Stormwater Management Report

Morrison Farm
116 - 120 Concord Road
Acton, MA

November 2015

COMMONWEALTH OF MASSACHUSETTS
DOUGLAS E. MILLER
CIVIL
No. 33965
REGISTERED PROFESSIONAL ENGINEER

11/11/15

Submitted to:
Acton Board of Selectmen and
Conservation Commission
Acton Town Hall
472 Main Street
Acton, MA 01720

Submitted by:
Morrison Farm Committee
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Project No:
121084

GPR Engineering Solutions for Land & Structures

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Attachments

"Notice of Intent - Morrison Farm, 120 Concord Road, Acton, MA" prepared for Morrison Farm Committee by Goldsmith, Prest & Ringwall, Inc. dated Nov. 2015.

Long-Term Pollution Prevention & Stormwater Operation and Maintenance Plan" prepared for

Section 1

Introduction and Methodology

Introduction and Methodology

This Stormwater Management Report is intended to accompany plans for the proposed parking and site improvements at Morrison Farm located at 116 - 120 Concord Road, Acton. MA. Included in this report are calculations that support a final engineering design as required by the state's Wetlands Protection Act Regulations and the Town of Acton's ordinances and regulations. Site specific information is presented under two scenarios, "pre-development" and "post-development" conditions, so that potential impacts due to the project can be identified, quantified and, as necessary, mitigated.

The final design intent seeks to meet the following interrelated goals:

1. Limit stormwater runoff rates for the 2- and 10-year storm events to existing (pre-development) levels;

2. Evaluate potential on- and off-site flooding during the 100-year storm event due to proposed development;

3. Maintain or increase the volume of stormwater recharged per storm event to those of existing (pre-development) levels;

4. Prevent appreciable sediment and other suspended solids and contaminants transport by trapping them on site via Best Management Practices;

5. Provide adequate drainage for new surfaces;

6. Maintain existing drainage patterns while providing a cost-effective engineering solution that addresses regulatory as well as real-world constraints.

Site Description

The proposed development is located at 116 -120 Concord Road, Acton, MA. It is located adjacent to Acton's Ice House Pond and off Great Road. The project area is comprised of two parcels, F4-34 and G4-27 per the Acton Town Assessor, and is currently used for recreation to the town's people as a nature walk with limited parking. To support the current use, the existing site provides gravel parking area that is approximately 8100± SF and a recycled asphalt product (RAP) boat launch that is approximately 1,030± SF. An existing foundation, which has become overrun with dense wooded vegetation over time, is centrally located within the project area. Bordering vegetated wetlands (BVW) exist along the bank of Ice House Pond, a tributary to Nashoba Brook on the eastern limit of the project area. From the shore of the pond, the BVW extends to the west, along the north of the existing foundation. A drainage swale which conveys stormwater from Concord Road into the northern BVW is also located to the west of the foundation. The site generally slopes from the southwest to the northeast with the existing foundation footing diverting stormwater along its edges. Existing grades of earth within foundation footing are relatively flat, ranging between 1 and 2 percent. Vehicular access from Concord Road into the site slopes

sharply downward, allowing stormwater from the street to outlet through the parking area directly into Ice House Pond.

The area of under study as part of the drainage analysis interest within the larger parcels is approximately 1± acre. It is mapped with soils consisting of Whitman fine sandy loam and Deerfield loamy sand. The Deerfield soils are typically associated with hydraulic soil group (HSG) B and with a HSG D paired with the Whitman soil areas. An onsite soil evaluation preformed on October 2, 2015, confirmed the patent soil within the project area to be loamy sands.

Under the pre-development scenario, the site has been divided into 2 subcatchments, as shown on the plan entitled "WATERSHED MAP – EXISTING CONDITIONS", included within the attached Appendix. These two subcatchments limit the watershed under study to a natural drainage boundary that encompasses the existing foundation, parking area, boat launch and section of the street that drains onto the site. In addition to the impervious surfaces described above, this site also consists of forested growth and brush. Subcatchment SC-1 outlines runoff generated within the existing foundation, flowing from the southern portion of the foundation to the BVW located to the north. Subcatchment SC-2 outlines runoff originating within the existing parking and access area, flowing to the east along the boat launch and ultimately into the pond.

Project Description

The proposed development's goal is to continue to use the project area as a recreational area available to Acton residents while expanding the available parking and trails along with associated Best Management Practices (BMP's) to attenuate and treat runoff prior to flowing into the surrounding resource areas. The project includes the installation of formal parking within the existing foundation along with a realigned access drive off of Concord Road. To minimize the developments footprint, Recycled Asphalt Product (RAP) will be used for the access drive and boat launch with the 26 proposed parking spaces being constructed of porous pavement. Also intended as part of the development is the rehab of the existing trail system, providing a 5-foot trail of handicap associable trail constructed with sections of woodcarpet and raised boardwalk.

Under the post-development scenario, the site has been divided into two subcatchments, shown on the plan entitled "WATERSHED MAP – DEVELOPED CONDITIONS", and included in the attached Appendix. Subcatchment SC-1 outlines rainfall onto the porous pavement. Due to design standards to provide a filtering and storage layer, the provided porous pavement retains and infiltrates calculated rainfall under all of the storm events analyzed. Subcatchment SC-2 outlines runoff generated from the RAP access drive area. Runoff generated within this subcatchment flows into a wet water quality swale, before continuing towards the pond via a pipe overflow. Surface runoff flow patterns of the proposed project have been maintained to those of pre-development conditions.

Hydrologic and Hydraulic Computation Methodology

Runoff rates and volumes were computed using the Soil Conservation Service TR-20 Method entitled "Urban Hydrology for Small Watersheds". The following 24-hour rainfall events were analyzed:

Frequency (years): 2, 10, and 100

Runoff from the site has been analyzed at two points under the pre-development and post-development conditions. As a standard for comparison, AP-1 and AP-2 are represented in both the pre and the post development cases. Analysis Point AP-1 represents runoff within the existing foundation / proposed parking area flowing to the BVW to the north. Analysis Point AP-2 represents calculated runoff to Ice House Pond from the access drive area.

Summary of Results

Peak discharge rates and volumes of the calculated runoff for both conditions analyzed are displayed in the HYDROLOGY SUMMARY that follows. As shown within the summary, the discharge rates and volumes at AP-1 and AP-2 under post-development conditions are less than or equal to those of pre-development conditions.

As outlined above and supported by the following computations, the proposed development will provide an expansion in recreational use to the residents of Acton while ensuring the reduced surface runoff to Ice House Pond and the surrounding BVW's is cleaner thru the TSS removal of the proposed BMP's while increasing groundwater infiltration to the surrounding area.

Section 2

Hydrology Summary for 24-hour Storm

HYDROLOGY SUMMARY FOR 24-HOUR STORM

Morrison Farm
116-120 Concord Road
Project No. 121084

PEAK DISCHARGE RATE

Pre-Development (cfs)

Analysis Point	2-YR	10-YR	100-YR
AP-1	0.1	0.4	1.0
AP-2	0.6	1.1	2.0

Development (cfs)

Analysis Point	2-YR	10-YR	100-YR
AP-1	0.0	0.0	0.0
AP-2	0.3	0.9	1.6

Pre-Development vs. Developed (cfs)

Analysis Point	2-YR	10-YR	100-YR
AP-1	**-0.1**	**-0.4**	**-1.0**
AP-2	**-0.3**	**-0.2**	**-0.4**

PEAK DISCHARGE VOLUME

Pre-Development (Cubic feet)

Analysis Point	2-YR	10-YR	100-YR
AP-1	593	1,636	3,620
AP-2	1,927	3,734	6,622

Development (Cubic feet)

Analysis Point	2-YR	10-YR	100-YR
AP-1	0	0	0
AP-2	690	2,127	4,721

Pre-Development vs. Developed (cubic feet)

Analysis Point	2-YR	10-YR	100-YR
AP-1	**-593**	**-1,636**	**-3,620**
AP-2	**-1,237**	**-1,607**	**-1,901**

Section 3

Mass DEP Stormwater Management Report Checklist

Massachusetts Department of Environmental Protection
Bureau of Resource Protection - Wetlands Program

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

The following checklist is intended to serve as a guide for applicants as to the elements that ordinarily need to be addressed in a complete Stormwater Report. The checklist is also intended to provide conservation commissions and other reviewing authorities with a summary of the components necessary for a comprehensive Stormwater Report that addresses the ten Stormwater Standards.

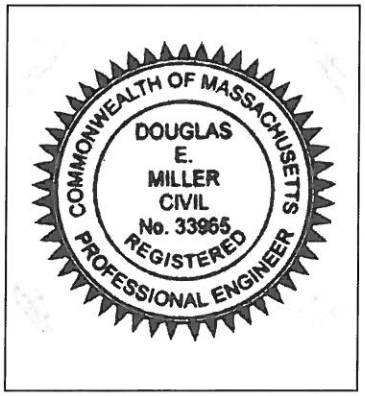
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the item is not applicable (N.A.) and provide the reasons for that determination.

A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan (if included), the Long-term Post-Construction Operation and Maintenance Plan, the Illicit Discharge Compliance Statement (if included) and the plans showing the stormwater management system, and have determined that they have been prepared in accordance with the requirements of the Stormwater Management Standards as further elaborated by the Massachusetts Stormwater Handbook. I have also determined that the information presented in the Stormwater Checklist is accurate and that the information presented in the Stormwater Report accurately reflects conditions at the site as of the date of this permit application.

Registered Professional Engineer Block and Signature



Doug E. C. Miller 11/11/15
Signature and Date

Checklist

Project Type: Is the application for new development, redevelopment, or a mix of new and redevelopment?

☐ New development

☐ Redevelopment

☒ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

LID Measures: Stormwater Standards require LID measures to be considered. Document what environmentally sensitive design and LID Techniques were considered during the planning and design of the project:

- ☐ No disturbance to any Wetland Resource Areas
- ☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- ☐ Reduced Impervious Area (Redevelopment Only)
- ☒ Minimizing disturbance to existing trees and shrubs
- ☐ LID Site Design Credit Requested:
  - ☐ Credit 1
  - ☐ Credit 2
  - ☐ Credit 3
- ☒ Use of "country drainage" versus curb and gutter conveyance and pipe
- ☐ Bioretention Cells (includes Rain Gardens)
- ☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- ☐ Treebox Filter
- ☐ Water Quality Swale
- ☐ Grass Channel
- ☐ Green Roof
- ☒ Other (describe): Porous Pavement, wet swale

Standard 1: No New Untreated Discharges

- ☒ No new untreated discharges
- ☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth
- ☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.

☒ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

☒ Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

☐ Required Recharge volume reduced through use of the LID site Design Credits.

☒ Sizing the infiltration, BMPs is based on the following method: Check the method used.

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

☐ Runoff from all impervious areas at the site discharging to the infiltration BMP.

☒ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.

☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.

☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:

- ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
- ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
- ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
- ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.

☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

[1] 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

☒ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.

☒ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

Standard 4: Water Quality

The Long-Term Pollution Prevention Plan typically includes the following:

- Good housekeeping practices;
- Provisions for storing materials and waste products inside or under cover;
- Vehicle washing controls;
- Requirements for routine inspections and maintenance of stormwater BMPs;
- Spill prevention and response plans;
- Provisions for maintenance of lawns, gardens, and other landscaped areas;
- Requirements for storage and use of fertilizers, herbicides, and pesticides;
- Pet waste management provisions;
- Provisions for operation and management of septic systems;
- Provisions for solid waste management;
- Snow disposal and plowing plans relative to Wetland Resource Areas;
- Winter Road Salt and/or Sand Use and Storage restrictions;
- Street sweeping schedules;
- Provisions for prevention of illicit discharges to the stormwater management system;
- Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
- Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
- List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.

☒ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.

☐ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:

- ☐ is within the Zone II or Interim Wellhead Protection Area
- ☐ is near or to other critical areas
- ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
- ☐ involves runoff from land uses with higher potential pollutant loads.

☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.

☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

☒ The BMP is sized (and calculations provided) based on:

- ☒ The ½" or 1" Water Quality Volume or
- ☐ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.

☐ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.

☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

Standard 5: Land Uses With Higher Potential Pollutant Loads (LUHPPLs)

☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.

☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted ***prior to*** the discharge of stormwater to the post-construction stormwater BMPs.

☒ The NPDES Multi-Sector General Permit does ***not*** cover the land use.

☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.

☐ All exposure has been eliminated.

☐ All exposure has ***not*** been eliminated and all BMPs selected are on MassDEP LUHPPL list.

☐ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

Standard 6: Critical Areas

☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.

☐ Critical areas and BMPs are identified in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 7: Redevelopments and Other Projects Subject to the Standards only to the maximum extent practicable

☐ The project is subject to the Stormwater Management Standards only to the maximum Extent Practicable as a:

- ☐ Limited Project
- ☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.
- ☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area
- ☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff
- ☐ Bike Path and/or Foot Path
- ☐ Redevelopment Project
- ☐ Redevelopment portion of mix of new and redevelopment.

☐ Certain standards are not fully met (Standard No. 1, 8, 9, and 10 must always be fully met) and an explanation of why these standards are not met is contained in the Stormwater Report.

☐ The project involves redevelopment and a description of all measures that have been taken to improve existing conditions is provided in the Stormwater Report. The redevelopment checklist found in Volume 2 Chapter 3 of the Massachusetts Stormwater Handbook may be used to document that the proposed stormwater management system (a) complies with Standards 2, 3 and the pretreatment and structural BMP requirements of Standards 4-6 to the maximum extent practicable and (b) improves existing conditions.

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control

A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan must include the following information:

- Narrative;
- Construction Period Operation and Maintenance Plan;
- Names of Persons or Entity Responsible for Plan Compliance;
- Construction Period Pollution Prevention Measures;
- Erosion and Sedimentation Control Plan Drawings;
- Detail drawings and specifications for erosion control BMPs, including sizing calculations;
- Vegetation Planning;
- Site Development Plan;
- Construction Sequencing Plan;
- Sequencing of Erosion and Sedimentation Controls;
- Operation and Maintenance of Erosion and Sedimentation Controls;
- Inspection Schedule;
- Maintenance Schedule;
- Inspection and Maintenance Log Form.

☒ A Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan containing the information set forth above has been included in the Stormwater Report.

Checklist for Stormwater Report

Checklist (continued)

Standard 8: Construction Period Pollution Prevention and Erosion and Sedimentation Control (continued)

☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has ***not*** been included in the Stormwater Report but will be submitted ***before*** land disturbance begins.

☒ The project is ***not*** covered by a NPDES Construction General Permit.

☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.

☐ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

Standard 9: Operation and Maintenance Plan

☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:

- ☒ Name of the stormwater management system owners;
- ☒ Party responsible for operation and maintenance;
- ☒ Schedule for implementation of routine and non-routine maintenance tasks;
- ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
- ☐ Description and delineation of public safety features;
- ☒ Estimated operation and maintenance budget; and
- ☒ Operation and Maintenance Log Form.

☐ The responsible party is ***not*** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:

- ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
- ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

Standard 10: Prohibition of Illicit Discharges

☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ An Illicit Discharge Compliance Statement is attached;

☐ NO Illicit Discharge Compliance Statement is attached but will be submitted ***prior to*** the discharge of any stormwater to post-construction BMPs.

Section 4

Appendix

Soil Map—Middlesex County, Massachusetts
(121084 - Morrison Farm)

Map Scale: 1:659 if printed on A landscape (11" x 8.5") sheet.

Meters: 0 5 10 20 30

Feet: 0 30 60 120 180

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:25,000.

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: http://websoilsurvey.nrcs.usda.gov
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: Middlesex County, Massachusetts
Survey Area Data: Version 15, Sep 28, 2015

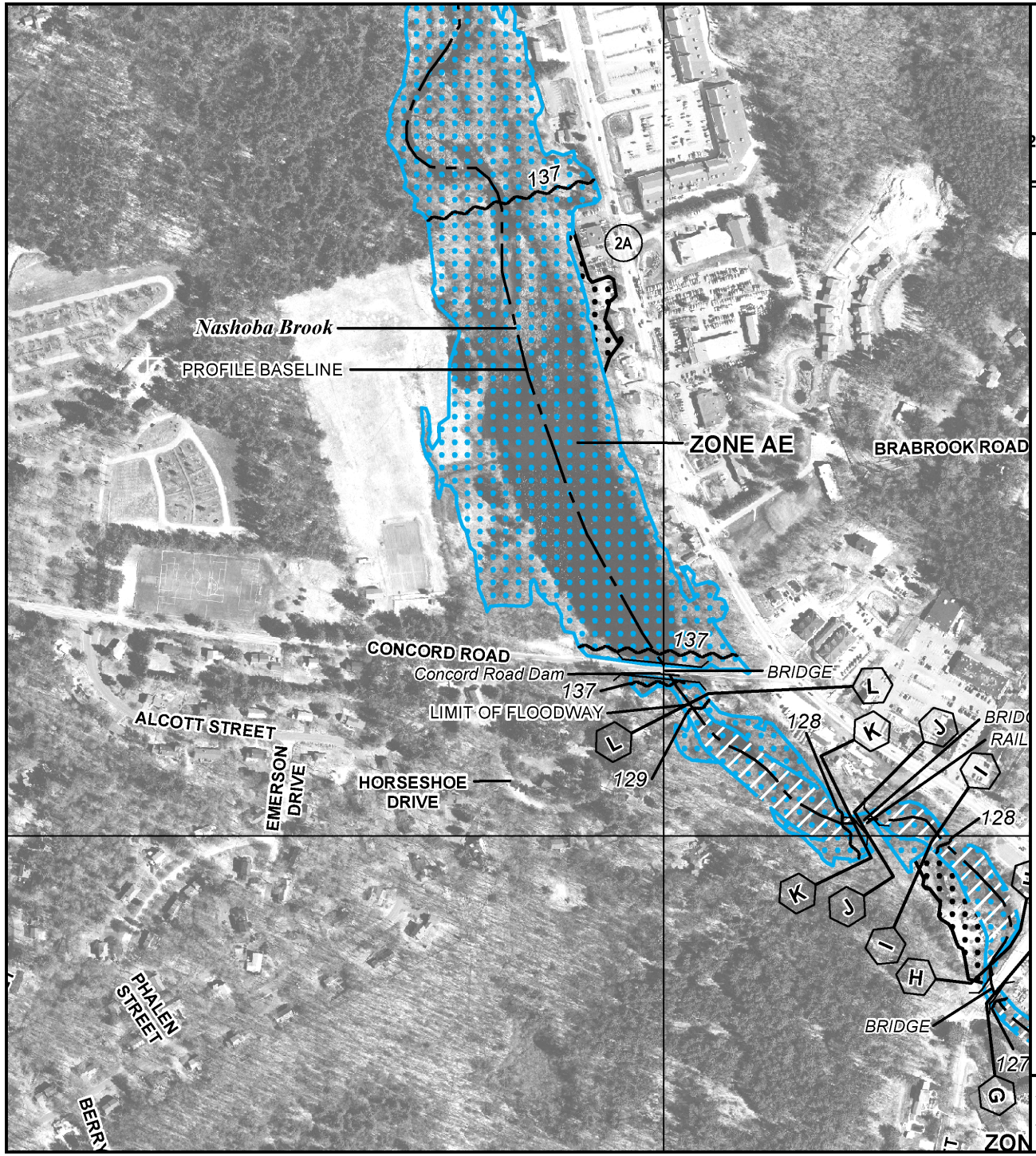
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Sep 12, 2014—Sep 28, 2014

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

Map Unit Legend

Middlesex County, Massachusetts (MA017)				
Map Unit Symbol	**Map Unit Name**	HSG	**Acres in AOI**	**Percent of AOI**
1	Water	-	0.0	1.9%
6A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	D	0.0	1.6%
73B	Whitman fine sandy loam, 0 to 5 percent slopes, extremely stony	D	0.4	25.6%
253C	Hinckley loamy sand, 8 to 15 percent slopes	A	0.1	7.7%
256B	Deerfield loamy sand, 3 to 8 percent slopes	B	1.0	63.3%
Totals for Area of Interest			**1.6**	**100.0%**



MAP SCALE 1" = 500'

250 0 500 1000

FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0356F

FIRM

FLOOD INSURANCE RATE MAP

MIDDLESEX COUNTY, MASSACHUSETTS

(ALL JURISDICTIONS)

PANEL 356 OF 656

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
ACTON, TOWN OF	250176	0356	F
CONCORD, TOWN OF	250189	0356	F

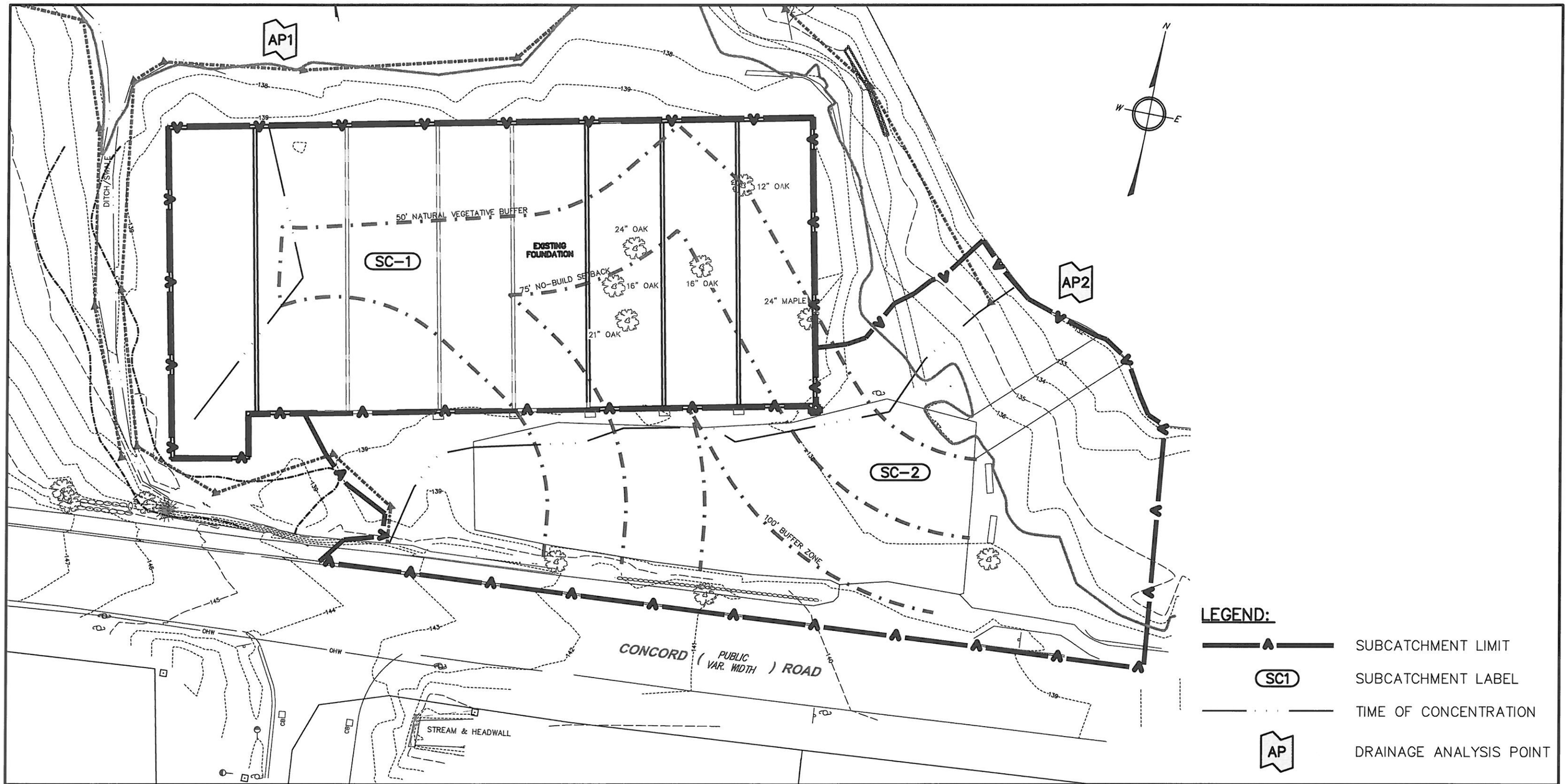
Notice to User: The **Map Number** shown below should be used when placing map orders; the **Community Number** shown above should be used on insurance applications for the subject community.

MAP NUMBER
25017C0356F

MAP REVISED
JULY 7, 2014

Federal Emergency Management Agency

This is an official copy of a portion of the above referenced flood map. It was extracted using F-MIT On-Line. This map does not reflect changes or amendments which may have been made subsequent to the date on the title block. For the latest product information about National Flood Insurance Program flood maps check the FEMA Flood Map Store at www.msc.fema.gov



GRAPHIC SCALE

30 0 15 30 60

(IN FEET)
1 INCH = 30 FEET

GPR
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PREPARED FOR:

MORRISON FARM COMMITTEE
472 MAIN STREET
ACTON, MA 01720

DES'D BY: JEG | CHK'D BY: DEM

DATE: NOVEMBER 2015

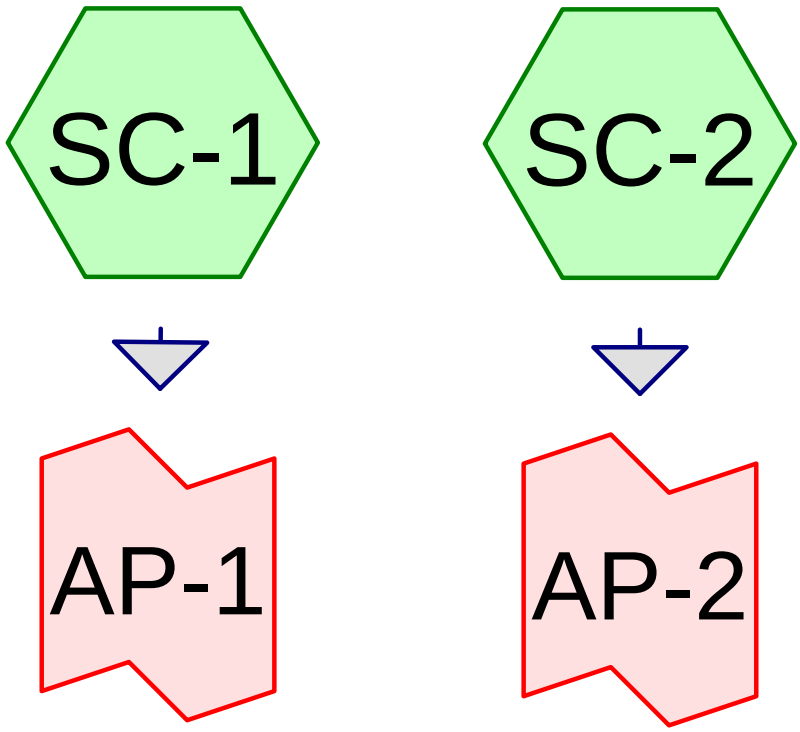
WATERSHED MAP EXISTING CONDITIONS

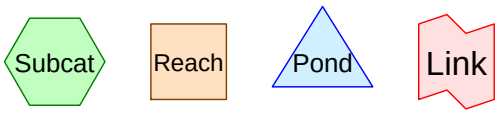
116 – 120 CONCORD ROAD
ACTON, MA

PROJECT: 121084 | PRE

P:\12---\121084\DWG\PERMIT\SITE IMPROVEMENTS.DWG 11-09-15 1:57:38 PM – LAYOUT PRE

PRE-DEVELOPMENT





Routing Diagram for PreDevelopment
Prepared by Goldsmith, Prest & Ringwall, Inc.
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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.096	56	Brush, Fair, HSG B (SC-2)
0.183	96	Gravel surface, HSG B (SC-2)
0.049	98	Paved roads w/curbs & sewers, HSG B (SC-2)
0.580	60	Woods, Fair, HSG B (SC-1, SC-2)
0.909	**69**	**TOTAL AREA**

Summary for Subcatchment SC-1:

Runoff = 0.1 cfs @ 12.20 hrs, Volume= 593 cf, Depth> 0.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Event Rainfall=3.10"

Area (sf)	CN	Description
19,291	60	Woods, Fair, HSG B
19,291		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
3.8	114	0.0100	0.50		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
8.4	124	Total			

Summary for Subcatchment SC-2:

Runoff = 0.6 cfs @ 12.12 hrs, Volume= 1,927 cf, Depth> 1.14"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Event Rainfall=3.10"

Area (sf)	CN	Description
4,195	56	Brush, Fair, HSG B
7,960	96	Gravel surface, HSG B
2,152	98	Paved roads w/curbs & sewers, HSG B
5,994	60	Woods, Fair, HSG B
20,300	77	Weighted Average
18,149		89.40% Pervious Area
2,152		10.60% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	28	0.0350	0.07		**Sheet Flow, Brush** Woods: Light underbrush n= 0.400 P2= 3.10"
0.3	16	0.0350	0.94		**Shallow Concentrated Flow, Shallow Concentrated** Woodland Kv= 5.0 fps
0.9	139	0.0150	2.49		**Shallow Concentrated Flow, Gravel Parking** Paved Kv= 20.3 fps
0.5	52	0.1000	1.58		**Shallow Concentrated Flow, Out to pond** Woodland Kv= 5.0 fps
8.0	235	Total			

Summary for Link AP-1:

Inflow Area = 0.443 ac, 0.00% Impervious, Inflow Depth > 0.37" for 2-yr Event event
Inflow = 0.1 cfs @ 12.20 hrs, Volume= 593 cf
Primary = 0.1 cfs @ 12.20 hrs, Volume= 593 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Link AP-2:

Inflow Area = 0.466 ac, 10.60% Impervious, Inflow Depth > 1.14" for 2-yr Event event
Inflow = 0.6 cfs @ 12.12 hrs, Volume= 1,927 cf
Primary = 0.6 cfs @ 12.12 hrs, Volume= 1,927 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Subcatchment SC-1:

Runoff = 0.4 cfs @ 12.14 hrs, Volume= 1,636 cf, Depth> 1.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Event Rainfall=4.50"

Area (sf)	CN	Description
19,291	60	Woods, Fair, HSG B
19,291		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
3.8	114	0.0100	0.50		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
8.4	124	Total			

Summary for Subcatchment SC-2:

Runoff = 1.1 cfs @ 12.12 hrs, Volume= 3,734 cf, Depth> 2.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Event Rainfall=4.50"

Area (sf)	CN	Description
4,195	56	Brush, Fair, HSG B
7,960	96	Gravel surface, HSG B
2,152	98	Paved roads w/curbs & sewers, HSG B
5,994	60	Woods, Fair, HSG B
20,300	77	Weighted Average
18,149		89.40% Pervious Area
2,152		10.60% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	28	0.0350	0.07		**Sheet Flow, Brush** Woods: Light underbrush n= 0.400 P2= 3.10"
0.3	16	0.0350	0.94		**Shallow Concentrated Flow, Shallow Concentrated** Woodland Kv= 5.0 fps
0.9	139	0.0150	2.49		**Shallow Concentrated Flow, Gravel Parking** Paved Kv= 20.3 fps
0.5	52	0.1000	1.58		**Shallow Concentrated Flow, Out to pond** Woodland Kv= 5.0 fps
8.0	235	Total			

Summary for Link AP-1:

Inflow Area = 0.443 ac, 0.00% Impervious, Inflow Depth > 1.02" for 10-yr Event event
Inflow = 0.4 cfs @ 12.14 hrs, Volume= 1,636 cf
Primary = 0.4 cfs @ 12.14 hrs, Volume= 1,636 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Link AP-2:

Inflow Area = 0.466 ac, 10.60% Impervious, Inflow Depth > 2.21" for 10-yr Event event
Inflow = 1.1 cfs @ 12.12 hrs, Volume= 3,734 cf
Primary = 1.1 cfs @ 12.12 hrs, Volume= 3,734 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Subcatchment SC-1:

Runoff = 1.0 cfs @ 12.13 hrs, Volume= 3,620 cf, Depth> 2.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Event Rainfall=6.50"

Area (sf)	CN	Description
19,291	60	Woods, Fair, HSG B
19,291		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow, Sheet Flow** Woods: Light underbrush n= 0.400 P2= 3.10"
3.8	114	0.0100	0.50		**Shallow Concentrated Flow, Shallow Concentrated Flow** Woodland Kv= 5.0 fps
8.4	124	Total			

Summary for Subcatchment SC-2:

Runoff = 2.0 cfs @ 12.11 hrs, Volume= 6,622 cf, Depth> 3.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Event Rainfall=6.50"

Area (sf)	CN	Description
4,195	56	Brush, Fair, HSG B
7,960	96	Gravel surface, HSG B
2,152	98	Paved roads w/curbs & sewers, HSG B
5,994	60	Woods, Fair, HSG B
20,300	77	Weighted Average
18,149		89.40% Pervious Area
2,152		10.60% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	28	0.0350	0.07		**Sheet Flow, Brush** Woods: Light underbrush n= 0.400 P2= 3.10"
0.3	16	0.0350	0.94		**Shallow Concentrated Flow, Shallow Concentrated** Woodland Kv= 5.0 fps
0.9	139	0.0150	2.49		**Shallow Concentrated Flow, Gravel Parking** Paved Kv= 20.3 fps
0.5	52	0.1000	1.58		**Shallow Concentrated Flow, Out to pond** Woodland Kv= 5.0 fps
8.0	235	Total			

Summary for Link AP-1:

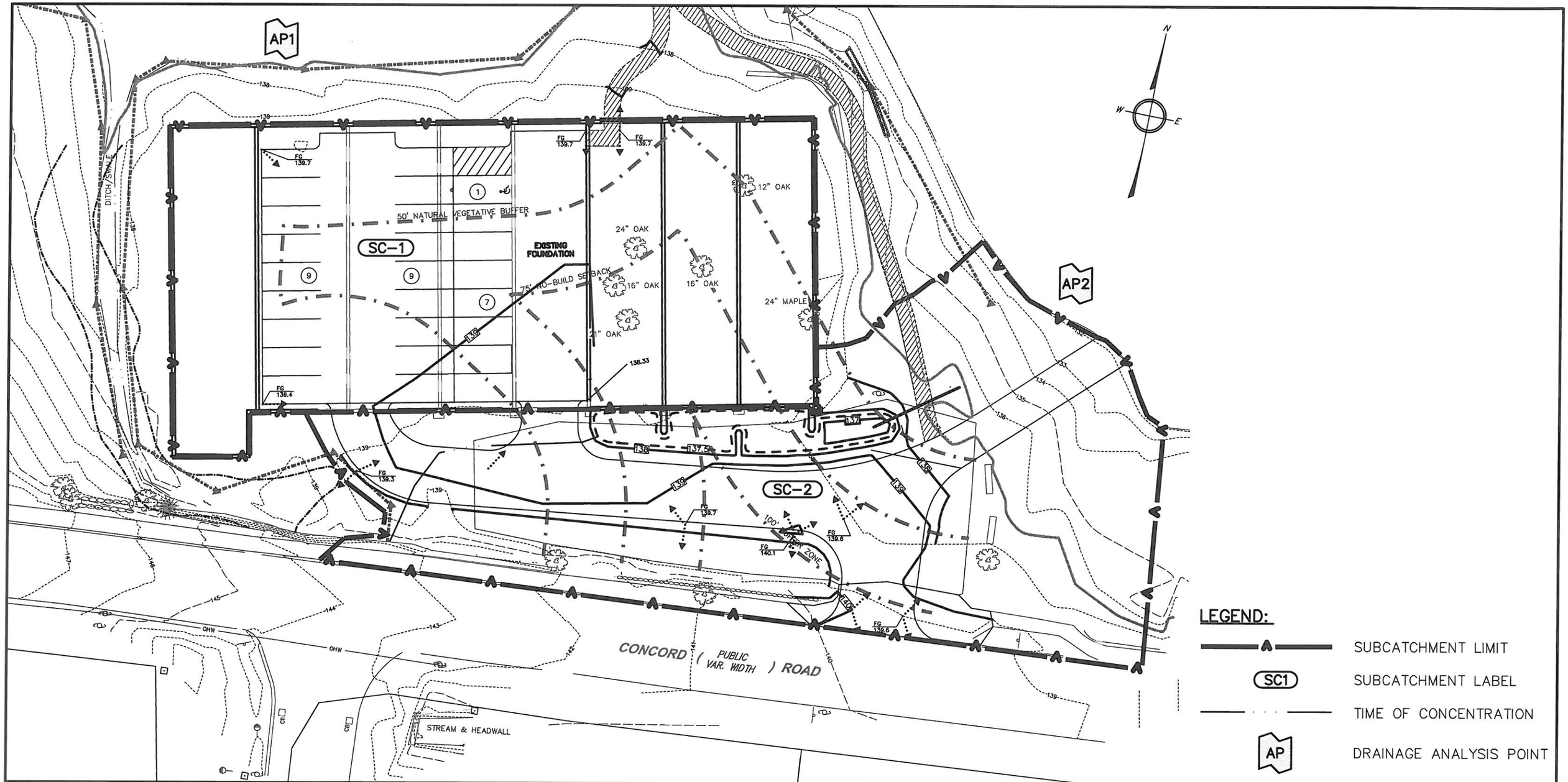
Inflow Area = 0.443 ac, 0.00% Impervious, Inflow Depth > 2.25" for 100-yr Event event
Inflow = 1.0 cfs @ 12.13 hrs, Volume= 3,620 cf
Primary = 1.0 cfs @ 12.13 hrs, Volume= 3,620 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Link AP-2:

Inflow Area = 0.466 ac, 10.60% Impervious, Inflow Depth > 3.91" for 100-yr Event event
Inflow = 2.0 cfs @ 12.11 hrs, Volume= 6,622 cf
Primary = 2.0 cfs @ 12.11 hrs, Volume= 6,622 cf, Atten= 0%, Lag= 0.0 min

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



GRAPHIC SCALE

30 0 15 30 60

(IN FEET)
1 INCH = 30 FEET

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472 MAIN STREET
ACTON, MA 01720

DES'D BY: JEG | CHK'D BY: DEM

DATE: NOVEMBER 2015

WATERSHED MAP DEVELOPED CONDITIONS

116 – 120 CONCORD ROAD
ACTON, MA

PROJECT: 121084 | POST

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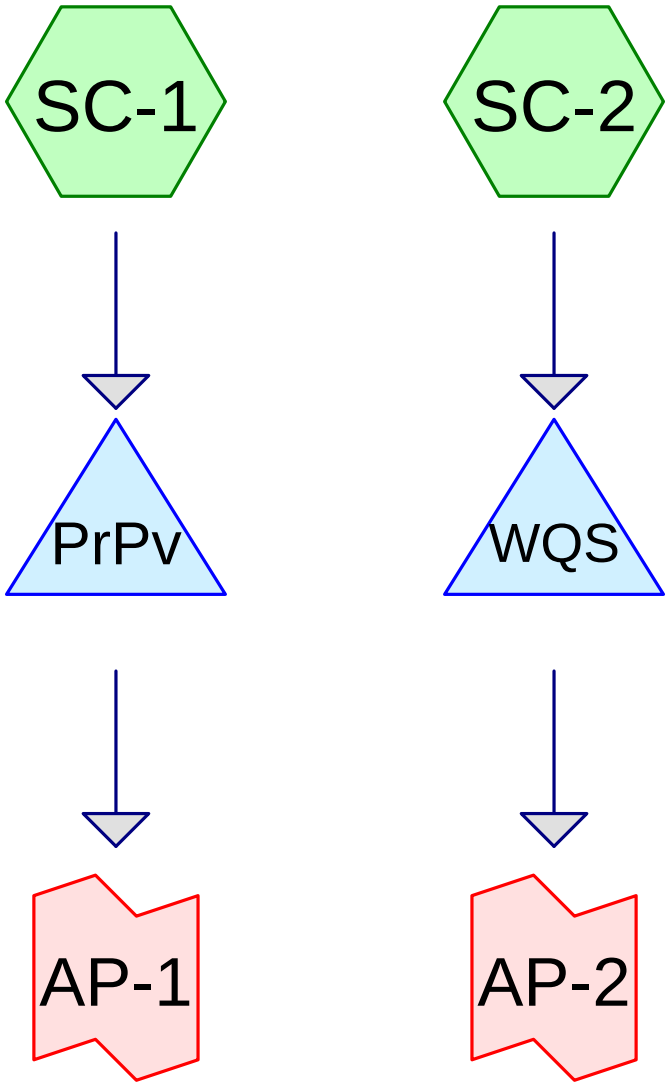
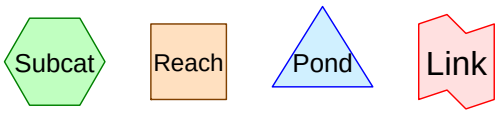
POST-DEVELOPMENT





Routing Diagram for PostDevelopment
Prepared by Goldsmith, Prest & Ringwall, Inc.
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Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.371	56	Brush, Fair, HSG B (SC-1, SC-2)
0.338	98	Paved parking, HSG B (SC-1, SC-2)
0.049	98	Paved roads w/curbs & sewers, HSG B (SC-2)
0.150	60	Woods, Fair, HSG B (SC-2)
0.909	**75**	**TOTAL AREA**

Summary for Subcatchment SC-1:

Runoff = 0.5 cfs @ 12.10 hrs, Volume= 1,739 cf, Depth> 1.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Event Rainfall=3.10"

Area (sf)	CN	Description
10,274	56	Brush, Fair, HSG B
9,016	98	Paved parking, HSG B
19,291	76	Weighted Average
10,274		53.26% Pervious Area
9,016		46.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow, through woods/brush** Woods: Light underbrush n= 0.400 P2= 3.10"
1.1	56	0.0300	0.87		**Shallow Concentrated Flow, to AP-2** Woodland Kv= 5.0 fps
5.7	66	Total			

Summary for Subcatchment SC-2:

Runoff = 0.5 cfs @ 12.12 hrs, Volume= 1,642 cf, Depth> 0.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-yr Event Rainfall=3.10"

Area (sf)	CN	Description
5,883	56	Brush, Fair, HSG B
5,727	98	Paved parking, HSG B
2,152	98	Paved roads w/curbs & sewers, HSG B
6,540	60	Woods, Fair, HSG B
20,302	74	Weighted Average
12,423		61.19% Pervious Area
7,879		38.81% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.10"
1.9	56	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.9	128	0.0150	2.49		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.0	5	0.0600	3.67		**Shallow Concentrated Flow, Grass Filter Strip** Grassed Waterway Kv= 15.0 fps
7.4	199	Total			

Summary for Pond PrPv:

Porous Pavement

Inflow Area =	0.443 ac,	46.74% Impervious,	Inflow Depth >	1.08"	for	2-yr Event event
Inflow =	0.5 cfs @	12.10 hrs,	Volume=	1,739 cf		
Outflow =	0.2 cfs @	12.39 hrs,	Volume=	1,744 cf,	Atten= 60%,	Lag= 17.5 min
Discarded =	0.2 cfs @	12.39 hrs,	Volume=	1,744 cf		
Primary =	0.0 cfs @	0.00 hrs,	Volume=	0 cf		

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 137.06' @ 12.39 hrs Surf.Area= 9,016 sf Storage= 209 cf
Flood Elev= 138.30' Surf.Area= 9,016 sf Storage= 4,688 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 4.2 min (860.7 - 856.6)

Volume	Invert	Avail.Storage	Storage Description
#1	137.00'	5,410 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc) 13,524 cf Overall x 40.0% Voids

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
137.00	9,016	0	0	9,016
138.00	9,016	9,016	9,016	9,396
138.30	9,016	2,705	11,721	9,510
138.50	9,016	1,803	13,524	9,586

Device	Routing	Invert	Outlet Devices
#1	Discarded	137.00'	**1.020 in/hr Exfiltration over Wetted area**
#2	Primary	138.30'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height

Discarded OutFlow Max=0.2 cfs @ 12.39 hrs HW=137.06' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.2 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=137.00' TW=0.00' (Dynamic Tailwater)
└**2=Sharp-Crested Rectangular Weir** (Controls 0.0 cfs)

Summary for Pond WQS:

Wet Water Quality Swale

Inflow Area =	0.466 ac,	38.81% Impervious,	Inflow Depth >	0.97"	for	2-yr Event event
Inflow =	0.5 cfs @	12.12 hrs,	Volume=	1,642 cf		
Outflow =	0.3 cfs @	12.25 hrs,	Volume=	1,549 cf,	Atten= 33%,	Lag= 8.0 min
Discarded =	0.0 cfs @	12.25 hrs,	Volume=	859 cf		
Primary =	0.3 cfs @	12.25 hrs,	Volume=	690 cf		

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Peak Elev= 137.61' @ 12.25 hrs Surf.Area= 996 sf Storage= 332 cf

Plug-Flow detention time= 87.6 min calculated for 1,549 cf (94% of inflow)
Center-of-Mass det. time= 57.8 min (922.3 - 864.5)

Volume	Invert	Avail.Storage	Storage Description
#1	137.00'	1,157 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
137.00	119	51.0	0	0	119
137.50	930	243.0	230	230	4,612
138.00	1,266	255.0	547	777	5,103
138.30	1,266	255.0	380	1,157	5,180

Device	Routing	Invert	Outlet Devices
#1	Discarded	137.00'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	137.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Device 2	135.30'	**10.0" Round Culvert** L= 30.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 135.30' / 135.00' S= 0.0100 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.55 sf
#4	Device 3	137.50'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.0 cfs @ 12.25 hrs HW=137.61' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.0 cfs)

Primary OutFlow Max=0.3 cfs @ 12.25 hrs HW=137.61' TW=0.00' (Dynamic Tailwater)
└─**2=Orifice/Grate** (Passes 0.3 cfs of 2.0 cfs potential flow)
  └─**3=Culvert** (Passes 0.3 cfs of 2.0 cfs potential flow)
    └─**4=Orifice/Grate** (Weir Controls 0.3 cfs @ 1.06 fps)

Summary for Link AP-1:

Inflow Area = 0.443 ac, 46.74% Impervious, Inflow Depth = 0.00" for 2-yr Event event
Inflow = 0.0 cfs @ 0.00 hrs, Volume= 0 cf
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Link AP-2:

Inflow Area = 0.466 ac, 38.81% Impervious, Inflow Depth = 0.41" for 2-yr Event event
Inflow = 0.3 cfs @ 12.25 hrs, Volume= 690 cf
Primary = 0.3 cfs @ 12.25 hrs, Volume= 690 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Subcatchment SC-1:

Runoff = 1.1 cfs @ 12.09 hrs, Volume= 3,421 cf, Depth> 2.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Event Rainfall=4.50"

Area (sf)	CN	Description
10,274	56	Brush, Fair, HSG B
9,016	98	Paved parking, HSG B
19,291	76	Weighted Average
10,274		53.26% Pervious Area
9,016		46.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow, through woods/brush** Woods: Light underbrush n= 0.400 P2= 3.10"
1.1	56	0.0300	0.87		**Shallow Concentrated Flow, to AP-2** Woodland Kv= 5.0 fps
5.7	66	Total			

Summary for Subcatchment SC-2:

Runoff = 1.0 cfs @ 12.11 hrs, Volume= 3,332 cf, Depth> 1.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-yr Event Rainfall=4.50"

Area (sf)	CN	Description
5,883	56	Brush, Fair, HSG B
5,727	98	Paved parking, HSG B
2,152	98	Paved roads w/curbs & sewers, HSG B
6,540	60	Woods, Fair, HSG B
20,302	74	Weighted Average
12,423		61.19% Pervious Area
7,879		38.81% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.10"
1.9	56	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.9	128	0.0150	2.49		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.0	5	0.0600	3.67		**Shallow Concentrated Flow, Grass Filter Strip** Grassed Waterway Kv= 15.0 fps
7.4	199	Total			

Summary for Pond PrPv:

Porous Pavement

Inflow Area =	0.443 ac,	46.74% Impervious,	Inflow Depth >	2.13"	for	10-yr Event event
Inflow =	1.1 cfs @	12.09 hrs,	Volume=	3,421 cf		
Outflow =	0.2 cfs @	12.55 hrs,	Volume=	3,424 cf,	Atten= 80%,	Lag= 27.8 min
Discarded =	0.2 cfs @	12.55 hrs,	Volume=	3,424 cf		
Primary =	0.0 cfs @	0.00 hrs,	Volume=	0 cf		

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 137.24' @ 12.55 hrs Surf.Area= 9,016 sf Storage= 869 cf
Flood Elev= 138.30' Surf.Area= 9,016 sf Storage= 4,688 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 24.6 min (861.1 - 836.5)

Volume	Invert	Avail.Storage	Storage Description
#1	137.00'	5,410 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc) 13,524 cf Overall x 40.0% Voids

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
137.00	9,016	0	0	9,016
138.00	9,016	9,016	9,016	9,396
138.30	9,016	2,705	11,721	9,510
138.50	9,016	1,803	13,524	9,586

Device	Routing	Invert	Outlet Devices
#1	Discarded	137.00'	**1.020 in/hr Exfiltration over Wetted area**
#2	Primary	138.30'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height

Discarded OutFlow Max=0.2 cfs @ 12.55 hrs HW=137.24' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.2 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=137.00' TW=0.00' (Dynamic Tailwater)
└**2=Sharp-Crested Rectangular Weir** (Controls 0.0 cfs)

Summary for Pond WQS:

Wet Water Quality Swale

Inflow Area =	0.466 ac,	38.81% Impervious,	Inflow Depth >	1.97"	for	10-yr Event event
Inflow =	1.0 cfs @	12.11 hrs,	Volume=	3,332 cf		
Outflow =	0.9 cfs @	12.16 hrs,	Volume=	3,149 cf,	Atten= 11%,	Lag= 3.1 min
Discarded =	0.0 cfs @	12.16 hrs,	Volume=	1,022 cf		
Primary =	0.9 cfs @	12.16 hrs,	Volume=	2,127 cf		

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Peak Elev= 137.72' @ 12.16 hrs Surf.Area= 1,070 sf Storage= 448 cf

Plug-Flow detention time= 52.8 min calculated for 3,143 cf (94% of inflow)
Center-of-Mass det. time= 23.9 min (867.1 - 843.2)

Volume	Invert	Avail.Storage	Storage Description
#1	137.00'	1,157 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
137.00	119	51.0	0	0	119
137.50	930	243.0	230	230	4,612
138.00	1,266	255.0	547	777	5,103
138.30	1,266	255.0	380	1,157	5,180

Device	Routing	Invert	Outlet Devices
#1	Discarded	137.00'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	137.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Device 2	135.30'	**10.0" Round Culvert** L= 30.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 135.30' / 135.00' S= 0.0100 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.55 sf
#4	Device 3	137.50'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.0 cfs @ 12.16 hrs HW=137.72' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.0 cfs)

Primary OutFlow Max=0.9 cfs @ 12.16 hrs HW=137.72' TW=0.00' (Dynamic Tailwater)
└─**2=Orifice/Grate** (Passes 0.9 cfs of 2.2 cfs potential flow)
  └─**3=Culvert** (Passes 0.9 cfs of 2.2 cfs potential flow)
    └─**4=Orifice/Grate** (Weir Controls 0.9 cfs @ 1.52 fps)

Summary for Link AP-1:

Inflow Area = 0.443 ac, 46.74% Impervious, Inflow Depth = 0.00" for 10-yr Event event
Inflow = 0.0 cfs @ 0.00 hrs, Volume= 0 cf
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Link AP-2:

Inflow Area = 0.466 ac, 38.81% Impervious, Inflow Depth = 1.26" for 10-yr Event event
Inflow = 0.9 cfs @ 12.16 hrs, Volume= 2,127 cf
Primary = 0.9 cfs @ 12.16 hrs, Volume= 2,127 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Subcatchment SC-1:

Runoff = 2.0 cfs @ 12.09 hrs, Volume= 6,128 cf, Depth> 3.81"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Event Rainfall=6.50"

Area (sf)	CN	Description
10,274	56	Brush, Fair, HSG B
9,016	98	Paved parking, HSG B
19,291	76	Weighted Average
10,274		53.26% Pervious Area
9,016		46.74% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow, through woods/brush** Woods: Light underbrush n= 0.400 P2= 3.10"
1.1	56	0.0300	0.87		**Shallow Concentrated Flow, to AP-2** Woodland Kv= 5.0 fps
5.7	66	Total			

Summary for Subcatchment SC-2:

Runoff = 1.9 cfs @ 12.11 hrs, Volume= 6,100 cf, Depth> 3.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-yr Event Rainfall=6.50"

Area (sf)	CN	Description
5,883	56	Brush, Fair, HSG B
5,727	98	Paved parking, HSG B
2,152	98	Paved roads w/curbs & sewers, HSG B
6,540	60	Woods, Fair, HSG B
20,302	74	Weighted Average
12,423		61.19% Pervious Area
7,879		38.81% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.6	10	0.0100	0.04		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.10"
1.9	56	0.0100	0.50		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
0.9	128	0.0150	2.49		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
0.0	5	0.0600	3.67		**Shallow Concentrated Flow, Grass Filter Strip** Grassed Waterway Kv= 15.0 fps
7.4	199	Total			

Summary for Pond PrPv:

Porous Pavement

Inflow Area =	0.443 ac,	46.74% Impervious,	Inflow Depth >	3.81"	for	100-yr Event event
Inflow =	2.0 cfs @	12.09 hrs,	Volume=	6,128 cf		
Outflow =	0.2 cfs @	12.88 hrs,	Volume=	6,133 cf,	Atten= 89%,	Lag= 47.2 min
Discarded =	0.2 cfs @	12.88 hrs,	Volume=	6,133 cf		
Primary =	0.0 cfs @	0.00 hrs,	Volume=	0 cf		

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Peak Elev= 137.59' @ 12.88 hrs Surf.Area= 9,016 sf Storage= 2,145 cf
Flood Elev= 138.30' Surf.Area= 9,016 sf Storage= 4,688 cf

Plug-Flow detention time= (not calculated: outflow precedes inflow)
Center-of-Mass det. time= 76.8 min (896.6 - 819.8)

Volume	Invert	Avail.Storage	Storage Description
#1	137.00'	5,410 cf	**Custom Stage Data (Pyramidal)** Listed below (Recalc) 13,524 cf Overall x 40.0% Voids

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
137.00	9,016	0	0	9,016
138.00	9,016	9,016	9,016	9,396
138.30	9,016	2,705	11,721	9,510
138.50	9,016	1,803	13,524	9,586

Device	Routing	Invert	Outlet Devices
#1	Discarded	137.00'	**1.020 in/hr Exfiltration over Wetted area**
#2	Primary	138.30'	**4.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 1.0' Crest Height

Discarded OutFlow Max=0.2 cfs @ 12.88 hrs HW=137.59' (Free Discharge)
└**1=Exfiltration** (Exfiltration Controls 0.2 cfs)

Primary OutFlow Max=0.0 cfs @ 0.00 hrs HW=137.00' TW=0.00' (Dynamic Tailwater)
└**2=Sharp-Crested Rectangular Weir** (Controls 0.0 cfs)

Summary for Pond WQS:

Wet Water Quality Swale

Inflow Area =	0.466 ac,	38.81% Impervious,	Inflow Depth >	3.61"	for	100-yr Event event
Inflow =	1.9 cfs @	12.11 hrs,	Volume=	6,100 cf		
Outflow =	1.6 cfs @	12.16 hrs,	Volume=	5,867 cf,	Atten= 15%,	Lag= 3.3 min
Discarded =	0.0 cfs @	12.16 hrs,	Volume=	1,146 cf		
Primary =	1.6 cfs @	12.16 hrs,	Volume=	4,721 cf		

Routing by Dyn-Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Peak Elev= 137.85' @ 12.16 hrs Surf.Area= 1,160 sf Storage= 595 cf

Plug-Flow detention time= 34.0 min calculated for 5,855 cf (96% of inflow)
Center-of-Mass det. time= 12.9 min (838.7 - 825.8)

Volume	Invert	Avail.Storage	Storage Description
#1	137.00'	1,157 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
137.00	119	51.0	0	0	119
137.50	930	243.0	230	230	4,612
138.00	1,266	255.0	547	777	5,103
138.30	1,266	255.0	380	1,157	5,180

Device	Routing	Invert	Outlet Devices
#1	Discarded	137.00'	**1.020 in/hr Exfiltration over Surface area**
#2	Primary	137.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Device 2	135.30'	**10.0" Round Culvert** L= 30.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 135.30' / 135.00' S= 0.0100 '/' Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 0.55 sf
#4	Device 3	137.50'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.0 cfs @ 12.16 hrs HW=137.85' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.0 cfs)

Primary OutFlow Max=1.5 cfs @ 12.16 hrs HW=137.85' TW=0.00' (Dynamic Tailwater)
└─**2=Orifice/Grate** (Passes 1.5 cfs of 2.4 cfs potential flow)
└─**3=Culvert** (Passes 1.5 cfs of 2.4 cfs potential flow)
└─**4=Orifice/Grate** (Orifice Controls 1.5 cfs @ 2.83 fps)

Summary for Link AP-1:

Inflow Area = 0.443 ac, 46.74% Impervious, Inflow Depth = 0.00" for 100-yr Event event
Inflow = 0.0 cfs @ 0.00 hrs, Volume= 0 cf
Primary = 0.0 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 0%, Lag= 0.0 min

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

Summary for Link AP-2:

Inflow Area = 0.466 ac, 38.81% Impervious, Inflow Depth > 2.79" for 100-yr Event event
Inflow = 1.6 cfs @ 12.16 hrs, Volume= 4,721 cf
Primary = 1.6 cfs @ 12.16 hrs, Volume= 4,721 cf, Atten= 0%, Lag= 0.0 min

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

Stormwater Management Standard 3
GROUNDWATER RECHARGE

Morrison Farm
116-120 Concord Road
Project No. 121084

Pre-Development Conditions

		Area (sf)	Area (Ac)
Total Subcatchment Areas		39,591	0.91
Total Area of Hydrolic Soil Groups	B	39,591	0.91
Surface Type Areas			
Paved, Gravel & Other Impervious Areas	B	10,111	0.23
Woods	B	25,285	0.58
Brush	B	4,195	0.10
Total Impervious Area	B	10,111	

Infiltration Volume

Inches of Recharge per Storm Event	B	0.35

Infiltration Volume =∑ {[(Total Subcatchment Area within HSG) - (Total Impervious Area within HSG)] x (inches of Recharge Per Storm)}

Infiltration Volume **860 CF**

Stormwater Management Standard 3
GROUNDWATER RECHARGE

Post Development Conditions

Morrison Farm
116-120 Concord Road
Project No. 121084

		Area (sf)	Area (Ac)
Total Subcatchment Area		39,591	0.91
Total Area of Hydrolic Soil Groups	B	39,591	0.91
Surface Type Areas			
Paved & Other Impervious Areas	B	16,894	0.39
Woods	B	6,540	0.15
Grass/Landscape Areas	B	16,157	0.37
Total Impervious Area	B	16,894	0.39

Infiltration Volume

Inches of Recharge per Storm Event B 0.35

Infiltration Volume = ∑ {[(Total Subcatchment Area within HSG) - (Total Impervious Area within HSG)] x (inches of Recharge Per Storm)}

Natural Infiltration Volume	662	CF	
Pre-Development Infiltration Volume	860	CF	
Required Iniltration Volume	**198**	**CF**	

Provided Infiltration Volume

Pervious Pavement	2,145	CF	* - Storage during 100-yr event
Wet Swale	230	CF	* - volume below overflow inlet grate
Total Provided Iniltration Volume	**2,375**	**CF**	

Stormwater Management Standard 3
GROUNDWATER RECHARGE

Infiltration Area Requirements

Morrison Farm
116-120 Concord Road
Project No. 121084

Drawdown Time

(Per Massachusetts Stormwater regulations, infiltration areas must completely drain within 72 hours)

		Pervious Pavement
Infiltration Area Storage Volume	cf	2,145
Design infiltration Rate	in/hr	1.02
Infiltration Bottom Area	sf	9,016

Drawdown Time = Infiltration Area Storage Volume / [Design Infiltration Rate x Infiltration Area Bottom Area]

Drawdown Time (Hrs)	**2.8**

Mounding Analysis

Per the Massachusetts Stormwater Handbook, mounding analysis is required when ".. The vertical separation from the bottom of an exfiltration system to seasonal high groundwater is less than four (4) feet and the recharge system is proposed to attenuate the peak discharge from a 10-year or higher 24-hour storm." The mounding analysis "... must show that the REQUIRED RECHARGE VOLUME is fully dewatered within 72 hours..."

Pervious Pavement			
Hydraulic Conductivity	ft/day	16	Standard Value for "Fine Sand" material
Specific Yield		0.23	Standard Value for "Fine Sand" material
Initial Saturated Thickness	ft	10	Depth to bedrock
Design Recharge Rate	ft/day	2.04	infiltration rate
Time	days	3	Minimum 72 hr evaluation period
Bottom Infiltrating Area	sf	9,016	
Length of Infiltration Area	ft	81	
Width of Infiltration Area	ft	111.3	
Time when Infiltration Stops	days	0.12	Calculated Drawdown Time (see Above)
Maximum Water table rise at 72 hours[1]	**ft**	**0.31**	
	in	**3 5/8**	

- Resulting mound will not interfere with the full draining of the infiltration area in accordance with Mass Stormwater Standards -

[1] - mounding analysis calculated using the Hantush (1967) method. Automated calculator available online from the Aquifer Test Forum sponsored by HydroSOLVE, Inc.

Stormwater Management Standard 4
WATER QUALITY RETENTION VOLUME

Morrison Farm
116-120 Concord Road
Project No. 121084

Parameter	Unit	Quantity	Remarks
Watershed area	sf	39,591	
Predevelopment impervious area	sf	10,111	
Total impervious area added	sf	6,783	
Total impervious area	sf	16,894	
Total impervious area required for retention	sf	6,783	
Runoff depth over impervious area	IN	0.5	
REQUIRED WATER QUALITY RETENTION VOLUME			**VOLUME PROVIDED BY:**
	CF	**283**	
DESIGN VOLUME PROVIDED	**CF**	2,145	Pervious Pavement

Stormwater Management Standard 4
TSS REMOVAL

Morrison Farm
116-120 Concord Road
Project No. 121084

Process Train No.	Impervious Area (SF)	BMP Type	TSS Removal Rate	TSS Remaining at Discharge	TSS Removed at Discharge
SC1	9,016	Por. Pvmt*	100%	0%	100%
SC2	7,879	Wet WQS	70%	30%	70%
Total:	16,895			Weighted Average =	**86%**

ABBREVIATIONS:

TSS=total suspended solids; SC=subcatchment; SS = Street Sweeping; GC=grassed channel; AP=analysis point; BMP=best management practices; TB = Tree Box Filter; BIO=bioretention area; CB=deep sump catch basin; FB = Sediment Forebay; WQS = Water Quality Swale

***** - 100% TSS removal rate used for Pervious Opavement rather than typical 80% value due to lack of runofff in all storm events analized.