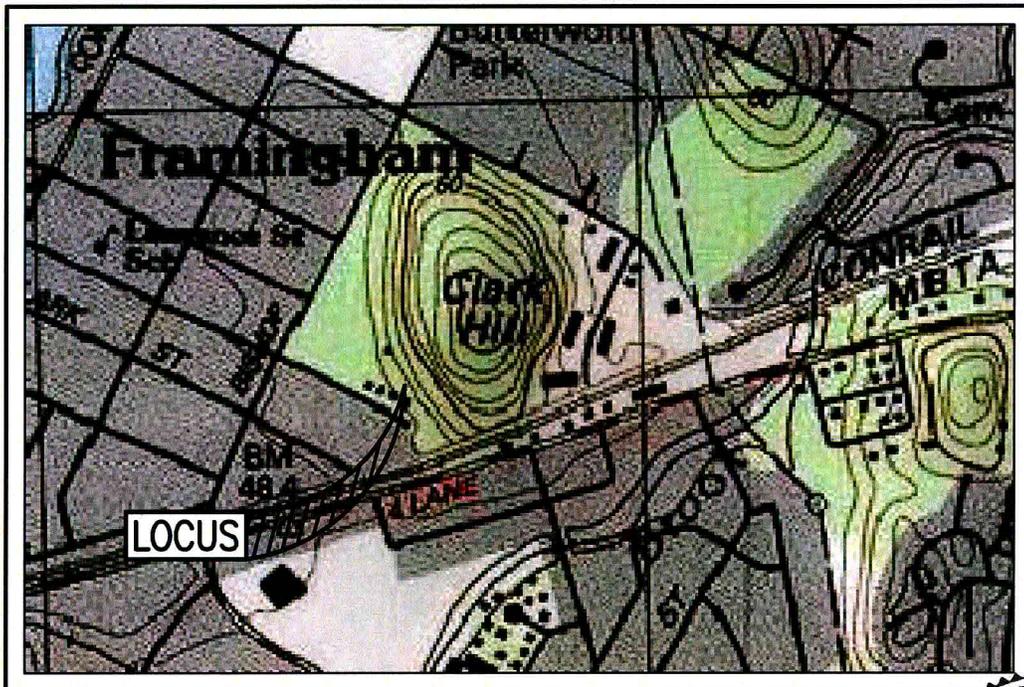


# STORMWATER MANAGEMENT REPORT

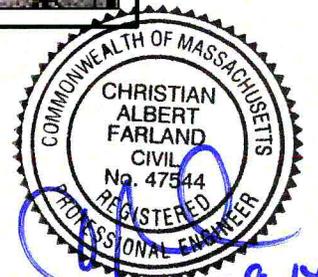
## SITE PLAN

ASSESSORS MAP 84 - LOT 7-11  
188 LAWRENCE STREET  
FRAMINGHAM, MASSACHUSETTS



PREPARED FOR:

MICHAEL SALKIND  
188 LAWRENCE STREET  
FRAMINGHAM, MA 01702



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# STORMWATER MANAGEMENT REPORT AND HYDROLOGIC-HYDRAULIC ANALYSIS

## Proposed Site Plan Middlesex Petroleum Distributors Framingham, Massachusetts

### Project Summary

The subject property associated with this project is located on the northerly side of Lawrence Street in Framingham, MA. The parcel is situated in the General Manufacturing Zoning District. The total parcel area is 59,955 S.F.

The applicant is seeking permission to construct a 6,915 S.F. steel building addition, bituminous pavement parking lot, associated grading and utility upgrades. Stormwater associated with the development will be controlled via surface and with a subsurface drainage system.

### Methodology

Drainage computations were performed using the Natural Resources Conservation Services (NRCS) TR-20 method and HydroCAD<sup>®</sup> Drainage Calculation Software. Sketches of the existing and proposed watershed areas, HydroCAD<sup>®</sup> Report, and copies of the calculation sheets are included as appendices to this report.

### Existing Conditions

The soils underlying the site are identified in the Soil Survey of Middlesex County (**see Appendix E**). Approximately 97% of the site soils consist of Urban Land and the other 3% consists of Broadbrook very fine sandy loam, 15-25 percent slopes, very stony

The soil has the following properties:

- Hydrologic Soil Group: HSG-C

### Proposed Conditions/Stormwater Management Overview

Under proposed conditions, roof drains will collect and direct roof runoff directly to the proposed subsurface recharge system. The parking lot expansion will direct stormwater to a deep sump catch basin will then take the stormwater to the subsurface recharge system.

The design of the stormwater system was designed for the post-development conditions to handle all storms' peak discharges and runoff volume to include the 1, 10, 25, 50 and 100-year storm events. The site drainage system was designed in consideration of the structural standards and techniques of the Best

Management Practices (BMP) outlined in the “Stormwater Management Handbook”.

The results of site drainage calculations are presented in the following Tables. The results are based upon evaluation of Pre-development conditions and the design of proposed surface and subsurface recharge system for the Post-development condition. These results show the Post-Development offsite volume and runoff rates are reduced to less than the Pre-development conditions, thus meeting the BMP guidelines for this site development.

<b>Table 1 - Comparison of Pre- versus Post-Development Offsite Runoff Rate, cfs</b>				
<b>Frequency Storm</b>	<b>2-Year</b>	<b>10-Year</b>	<b>25-Year</b>	<b>100-Year</b>
Pre-Development	1.88	3.53	4.52	6.03
Post-Development	1.20	2.51	3.55	5.08

<b>Table 2 - Comparison of Pre- versus Post-Development Offsite Runoff Volume, af</b>				
<b>Frequency Storm</b>	<b>2-Year</b>	<b>10-Year</b>	<b>25-Year</b>	<b>100-Year</b>
Pre-Development	0.135	0.251	0.321	0.431
Post-Development	0.087	0.207	0.280	0.392

Groundwater recharge is a factor in the design of the subsurface drainage system. Table-3 below presents the minimum recharge required and the proposed recharge of stormwater based upon the BMP methods of the “Stormwater Management Handbook”. The proposed recharge quantities meet or exceed the required minimum recharges.

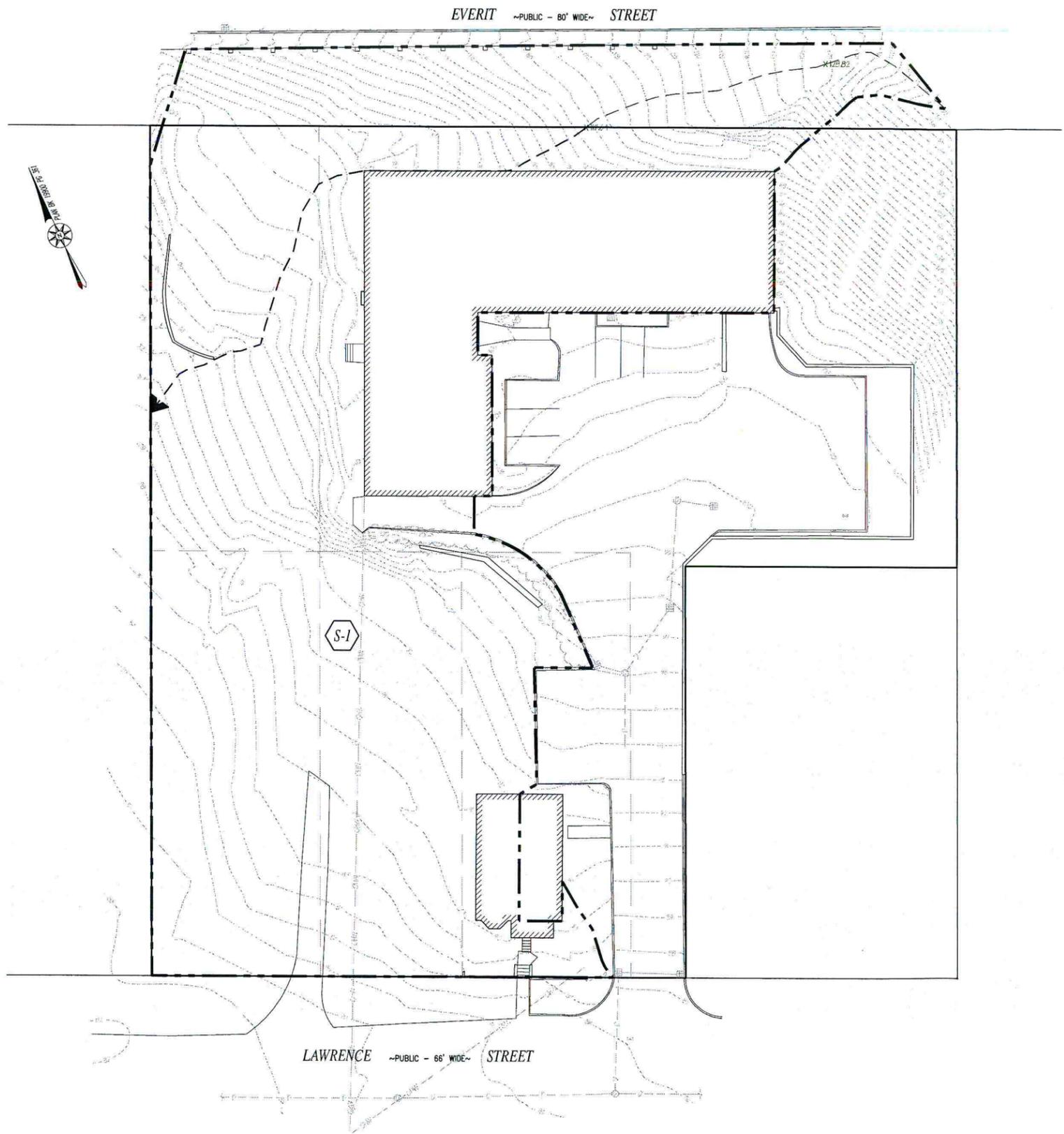
<b>Table 3 - Drainage Recharge Calculation (Required Recharge = 0.25” Total Site Runoff for Class-C Soils)</b>	
<b>Required Recharge</b>	<b>Proposed Recharge</b>
1.22 Acres x 0.25” = 0.025 AF = 1,089 CF	3,049 CF = 0.070 AF

*PRE-DEVELOPMENT*  
*WATERSHED PLAN*

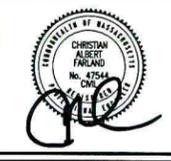
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DRAWN BY: SC  
 DESIGNED BY: SC/CAF  
 CHECKED BY: CAF

**SITE PLAN**  
 188 LAWRENCE STREET  
 ASSESSORS MAP 84 LOTS 7-11  
 FRAMINGHAM, MASSACHUSETTS  
 PREPARED FOR: MICHAEL SALKIND  
 188 LAWRENCE STREET  
 FRAMINGHAM, MA 01702

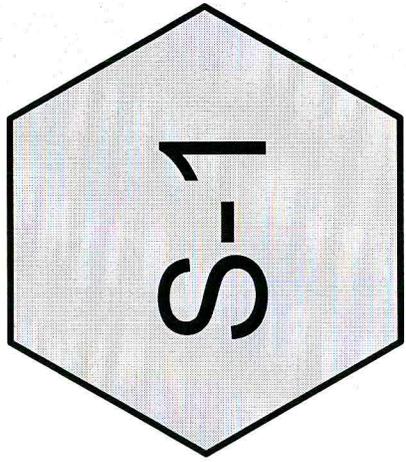
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 JOB NO. 12-047  
 LATEST REVISION:

PRE SUBCATCHMENT  
 SHEET 4A OF 6

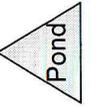
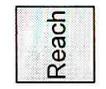
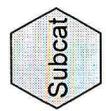
*PRE-DEVELOPMENT*  
*ANALYSIS*

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# Tributary to Lawrence Street



**Drainage Diagram for 12047PRE**

Prepared by Thompson Farland, Inc., Printed 9/25/2014

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**Summary for Subcatchment S-1: Tributary to Lawrence Street**

Runoff = 1.23 cfs @ 12.09 hrs, Volume= 0.091 af, Depth= 0.89"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Type III 24-hr 1yr Rainfall=2.50"

Area (sf)	CN	Description
10,922	98	Paved parking & roofs
1,421	98	Paved parking & roofs
10,636	79	50-75% Grass cover, Fair, HSG C
30,262	73	Woods, Fair, HSG C
53,241	80	Weighted Average
40,898		Pervious Area
12,343		Impervious Area

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

**Summary for Subcatchment S-1: Tributary to Lawrence Street**

Runoff = 4.52 cfs @ 12.09 hrs, Volume= 0.321 af, Depth= 3.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Type III 24-hr 25yr Rainfall=5.30"

Area (sf)	CN	Description
10,922	98	Paved parking & roofs
1,421	98	Paved parking & roofs
10,636	79	50-75% Grass cover, Fair, HSG C
30,262	73	Woods, Fair, HSG C
53,241	80	Weighted Average
40,898		Pervious Area
12,343		Impervious Area

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

**Summary for Subcatchment S-1: Tributary to Lawrence Street**

Runoff = 6.03 cfs @ 12.09 hrs, Volume= 0.431 af, Depth= 4.24"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Type III 24-hr 100yr Rainfall=6.50"

Area (sf)	CN	Description
10,922	98	Paved parking & roofs
1,421	98	Paved parking & roofs
10,636	79	50-75% Grass cover, Fair, HSG C
30,262	73	Woods, Fair, HSG C
53,241	80	Weighted Average
40,898		Pervious Area
12,343		Impervious Area

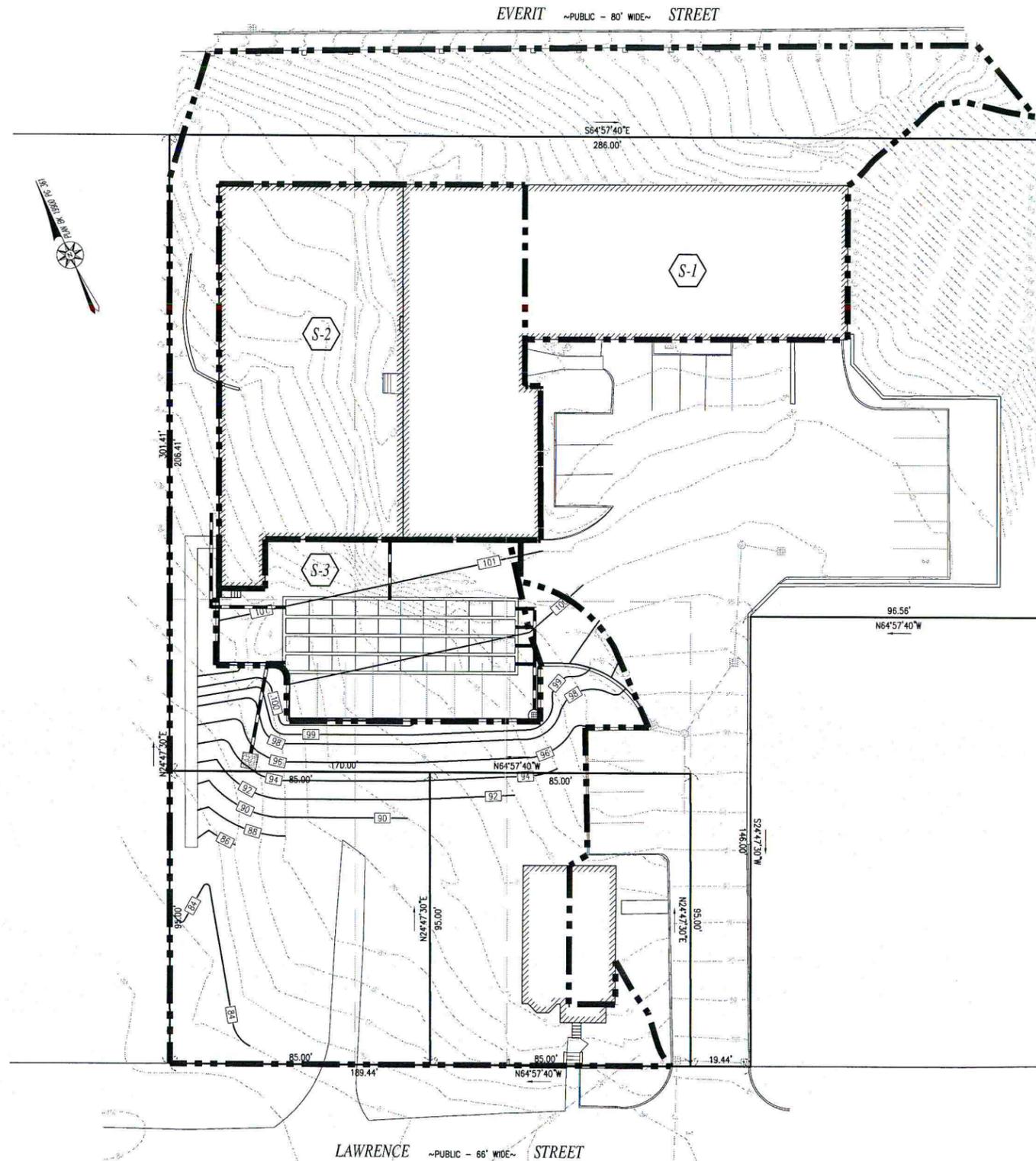
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					Direct Entry, Minimum Tc

POST-DEVELOPMENT  
WATERSHED PLAN

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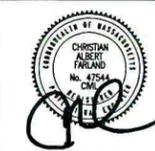
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 DESIGNED BY: SC/CAF  
 CHECKED BY: CAF

**SITE PLAN**  
 188 LAWRENCE STREET  
 ASSESSORS MAP 84 LOTS 7-11  
 FRAMINGHAM, MASSACHUSETTS  
 PREPARED BY: MICHAEL SALKIND  
 FOR: 188 LAWRENCE STREET  
 FRAMINGHAM, MA 01702

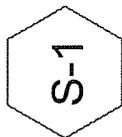
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*ANALYSIS*

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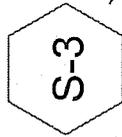
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Tributary to Lawrence Street



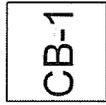
Roof Runoff to Subsurface Recharge System



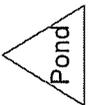
Tributary to CB-1



Subsurface Recharge System



Catch Basin



### Drainage Diagram for 12047POST

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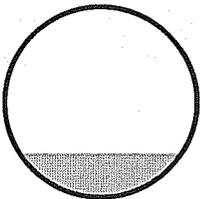
**Summary for Reach CB-1: Catch Basin**

Inflow Area = 0.123 ac, 100.00% Impervious, Inflow Depth = 2.27" for 1yr event  
 Inflow = 0.30 cfs @ 12.08 hrs, Volume= 0.023 af  
 Outflow = 0.30 cfs @ 12.08 hrs, Volume= 0.023 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Max. Velocity= 2.15 fps, Min. Travel Time= 0.1 min  
 Avg. Velocity = 0.70 fps, Avg. Travel Time= 0.2 min

Peak Storage= 1 cf @ 12.08 hrs, Average Depth at Peak Storage= 0.23'  
 Bank-Full Depth= 1.00', Capacity at Bank-Full= 2.52 cfs

12.0" Diameter Pipe, n= 0.013  
 Length= 10.0' Slope= 0.0050 1/  
 Inlet Invert= 95.00', Outlet Invert= 94.95'



**Summary for Pond SRS: Subsurface Recharge System**

Inflow Area = 0.399 ac, 100.00% Impervious, Inflow Depth = 2.27" for 1yr event  
 Inflow = 0.96 cfs @ 12.08 hrs, Volume= 0.075 af  
 Outflow = 0.01 cfs @ 7.05 hrs, Volume= 0.067 af, Atten= 99%, Lag= 0.0 min  
 Discarded = 0.01 cfs @ 7.05 hrs, Volume= 0.067 af  
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Peak Elev= 95.41' @ 20.95 hrs Surf.Area= 1,925 sf Storage= 2,475 cf

Plug-Flow detention time= 1,597.4 min calculated for 0.067 af (88% of inflow)  
 Center-of-Mass det. time= 1,543.2 min ( 2,305.2 - 762.0 )

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	2,008 cf	<b>25.00'W x 77.00'L x 4.00'H Prismaoid</b> 7,700 cf Overall - 2,679 cf Embedded = 5,021 cf x 40.0% Voids
#2	94.00'	2,679 cf	<b>52.6"W x 34.0"H x 7.50'L Cultec R-V8</b> x 40 Inside #1
		4,688 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.50'	<b>0.270 in/hr Exfiltration over Surface area</b>
#2	Primary	96.00'	<b>8.0" x 35.0' long Culvert</b> CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 96.00' S= -0.0143 1/' Cc= 0.900 n= 0.013

**Summary for Subcatchment S-1: Tributary to Lawrence Street**

Runoff = 0.77 cfs @ 12.10 hrs, Volume= 0.057 af, Depth= 0.84"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 1yr Rainfall=2.50"

Area (sf)	CN	Description
5,875	98	Paved parking & roofs
10,943	79	50-75% Grass cover, Fair, HSG C
19,050	73	Woods, Fair, HSG C
35,868	79	Weighted Average
29,993		Pervious Area
5,875		Impervious Area

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

**Summary for Subcatchment S-2: Roof Runoff to Subsurface Recharge System**

Runoff = 0.66 cfs @ 12.08 hrs, Volume= 0.052 af, Depth= 2.27"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 1yr Rainfall=2.50"

Area (sf)	CN	Description
* 12,013	98	Rooftop
12,013		Impervious Area

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

**Summary for Subcatchment S-3: Tributary to CB-1**

Runoff = 0.30 cfs @ 12.08 hrs, Volume= 0.023 af, Depth= 2.27"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 1yr Rainfall=2.50"

Area (sf)	CN	Description
5,360	98	Paved parking & roofs
5,360		Impervious Area

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

**12047POST**

Type III 24-hr 1yr Rainfall=2.50"

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Page 3

**Discarded OutFlow** Max=0.01 cfs @ 7.05 hrs HW=93.54' (Free Discharge)  
↳1=Exfiltration (Exfiltration Controls 0.01 cfs)

**Primary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=93.50' (Free Discharge)  
↳2=Culvert ( Controls 0.00 cfs)

**Summary for Subcatchment S-1: Tributary to Lawrence Street**

Runoff = 2.29 cfs @ 12.09 hrs, Volume= 0.163 af, Depth= 2.38"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 10yr Rainfall=4.50"

Area (sf)	CN	Description
5,875	98	Paved parking & roofs
10,943	79	50-75% Grass cover, Fair, HSG C
19,050	73	Woods, Fair, HSG C
35,868	79	Weighted Average
29,993		Pervious Area
5,875		Impervious Area

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

**Summary for Subcatchment S-2: Roof Runoff to Subsurface Recharge System**

Runoff = 1.21 cfs @ 12.08 hrs, Volume= 0.098 af, Depth= 4.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 10yr Rainfall=4.50"

Area (sf)	CN	Description
* 12,013	98	Rooftop
12,013		Impervious Area

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

**Summary for Subcatchment S-3: Tributary to CB-1**

Runoff = 0.54 cfs @ 12.08 hrs, Volume= 0.044 af, Depth= 4.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 10yr Rainfall=4.50"

Area (sf)	CN	Description
5,360	98	Paved parking & roofs
5,360		Impervious Area

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

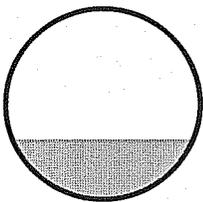
**Summary for Reach CB-1: Catch Basin**

Inflow Area = 0.123 ac, 100.00% Impervious, Inflow Depth = 4.26" for 10yr event  
 Inflow = 0.54 cfs @ 12.08 hrs, Volume= 0.044 af  
 Outflow = 0.54 cfs @ 12.08 hrs, Volume= 0.044 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Max. Velocity= 2.55 fps, Min. Travel Time= 0.1 min  
 Avg. Velocity = 0.84 fps, Avg. Travel Time= 0.2 min

Peak Storage= 2 cf @ 12.08 hrs, Average Depth at Peak Storage= 0.31'  
 Bank-Full Depth= 1.00', Capacity at Bank-Full= 2.52 cfs

12.0" Diameter Pipe, n= 0.013  
 Length= 10.0' Slope= 0.0050 '/'  
 Inlet Invert= 95.00', Outlet Invert= 94.95'



**Summary for Pond SRS: Subsurface Recharge System**

Inflow Area = 0.399 ac, 100.00% Impervious, Inflow Depth = 4.26" for 10yr event  
 Inflow = 1.75 cfs @ 12.08 hrs, Volume= 0.142 af  
 Outflow = 0.24 cfs @ 12.60 hrs, Volume= 0.113 af, Atten= 87%, Lag= 30.8 min  
 Discarded = 0.01 cfs @ 3.98 hrs, Volume= 0.069 af  
 Primary = 0.22 cfs @ 12.60 hrs, Volume= 0.044 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Peak Elev= 96.30' @ 12.60 hrs Surf.Area= 1,925 sf Storage= 3,655 cf

Plug-Flow detention time= 1,048.3 min calculated for 0.113 af (80% of inflow)  
 Center-of-Mass det. time= 971.0 min ( 1,720.8 - 749.9 )

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	2,008 cf	<b>25.00'W x 77.00'L x 4.00'H Prismatic</b> 7,700 cf Overall - 2,679 cf Embedded = 5,021 cf x 40.0% Voids
#2	94.00'	2,679 cf	<b>52.6"W x 34.0"H x 7.50'L Cultec R-V8</b> x 40 Inside #1
		4,688 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.50'	<b>0.270 in/hr Exfiltration over Surface area</b>
#2	Primary	96.00'	<b>8.0" x 35.0' long Culvert</b> CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 96.00' S= -0.0143 '/ Cc= 0.900 n= 0.013

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*Type III 24-hr 10yr Rainfall=4.50"*

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**Discarded OutFlow** Max=0.01 cfs @ 3.98 hrs HW=93.54' (Free Discharge)

↳ **1=Exfiltration** (Exfiltration Controls 0.01 cfs)

**Primary OutFlow** Max=0.22 cfs @ 12.60 hrs HW=96.30' (Free Discharge)

↳ **2=Culvert** (Inlet Controls 0.22 cfs @ 1.47 fps)

**Summary for Subcatchment S-1: Tributary to Lawrence Street**

Runoff = 2.96 cfs @ 12.09 hrs, Volume= 0.210 af, Depth= 3.06"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 25yr Rainfall=5.30"

Area (sf)	CN	Description
5,875	98	Paved parking & roofs
10,943	79	50-75% Grass cover, Fair, HSG C
19,050	73	Woods, Fair, HSG C
35,868	79	Weighted Average
29,993		Pervious Area
5,875		Impervious Area

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

**Summary for Subcatchment S-2: Roof Runoff to Subsurface Recharge System**

Runoff = 1.43 cfs @ 12.08 hrs, Volume= 0.116 af, Depth= 5.06"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 25yr Rainfall=5.30"

Area (sf)	CN	Description
* 12,013	98	Rooftop
12,013		Impervious Area

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

**Summary for Subcatchment S-3: Tributary to CB-1**

Runoff = 0.64 cfs @ 12.08 hrs, Volume= 0.052 af, Depth= 5.06"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 25yr Rainfall=5.30"

Area (sf)	CN	Description
5,360	98	Paved parking & roofs
5,360		Impervious Area

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

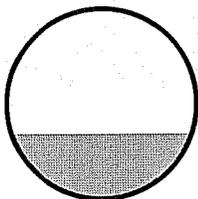
**Summary for Reach CB-1: Catch Basin**

Inflow Area = 0.123 ac, 100.00% Impervious, Inflow Depth = 5.06" for 25yr event  
 Inflow = 0.64 cfs @ 12.08 hrs, Volume= 0.052 af  
 Outflow = 0.64 cfs @ 12.08 hrs, Volume= 0.052 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Max. Velocity= 2.68 fps, Min. Travel Time= 0.1 min  
 Avg. Velocity = 0.89 fps, Avg. Travel Time= 0.2 min

Peak Storage= 2 cf @ 12.08 hrs, Average Depth at Peak Storage= 0.34'  
 Bank-Full Depth= 1.00', Capacity at Bank-Full= 2.52 cfs

12.0" Diameter Pipe, n= 0.013  
 Length= 10.0' Slope= 0.0050 '/  
 Inlet Invert= 95.00', Outlet Invert= 94.95'



**Summary for Pond SRS: Subsurface Recharge System**

Inflow Area = 0.399 ac, 100.00% Impervious, Inflow Depth = 5.06" for 25yr event  
 Inflow = 2.07 cfs @ 12.08 hrs, Volume= 0.168 af  
 Outflow = 0.61 cfs @ 12.40 hrs, Volume= 0.139 af, Atten= 71%, Lag= 19.3 min  
 Discarded = 0.01 cfs @ 3.30 hrs, Volume= 0.069 af  
 Primary = 0.59 cfs @ 12.40 hrs, Volume= 0.070 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Peak Elev= 96.54' @ 12.40 hrs Surf.Area= 1,925 sf Storage= 3,918 cf

Plug-Flow detention time=871.5 min calculated for 0.139 af (83% of inflow)  
 Center-of-Mass det. time=800.9 min ( 1,548.0 - 747.1 )

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	2,008 cf	<b>25.00'W x 77.00'L x 4.00'H Prismaoid</b> 7,700 cf Overall - 2,679 cf Embedded = 5,021 cf x 40.0% Voids
#2	94.00'	2,679 cf	<b>52.6"W x 34.0"H x 7.50'L Cultec R-V8</b> x 40 Inside #1
		4,688 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.50'	<b>0.270 in/hr Exfiltration over Surface area</b>
#2	Primary	96.00'	<b>8.0" x 35.0' long Culvert</b> CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 96.00' S= -0.0143 '/ Cc= 0.900 n= 0.013

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Type III 24-hr 25yr Rainfall=5.30"

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**Discarded OutFlow** Max=0.01 cfs @ 3.30 hrs HW=93.54' (Free Discharge)  
↑1=Exfiltration (Exfiltration Controls 0.01 cfs)

**Primary OutFlow** Max=0.59 cfs @ 12.40 hrs HW=96.54' (Free Discharge)  
↑2=Culvert (Inlet Controls 0.59 cfs @ 1.97 fps)

**Summary for Subcatchment S-1: Tributary to Lawrence Street**

Runoff = 3.46 cfs @ 12.09 hrs, Volume= 0.246 af, Depth= 3.59"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 50yr Rainfall=5.90"

Area (sf)	CN	Description
5,875	98	Paved parking & roofs
10,943	79	50-75% Grass cover, Fair, HSG C
19,050	73	Woods, Fair, HSG C
35,868	79	Weighted Average
29,993		Pervious Area
5,875		Impervious Area

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

**Summary for Subcatchment S-2: Roof Runoff to Subsurface Recharge System**

Runoff = 1.59 cfs @ 12.08 hrs, Volume= 0.130 af, Depth= 5.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 50yr Rainfall=5.90"

Area (sf)	CN	Description
* 12,013	98	Rooftop
12,013		Impervious Area

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

**Summary for Subcatchment S-3: Tributary to CB-1**

Runoff = 0.71 cfs @ 12.08 hrs, Volume= 0.058 af, Depth= 5.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 50yr Rainfall=5.90"

Area (sf)	CN	Description
5,360	98	Paved parking & roofs
5,360		Impervious Area

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

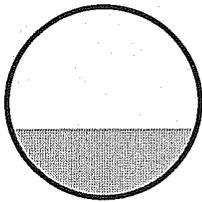
**Summary for Reach CB-1: Catch Basin**

Inflow Area = 0.123 ac, 100.00% Impervious, Inflow Depth = 5.66" for 50yr event  
 Inflow = 0.71 cfs @ 12.08 hrs, Volume= 0.058 af  
 Outflow = 0.71 cfs @ 12.08 hrs, Volume= 0.058 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Max. Velocity= 2.76 fps, Min. Travel Time= 0.1 min  
 Avg. Velocity= 0.92 fps, Avg. Travel Time= 0.2 min

Peak Storage= 3 cf @ 12.08 hrs, Average Depth at Peak Storage= 0.36'  
 Bank-Full Depth= 1.00', Capacity at Bank-Full= 2.52 cfs

12.0" Diameter Pipe, n= 0.013  
 Length= 10.0' Slope= 0.0050 '/'  
 Inlet Invert= 95.00', Outlet Invert= 94.95'



**Summary for Pond SRS: Subsurface Recharge System**

Inflow Area = 0.399 ac, 100.00% Impervious, Inflow Depth = 5.66" for 50yr event  
 Inflow = 2.31 cfs @ 12.08 hrs, Volume= 0.188 af  
 Outflow = 0.87 cfs @ 12.32 hrs, Volume= 0.159 af, Atten= 62%, Lag= 14.0 min  
 Discarded = 0.01 cfs @ 2.92 hrs, Volume= 0.070 af  
 Primary = 0.85 cfs @ 12.32 hrs, Volume= 0.089 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Peak Elev= 96.75' @ 12.32 hrs Surf.Area= 1,925 sf Storage= 4,106 cf

Plug-Flow detention time= 776.3 min calculated for 0.159 af (85% of inflow)  
 Center-of-Mass det. time= 710.1 min ( 1,455.5 - 745.4 )

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	2,008 cf	<b>25.00'W x 77.00'L x 4.00'H Prisma</b> 7,700 cf Overall - 2,679 cf Embedded = 5,021 cf x 40.0% Voids
#2	94.00'	2,679 cf	<b>52.6"W x 34.0"H x 7.50'L Cul</b> x 40 Inside #1
		4,688 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.50'	<b>0.270 in/hr Exfiltration over Surface area</b>
#2	Primary	96.00'	<b>8.0" x 35.0' long Culvert</b> CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 96.00' S= -0.0143 '/' Cc= 0.900 n= 0.013

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*Type III 24-hr 50yr Rainfall=5.90"*

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**Discarded OutFlow** Max=0.01 cfs @ 2.92 hrs HW=93.54' (Free Discharge)

↳1=Exfiltration (Exfiltration Controls 0.01 cfs)

**Primary OutFlow** Max=0.85 cfs @ 12.32 hrs HW=96.75' (Free Discharge)

↳2=Culvert (Inlet Controls 0.85 cfs @ 2.44 fps)

**Summary for Subcatchment S-1: Tributary to Lawrence Street**

Runoff = 3.97 cfs @ 12.09 hrs, Volume= 0.283 af, Depth= 4.13"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 100yr Rainfall=6.50"

Area (sf)	CN	Description
5,875	98	Paved parking & roofs
10,943	79	50-75% Grass cover, Fair, HSG C
19,050	73	Woods, Fair, HSG C
35,868	79	Weighted Average
29,993		Pervious Area
5,875		Impervious Area

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

**Summary for Subcatchment S-2: Roof Runoff to Subsurface Recharge System**

Runoff = 1.76 cfs @ 12.08 hrs, Volume= 0.144 af, Depth= 6.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 100yr Rainfall=6.50"

Area (sf)	CN	Description
* 12,013	98	Rooftop
12,013		Impervious Area

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

**Summary for Subcatchment S-3: Tributary to CB-1**

Runoff = 0.78 cfs @ 12.08 hrs, Volume= 0.064 af, Depth= 6.26"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
Type III 24-hr 100yr Rainfall=6.50"

Area (sf)	CN	Description
5,360	98	Paved parking & roofs
5,360		Impervious Area

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

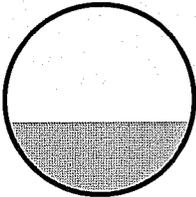
**Summary for Reach CB-1: Catch Basin**

Inflow Area = 0.123 ac, 100.00% Impervious, Inflow Depth = 6.26" for 100yr event  
 Inflow = 0.78 cfs @ 12.08 hrs, Volume= 0.064 af  
 Outflow = 0.78 cfs @ 12.08 hrs, Volume= 0.064 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Max. Velocity= 2.83 fps, Min. Travel Time= 0.1 min  
 Avg. Velocity = 0.95 fps, Avg. Travel Time= 0.2 min

Peak Storage= 3 cf @ 12.08 hrs, Average Depth at Peak Storage= 0.38'  
 Bank-Full Depth= 1.00', Capacity at Bank-Full= 2.52 cfs

12.0" Diameter Pipe, n= 0.013  
 Length= 10.0' Slope= 0.0050 '/'  
 Inlet Invert= 95.00', Outlet Invert= 94.95'



**Summary for Pond SRS: Subsurface Recharge System**

Inflow Area = 0.399 ac, 100.00% Impervious, Inflow Depth = 6.26" for 100yr event  
 Inflow = 2.54 cfs @ 12.08 hrs, Volume= 0.208 af  
 Outflow = 1.12 cfs @ 12.26 hrs, Volume= 0.179 af, Atten= 56%, Lag= 10.6 min  
 Discarded = 0.01 cfs @ 2.60 hrs, Volume= 0.070 af  
 Primary = 1.11 cfs @ 12.26 hrs, Volume= 0.109 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs  
 Peak Elev= 97.03' @ 12.26 hrs Surf.Area= 1,925 sf Storage= 4,327 cf

Plug-Flow detention time=701.9 min calculated for 0.179 af (86% of inflow)  
 Center-of-Mass det. time=639.4 min ( 1,383.4 - 744.0 )

Volume	Invert	Avail.Storage	Storage Description
#1	93.50'	2,008 cf	<b>25.00'W x 77.00'L x 4.00'H Prismatic</b> 7,700 cf Overall - 2,679 cf Embedded = 5,021 cf x 40.0% Voids
#2	94.00'	2,679 cf	<b>52.6"W x 34.0"H x 7.50'L Cultec R-V8</b> x 40 Inside #1
		4,688 cf	Total Available Storage

Device	Routing	Invert	Outlet Devices
#1	Discarded	93.50'	<b>0.270 in/hr Exfiltration over Surface area</b>
#2	Primary	96.00'	<b>8.0" x 35.0' long Culvert</b> CMP, projecting, no headwall, Ke= 0.900 Outlet Invert= 96.00' S= -0.0143 '/' Cc= 0.900 n= 0.013

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Type III 24-hr 100yr Rainfall=6.50"

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**Discarded OutFlow** Max=0.01 cfs @ 2.60 hrs HW=93.54' (Free Discharge)  
↑1=Exfiltration (Exfiltration Controls 0.01 cfs)

**Primary OutFlow** Max=1.11 cfs @ 12.26 hrs HW=97.03' (Free Discharge)  
↑2=Culvert (Inlet Controls 1.11 cfs @ 3.18 fps)

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**Map Unit Legend**

Middlesex County, Massachusetts (MA017)			
Map Unit Symbol	Map Unit Name	Acres In AOI	Percent of AOI
341D	Broadbrook very fine sandy loam, 15 to 25 percent slopes, very stony	0.1	2.3%
602	Urban land	2.6	97.7%
<b>Totals for Area of Interest</b>		<b>2.7</b>	<b>100.0%</b>



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

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## Engineering Properties

This table gives the engineering classifications and the range of engineering properties for the layers of each soil in the survey area.

*Hydrologic soil group* is a group of soils having similar runoff potential under similar storm and cover conditions. The criteria for determining Hydrologic soil group is found in the National Engineering Handbook, Chapter 7 issued May 2007(<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>). Listing HSGs by soil map unit component and not by soil series is a new concept for the engineers. Past engineering references contained lists of HSGs by soil series. Soil series are continually being defined and redefined, and the list of soil series names changes so frequently as to make the task of maintaining a single national list virtually impossible. Therefore, the criteria is now used to calculate the HSG using the component soil properties and no such national series lists will be maintained. All such references are obsolete and their use should be discontinued. Soil properties that influence runoff potential are those that influence the minimum rate of infiltration for a bare soil after prolonged wetting and when not frozen. These properties are depth to a seasonal high water table, saturated hydraulic conductivity after prolonged wetting, and depth to a layer with a very slow water transmission rate. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. The influence of ground cover is treated independently. There are four hydrologic soil groups, A, B, C, and D, and three dual groups, A/D, B/D, and C/D. In the dual groups, the first letter is for drained areas and the second letter is for undrained areas.

The four hydrologic soil groups are described in the following paragraphs:

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

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

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

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

*Depth* to the upper and lower boundaries of each layer is indicated.

*Texture* is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is 15 percent or more, an appropriate modifier is added, for example, "gravelly."

*Classification* of the soils is determined according to the Unified soil classification system (ASTM, 2005) and the system adopted by the American Association of State Highway and Transportation Officials (AASHTO, 2004).

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to particle-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, CL-ML.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of particle-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

*Rock fragments* larger than 10 inches in diameter and 3 to 10 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

*Percentage (of soil particles) passing designated sieves* is the percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

*Liquid limit and plasticity index (Atterberg limits)* indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

#### References:

American Association of State Highway and Transportation Officials (AASHTO). 2004. Standard specifications for transportation materials and methods of sampling and testing. 24th edition.

American Society for Testing and Materials (ASTM). 2005. Standard classification of soils for engineering purposes. ASTM Standard D2487-00.

## Report—Engineering Properties

Absence of an entry indicates that the data were not estimated. The asterisk "\*" denotes the representative texture; other possible textures follow the dash. The criteria for determining the hydrologic soil group for individual soil components is found in the National Engineering Handbook, Chapter 7 issued May 2007(<http://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17757.wba>).

Engineering Properties—Middlesex County, Massachusetts															
Map unit symbol and soil name	Pct. of map unit	Hydrologic group	Depth	USDA texture	Classification					Fragments			Liquid limit	Plasticity index	
					Unified	AASHTO	>10 inches	3-10 inches	Percentage passing sieve number—	4	10	40			200
341D—Broadbroom very fine sandy loam, 15 to 25 percent slopes, very stony			In												
Broadbroom	85	C	0-2	Moderately decomposed plant material	PT	A-8	0	—	—	—	—	—	—	—	—
			2-10	Very fine sandy loam	ML, CL-ML	A-4	0-6	0	90-100	75-100	65-95	55-80	15-35	NP-10	
			10-20	Silt loam, gravelly very fine sandy loam, gravelly loam	ML, SM	A-4	0	0-10	75-100	65-100	55-90	45-80	15-20	NP-6	
			20-65	Gravelly fine sandy loam, sandy loam, gravelly sandy loam	GM, ML, SM	A-1, A-2, A-4	0-6	0	65-90	55-90	40-70	20-55	15-25	NP-4	

## Data Source Information

Soil Survey Area: Middlesex County, Massachusetts  
 Survey Area Data: Version 13, Dec 17, 2013