTURES	Inspect structure inlets at least twice a year. Remove debris that may clog the system as needed.	Because subsurface structures are installed underground, they are extremely difficult to maintain. Remove any debris that might clog the system.	$1,000		

OTHER BMP's	**POROUS PAVEMENT**	Assess exfiltration capability at least once a year. Inspect for deterioration annually. Monitor if paving surface is draining properly as needed.	Monitor to ensure that the paving surface drains properly after storms. For porous asphalts and concretes, clean the surface using power washer to dislodge trapped particles and then vacuum sweep the area. Inspect the surface annually for deterioration.	$2,000		
BMP ACCESSORIES	**LEVEL SPREADERS**	Inspect regularly, especially after large rainfall events.	Inspect level spreaders regularly, especially after large rainfall events. Note and repair any erosion or low spots in the spreader.	$1,000		
	OUTLET STRUCTURES	Periodic cleaning of Outlet Control Structures as needed.	Clear trash and debris as necessary.	$500		
OTHER MAINTENANCE ACTIVITY	**MISQUITO CONTROL**	Inspect BMPs as needed to ensure the system's drainage time is less than the maximum 72 hour period.	Massachusetts stormwater handbook requires all stormwater practices that are designed to drain do so within 72 hours to reduce the number of mosquitos that mature to adults since the aquatic stage of a mosquito is 7-10 days.	$300		
	SNOW STORAGE	Clear and remove snow to approved storage locations as necessary to ensure systems are working properly and are protected from meltwater pollutants.	Carefully select snow disposal sites before winter. Avoid dumping removed snow over catch basins, or in detention ponds, sediment forebays, rivers, wetlands, and flood plains. It is also prohibited to dump snow in the bioretention basins or gravel swales.	$500		
	STREET SWEEPING	Clear accumulations of winter sand in parking lots and along roadways at least once a year, preferably in the spring.	Sweep, power broom or vacuum paved areas. Submit information that confirms that all street sweepings have been completed in accordance with state and local requirements	$2,000		

STORMCEPTOR OPERATION & MAINTENANCE

CONTECH®
ENGINEERED SOLUTIONS

Stormceptor® STC
Operation and Maintenance Guide



Stormceptor® STC

Stormceptor Design Notes

- Only the STC 450i is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 450i to STC 7200 may accommodate multiple inlet pipes.

Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences			
Inlet Pipe Configuration	STC 450i	STC 900 to STC 7200	STC 11000 to STC 16000
Single inlet pipe	3 in. (75 mm)	1 in. (25 mm)	3 in. (75 mm)
Multiple inlet pipes	3 in. (75 mm)	3 in. (75 mm)	Only one inlet pipe.

Maximum inlet and outlet pipe diameters:

Inlet/Outlet Configuration	Inlet Unit STC 450i	In-Line Unit STC 900 to STC 7200	Series* STC 11000 to STC 16000
Straight Through	24 inch (600 mm)	42 inch (1050 mm)	60 inch (1500 mm)
Bend (90 degrees)	18 inch (450 mm)	33 inch (825 mm)	33 inch (825 mm)

- The inlet and in-line Stormceptor units can accommodate turns to a maximum of 90 degrees.
- Minimum distance from top of grade to crown is 2 feet (0.6 m)
- Submerged conditions. A unit is submerged when the standing water elevation at the proposed location of the Stormceptor unit is greater than the outlet invert elevation during zero flow conditions. In these cases, please contact your local Stormceptor representative and provide the following information:
- Top of grade elevation
- Stormceptor inlet and outlet pipe diameters and invert elevations
- Standing water elevation
- Stormceptor head loss, K = 1.3 (for submerged condition, K = 4)

Stormceptor® STC

OPERATION AND MAINTENANCE GUIDE

Table of Content

1. About Stormceptor

The Stormceptor® STC (Standard Treatment Cell) was developed by Imbrium™ Systems to address the growing need to remove and isolate pollution from the storm drain system before it enters the environment. The Stormceptor STC targets hydrocarbons and total suspended solids (TSS) in stormwater runoff. It improves water quality by removing contaminants through the gravitational settling of fine sediments and floatation of hydrocarbons while preventing the re-suspension or scour of previously captured pollutants.

The development of the Stormceptor STC revolutionized stormwater treatment, and created an entirely new category of environmental technology. Protecting thousands of waterways around the world, the Stormceptor System has set the standard for effective stormwater treatment.

1.1. Patent Information

The Stormceptor technology is protected by the following patents:

- Australia Patent No. 693,164 • 693,164 • 707,133 • 729,096 • 779401
- Austrian Patent No. 289647
- Canadian Patent No 2,009,208 •2,137,942 • 2,175,277 • 2,180,305 • 2,180,383 • 2,206,338 • 2,327,768 (Pending)
- China Patent No 1168439
- Denmark DK 711879
- German DE 69534021
- Indonesian Patent No 16688
- Japan Patent No 9-11476 (Pending)
- Korea 10-2000-0026101 (Pending)
- Malaysia Patent No PI9701737 (Pending)
- New Zealand Patent No 314646
- United States Patent No 4,985,148 • 5,498,331 • 5,725,760 • 5,753,115 • 5,849,181 • 6,068,765 • 6,371,690
- Stormceptor OSR Patent Pending • Stormceptor LCS Patent Pending

2. Stormceptor Design Overview

2.1. Design Philosophy

The patented Stormceptor System has been designed to focus on the environmental objective of providing long-term pollution control. The unique and innovative Stormceptor design allows for continuous positive treatment of runoff during all rainfall events, while ensuring that all captured pollutants are retained within the system, even during intense storm events.

An integral part of the Stormceptor design is PCSWMM for Stormceptor - sizing software developed in conjunction with Computational Hydraulics Inc. (CHI) and internationally acclaimed expert, Dr. Bill James. Using local historical rainfall data and continuous simulation modeling, this software allows a Stormceptor unit to be designed for each individual site and the corresponding water quality objectives.

By using PCSWMM for Stormceptor, the Stormceptor System can be designed to remove a wide range of particles (typically from 20 to 2,000 microns), and can also be customized to remove a specific particle size distribution (PSD). The specified PSD should accurately reflect what is in the stormwater runoff to ensure the device is achieving the desired water quality objective. Since stormwater runoff contains small particles (less than 75 microns), it is important to design a treatment system to remove smaller particles in addition to coarse particles.

2.2. Benefits

The Stormceptor System removes free oil and suspended solids from stormwater, preventing spills and non-point source pollution from entering downstream lakes and rivers. The key benefits, capabilities and applications of the Stormceptor System are as follows:

- Provides continuous positive treatment during all rainfall events
- Can be designed to remove over 80% of the annual sediment load
- Removes a wide range of particles
- Can be designed to remove a specific particle size distribution (PSD)
- Captures free oil from stormwater
- Prevents scouring or re-suspension of trapped pollutants
- Pre-treatment to reduce maintenance costs for downstream treatment measures (ponds, swales, detention basins, filters)
- Groundwater recharge protection
- Spills capture and mitigation
- Simple to design and specify
- Designed to your local watershed conditions
- Small footprint to allow for easy retrofit installations
- Easy to maintain (vacuum truck)
- Multiple inlets can connect to a single unit
- Suitable as a bend structure
- Pre-engineered for traffic loading (minimum AASHTO HS-20)
- Minimal elevation drop between inlet and outlet pipes
- Small head loss
- Additional protection provided by an 18” (457 mm) fiberglass skirt below the top of the insert, for the containment of hydrocarbons in the event of a spill.

2.3. Environmental Benefit

Freshwater resources are vital to the health and welfare of their surrounding communities. There is increasing public awareness, government regulations and corporate commitment to reducing the pollution entering our waterways. A major source of this pollution originates from stormwater runoff from urban areas. Rainfall runoff carries oils, sediment and other contaminants from roads and parking lots discharging directly into our streams, lakes and coastal waterways.

The Stormceptor System is designed to isolate contaminants from getting into the natural environment. The Stormceptor technology provides protection for the environment from spills that occur at service stations and vehicle accident sites, while also removing contaminated sediment in runoff that washes from roads and parking lots.

3. Key Operation Features

3.1. Scour Prevention

A key feature of the Stormceptor System is its patented scour prevention technology. This innovation ensures pollutants are captured and retained during all rainfall events, even extreme storms. The Stormceptor System provides continuous positive treatment for all rainfall events, including intense storms. Stormceptor slows incoming runoff, controlling and reducing velocities in the lower chamber to create a non-turbulent environment that promotes free oils and floatable debris to rise and sediment to settle.

The patented scour prevention technology, the fiberglass insert, regulates flows into the lower chamber through a combination of a weir and orifice while diverting high energy flows away through the upper chamber to prevent scouring. Laboratory testing demonstrated no scouring when tested up to 125% of the unit's operating rate, with the unit loaded to 100% sediment capacity (NJDEP, 2005). Second, the depth of the lower chamber ensures the sediment storage zone is adequately separated from the path of flow in the lower chamber to prevent scouring.

3.2. Operational Hydraulic Loading Rate

Designers and regulators need to evaluate the treatment capacity and performance of manufactured stormwater treatment systems. A commonly used parameter is the "operational hydraulic loading rate" which originated as a design methodology for wastewater treatment devices.

Operational hydraulic loading rate may be calculated by dividing the flow rate into a device by its settling area. This represents the critical settling velocity that is the prime determinant to quantify the influent particle size and density captured by the device. PCSWMM for Stormceptor uses a similar parameter that is calculated by dividing the hydraulic detention time in the device by the fall distance of the sediment.

$$v_{SC} = \frac{H}{6_H} = \frac{Q}{A_S}$$

Where:

v_{SC} = critical settling velocity, ft/s (m/s)

H = tank depth, ft (m)

Ø_H = hydraulic detention time, ft/s (m/s)

Q = volumetric flow rate, ft3/s (m3/s)

A_S = surface area, ft^2 (m^2)

(Tchobanoglous, G. and Schroeder, E.D. 1987. Water Quality. Addison Wesley.)

Unlike designing typical wastewater devices, stormwater systems are designed for highly variable flow rates including intense peak flows. PCSWMM for Stormceptor incorporates all of the flows into its calculations, ensuring that the operational hydraulic loading rate is considered not only for one flow rate, but for all flows including extreme events.

3.3. Double Wall Containment

The Stormceptor System was conceived as a pollution identifier to assist with identifying illicit discharges. The fiberglass insert has a continuous skirt that lines the concrete barrel wall for a depth of 18 inches (457 mm) that provides double wall containment for hydrocarbons storage. This protective barrier ensures that toxic floatables do not migrate through the concrete wall into the surrounding soils.

4. Stormceptor Product Line

4.1. Stormceptor Models

A summary of Stormceptor models and capacities are listed in Table 1.

Table 1. Stormceptor Models

Stormceptor Model	Total Storage Volume U.S. Gal (L)	Hydrocarbon Storage Capacity U.S. Gal (L)	Maximum Sediment Capacity ft^3 (L)
STC 450i	470 (1,780)	86 (330)	46 (1,302)
STC 900	952 (3,600)	251 (950)	89 (2,520)
STC 1200	1,234 (4,670)	251 (950)	127 (3,596)
STC 1800	1,833 (6,940)	251 (950)	207 (5,861)
STC 2400	2,462 (9,320)	840 (3,180)	205 (5,805)
STC 3600	3,715 (1,406)	840 (3,180)	373 (10,562)
STC 4800	5,059 (1,950)	909 (3,440)	543 (15,376)
STC 6000	6,136 (23,230)	909 (3,440)	687 (19,453)
STC 7200	7,420 (28,090)	1,059 (4,010)	839 (23,757)
STC 11000	11,194 (42,370)	2,797 (10, 590)	1,086 (30,752)
STC 13000	13,348 (50,530)	2,797 (10, 590)	1,374 (38,907)
STC 16000	15,918 (60,260)	3,055 (11, 560)	1,677 (47,487)

NOTE: Storage volumes may vary slightly from region to region. For detailed information, contact your local Stormceptor representative.

4.2. Inline Stormceptor

The Inline Stormceptor, Figure 1, is the standard design for most stormwater treatment applications. The patented Stormceptor design allows the Inline unit to maintain continuous positive treatment of total suspended solids (TSS) year-round, regardless of flow rate. The Inline Stormceptor is composed of a precast concrete tank with a fiberglass insert situated at the invert of the storm sewer pipe, creating an upper chamber above the insert and a lower chamber below the insert.

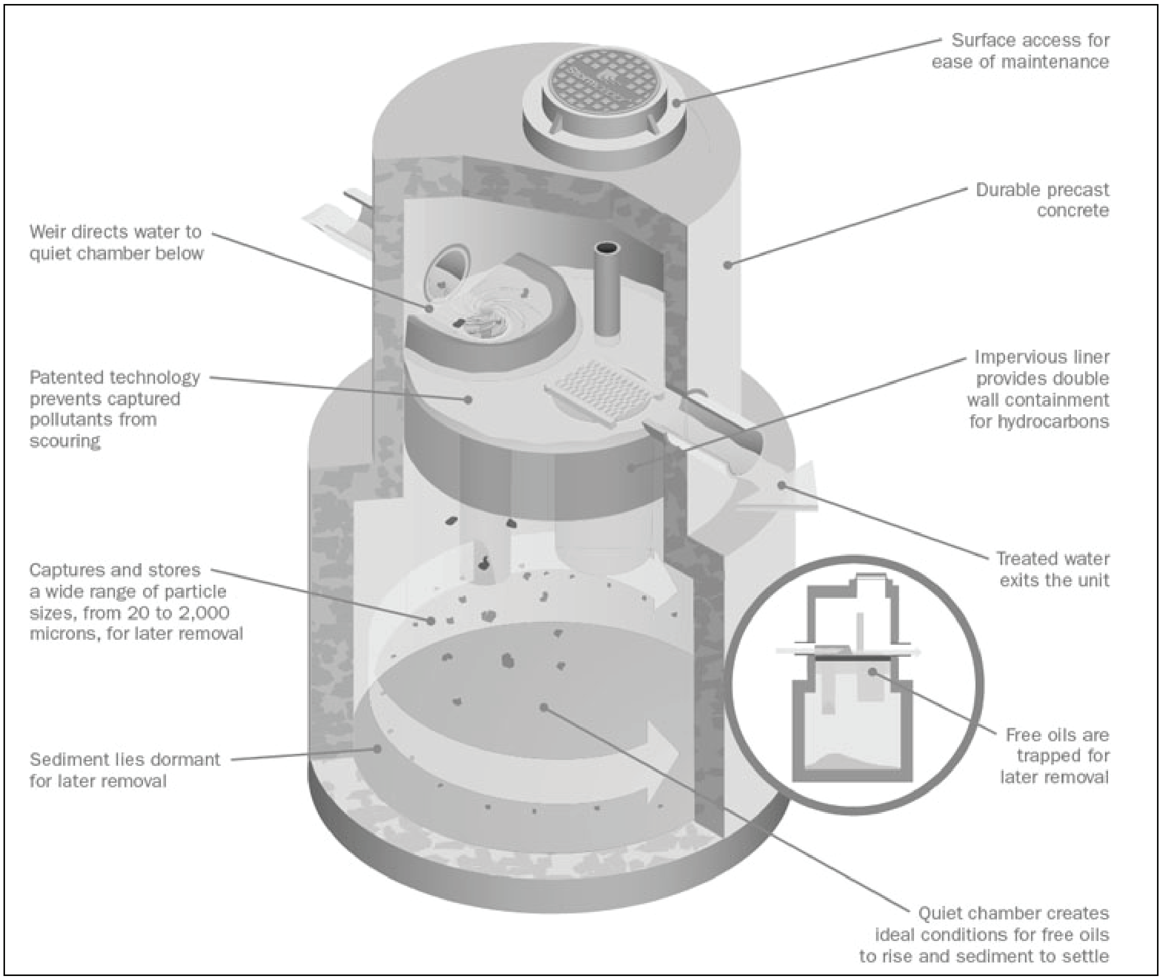


Figure 1. Inline Stormceptor

Operation

As water flows into the Stormceptor unit, it is slowed and directed to the lower chamber by a weir and drop tee. The stormwater enters the lower chamber, a non-turbulent environment, allowing free oils to rise and sediment to settle. The oil is captured underneath the fiberglass insert and shielded from exposure to the concrete walls by a fiberglass skirt. After the pollutants separate, treated water continues up a riser pipe, and exits the lower chamber on the downstream side of the weir before leaving the unit. During high flow events, the Stormceptor System's patented scour prevention technology ensures continuous pollutant removal and prevents re-suspension of previously captured pollutants.

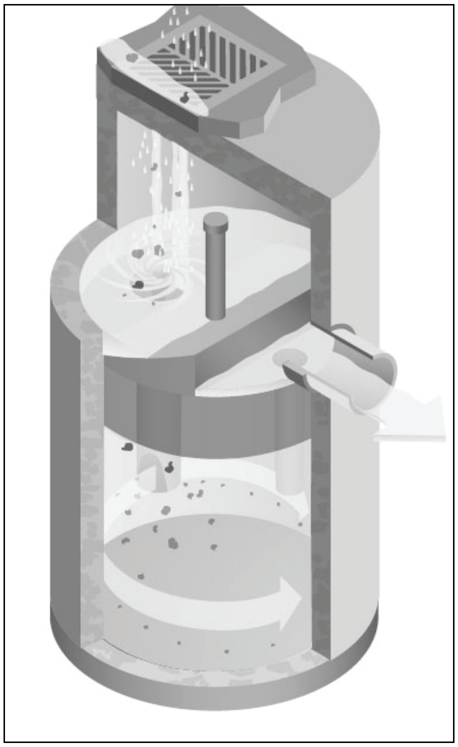


Figure 2. Inlet Stormceptor

4.3. Inlet Stormceptor

The Inlet Stormceptor System, Figure 2, was designed to provide protection for parking lots, loading bays, gas stations and other spill-prone areas. The Inlet Stormceptor is designed to remove sediment from stormwater introduced through a grated inlet, a storm sewer pipe, or both.

The Inlet Stormceptor design operates in the same manner as the Inline unit, providing continuous positive treatment, and ensuring that captured material is not re-suspended.

4.4. Series Stormceptor

Designed to treat larger drainage areas, the Series Stormceptor System, Figure 3, consists of two adjacent Stormceptor models that function in parallel. This design eliminates the need for additional structures and piping to reduce installation costs.

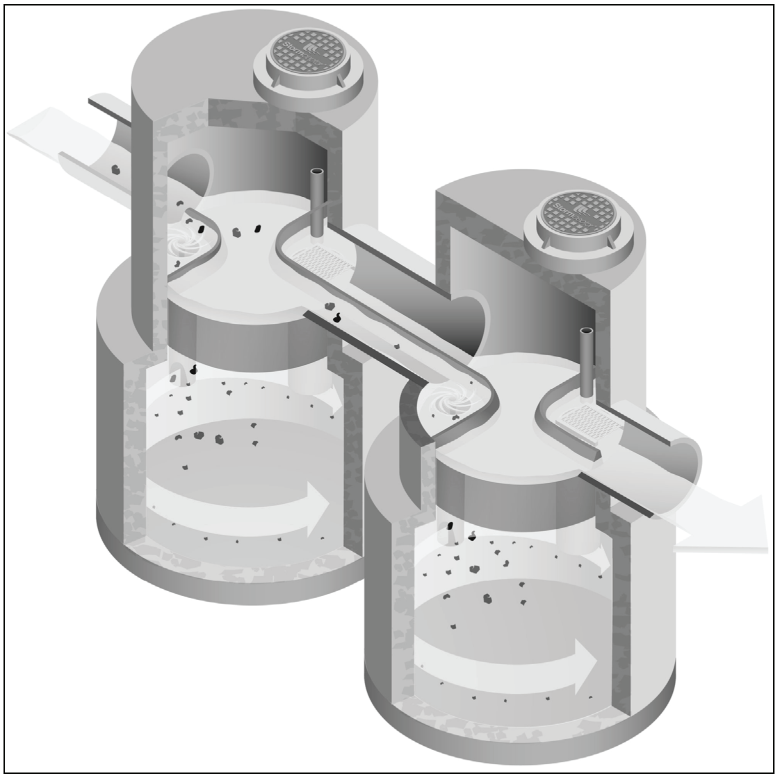


Figure 3. Series System

The Series Stormceptor design operates in the same manner as the Inline unit, providing continuous positive treatment, and ensuring that captured material is not re-suspended.

5. Sizing the Stormceptor System

The Stormceptor System is a versatile product that can be used for many different aspects of water quality improvement. While addressing these needs, there are conditions that the designer needs to be aware of in order to size the Stormceptor model to meet the demands of each individual site in an efficient and cost-effective manner.

PCSWMM for Stormceptor is the support tool used for identifying the appropriate Stormceptor model. In order to size a unit, it is recommended the user follow the seven design steps in the program. The steps are as follows:

STEP 1 – Project Details

The first step prior to sizing the Stormceptor System is to clearly identify the water quality objective for the development. It is recommended that a level of annual sediment (TSS) removal be identified and defined by a particle size distribution.

STEP 2 – Site Details

Identify the site development by the drainage area and the level of imperviousness. It is recommended that imperviousness be calculated based on the actual area of imperviousness based on paved surfaces, sidewalks and rooftops.

STEP 3 – Upstream Attenuation

The Stormceptor System is designed as a water quality device and is sometimes used in conjunction with onsite water quantity control devices such as ponds or underground detention systems. When possible, a greater benefit is typically achieved when installing a Stormceptor unit upstream of a detention facility. By placing the Stormceptor unit upstream of a detention structure, a benefit of less maintenance of the detention facility is realized.

STEP 4 – Particle Size Distribution

It is critical that the PSD be defined as part of the water quality objective. PSD is critical for the design of treatment system for a unit process of gravity settling and governs the size of a treatment system. A range of particle sizes has been provided and it is recommended that clays and silt-sized particles be considered in addition to sand and gravel-sized particles. Options and sample PSDs are provided in PCSWMM for Stormceptor. The default particle size distribution is the Fine Distribution, Table 2, option.

Table 2. Fine Distribution

Particle Size	Distribution	Specific Gravity
20	20%	1.3
60	20%	1.8
150	20%	2.2
400	20%	2.65
2000	20%	2.65

If the objective is the long-term removal of 80% of the total suspended solids on a given site, the PSD should be representative of the expected sediment on the site. For example, a system designed to remove 80% of coarse particles (greater than 75 microns) would provide relatively poor removal efficiency of finer particles that may be naturally prevalent in runoff from the site.

Since the small particle fraction contributes a disproportionately large amount of the total available particle surface area for pollutant adsorption, a system designed primarily for coarse particle capture will compromise water quality objectives.

STEP 5 – Rainfall Records

Local historical rainfall has been acquired from the U.S. National Oceanic and Atmospheric Administration, Environment Canada and regulatory agencies across North America. The rainfall data provided with PCSMM for Stormceptor provides an accurate estimation of small storm hydrology by modeling actual historical storm events including duration, intensities and peaks.

STEP 6 – Summary

At this point, the program may be executed to predict the level of TSS removal from the site. Once the simulation has completed, a table shall be generated identifying the TSS removal of each Stormceptor unit.

STEP 7 – Sizing Summary

Performance estimates of all Stormceptor units for the given site parameters will be displayed in a tabular format. The unit that meets the water quality objective, identified in Step 1, will be highlighted.

5.1. PCSWMM for Stormceptor

The Stormceptor System has been developed in conjunction with PCSWMM for Stormceptor as a technological solution to achieve water quality goals. Together, these two innovations model, simulate, predict and calculate the water quality objectives desired by a design engineer for TSS removal.

PCSWMM for Stormceptor is a proprietary sizing program which uses site specific inputs to a computer model to simulate sediment accumulation, hydrology and long-term total suspended solids removal. The model has been calibrated to field monitoring results from Stormceptor units that have been monitored in North America. The sizing methodology can be described by three processes:

1. Determination of real time hydrology
2. Buildup and wash off of TSS from impervious land areas
3. TSS transport through the Stormceptor (settling and discharge). The use of a calibrated model is the preferred method for sizing stormwater quality structures for the following reasons:
   » The hydrology of the local area is properly and accurately incorporated in the sizing (distribution of flows, flow rate ranges and peaks, back-to-back storms, inter-event times)
   » The distribution of TSS with the hydrology is properly and accurately considered in the sizing
   » Particle size distribution is properly considered in the sizing
   » The sizing can be optimized for TSS removal
   » The cost benefit of alternate TSS removal criteria can be easily assessed
   » The program assesses the performance of all Stormceptor models. Sizing may be selected based on a specific water quality outcome or based on the Maximum Extent Practicable

For more information regarding PCSWMM for Stormceptor, contact your local Stormceptor representative, or visit www.imbriumsystems.com to download a free copy of the program.

5.2. Sediment Loading Characteristics

The way in which sediment is transferred to stormwater can have a considerable effect on which type of system is implemented. On typical impervious surfaces (e.g. parking lots) sediment will build over time and wash off with the next rainfall. When rainfall patterns are examined, a short intense storm will have a higher concentration of sediment than a long slow drizzle. Together with rainfall data representing the site's typical rainfall patterns, sediment loading characteristics play a part in the correct sizing of a stormwater quality device.

Typical Sites

For standard site design of the Stormceptor System, PCSWMM for Stormceptor is utilized to accurately assess the unit's performance. As an integral part of the product's design, the program can be used to meet local requirements for total suspended solid removal. Typical installations of manufactured stormwater treatment devices would occur on areas such as paved parking lots or paved roads. These are considered "stable" surfaces which have non – erodible surfaces.

Unstable Sites

While standard sites consist of stable concrete or asphalt surfaces, sites such as gravel parking lots, or maintenance yards with stockpiles of sediment would be classified as "unstable". These types of sites do not exhibit first flush characteristics, are highly erodible and exhibit atypical sediment loading characteristics and must therefore be sized more carefully. Contact your local Stormceptor representative for assistance in selecting a proper unit sized for such unstable sites.

6. Spill Controls

When considering the removal of total petroleum hydrocarbons (TPH) from a storm sewer system there are two functions of the system: oil removal, and spill capture.

'Oil Removal' describes the capture of the minute volumes of free oil mobilized from impervious surfaces. In this instance relatively low concentrations, volumes and flow rates are considered. While the Stormceptor unit will still provide an appreciable oil removal function during higher flow events and/or with higher TPH concentrations, desired effluent limits may be exceeded under these conditions.

‘Spill Capture’ describes a manner of TPH removal more appropriate to recovery of a relatively high volume of a single phase deleterious liquid that is introduced to the storm sewer system over a relatively short duration. The two design criteria involved when considering this manner of introduction are overall volume and the specific gravity of the material. A standard Stormceptor unit will be able to capture and retain a maximum spill volume and a minimum specific gravity.

For spill characteristics that fall outside these limits, unit modifications are required. Contact your local Stormceptor Representative for more information.

One of the key features of the Stormceptor technology is its ability to capture and retain spills. While the standard Stormceptor System provides excellent protection for spill control, there are additional options to enhance spill protection if desired.

6.1. Oil Level Alarm

The oil level alarm is an electronic monitoring system designed to trigger a visual and audible alarm when a pre-set level of oil is reached within the lower chamber. As a standard, the oil

level alarm is designed to trigger at approximately 85% of the unit’s available depth level for oil capture. The feature acts as a safeguard against spills caused by exceeding the oil storage capacity of the separator and eliminates the need for manual oil level inspection.

The oil level alarm installed on the Stormceptor insert is illustrated in Figure 4.

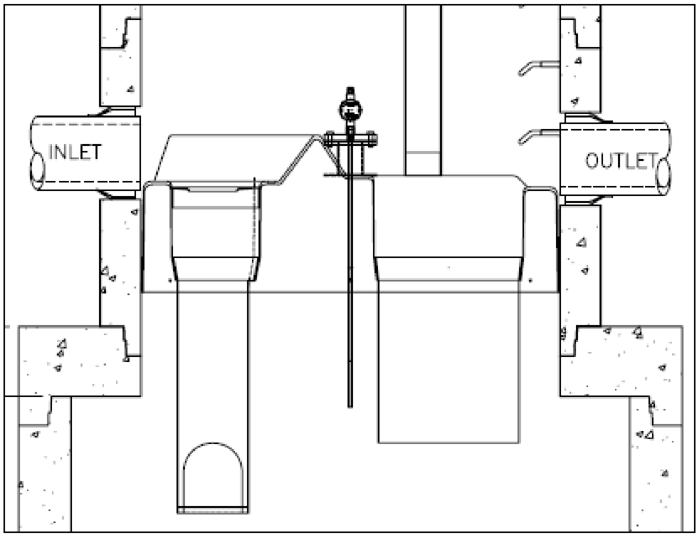


Figure 4. Oil level alarm

6.2. Increased Volume Storage Capacity

The Stormceptor unit may be modified to store a greater spill volume than is typically available. Under such a scenario, instead of installing a larger than required unit, modifications can be made to the recommended Stormceptor model to accommodate larger volumes. Contact your local Stormceptor representative for additional information and assistance for modifications.

7. Stormceptor Options

The Stormceptor System allows flexibility to incorporate to existing and new storm drainage infrastructure. The following section identifies considerations that should be reviewed when installing the system into a drainage network. For conditions that fall outside of the recommendations in this section, please contact your local Stormceptor representative for further guidance.

7.1. Installation Depth Minimum Cover

The minimum distance from the top of grade to the crown of the inlet pipe is 24 inches (600 mm). For situations that have a lower minimum distance, contact your local Stormceptor representative.

7.2. Maximum Inlet and Outlet Pipe Diameters

Maximum inlet and outlet pipe diameters are illustrated in Figure 5. Contact your local Stormceptor representative for larger pipe diameters

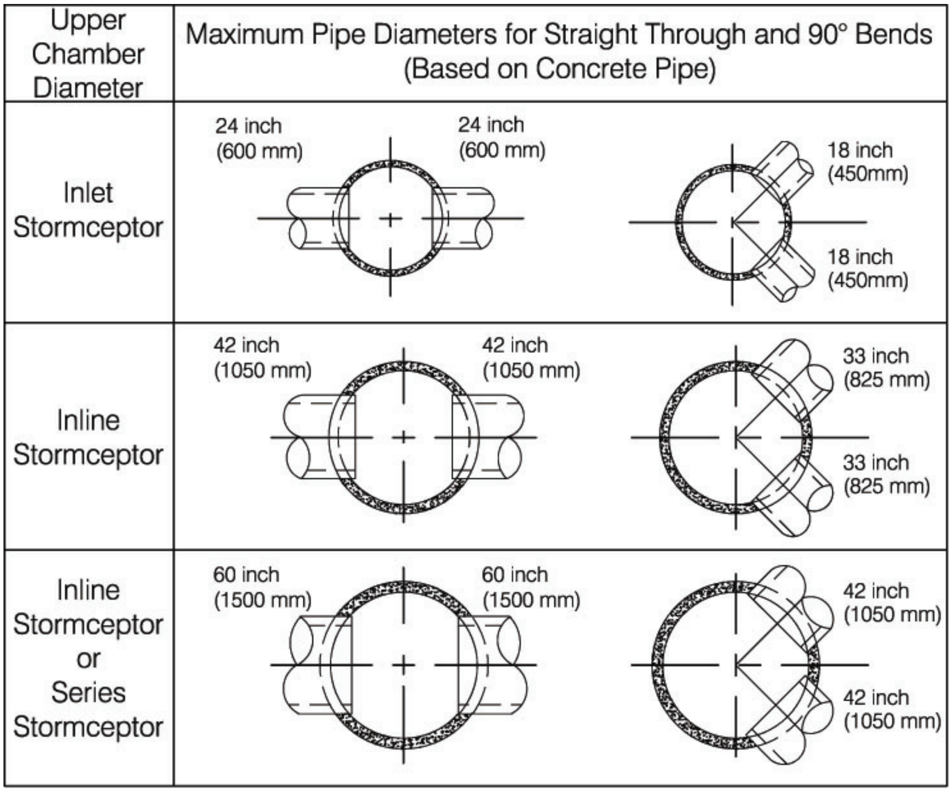


Figure 5. Maximum pipe diameters for straight through and bend applications

*The bend should only be incorporated into the second structure (downstream structure) of the Series Stormceptor System

7.3. Bends

The Stormceptor System can be used to change horizontal alignment in the storm drain network up to a maximum of 90 degrees. Figure 6 illustrates the typical bend situations of the Stormceptor System. Bends should only be applied to the second structure (downstream structure) of the Series Stormceptor System.

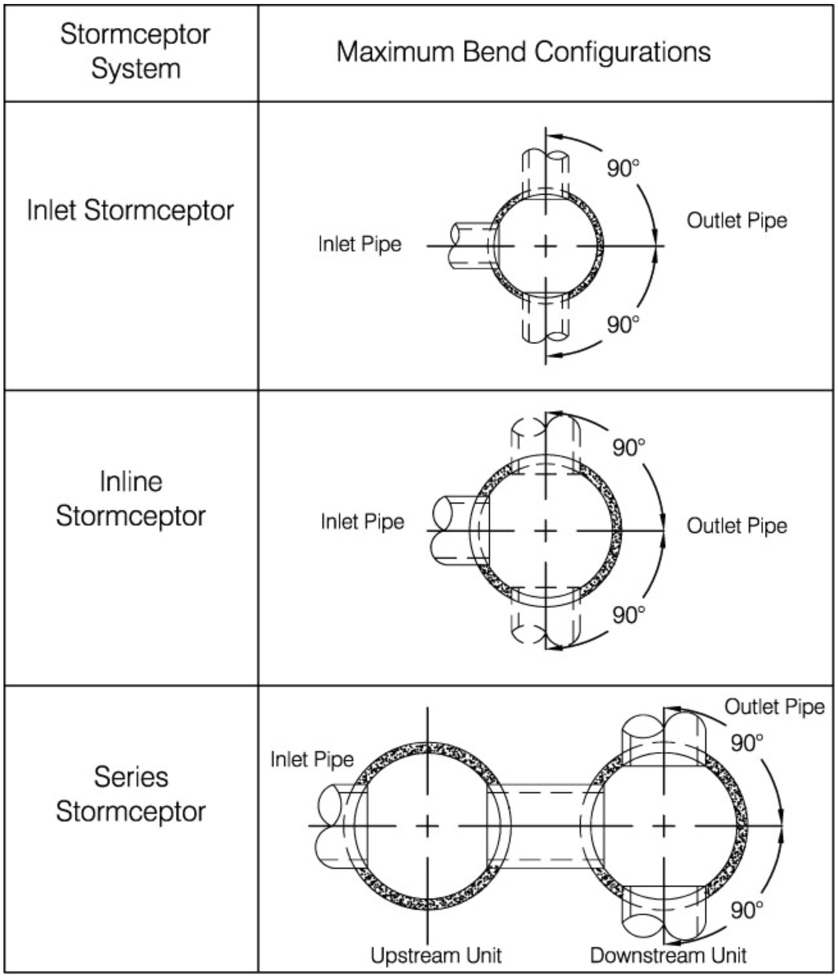


Figure 6. Maximum bend angles

7.4. Multiple Inlet Pipes

The Inlet and Inline Stormceptor System can accommodate two or more inlet pipes. The maximum number of inlet pipes that can be accommodated into a Stormceptor unit is a function of the number, alignment and diameter of the pipes and its effects on the structural integrity of the precast concrete. When multiple inlet pipes are used for new developments, each inlet pipe shall have an invert elevation 3 inches (75 mm) higher than the outlet pipe invert elevation.

7.5. Inlet/Outlet Pipe Invert Elevations

Recommended inlet and outlet pipe invert differences are listed in Table 3.

Table 3. Recommended Drops Between Inlet and Outlet Pipe Inverts

Number of Inlet Pipes	Inlet System	In-Line System	Series System
1	3 inches (75 mm)	1 inch (25 mm)	3 inches (75 mm)
>1	3 inches (75 mm)	3 inches (75 mm)	Not Applicable

7.6. Shallow Stormceptor

In cases where there may be restrictions to the depth of burial of storm sewer systems. In this situation, for selected Stormceptor models, the lower chamber components may be increased in diameter to reduce the overall depth of excavation required.

7.7. Customized Live Load

The Stormceptor system is typically designed for local highway truck loading (AASHTO HS- 20). When the project requires live loads greater than HS-20, the Stormceptor System may be customized structurally for a pre-specified live load. Contact your local Stormceptor representative for customized loading conditions.

7.8. Pre-treatment

The Stormceptor System may be sized to remove sediment and for spills control in conjunction with other stormwater BMPs to meet the water quality objective. For pretreatment applications, the Stormceptor System should be the first unit in a treatment train. The benefits of pre-treatment include the extension of the operational life (extension of maintenance frequency) of large stormwater management facilities, prevention of spills and lower total life- cycle maintenance cost.

7.9. Head loss

The head loss through the Stormceptor System is similar to a 60 degree bend at a manhole. The K value for calculating minor losses is approximately 1.3 (minor loss = k*1.3v2/2g).

However, when a Submerged modification is applied to a Stormceptor unit, the corresponding K value is 4.

7.10. Submerged

The Submerged modification, Figure 7, allows the Stormceptor System to operate in submerged or partially submerged storm sewers. This configuration can be installed on all models of the Stormceptor System by modifying the fiberglass insert. A customized weir height and a secondary drop tee are added.

Submerged instances are defined as standing water in the storm drain system during zero flow conditions. In these instances, the following information is necessary for the proper design and application of submerged modifications:

- Stormceptor top of grade elevation
- Stormceptor outlet pipe invert elevation
- Standing water elevation

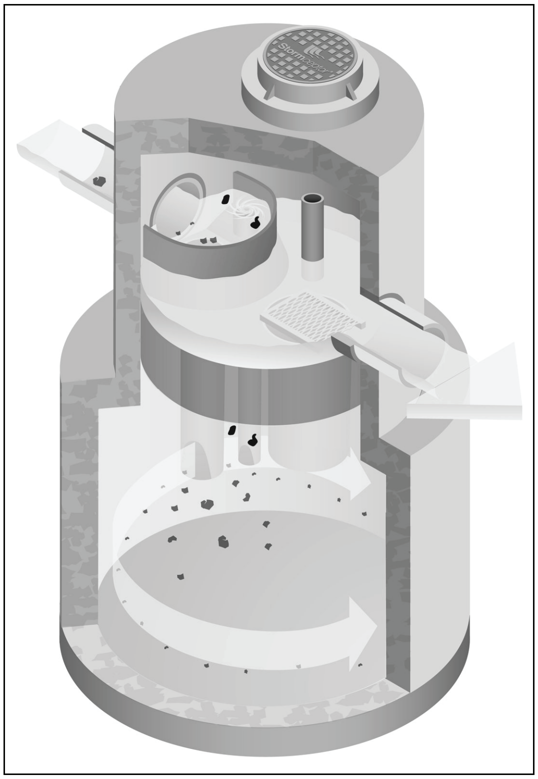


Figure 7. Submerged Stormceptor

8. Comparing Technologies

Designers have many choices available to achieve water quality goals in the treatment of stormwater runoff. Since many alternatives are available for use in stormwater quality treatment it is important to consider how to make an appropriate comparison between "approved alternatives". The following is a guide to assist with the accurate comparison of differing technologies and performance claims.

8.1. Particle Size Distribution (PSD)

The most sensitive parameter to the design of a stormwater quality device is the selection of the design particle size. While it is recommended that the actual particle size distribution (PSD) for sites be measured prior to sizing, alternative values for particle size should be selected to represent what is likely to occur naturally on the site. A reasonable estimate of a particle size distribution likely to be found on parking lots or other impervious surfaces should consist of a wide range of particles such as 20 microns to 2,000 microns (Ontario MOE, 1994).

There is no absolute right particle size distribution or specific gravity and the user is cautioned to review the site location, characteristics, material handling practices and regulatory requirements when selecting a particle size distribution. When comparing technologies, designs using different PSDs will result in incomparable TSS removal efficiencies. The PSD of the TSS removed needs to be standard between two products to allow for an accurate comparison.

8.2. Scour Prevention

In order to accurately predict the performance of a manufactured treatment device, there must be confidence that it will perform under all conditions. Since rainfall patterns cannot be predicted, stormwater quality devices placed in storm sewer systems must be able to withstand extreme events, and ensure that all pollutants previously captured are retained in the system.

In order to have confidence in a system's performance under extreme conditions, independent validation of scour prevention is essential when examining different technologies. Lack of independent verification of scour prevention should make a designer wary of accepting any product's performance claims.

8.3. Hydraulics

Full scale laboratory testing has been used to confirm the hydraulics of the Stormceptor System. Results of lab testing have been used to physically design the Stormceptor System and the sewer pipes entering and leaving the unit. Key benefits of Stormceptor are:

- Low head loss (typical k value of 1.3)
- Minimal inlet/outlet invert elevation drop across the structure
- Use as a bend structure
- Accommodates multiple inlets

The adaptability of the treatment device to the storm sewer design infrastructure can affect the overall performance and cost of the site.

8.4. Hydrology

Stormwater quality treatment technologies need to perform under varying climatic conditions. These can vary from long low intensity rainfall to short duration, high intensity storms. Since a treatment device is expected to perform under all these conditions, it makes sense that any system's design should accommodate those conditions as well.

Long-term continuous simulation evaluates the performance of a technology under the varying conditions expected in the climate of the subject site. Single, peak event design does not provide this information and is not equivalent to long-term simulation. Designers should request long-term simulation performance to ensure the technology can meet the long-term water quality objective.

9. Testing

The Stormceptor System has been the most widely monitored stormwater treatment technology in the world. Performance verification and monitoring programs are completed to the strictest standards and integrity. Since its introduction in 1990, numerous independent field tests and studies detailing the effectiveness of the Stormceptor System have been completed.

- Coventry University, UK – 97% removal of oil, 83% removal of sand and 73% removal of peat
- National Water Research Institute, Canada, - scaled testing for the development of the Stormceptor System identifying both TSS removal and scour prevention.
- New Jersey TARP Program – full scale testing of an STC 900 demonstrating 75% TSS removal of particles from 1 to 1000 microns. Scour testing completed demonstrated that the system does not scour. The New Jersey Department of Environmental Protection was followed.
- City of Indianapolis – full scale testing of an STC 900 demonstrating over 80% TSS removal of particles from 50 microns to 300 microns at 130% of the unit's operating rate. Scour testing completed demonstrated that the system does not scour.
- Westwood Massachusetts (1997), demonstrated >80% TSS removal
- Como Park (1997), demonstrated 76% TSS removal
- Ontario MOE SWAMP Program – 57% removal of 1 to 25 micron particles
- Laval Quebec – 50% removal of 1 to 25 micron particles

10. Installation

The installation of the concrete Stormceptor should conform in general to state highway, or local specifications for the installation of manholes. Selected sections of a general specification that are applicable are summarized in the following sections.

10.1. Excavation

Excavation for the installation of the Stormceptor should conform to state highway, or local specifications. Topsoil removed during the excavation for the Stormceptor should be stockpiled in designated areas and should not be mixed with subsoil or other materials.

Topsoil stockpiles and the general site preparation for the installation of the Stormceptor should conform to state highway or local specifications.

The Stormceptor should not be installed on frozen ground. Excavation should extend a minimum of 12 inches (300 mm) from the precast concrete surfaces plus an allowance for shoring and bracing where required. If the bottom of the excavation provides an unsuitable foundation additional excavation may be required.

In areas with a high water table, continuous dewatering may be required to ensure that the excavation is stable and free of water.

10.2. Backfilling

Backfill material should conform to state highway or local specifications. Backfill material should be placed in uniform layers not exceeding 12 inches (300mm) in depth and compacted to state highway or local specifications.

11. Stormceptor Construction Sequence

The concrete Stormceptor is installed in sections in the following sequence:

1. Aggregate base
2. Base slab
3. Lower chamber sections
4. Upper chamber section with fiberglass insert
5. Connect inlet and outlet pipes
6. Assembly of fiberglass insert components (drop tee, riser pipe, oil cleanout port and orifice plate
7. Remainder of upper chamber
8. Frame and access cover

The precast base should be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, should be installed in accordance with the precast concrete manufacturer's recommendations.

Adjustment of the Stormceptor can be performed by lifting the upper sections free of the excavated area, re-leveling the base and re-installing the sections. Damaged sections and gaskets should be repaired or replaced as necessary. Once the Stormceptor has been constructed, any lift holes must be plugged with mortar.

12. Maintenance

12.1. Health and Safety

The Stormceptor System has been designed considering safety first. It is recommended that confined space entry protocols be followed if entry to the unit is required. In addition, the fiberglass insert has the following health and safety features:

- Designed to withstand the weight of personnel
- A safety grate is located over the 24 inch (600 mm) riser pipe opening
- Ladder rungs can be provided for entry into the unit, if required

12.2. Maintenance Procedures

Maintenance of the Stormceptor system is performed using vacuum trucks. No entry into the unit is required for maintenance (in most cases). The vacuum service industry is a well- established sector of the service industry that cleans underground tanks, sewers and catch basins. Costs to clean a Stormceptor will vary based on the size of unit and transportation distances.

The need for maintenance can be determined easily by inspecting the unit from the surface. The depth of oil in the unit can be determined by inserting a dipstick in the oil inspection/cleanout port.

Similarly, the depth of sediment can be measured from the surface without entry into the Stormceptor via a dipstick tube equipped with a ball valve. This tube would be inserted through the riser pipe. Maintenance should be performed once the sediment depth exceeds the guideline values provided in the Table 4.

Table 4. Sediment Depths Indicating Required Servicing*

Particle Size	Specific Gravity
Model	Sediment Depth inches (mm)
450i	8 (200)
900	8 (200)
1200	10 (250)
1800	15 (381)
2400	12 (300)
3600	17 (430)
4800	15 (380)
6000	18 (460)
7200	15 (381)
11000	17 (380)
13000	20 (500)
16000	17 (380)
* based on 15% of the Stormceptor unit's total storage	

Although annual servicing is recommended, the frequency of maintenance may need to be increased or reduced based on local conditions (i.e. if the unit is filling up with sediment more quickly than projected, maintenance may be required semi-annually; conversely once the site has stabilized maintenance may only be required every two or three years).

Oil is removed through the oil inspection/cleanout port and sediment is removed through the riser pipe. Alternatively oil could be removed from the 24 inches (600 mm) opening if water is removed from the lower chamber to lower the oil level below the drop pipes.

The following procedures should be taken when cleaning out Stormceptor:

1. Check for oil through the oil cleanout port
2. Remove any oil separately using a small portable pump
3. Decant the water from the unit to the sanitary sewer, if permitted by the local regulating authority, or into a separate containment tank
4. Remove the sludge from the bottom of the unit using the vacuum truck
5. Re-fill Stormceptor with water where required by the local jurisdiction

12.3. Submerged Stormceptor

Careful attention should be paid to maintenance of the Submerged Stormceptor System. In cases where the storm drain system is submerged, there is a requirement to plug both the inlet and outlet pipes to economically clean out the unit.

12.4. Hydrocarbon Spills

The Stormceptor is often installed in areas where the potential for spills is great. The Stormceptor System should be cleaned immediately after a spill occurs by a licensed liquid waste hauler.

12.5. Disposal

Requirements for the disposal of material from the Stormceptor System are similar to that of any other stormwater Best Management Practice (BMP) where permitted. Disposal options for the sediment may range from disposal in a sanitary trunk sewer upstream of a sewage treatment plant, to disposal in a sanitary landfill site. Petroleum waste products collected in the Stormceptor (free oil/chemical/fuel spills) should be removed by a licensed waste management company.

12.6. Oil Sheens

With a steady influx of water with high concentrations of oil, a sheen may be noticeable at the Stormceptor outlet. This may occur because a rainbow or sheen can be seen at very small oil concentrations (<10 mg/L). Stormceptor will remove over 98% of all free oil spills from storm sewer systems for dry weather or frequently occurring runoff events.

The appearance of a sheen at the outlet with high influent oil concentrations does not mean the unit is not working to this level of removal. In addition, if the influent oil is emulsified the Stormceptor will not be able to remove it. The Stormceptor is designed for free oil removal and not emulsified conditions.

SUPPORT

Drawings and specifications are available at www.ContechES.com.

Site-specific design support is available from our engineers.

Contech Engineered Solutions LLC provides site solutions for the civil engineering industry. Contech's portfolio includes bridges, drainage, sanitary sewer, stormwater, and earth stabilization products. For information, visit www.ContechES.com or call 800.338.1122

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SC-740


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THE ISOLATOR® ROW

INTRODUCTION

An important component of any Stormwater Pollution Prevention Plan is inspection and maintenance. The StormTech Isolator Row is a technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance.

THE ISOLATOR ROW

The Isolator Row is a row of StormTech chambers, either SC-160LP, SC-310, SC-310-3, SC-740, DC-780, MC-3500 or MC-4500 models, that is surrounded with filter fabric and connected to a closely located manhole for easy access. The fabric-wrapped chambers provide for settling and filtration of sediment as storm water rises in the Isolator Row and ultimately passes through the filter fabric. The open bottom chambers and perforated sidewalls (SC-310, SC- 310-3 and SC-740 models) allow storm water to flow both vertically and horizontally out of the chambers. Sediments are captured in the Isolator Row protecting the storage areas of the adjacent stone and chambers from sediment accumulation.

Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of the underlying stone and remain intact during high pressure jetting. A non-woven fabric is placed over the chambers to provide a filter media for flows passing through the perforations in the sidewall of the chamber. The non-woven fabric is not required over the SC-160LP, DC-780, MC-3500 or MC-4500 models as these chambers do not have perforated side walls.

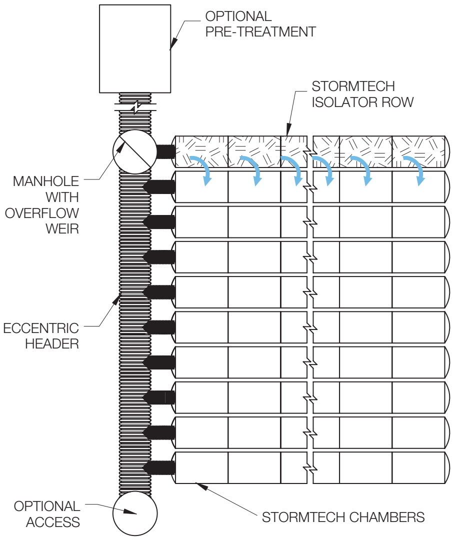
The Isolator Row is typically designed to capture the “first flush” and offers the versatility to be sized on a volume basis or flow rate basis. An upstream manhole not only provides access to the Isolator Row but typically includes a high flow weir such that storm water flowrates or volumes that exceed the capacity of the Isolator Row overtop the over flow weir and discharge through a manifold to the other chambers.

The Isolator Row may also be part of a treatment train. By treating storm water prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins, oil-water separators or can be innovative storm water treatment devices. The design of the treatment train and selection of pretreatment devices by the design engineer is often driven by regulatory requirements. Whether pretreatment is used or not, the Isolator Row is recommended by StormTech as an effective means to minimize maintenance requirements and maintenance costs.

Note: See the StormTech Design Manual for detailed information on designing inlets for a StormTech system, including the Isolator Row.

Looking down the Isolator Row from the manhole opening, woven geotextile is shown between the chamber and stone base.

StormTech Isolator Row with Overflow Spillway (not to scale)



ISOLATOR ROW INSPECTION/MAINTENANCE

INSPECTION

The frequency of inspection and maintenance varies by location. A routine inspection schedule needs to be established for each individual location based upon site specific variables. The type of land use (i.e. industrial, commercial, residential), anticipated pollutant load, percent imperviousness, climate, etc. all play a critical role in determining the actual frequency of inspection and maintenance practices.

At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row should be inspected every 6 months for the first year of operation. For subsequent years, the inspection should be adjusted based upon previous observation of sediment deposition.

The Isolator Row incorporates a combination of standard manhole(s) and strategically located inspection ports (as needed). The inspection ports allow for easy access to the system from the surface, eliminating the need to perform a confined space entry for inspection purposes.

If upon visual inspection it is found that sediment has accumulated, a stadia rod should be inserted to determine the depth of sediment. When the average depth of sediment exceeds 3 inches throughout the length of the Isolator Row, clean-out should be performed.

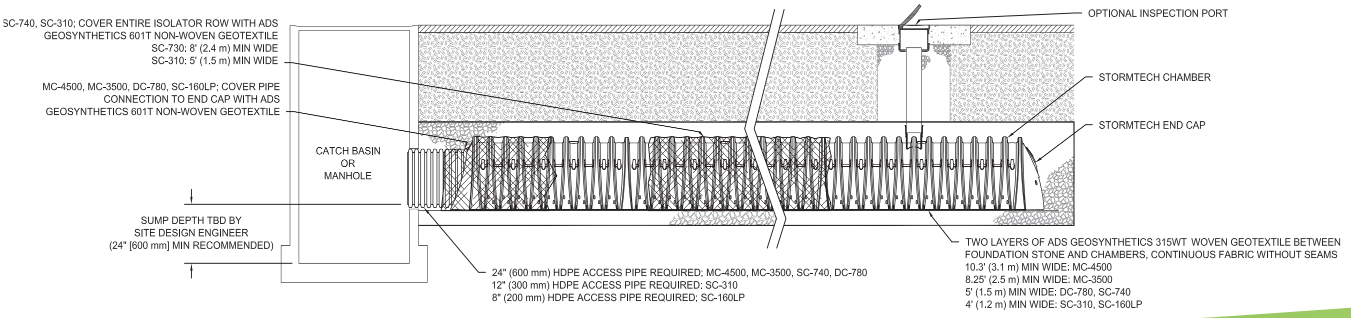
MAINTENANCE

The Isolator Row was designed to reduce the cost of periodic maintenance. By “isolating” sediments to just one row, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via a manhole(s) located on the end(s) of the row for cleanout. If entry into the manhole is required, please follow local and OSHA rules for a confined space entries.

Maintenance is accomplished with the JetVac process. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, the captured pollutants are flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Selection of an appropriate JetVac nozzle will improve maintenance efficiency. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45” are best. Most JetVac reels have 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. **The JetVac process shall only be performed on StormTech Isolator Rows that have AASHTO class 1 woven geotextile (as specified by StormTech) over their angular base stone.**

StormTech Isolator Row (not to scale)

Note: Non-woven fabric is only required over the inlet pipe connection into the end cap for SC-160LP, DC-780, MC-3500 and MC-4500 chamber models and is not required over the entire Isolator Row.



ISOLATOR ROW STEP BY STEP MAINTENANCE PROCEDURES

STEP 1

Inspect Isolator Row for sediment.

- A) Inspection ports (if present)
  - i. Remove lid from floor box frame
  - ii. Remove cap from inspection riser
  - iii. Using a flashlight and stadia rod,measure depth of sediment and record results on maintenance log.
  - iv. If sediment is at or above 3 inch depth, proceed to Step 2. If not, proceed to Step 3.
- B) All Isolator Rows
  - i. Remove cover from manhole at upstream end of Isolator Row
  - ii. Using a flashlight, inspect down Isolator Row through outlet pipe
    1. Mirrors on poles or cameras may be used to avoid a confined space entry
    2. Follow OSHA regulations for confined space entry if entering manhole
  - iii. If sediment is at or above the lower row of sidewall holes (approximately 3 inches), proceed to Step 2. If not, proceed to Step 3.

STEP 2

Clean out Isolator Row using the JetVac process.

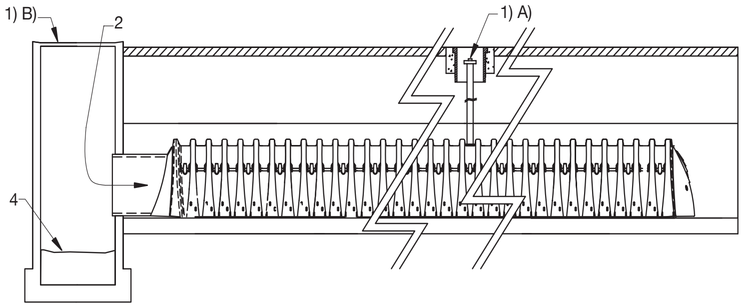
- A) A fixed floor cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable
- B) Apply multiple passes of JetVac until backflush water is clean
- C) Vacuum manhole sump as required

STEP 3

Replace all caps, lids and covers, record observations and actions.

STEP 4

Inspect & clean catch basins and manholes upstream of the StormTech system.



SAMPLE MAINTENANCE LOG

Date	Stadia Rod Readings		Sediment Depth (1)–(2)	Observations/Actions	Inspector
	Fixed point to chamber bottom (1)	Fixed point to top of sediment (2)			
3/15/11	6.3 ft	none		New installation. Fixed point is CI frame at grade	DJM
9/24/11		6.2	0.1 ft	Some grit felt	SM
6/20/13		5.8	0.5 ft	Mucky feel, debris visible in manhole and in Isolator Row, maintenance due	NV
7/7/13	6.3 ft		0	System jetted and vacuumed	DJM

Advanced Drainage Systems, Inc.
4640 Trueman Blvd., Hilliard, OH 43026
1-800-821-6710 www.ads-pipe.com

StormTech Maintenance Log

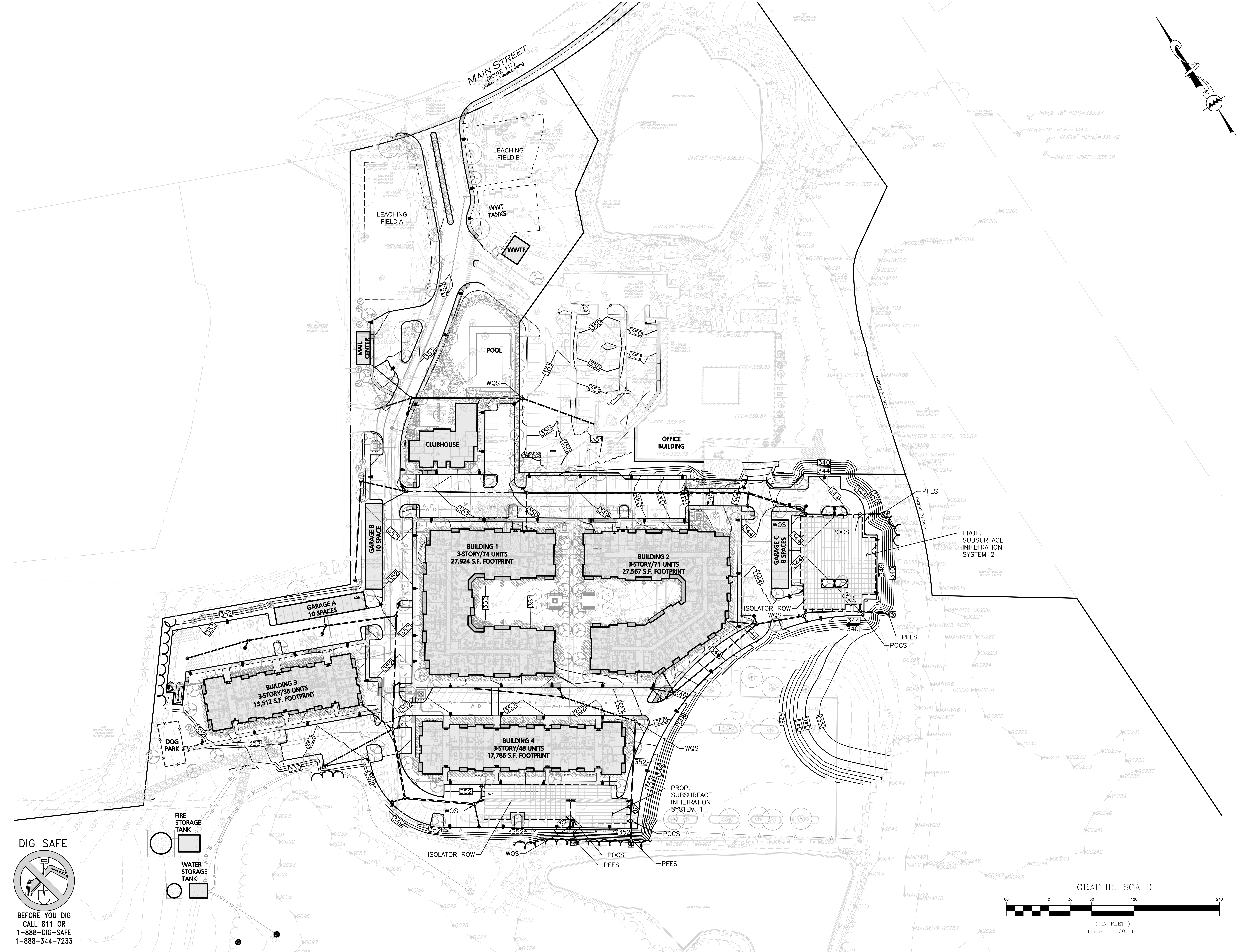
Project Name:
Location:

StormTech®
www.stormtech.com

	Stadia Rod Readings				
Date	**Fixed point to chamber bottom (1)**	**Fixed point to top of sediment (2)**	**Sediment Depth (1) - (2)**	**Observations / Actions**	**Inspector**

APPENDIX B SITE PLANS

SITE PLAN



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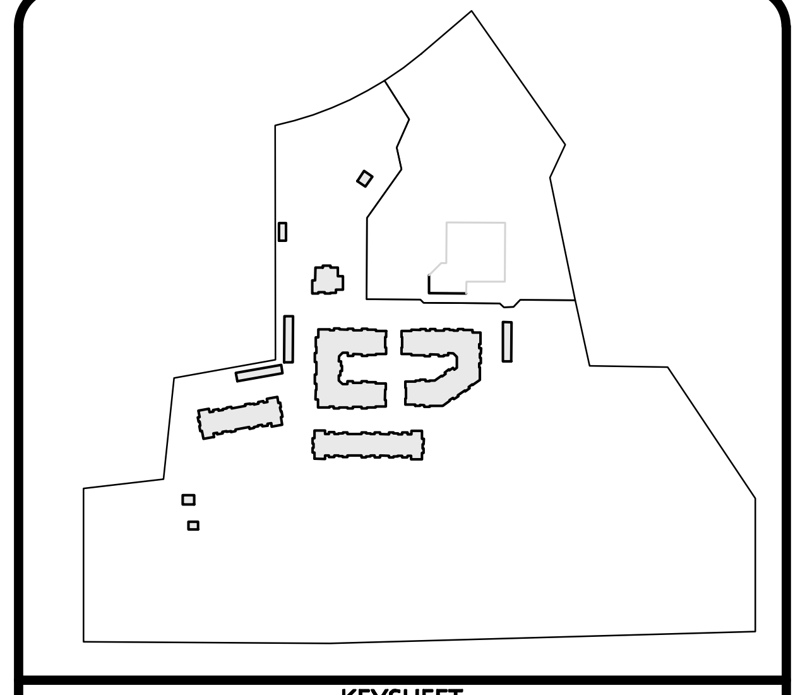

KEYSHEET

ISSUED FOR COMPREHENSIVE PERMIT APPLICATION
SEPTEMBER 10, 2021

PROFESSIONAL ENGINEER FOR
ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION

APPLICANT\OWNER:

WP EAST ACQUISITIONS, LLC.
91 HARTWELL AVENUE, 3RD FLOOR
LEXINGTON, MA 02421

PROJECT:

PRELIMINARY APPLICATION
FOR COMPREHENSIVE PERMIT
ALTA NASHOBA VALLEY
580 MAIN STREET BOLTON, MA

PROJECT NO.	1670-15	DATE:	09-10-2021
SCALE:	1" = 60'	DWG. NAME:	C1670-15
DESIGNED BY:	PGM	CHECKED BY:	PLC

PREPARED BY:

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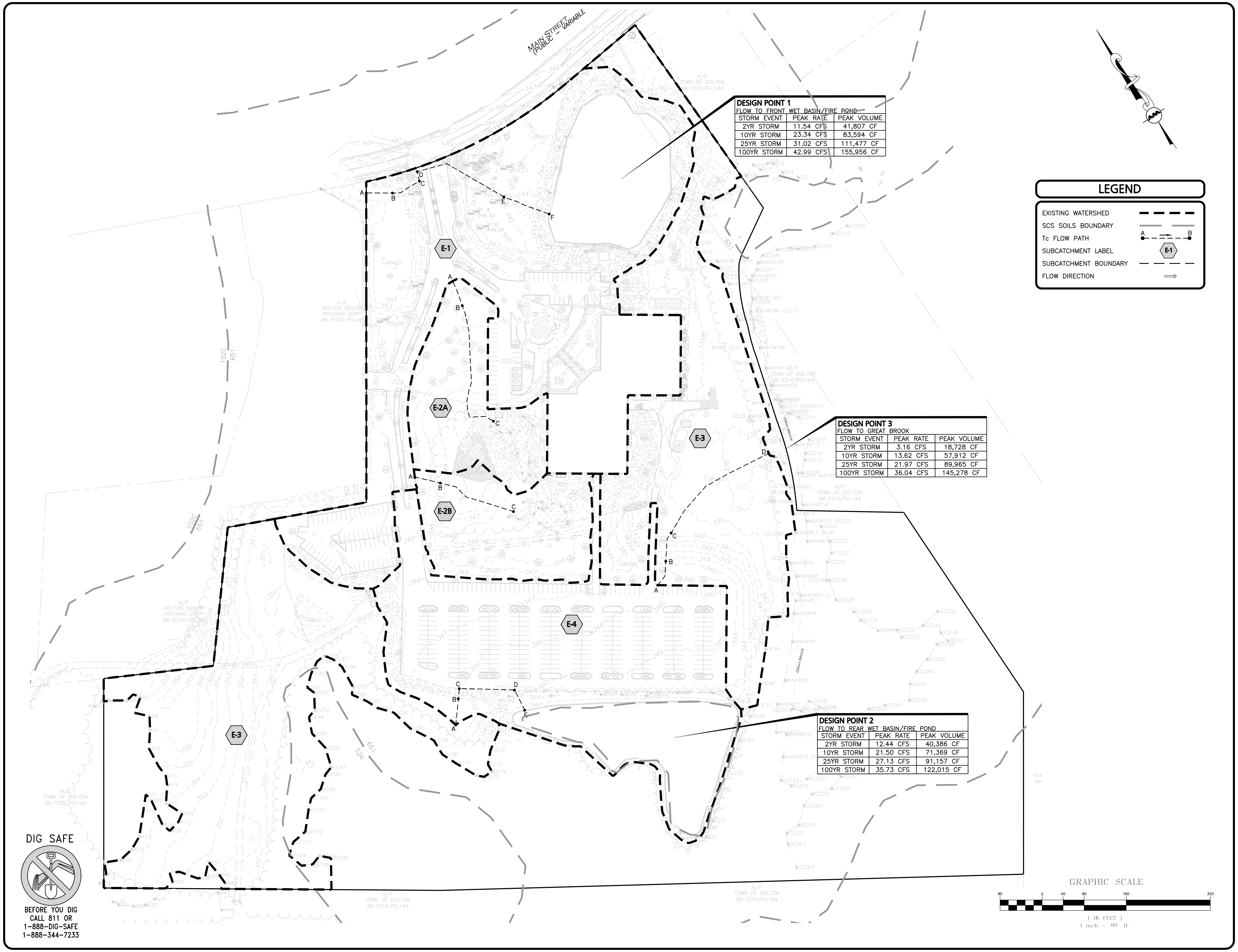
OPERATION & MAINTENANCE PLAN	O&M 1

APPENDIX J

WATERSHED PLANS

EXISTING WATERSHED PLAN EWS-1



DESIGN POINT 1
FLOW TO FRONT WET BASIN/FIRE POND

STORM EVENT	PEAK RATE	PEAK VOLUME
2YR STORM	11.54 CFS	41,807 CF
10YR STORM	23.34 CFS	83,594 CF
25YR STORM	31.02 CFS	111,477 CF
100YR STORM	42.99 CFS	155,956 CF

DESIGN POINT 3
FLOW TO GREAT BROOK

STORM EVENT	PEAK RATE	PEAK VOLUME
2YR STORM	3.16 CFS	18,728 CF
10YR STORM	13.62 CFS	57,912 CF
25YR STORM	21.97 CFS	89,965 CF
100YR STORM	36.04 CFS	145,278 CF

DESIGN POINT 2
FLOW TO REAR WET BASIN/FIRE POND

STORM EVENT	PEAK RATE	PEAK VOLUME
2YR STORM	12.44 CFS	40,386 CF
10YR STORM	21.50 CFS	71,369 CF
25YR STORM	27.13 CFS	91,157 CF
100YR STORM	35.73 CFS	122,015 CF

LEGEND

EXISTING WATERSHED	▬ ▬ ▬
SCS SOILS BOUNDARY	— —
Tc FLOW PATH	A ●- - -● B
SUBCATCHMENT LABEL	E-1
SUBCATCHMENT BOUNDARY	— — —
FLOW DIRECTION	⇒

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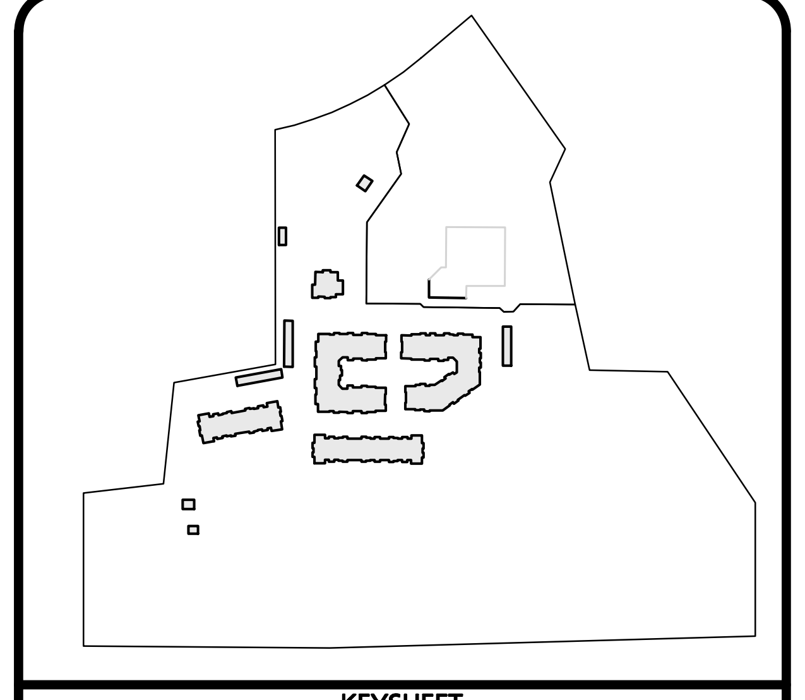

KEYSHEET

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SEPTEMBER 10, 2021

PHILIP L. CORDEIRO
CIVIL
NO. 47083

PROFESSIONAL ENGINEER FOR
ALLEN & MAJOR ASSOCIATES, INC.

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PREPARED BY:

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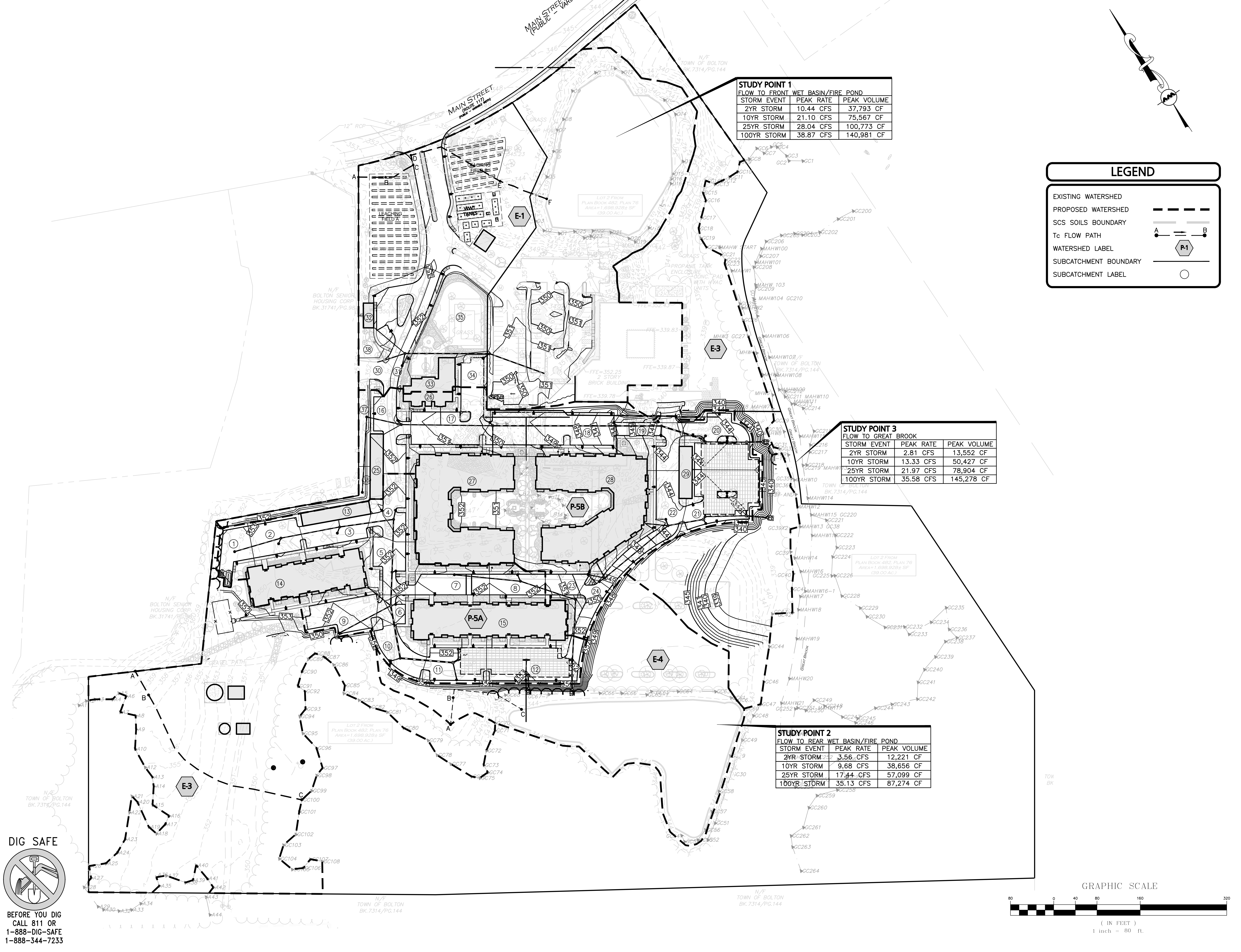
DRAWING TITLE:	SHEET No.
EXISTING WATERSHED PLAN	EWS-1

PROPOSED WATERSHED PLAN – PWS-1



STUDY POINT 1
FLOW TO FRONT WET BASIN/FIRE POND

STORM EVENT	PEAK RATE	PEAK VOLUME
2YR STORM	10.44 CFS	37,793 CF
10YR STORM	21.10 CFS	75,567 CF
25YR STORM	28.04 CFS	100,773 CF
100YR STORM	38.87 CFS	140,981 CF

STUDY POINT 3
FLOW TO GREAT BROOK

STORM EVENT	PEAK RATE	PEAK VOLUME
2YR STORM	2.81 CFS	13,552 CF
10YR STORM	13.33 CFS	50,427 CF
25YR STORM	21.97 CFS	78,904 CF
100YR STORM	35.58 CFS	145,278 CF

STUDY POINT 2
FLOW TO REAR WET BASIN/FIRE POND

STORM EVENT	PEAK RATE	PEAK VOLUME
2YR STORM	3.56 CFS	12,221 CF
10YR STORM	9.68 CFS	38,656 CF
25YR STORM	17.44 CFS	57,099 CF
100YR STORM	35.13 CFS	87,274 CF

LEGEND

EXISTING WATERSHED	
PROPOSED WATERSHED	— — — —
SCS SOILS BOUNDARY	— —
Tc FLOW PATH	A ●—— → ——● B
WATERSHED LABEL	P-1
SUBCATCHMENT BOUNDARY	——
SUBCATCHMENT LABEL	○

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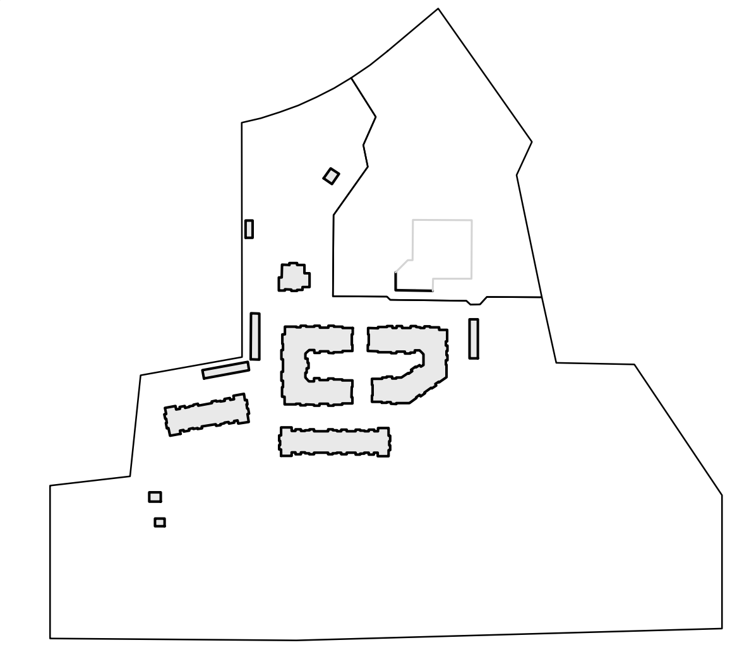

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PROFESSIONAL ENGINEER FOR
ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION

APPLICANT\OWNER:

WP EAST ACQUISITIONS, LLC.
91 HARTWELL AVENUE, 3RD FLOOR
LEXINGTON, MA 02421

PROJECT:

PRELIMINARY APPLICATION
FOR COMPREHENSIVE PERMIT
ALTA NASHOBA VALLEY
580 MAIN STREET BOLTON, MA

PROJECT NO.	1670-15	DATE:	09-10-2021
SCALE:	1" = 80'	DWG. NAME:	C1670-15
DESIGNED BY:	PGM	CHECKED BY:	PLC

PREPARED BY:

ALLEN & MAJOR
ASSOCIATES, INC.
civil engineering ◆ land surveying
environmental consulting ◆ landscape architecture
www.allenmajor.com

10 MAIN STREET
LAKEVILLE, MA 02347
TEL: (508) 923-1010
FAX: (508) 923-6309

WOBURN, MA ◆ LAKEVILLE, MA ◆ MANCHESTER, NH

DRAWING TITLE:	SHEET No.
PROPOSED WATERSHED PLAN	PWS-1