Subdivision
Engineering Drainage Calculations
For
Sleepy Hollow Road
Board of Survey Roadway
at
178 Marsh Street
Belmont, Massachusetts

Prepared by

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TOWN OF BELMONT
Checklist for Stormwater Management and Erosion Control Report

A. Introduction

Important: When filling out forms on the computer, use only the tab key to move your cursor - do not use the return key.

A Stormwater Management and Erosion Control Report must be submitted with the building permit application for a project that is covered by the Town of Belmont Stormwater Management and Erosion Control Bylaw. The following checklist is NOT a substitute for the Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management and Erosion Control documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Report must contain the engineering computations and supporting information set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Stormwater Report must be prepared and certified by a Registered Professional Engineer (RPE) licensed in the Commonwealth.

The Report must include:

- The Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Report.
- Applicant/Project Name
- Project Address
- Name of Firm and Registered Professional Engineer that prepared the Report
- Long-Term Pollution Prevention Plan required by Standards 4-6
- Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan required by Standard 8[2]
- Operation and Maintenance Plan required by Standard 9

In addition to all plans and supporting information, the Report must include a brief narrative describing stormwater management practices, including environmentally sensitive site design and LID techniques, along with a diagram depicting runoff through the proposed BMP treatment train. Plans are required to show existing and proposed conditions, identify all wetland resource areas, NRCS soil types, critical areas, Land Uses with Higher Potential Pollutant Loads (LUHPPL), and any areas on the site where infiltration rate is greater than 2.4 inches per hour. The Plans shall identify the drainage areas for both existing and proposed conditions at a scale that enables verification of supporting calculations.

As noted in the Checklist, the Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook. The Report shall also document compliance with the Stormwater Management and Erosion Control Bylaw recognizing the bylaw contains provisions that could be more strict or broader in scope than the Stormwater Management Standards.

To ensure that the Report is complete, applicants are required to fill in the Report Checklist by checking the box to indicate that the specified information has been included in the Report. If any of the information specified in the checklist has not been submitted, the applicant must provide an explanation. The completed Stormwater Management and Erosion Control Checklist and Certification must be

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[1] The Stormwater Report may also include the Illicit Discharge Compliance Statement required by Standard 10. If not included in the Stormwater Report, the Illicit Discharge Compliance Statement must be submitted prior to the discharge of stormwater runoff to the post-construction best management practices.

[2] For some complex projects, it may not be possible to include the Construction Period Erosion and Sedimentation Control Plan in the Stormwater Report. In that event, the issuing authority has the discretion to issue a permit that approves the project and includes a condition requiring the proponent to submit the Construction Period Erosion and Sedimentation Control Plan before commencing any land disturbance activity on the site.

B. Report 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 Report. The checklist is also intended to provide the reviewing authority with a summary of the components necessary for a comprehensive Report that addresses the ten Stormwater Standards.

Note: Because stormwater requirements vary from project to project, it is possible that a complete 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 Report.

Registered Professional Engineer's Certification

I have reviewed the Stormwater Management and Erosion Control Report, including the soil evaluation, computations, Long-term Pollution Prevention Plan, the Construction Period Erosion and Sedimentation Control Plan, 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

Signature and Date   10/19/2016

TOWN OF BELMONT
Checklist for Stormwater Management and Erosion Control Report

60-325 - Stormwater Management and Erosion Control Bylaw (excerpt)

F   **Stormwater Management and Erosion Control**

F (1) Regulated Activities

A Stormwater Management and Erosion Control Permit shall be required prior to undertaking any land disturbance that involves:

- (a) An alteration that will result in land disturbances of 2,500 square feet of total area or more, or that is part of a common plan for development that will disturb 2,500 square feet or more;
- (b) An alteration that will increase the amount of a lot's impervious surface area to more than 25% of the lot's total area; or
- (c) Storage or permanent placement of more than 100 cubic yards of excavated material, fill, snow or ice.

F (3) General Requirements

(a) An Operation and Maintenance Plan shall be submitted to the OCD for approval prior to the issuance of a Stormwater Management and Erosion Control Permit. The Operation and Maintenance Plan shall be designed to ensure compliance with the Stormwater Management and Erosion Control Permit, this Bylaw, and the Massachusetts Surface Water Quality Standards, 314 CMR 4.00, in all seasons and throughout the life of the system.

(b) As-built drawings showing all stormwater management systems shall be submitted to the OCD at the completion of a project.

(c) The OCD may require the applicant to contribute to the cost of design, construction, and maintenance of a public or shared stormwater facility in lieu of an onsite stormwater facility where the OCD determines that there are not sufficient site conditions for onsite Best Management Practices that will satisfy the design criteria set forth in Section 34.6.4.1 of this Bylaw and the performance standards set forth in the regulations promulgated under this Bylaw. Funds so contributed may be used to design, construct, and maintain stormwater projects that will improve the quality and quantity of surface waters in Belmont by treating and recharging stormwater from existing impervious surfaces that is now discharged to said waters with inadequate treatment or recharge. The amount of any required contribution to the fund shall be determined by the OCD pursuant to standards established in the Regulations adopted pursuant to this Bylaw.

F (4) Design Criteria (The Report shall consider all of the design criteria below)

All Development shall satisfy the following design criteria:

- (a) Compliance with all applicable provisions of the Stormwater Management Standards, regardless of the proximity of the development to resource areas or their buffer zones, as defined by the *Wetlands Protection Act, M.G.L.* c. 131, § 40 and its implementing regulations.
- (b) Erosion and sediment controls must be implemented to prevent adverse impacts during disturbance and construction activities.
- (c) There shall be no change to the existing conditions of abutting properties from any increase in volume of stormwater runoff or from erosion, silting, flooding, sedimentation or impacts to wetlands, ground water levels or wells.
- (d) When any proposed discharge may have an impact upon streams, wetlands and/or storm sewers, the OCD may require minimization or elimination of this impact based on site conditions and existing stormwater system capacity.

TOWN OF BELMONT
Checklist for Stormwater Management and Erosion Control Report

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

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

☐ 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): _SUBSURFACE DRAINAGE_

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.

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.

☑ Any potential change to the existing conditions of abutting properties from any increase in volume of stormwater runoff have been identified in the Report

☑ The Report provides calculations demonstrating that the post-development discharge volume is equal to or less than the pre-development discharge volume from the 2-year and the 10-year 24-hour storms.

☑ The Report provides a quantitative impact of discharge volumes from the 100-year 24-hour storm. If this evaluation shows that increased off-site flooding result from the discharge volumes from the 100-year 24-hour storms, BMPs also are described in the Report that the applicant will implement and maintained to attenuate these discharges.

☑ Any potential change to the existing conditions of abutting properties from erosion, silting, flooding, or sedimentation have been identified in the Report.

☑ The Report describes the practices and controls that the Applicant will implement and maintain to prevent adverse impacts from erosion, silting, flooding, or sedimentation.

☑ Any potential impacts to wetlands have been identified in the Report.

☑ The Report describes the practices and controls that the Applicant will implement and maintain to prevent adverse impacts to wetlands.

Additional Requirements for Projects other than One and Two Family Developments:

☑ Any potential impacts to ground water levels or wells have been identified in the Report, including quantitative projections of changes in the seasonal high water table and quantitative projections of storm-related short-term mounding calculations associated with infiltration BMPs for a 24-hour 10 year design storm.

☐ The Report describes the practices and controls that the Applicant will implement and maintain (if required) to prevent adverse impacts to ground water levels or wells for a 24-hour 10 year design storm.

Requirements Specific to Section F (4)(d)

☑ Is stormwater from the pre-development site discharged directly to (check all that apply):

☐ A surface water body (specify the water body)

☐ The Belmont MS4 (storm sewers)

☐ Another MS4 (specify the MS4)

☑ Other (specify)   LEACHING PIT ON MARSH STREET

☑ Will stormwater from the post-development site be discharges directly to (check all that apply):

☐ A surface water body (specify the water body)

☐ The Belmont MS4 (storm sewers)

☐ Another MS4 (specify the MS4)

☑ Other (specify)   LEACHING PIT ON MARSH STREET

☑ Any potential impacts upon streams, wetlands and/or storm sewers have been identified in the Report. (Explain in Report narrative)

☑ These will be prevented with mitigating measures that the Applicant will implement and maintain (explain in Report narrative)

☐ These will be prevented without mitigating measures (explain in Report narrative)

☑ The Report describes the practices and controls that the Applicant will implement and maintain to prevent any adverse impacts to streams, wetlands and/or storm sewers.

Additional Requirements for Projects other than One and Two Family Developments:

☐ If the discharge is to an MS4, a certification that the discharge meets Massachusetts Surface Water Quality Standards and any applicable approved Total Maximum Daily Load (TMDL) waste load allocation is included in the Report.

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.

☑ 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

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.

☑ 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.

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.

☑ Adverse impacts due to erosion, sedimentation, or both during disturbance and construction activities are prevented:

☑ With erosion and sediment controls that the Applicant will implemented and maintain (explain in Report narrative)

☐ Without erosion and sediment controls (explain in Report narrative)

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

☐ 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.

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Project Narrative

The project consists of the redevelopment of a 6.864 +/- acre lot at 178 Marsh Street, Belmont. Under existing conditions, the site contains a 2.5 story single family home with a driveway and garage, two Isolated Lands Subject to Flooding (I.L.S.F), and a Bordering Vegetated Wetland (BVW). Woodbine Road meets the lot at its rear, northwesterly side.

The proposed development layout consists of a 751.5 foot road to be located on the westerly side of the property, named Sleepy Hollow Road, ending in a cul-de-sac. New utility services would include, an 8" water line, 2 fire hydrants, 8" sanitary sewer, and 12" stormwater sewer. The 8" water line would connect the existing services on Marsh Street (8") and Woodbine Road (10"), running cross country from the end of the proposed cul-de-sac to Woodbine Road via a utility easement.

Two walls totaling approximately 600 linear feet would need to be constructed in order to raise the existing grade for the road. A culvert system would then need to be installed under the road to allow for stormwater runoff from off-site properties to flow into the I.L.S.F. All of the roadway drainage, with the exception of the entrance area, is routed via catch basins, drain manholes, a sediment and oil separator, and leaching pit into a detention/infiltration basin, with an overflow to the I.L.S.F.

All work required for the construction of the roadway, is proposed outside of the 100' Buffer Zone of the BVW.

Summary of Results:

The following table summarizes the peak flows and volumes from the property under Existing and Proposed Conditions.

Table 1: Summary of Stormwater Runoff and Volume to Wetlands (1R)

Storm Event	Existing Conditions Peak		Proposed Conditions Peak		Δ	
	Runoff (cfs)	Volume (af)	Runoff (cfs)	Volume (af)	Runoff (cfs)	Volume (af)
2-Year (3.21 in)	14.99	1.805	14.85	1.718	-0.14	-0.087
10-Year (4.86 in)	39.92	4.319	36.90	4.221	-3.02	-0.098
100-Year (8.84 in)	113.10	11.454	112.34	11.348	-0.76	-0.106

Table 2: Summary of Stormwater Runoff and Volume to Marsh Street (1S)

Storm Event	Existing Conditions Peak		Proposed Conditions Peak		Δ	
	Runoff (cfs)	Volume (af)	Runoff (cfs)	Volume (af)	Runoff (cfs)	Volume (af)
2-Year (3.21 in)	0.41	0.033	0.32	0.026	-0.09	-0.007
10-Year (4.86 in)	1.04	0.077	0.83	0.061	-0.21	-0.016
100-Year (8.84 in)	2.84	0.206	2.31	0.168	-0.53	-0.038

Table 3: Summary of Stormwater Runoff and Volume to Site Depression (3S+4S+5S)

Storm Event	Existing Conditions Peak		Proposed Conditions Peak		Δ	
	Runoff (cfs)	Volume (af)	Runoff (cfs)	Volume (af)	Runoff (cfs)	Volume (af)
2-Year (3.21 in)	6.90	0.605	5.60	0.533	-1.30	-0.072
10-Year (4.86 in)	17.11	1.396	14.07	1.226	-3.04	-0.170
100-Year (8.84 in)	46.45	3.757	38.45	3.291	-8.00	-0.466

Table 4: Summary of Stormwater Runoff and Volume to Woodbine Depression (6S +7S)

Storm Event	Existing Conditions Peak		Proposed Conditions Peak		Δ	
	Runoff (cfs)	Volume (af)	Runoff (cfs)	Volume (af)	Runoff (cfs)	Volume (af)
2-Year (3.21 in)	14.77	1.463	14.74	1.459	-0.14	-0.011
10-Year (4.86 in)	31.77	3.047	31.74	3.043	-0.22	-0.019
100-Year (8.84 in)	77.49	7.443	77.48	7.438	-0.43	-0.036

Conclusions:

1. As analyzed, the peak rates of runoff and volumes will be maintained for the 2, 10, and 100 year storm events.

Required Recharge Volume Calculation:

R_v = Required Recharge Volume
F = Target Depth Factor
A_{imp} = Impervious Area

$R_v = F * A_{imp}$

$F_A = 0.60" = 0.05'$ $A_A = 10,895 \text{ ft}^2$
$F_D = 0.10" = 0.01'$ $A_D = 28,768 \text{ ft}^2$

$R_v = (F_A * A_A) + (F_D * A_D)$
$R_v = (0.05 * 10,895) + (0.01 * 28,768)$

$R_v = 832.4 \text{ ft}^3$

This value is met, as seen in Table 5.

Required Water Quality Volume Calculation:

V_{WQ} = Required Water Quality Volume
D_{WQ} = Water Quality Depth
A_{imp} = Impervious area

$V_{WQ} = D_{WQ} * A_{imp}$

$D_{WQ} = 1" = 0.083'$
$A_{imp} = 39,663 \text{ ft}^2$
$V_{WQ} = 0.083 * 39,663$

$V_{WQ} = 3292. \text{ ft}^3$

This value is met as seen in Table 5.

Table 5: Infiltration System Volumes for the 100-Year Storm Event

Infiltration System	Total Storage Volume (cf)	Total Volumetric Capacity (cf)	Total Water Quality Volume @ El. 89.80 (cf)
Detention/Infiltration Pond	11,905	14,998	4702

TSS Removal Estimate:

Table 6: TSS Removal Calculation

	BMP	TSS Removal Rate	Starting TSS Load	Amount Removed	Remaining Load
	Street Sweeping	0.100	1.000	0.100	0.900
Pretreatment BMPs	Deep Sump Catch Basin	0.250	0.900	0.225	0.675
	Oil Grit Separator	0.250	0.675	0.169	0.506
Infiltration BMPs	Subsurface Structure	0.800	0.506	0.405	0.101
Other BMPs	Dry Detention Basin	0.000	0.101	0.000	0.101

Pretreatment TSS Removal (%)=	49.4
Total TSS Removal (%)=	89.9

72-Hour draw down of BMPs

Table 7: Summary of Draw Down for Infiltration Systems from HydroCAD

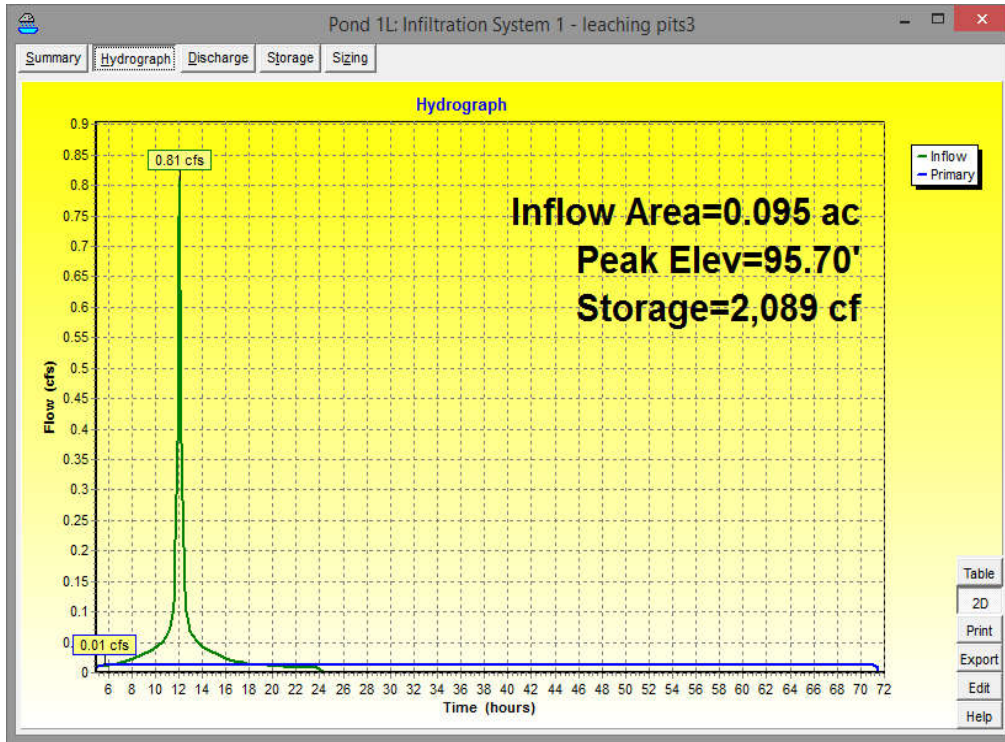| System	Time (hrs)
1	71.5
7	24.5
Detention/Infiltration Pond	33.0

Figure 1: Infiltration System 1 Draw-Down
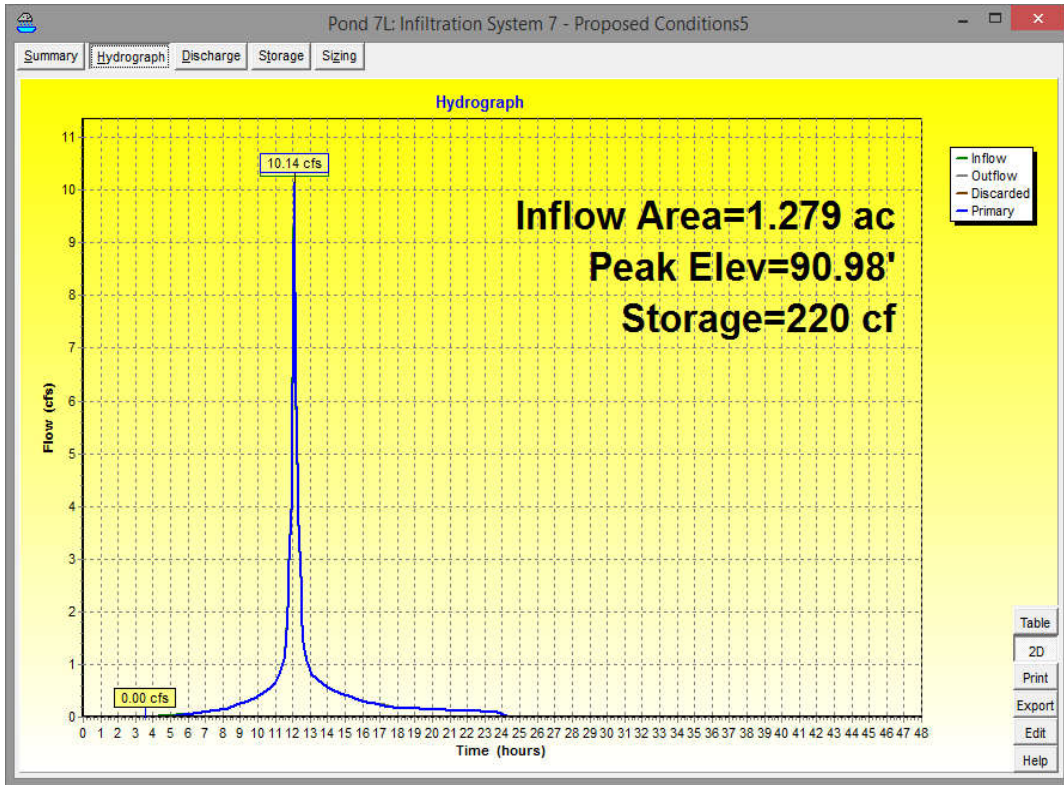
Figure 2: Infiltration System 7 Draw-Down
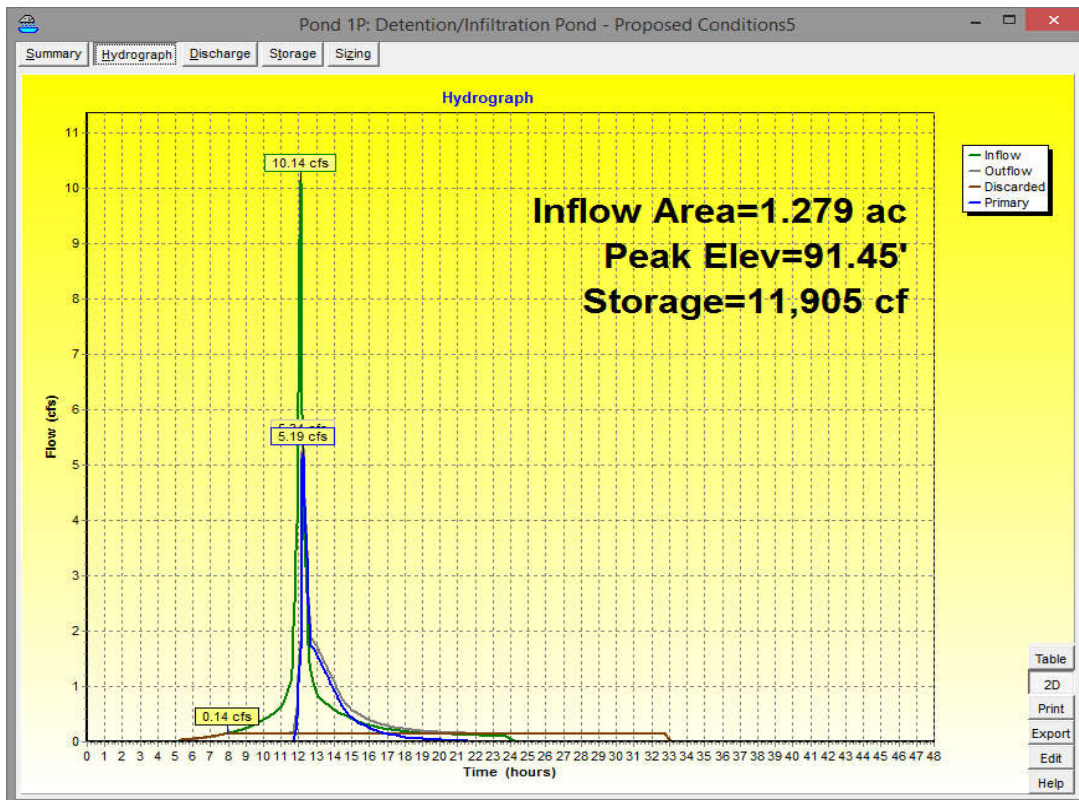
Figure 3: Detention/Infiltration Pond Draw-Down

Table 8: Summary of Draw Down for Infiltration Systems using Formula from Massachusetts Stormwater
Handbook (Vol. 3, Ch. 1, pg. 25)

System	Base Area (sf)	R_v (cf)	Time$_{drawdown}$* (hr)
1	512	2089	48.0
7	79	220	32.8
Detention/Infiltration Pond	6049	11,905	23.2

*Rawls Rate (HSG B) = 1.02 in/hr = 0.085 ft/hr

Time$_{drawdown}$= R_v /(Rawls * Base Area)

Where R_v = Storage Volume for 100-Year Storm Event

Calculation of Exfiltration Rates for Infiltration Systems

Exfiltration Rate = Rawls Rate * Base Area of System

Rawls Rate (HSG B) = 1.02 in/hr = $2.36*10^{-5}$ ft/s

Table 9: Summary of Infiltration System Exfiltration Rates

System	Base Area (sf)	Exfiltration Rate (cfs)
1	512	0.012
7	79	0.002
Detention/Infiltration Pond	6049	0.143

USDA Soils

Please refer to plan C-3 for site specific soil data, obtained via soil testing by Gala Simon Associates on February 4, 2014.

Hydrologic Soil Group

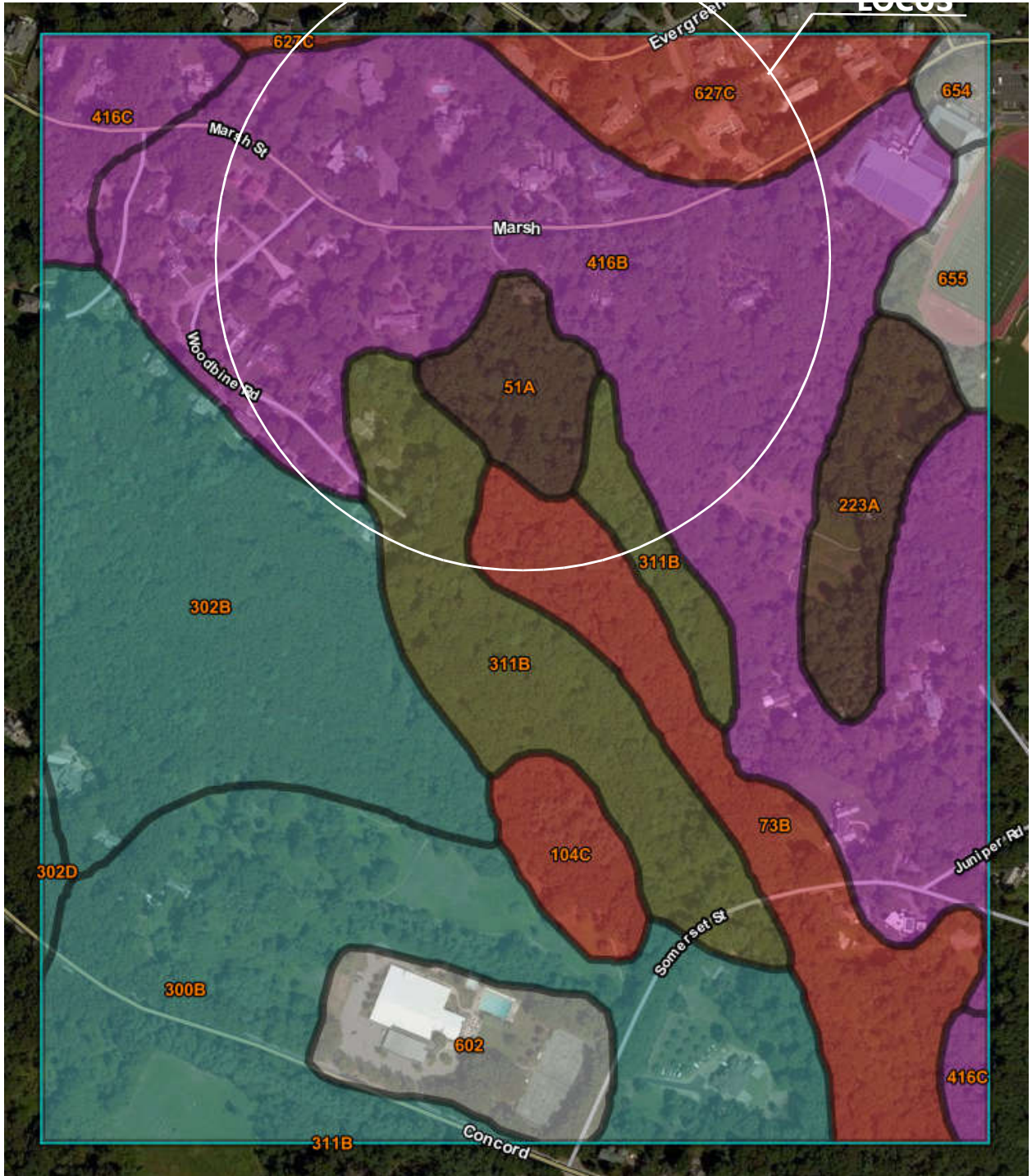| Hydrologic Soil Group— Summary by Map Unit — Middlesex County, Massachusetts (MA017)				
Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
51A	Swansea muck, 0 to 1 percent slopes	B/D	3.4	2.3%
73B	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	10.5	7.1%
104C	Hollis-Rock outcrop-Charlton complex, 0 to 15 percent slopes	D	2.9	2.0%
223A	Scio very fine sandy loam, 0 to 3 percent slopes	B/D	4.9	3.3%
300B	Montauk fine sandy loam, 3 to 8 percent slopes	C	24.0	16.2%
302B	Montauk fine sandy loam, 0 to 8 percent slopes, extremely stony	C	22.2	15.0%
302D	Montauk fine sandy loam, 15 to 35 percent slopes, extremely stony	C	0.5	0.3%
311B	Woodbridge fine sandy loam, 0 to 8 percent slopes, very stony	C/D	13.3	9.0%
416B	Narragansett silt loam, 3 to 8 percent slopes, very stony	A	46.3	31.2%
416C	Narragansett silt loam, 8 to 15 percent slopes, very stony	A	4.4	3.0%
602	Urban land		5.7	3.9%
627C	Newport-Urban land complex, 3 to 15 percent slopes	D	6.7	4.5%
654	Udorthents, loamy		1.0	0.7%
655	Udorthents, wet substratum		2.3	1.6%
Totals for Area of Interest			148.2	100.0%

NRCC Precipitation Estimates

Extreme Precipitation Tables
Northeast Regional Climate Center

Data represents point estimates calculated from partial duration series. All precipitation amounts are displayed in inches.

Smoothing	Yes
State	Massachusetts
Location	
Longitude	71.191 degrees West
Latitude	42.406 degrees North
Elevation	0 feet
Date/Time	Fri, 24 Feb 2017 13:24:36 -0500

Extreme Precipitation Estimates

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.28	0.43	0.53	0.70	0.87	1.10	1yr	0.75	1.04	1.28	1.63	2.08	2.67	2.91	1yr	2.36	2.80	3.27	3.95	4.63	1yr
2yr	0.35	0.54	0.67	0.88	1.11	1.40	2yr	0.96	1.28	1.62	2.03	2.55	3.21	3.56	2yr	2.84	3.42	3.92	4.67	5.32	2yr
5yr	0.42	0.65	0.81	1.09	1.39	1.77	5yr	1.20	1.61	2.06	2.59	3.24	4.07	4.53	5yr	3.60	4.35	4.98	5.93	6.65	5yr
10yr	0.47	0.74	0.93	1.27	1.65	2.12	10yr	1.42	1.91	2.47	3.11	3.90	4.86	5.44	10yr	4.30	5.23	5.96	7.12	7.88	10yr
25yr	0.56	0.89	1.13	1.56	2.07	2.67	25yr	1.78	2.40	3.13	3.96	4.96	6.16	6.92	25yr	5.46	6.66	7.57	9.06	9.86	25yr
50yr	0.63	1.01	1.30	1.82	2.46	3.22	50yr	2.12	2.85	3.77	4.77	5.96	7.38	8.32	50yr	6.53	8.00	9.07	10.87	11.69	50yr
100yr	0.72	1.17	1.51	2.14	2.92	3.85	100yr	2.52	3.39	4.53	5.74	7.16	8.84	10.00	100yr	7.82	9.62	10.87	13.06	13.87	100yr
200yr	0.83	1.36	1.76	2.52	3.48	4.61	200yr	3.00	4.03	5.43	6.88	8.59	10.59	12.03	200yr	9.37	11.57	13.04	15.69	16.45	200yr
500yr	1.01	1.66	2.16	3.14	4.39	5.85	500yr	3.79	5.07	6.92	8.77	10.94	13.46	15.36	500yr	11.92	14.77	16.59	20.01	20.64	500yr

Construction Period Pollution Preventions and Erosion and Sedimentation Control

Narrative

Erosion control measures will be installed before construction begins, and maintained throughout the course of the project. Silt fencing will be installed at the boundary of the proposed work and maintained based on the requirements set forth in this plan. A stabilized construction entrance will be installed at the entrance to 178 Marsh street to mitigate construction vehicle track out. A silt sack will be installed at the street catch basin in front of 178 Marsh Street to prevent sediment from entering. All pollution prevention measures set forth in this plan must be carried out during construction, with regular inspection and maintenance.

Responsible Entity for Plan Compliance

Donald Chiofaro
178 Marsh Street
Belmont, MA 02478

Erosion and Sedimentation Control

Erosion Control
Erosion controls such as silt fencing and fiber rolls will be installed below upland disturbing activities. See sheet C-1 of plans for layout and C-2 for detail.

Maintenance Requirements
- Remove sediment when it reaches ½ the height of the above ground height of the fence/roll.

Stabilized Construction Entrance
Stabilized construction entrances will be installed where trucks enter and exit the project in order to reduce sediment from being tracked out. See sheet C-1 of plans for layout and C-2 for detail.

Maintenance Requirements
- Add and/or reshape crushed stone as needed
- If any sediment is tracked onto the existing road, it is to be removed immediately.

Soil Compaction Control
Areas for subsurface infiltration will be protected with snow fencing upon completion.
- Heavy equipment will be excluded from subsurface infiltration areas by surrounding them with snow fencing
- Equipment will only be allowed over subsurface roadway system upon installation of roadway binder.

Construction Period Pollution Prevention Measures

Construction Site Pollutants:
- Oils used during paving
- Washout from pouring concrete
- Paints and Solvents

Spill Prevention and Response
Where a leak, spill, or other release containing a hazardous substance or oil occurs, owner/contractor is to notify MADEP at 617-654-6500 and the NRC (National Response Center) at (800)424-8802. Notify local authorities also.

Fueling and Maintenance of Equipment or Vehicles
- Dispose of recycled oil and oily wastes in accordance with local, State and Federal requirements.
- Use drip pans and absorbents under and around leaky vehicles
- Do not clean surfaces by hosing them down
- Clean up spills or contaminated surfaces immediately.
- Adequate supplies to be available at all times to handle spills, leaks and disposal of used liquids

Washing of Equipment and Vehicles
- Wash vehicles away from stormwater inlets
- All washing products are to be protected from rainfall by covering them with plastic sheeting or kept in a storage shed.

Maintenance Requirements
- Verify that products are dry. Check for leaks in sheeting or holes in shed roofs.

Storage, Handling, and Disposal of Construction Products, Materials, and Wastes

- Store/cover building products that could create releases onto the site.
- Separate hazardous or toxic waste from construction and domestic waste
- Provide cover to construction products by maintaining them under roof cover of plastic sheeting cover.
- A covered dumpster is to be provided at the site for any construction wastes.

Maintenance Requirements
- Dumpster is to be emptied on an "as need" basis without any overflow of debris. Hazardous waste is to be stored in sealed containers and removed by following local, State and Federal requirements.

Pesticides, Herbicides, Insecticides, Fertilizers, and Landscape Materials
- Discharges from herbicides, insecticides and fertilizers shall be at a minimum.
- Apply these products only at a rate and amount that is consistent with manufacturer recommendations
- Avoid application of products prior to rainfall or frozen ground

Maintenance Requirements
- Follow local, State and Federal requirements regarding these products

<u>Hazardous or Toxic Waste</u>
(Note: Examples include paints, solvents, petroleum-based products, wood preservatives, additives, curing compounds, acids.)
- If stored on site, all of these products are to be kept in sealed containers and protected from the weather.
- Provide a spill kit to be available to all site workers.

Maintenance Requirements
- Verify location of kit at all times and provide training to workers on its use.

<u>Construction and Domestic Waste</u>
- Construction wastes and domestic wastes are to be stored in a closed dumpster.
- Operator is to contract with a waste hauler to remove debris off site.
- A dumpster is to be located on site.

Maintenance Requirements
- Verify amount of debris in dumpster on a daily basis. Contact hauler for removal on an "as need basis'.
-
<u>Sanitary Waste</u>
- Install portable toilet facilities in accessible locations and sufficient number for the project
- A septic hauler shall remove the waste on a weekly basis or on an 'as need" basis

<u>Washing of Applicators and Containers used for Paint, Concrete or Other Materials</u>
- When washing tools containing paint, concrete or other potentially deleterious materials, an effective means of eliminating these discharges must be in place.
- Do not dump liquid wastes in storm sewers
- Remove and dispose of hardened concrete waste in a manner that is consistent with construction wastes
- Locate any washing activities as far as possible from any stormwater inlets on conveyances
- Designate a specific area on site for this activity.

Maintenance Requirements
- Clean and dispose of wastes on same work day.

<u>Fertilizers</u>
- Fertilizers containing nitrogen and phosphorous shall be minimal
- Apply fertilizers at the appropriate time of the year.
- Do not apply these products before heavy rainfall events and never on frozen ground
- Follow all federal, state and local regulations with the use of these products

<u>Vegetation Planning</u>
- All new plantings are to be non-invasive, and approved local species.
- Street trees are to be planted as indicated on site plan, sheet C-1.
- Specified replanting areas and wetland restoration areas are to be detailed by environmental consultant.

Sequencing of Erosion and Sedimentation Controls
Prior to any earth-disturbing activities, the following erosion and sedimentation controls should be installed.
1. Installation of silt fencing along the limit of work.
2. Installation of silk sack in catch basin at the front of 178 Marsh Street.
3. Installation of stabilized construction entrance at the entrance of 178 Marsh Street.
4. Routine maintenance of all installed controls, as specified in this plan.

Construction Sequencing Plan
1. Installation of erosion control measures.
2. Site clearing.
3. Installation of roadway utilities and stormwater BMPs within drainage easement on Lot 2.
4. Removal of existing sewer line from dwelling at 178 Marsh Street, and installation of new lateral connection to newly constructed sewer line on Sleepy Hollow Road.
5. Construction of proposed walls, and culvert. Concurrent installation of infiltration system on Lot 1.
6. Construction of roadway and sidewalks.
7. Development of residential lots, including installation of infiltration systems.
8. Landscaping, replanting, and wetland restoration.

Inspection and Maintenance Schedule

A weekly patrol of the project's boundaries will be conducted to check for signs of erosion or discharges. This includes inspection of sediment build up at silt fencing/hay bale barriers and the status of stabilized construction entrances. All inspection and maintenance operations conducted are to be logged in the Inspection and Maintenance Log Form of this plan.

Inspection and Maintenance Log Form

Description	Name	Date

Description	Name	Date

Operation and Maintenance Plan for Drainage Systems

Project Name: Sleepy Hollow Road, Belmont, MA

Date: March 16, 2017

Site Location: 178 Marsh Street
Belmont Massachusetts

Site Operator:
        Current Owner: Donald Chiofaro
        Address: 178 Marsh Street
                                  Belmont, MA 02478

The following Operation and Maintenance Plan (O & M Plan) has been developed to comply with DEP's Stormwater Management Policy. The responsibilities outlined in the O&M Plan run with ownership of the property.

Catch basins

Maintenance:

- Catch basins are to be cleaned at least twice a year or when the depth of sediment in the sump is within 12" of the invert of the outlet pipe.
- Cleaning of catch basins should be performed at the end of the winter and fall seasons.

Leaching Pits

Maintenance:

- Drainage leaching pits are to be cleaned at least twice a year or when the depth of sediment in the bottom is 24".
- Cleaning of drainage leaching pits should be performed at the end of the winter and fall seasons.

Detention Area

Maintenance:

- Cleaning of sediment from the detention area should occur every 2 years.

Sediment & Oil Separator

Maintenance:

- The unit is to be cleaned of sediment and debris once a year.
- Cleaning procedures are to follow manufacturer recommendations
- Oils and sediments shall only be removed and disposed of in accordance with Local, State and Federal regulations.

Roadway and Walks

Maintenance:

- The roadway is to be swept at least once per year by mechanical means.

Culvert
- Inspect after heavy storms and high flows for soil erosion scouring and dislodged stones under the inlet and outlet. Repair damage promptly.
- Inspect the culvert inlet, outlet, and pipes, if possible, for tree or other vegetation roots, signs of vegetation growth, mineral deposits, trash or silt accumulations and other foreign objects obstructing flow paths. Promptly remove if found.
- Inspect the culvert pipes for signs of visible wear or breakage. Check for change of shape, abrasion, and deterioration of lining.

Riprap Basin
- Inspect after heavy storms and high flows for soil erosion, scouring, and dislodged stones, under the outlet. Repair damage promptly.
- Regularly inspect for trash and debris, removing material if found.

Long-Term Pollution Prevention Plan

Spill Prevention and Response
Where a leak, spill, or other release containing a hazardous substance or oil occurs, owner/contractor is to notify MADEP at 617-654-6500 and the NRC (National Response Center) at (800)424-8802. Notify local authorities also.

Vehicle Washing Controls
- Wash vehicles away from stormwater inlets
- All washing products are to be protected from rainfall by covering them with plastic sheeting or kept in a storage shed.

Maintenance Requirements
- Verify that products are dry. Check for leaks in sheeting or holes in shed roofs.

Requirements for Routine Inspection and Maintenance of Stormwater BMPs
- Refer to Operation and Management section of Stormwater Report

Storage and use of Pesticides, Herbicides, Insecticides, Fertilizers, and Landscape Materials
- Apply these products only at a rate and amount that is consistent with manufacturer recommendations
- Avoid application of products prior to rainfall or frozen ground
- Fertilizers containing nitrogen and phosphorous shall be minimal
- Apply fertilizers at the appropriate time of the year.

Maintenance Requirements
- Follow local, State and Federal requirements regarding these products

Snow Disposal and Plowing
- Snow is to be stored only in the designated areas on site and indicated by signage. (Refer to the Layout Plan for location of said signs and dumping areas).
- Usage of snow salt and sand is to be kept to a minimum.

Maintenance of Lawns, Gardens, and Landscaped Areas
- Pesticides, herbicides, insecticides, and fertilizers shall be used at a minimum and applied only at a rate as specified by the manufacturer.
- Avoid application of products prior to rainfall or on frozen ground.
- Fertilizers containing nitrogen and phosphorous shall be minimal
- Landscaping irrigation is under no circumstances to be directed towards the stormwater sewer system.

Pet Waste Management Provisions
- Pet waste is to be collected and removed from the site by the responsible owner of the pet, so that waste does not enter the stormwater sewer system.

Snow Disposal and Plowing in Relation to Wetland Resource Areas
- Snow is not to be stored near or moved toward wetland resource areas.

<u>Winter Road Salt and/or Sand Use and Storage Restrictions</u>
- Use of road salt/sand is to be kept to a minimum, dependent on the severity of the snowfall.
- Anti-icing/pre-wetting measures, such as use of brines, should be considered if combined with accurate weather forecasts.

<u>Street Sweeping Schedules</u>
- Street sweeping schedule is to be determined by Town of Belmont.

<u>Prevention of Illicit Discharges to Stormwater Management System</u>
- Dumping into the stormwater sewer service is strictly prohibited.
- Discharge from car washing or driveway cleaning should not be directed towards the stormwater sewer service.
- Landscaping irrigation is under no circumstances to be directed towards the stormwater sewer system.
- Swimming pool discharges shall not be directed towards the stormwater sewer system.
- Power washing activities should not be allowed to discharge directly into the stormwater sewer system.

<u>Stormwater BMP Containment Plan in the Event of a Spill or Discharge</u>

In the event of a spill or discharge into the stormwater system, the stormwater shutoff valve (located on the sidewalk, within the drainage easement on Lot 2) is to be activated. The MADEP, NRC, and Town of Belmont should be contacted immediately, and the point source of the spill or discharge should be deactivated as quickly as possible.

<u>Emergency Contacts</u>

EPA	888-372-7341
MADEP	617-654-6500
NRC	800-424-8802
Town of Belmont DPW	617-993-2680 617-993-2698 (severe weather hotline)
Town of Belmont Conservation Department	617-993-2667
Town of Belmont Fire Department	911 (emergency) 617-993-2200 (non-emergency)
Gala Simon Associates	781-676-2962

Illicit Discharge Compliance Statement

An illicit discharge is considered to be any discharge to a municipal separate storm sewer that is not entirely comprised of stormwater, or discharges from fire protection services.

The Owner is responsible for full compliance with the Massachusetts Stormwater Managements Policy, EPA NPDES Construction General Permit, and takes responsibility for identification and elimination of illicit discharges, as defined by the EPA.

Owner's Name: Donald Chiofaro
Address: 178 Marsh Street, Belmont, MA

To the best of my knowledge, no detectable illicit discharges exist on the site, nor are any proposed. The included plans, calculations, specifications and documentation detail the methods of stormwater management designed to the standards of the Massachusetts Stormwater Handbook. The site plans identify the locations of all stormwater systems and show that entry is not allowed for any illicit discharges. A Long Term Pollution Prevention Plan is included, detailing prevention measures for illicit discharges. As the Site Owner, I will be responsible for implementing the Long Term Pollution Prevention Plan.

Signature:_____

Appendix A
Existing Conditions

Existing Conditions
2 Year Storm Event
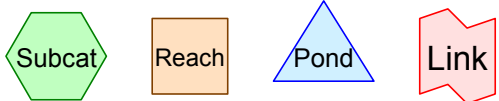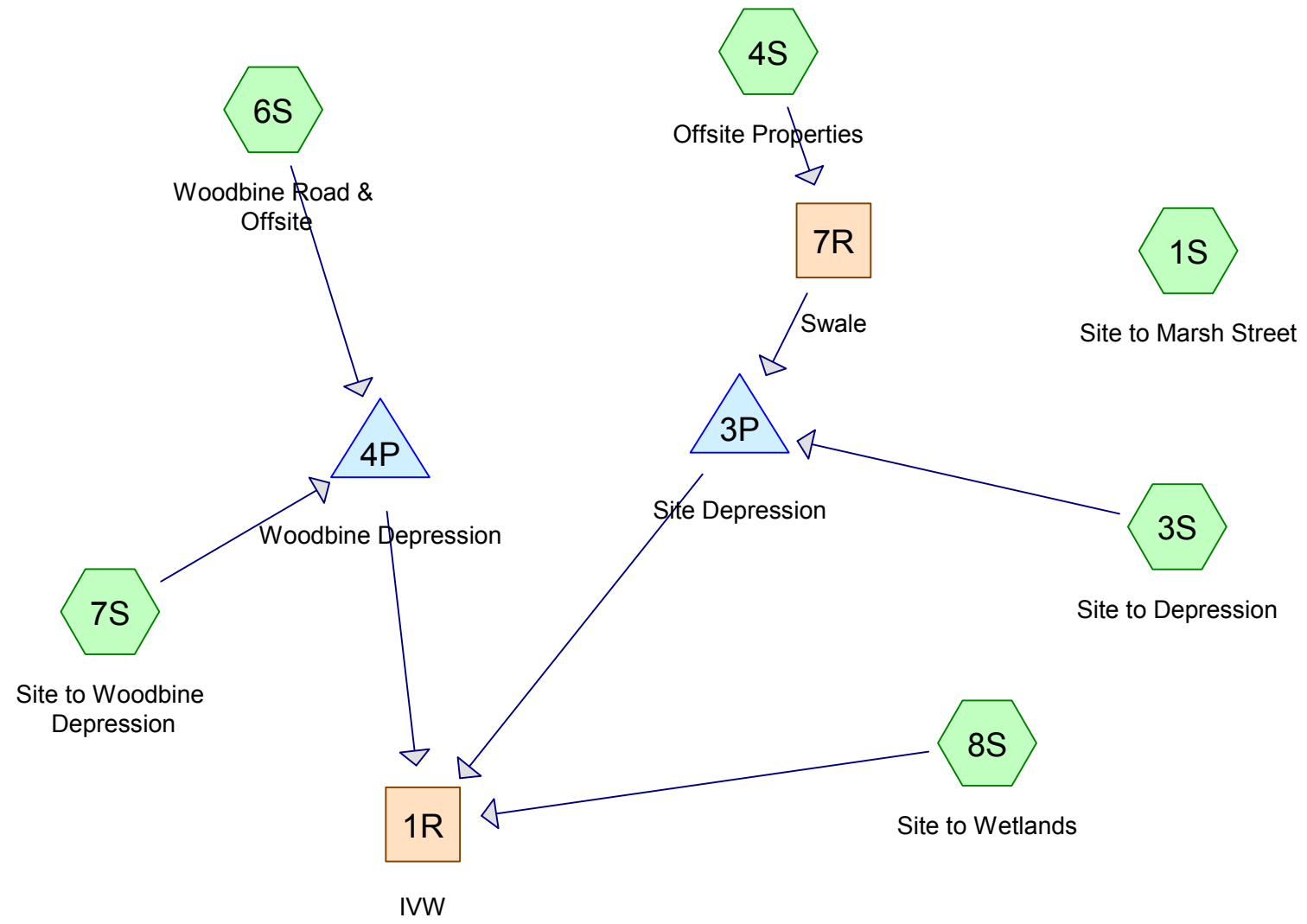
Drainage Diagram for Existing Conditions3

Prepared by Gala Simon Associates   3/17/2017

HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Subcatchment 1S: Site to Marsh Street

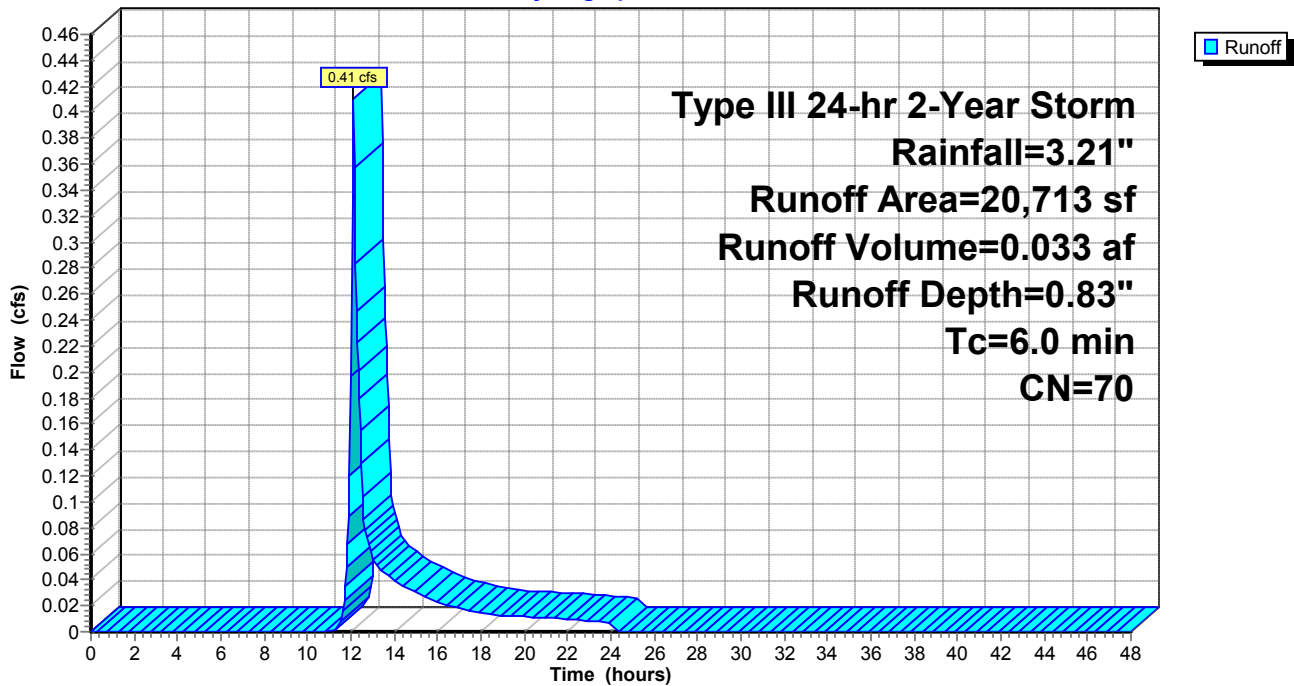Runoff   =   0.41 cfs @ 12.10 hrs, Volume=   0.033 af, Depth= 0.83"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
5,036	98	Paved parking & roofs
15,677	61	>75% Grass cover, Good, HSG B
20,713	70	Weighted Average
15,677		Pervious Area
5,036		Impervious Area

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

Subcatchment 1S: Site to Marsh Street

Hydrograph

Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=20,713 sf
Runoff Volume=0.033 af
Runoff Depth=0.83"
Tc=6.0 min
CN=70

Existing Conditions3
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Type III 24-hr 2-Year Storm Rainfall=3.21"
Page 2
3/17/2017

Subcatchment 3S: Site to Depression

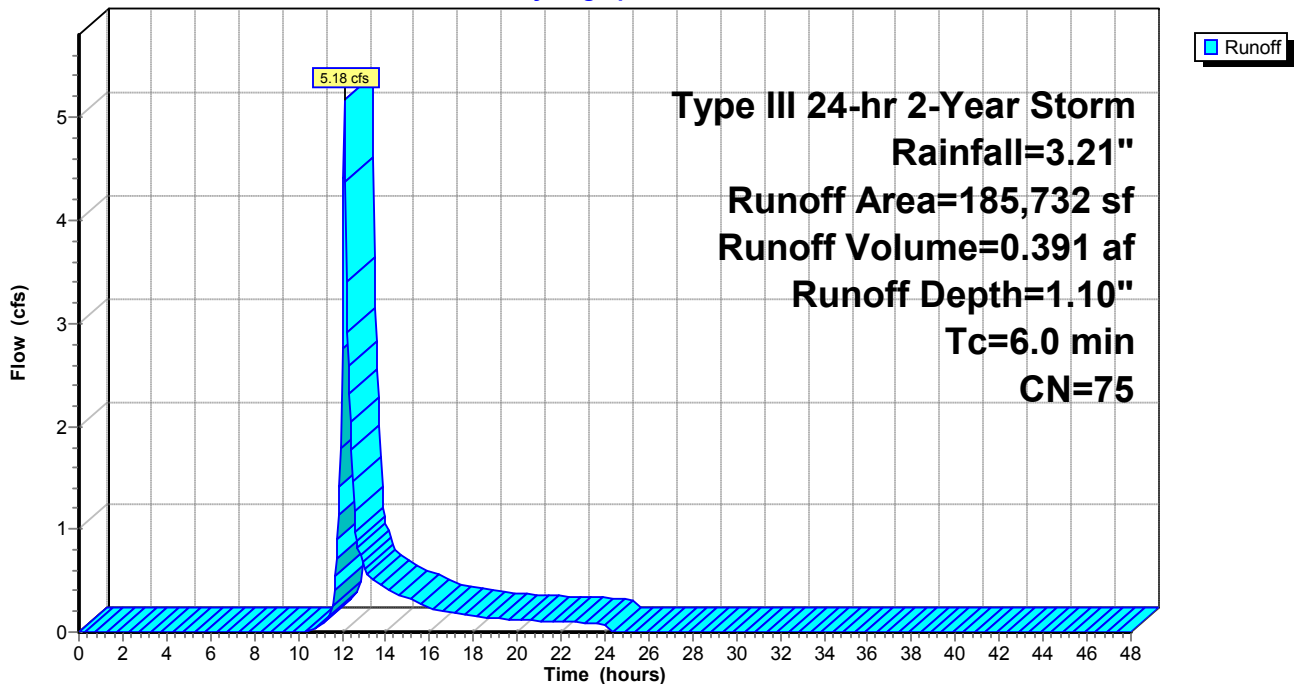Runoff   =   5.18 cfs @ 12.10 hrs, Volume=   0.391 af, Depth= 1.10"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
1,495	98	Paved roads w/curbs & sewers
13,425	39	>75% Grass cover, Good, HSG A
6,625	80	>75% Grass cover, Good, HSG D
4,530	36	Woods, Fair, HSG A
159,657	79	Woods, Fair, HSG D
185,732	75	Weighted Average
184,237		Pervious Area
1,495		Impervious Area

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

Subcatchment 3S: Site to Depression

Existing Conditions3
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Type III 24-hr 2-Year Storm Rainfall=3.21"
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Subcatchment 4S: Offsite Properties

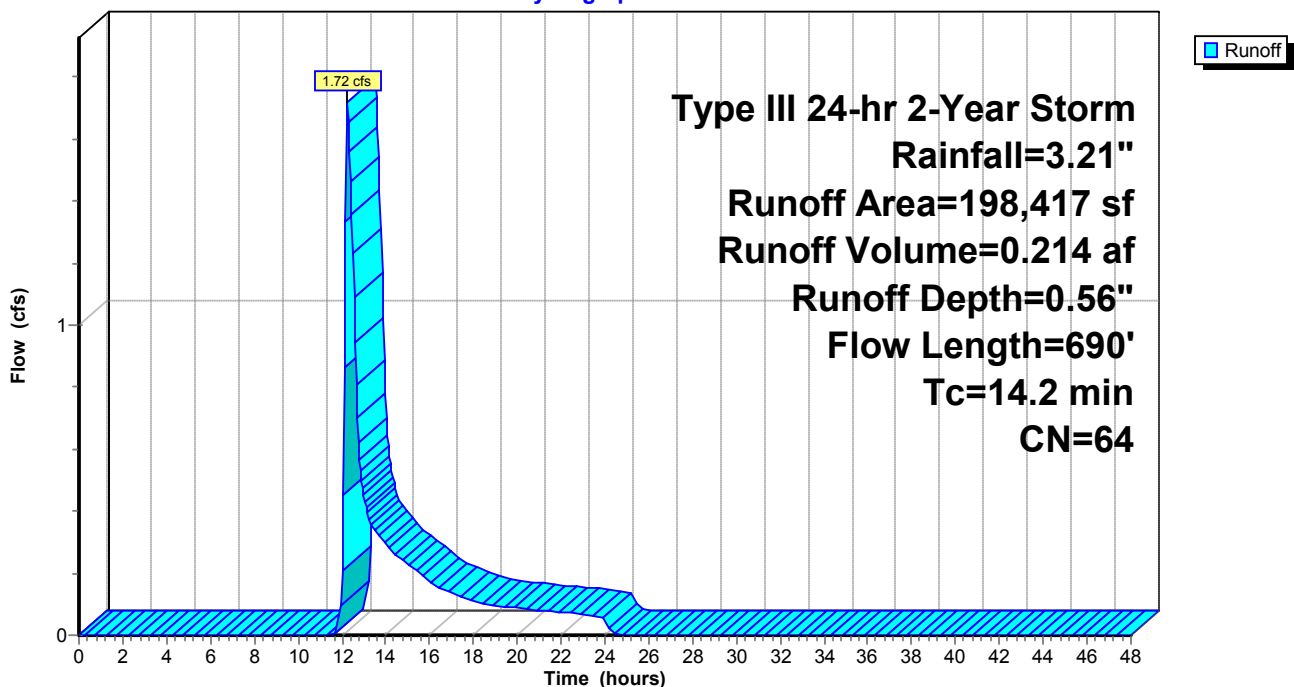Runoff   =   1.72 cfs @ 12.25 hrs, Volume=   0.214 af, Depth= 0.56"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
132,278	54	1/2 acre lots, 25% imp, HSG A
41,772	85	1/2 acre lots, 25% imp, HSG D
24,367	85	1/2 acre lots, 25% imp, HSG D
198,417	64	Weighted Average
148,813		Pervious Area
49,604		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
4.3	550	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
1.7	90	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.2	690	Total			

Subcatchment 4S: Offsite Properties

Hydrograph

Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=198,417 sf
Runoff Volume=0.214 af
Runoff Depth=0.56"
Flow Length=690'
Tc=14.2 min
CN=64

Subcatchment 6S: Woodbine Road & Offsite

Runoff   =   13.44 cfs @ 12.24 hrs, Volume=   1.366 af, Depth= 1.16"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
362,024	73	Woods, Fair, HSG C
254,113	80	1/2 acre lots, 25% imp, HSG C
616,137	76	Weighted Average
552,609		Pervious Area
63,528		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	125	0.0150	0.61		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	200	0.0150	1.84		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.7	710	0.0250	3.21		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.5	100	0.0180	0.67		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
16.3	1,185	Total			

Subcatchment 6S: Woodbine Road & Offsite

Hydrograph

□ Runoff

13.44 cfs

**Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=616,137 sf
Runoff Volume=1.366 af
Runoff Depth=1.16"
Flow Length=1,185'
Tc=16.3 min
CN=76**

Flow (cfs)

Time (hours)

Existing Conditions3
Prepared by Gala Simon Associates
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Type III 24-hr 2-Year Storm Rainfall=3.21"
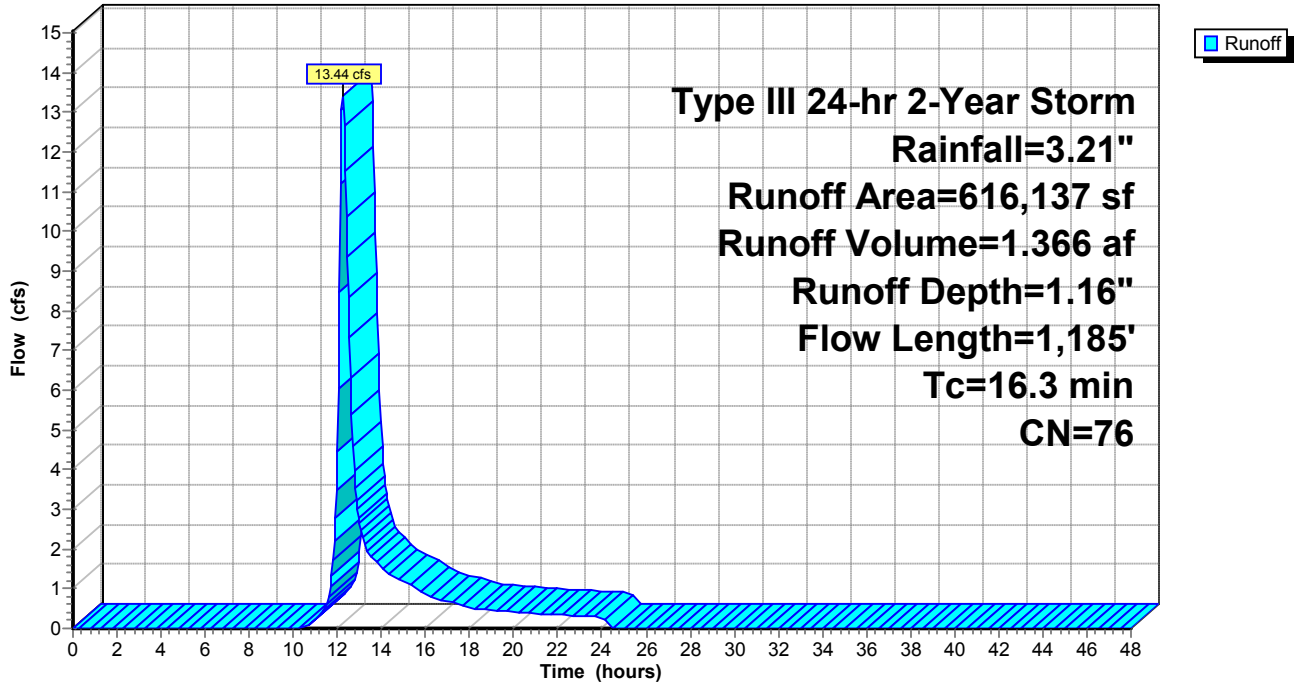Page 6
3/17/2017

Subcatchment 7S: Site to Woodbine Depression

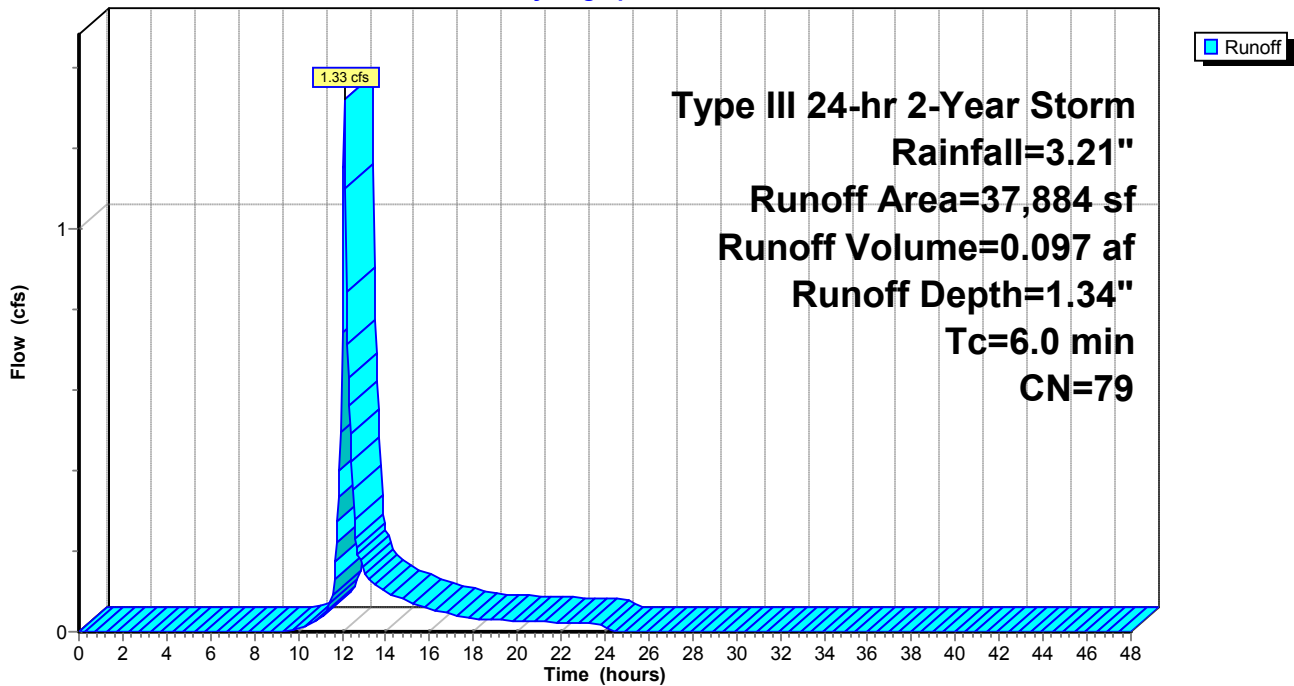Runoff   =   1.33 cfs @ 12.10 hrs, Volume=   0.097 af, Depth= 1.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
179	98	Paved parking & roofs
37,705	79	Woods, Fair, HSG D
37,884	79	Weighted Average
37,705		Pervious Area
179		Impervious Area

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

Subcatchment 7S: Site to Woodbine Depression

**Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=37,884 sf
Runoff Volume=0.097 af
Runoff Depth=1.34"
Tc=6.0 min
CN=79**

Existing Conditions3
Prepared by Gala Simon Associates
HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 2-Year Storm Rainfall=3.21"
Page 7
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Subcatchment 8S: Site to Wetlands

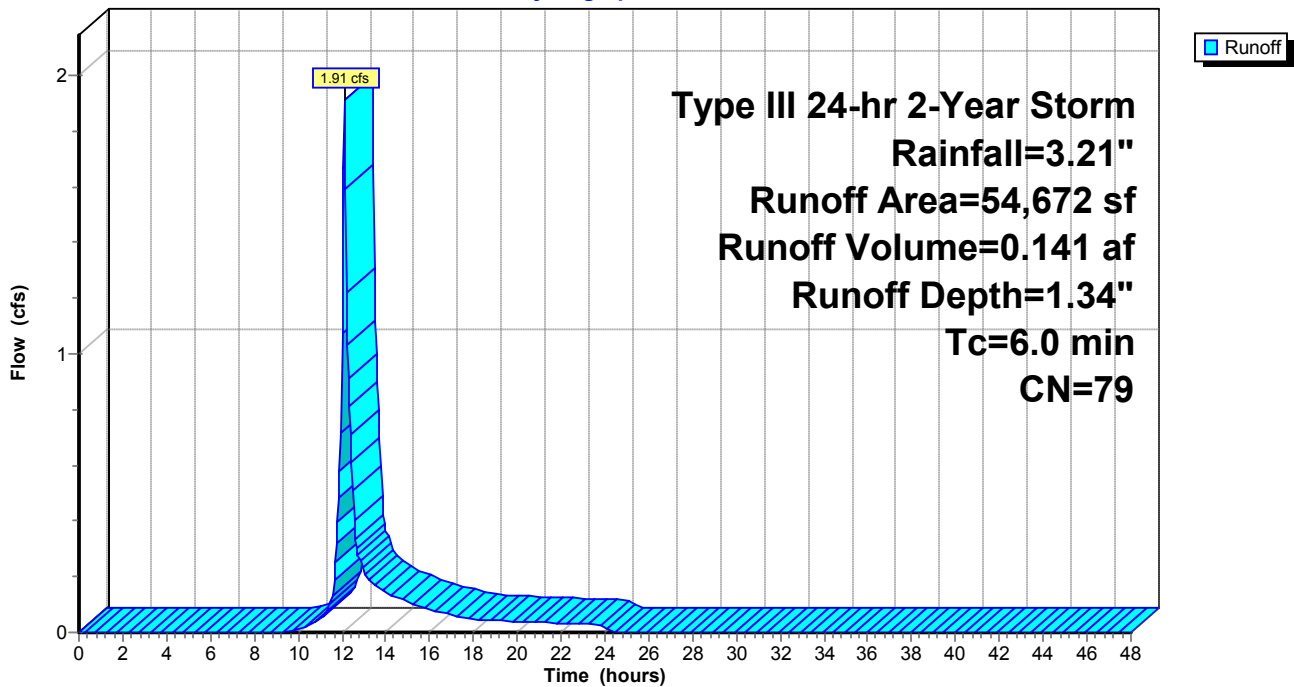Runoff   =   1.91 cfs @ 12.10 hrs, Volume=   0.141 af, Depth= 1.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
54,672	79	Woods, Fair, HSG D
54,672		Pervious Area

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

Subcatchment 8S: Site to Wetlands
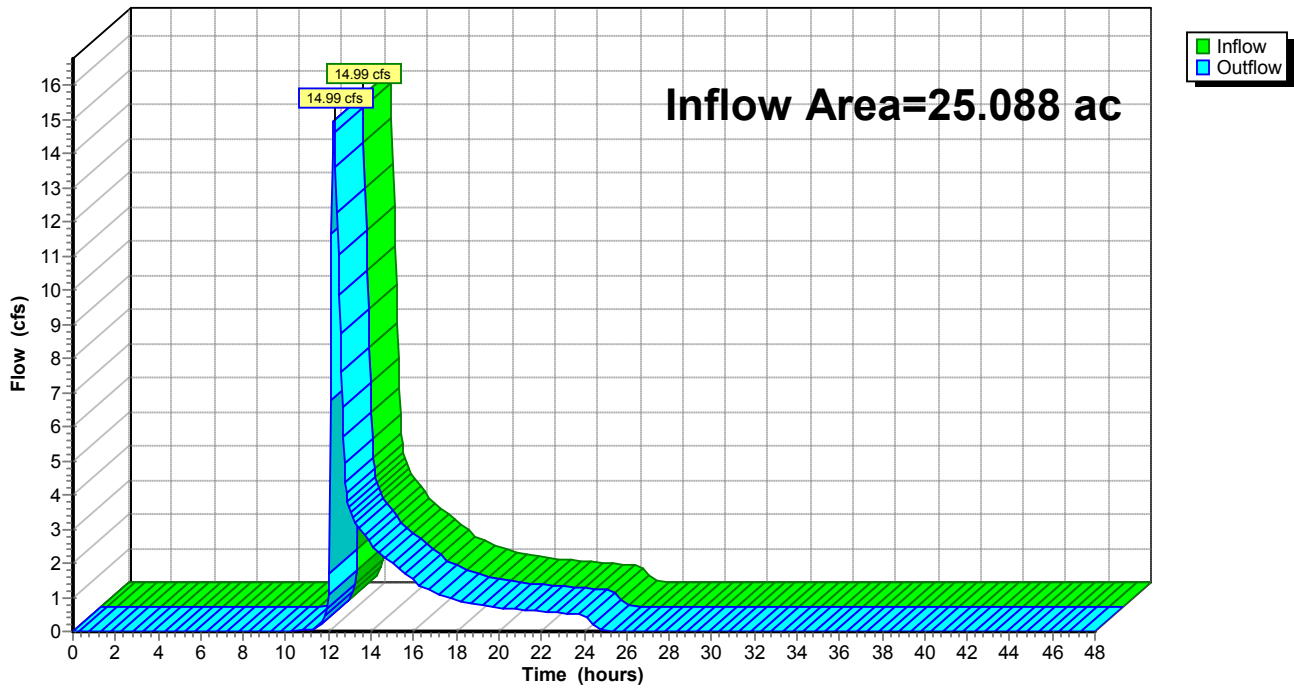
Reach 1R: IVW

Inflow Area =   25.088 ac, Inflow Depth = 0.86"   for 2-Year Storm event
Inflow   =   14.99 cfs @   12.26 hrs, Volume=   1.805 af
Outflow   =   14.99 cfs @   12.26 hrs, Volume=   1.805 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Reach 1R: IVW

Existing Conditions3
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Type III 24-hr 2-Year Storm Rainfall=3.21"
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Reach 7R: Swale

Inflow Area =   4.555 ac, Inflow Depth = 0.56"   for 2-Year Storm event
Inflow   =   1.72 cfs @   12.25 hrs, Volume=   0.214 af
Outflow   =   1.69 cfs @   12.28 hrs, Volume=   0.214 af, Atten= 1%, Lag= 1.6 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 0.98 fps, Min. Travel Time= 0.9 min
Avg. Velocity = 0.45 fps, Avg. Travel Time= 2.0 min
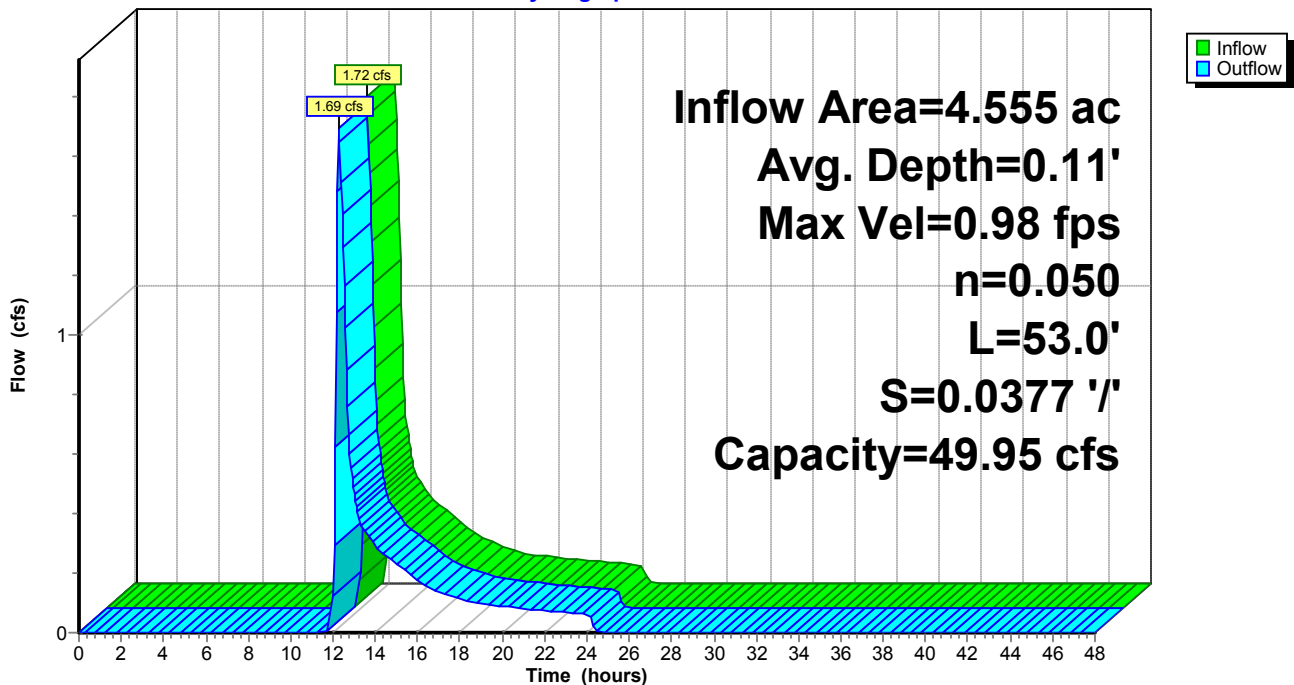
Peak Storage= 93 cf @ 12.26 hrs, Average Depth at Peak Storage= 0.11'
Bank-Full Depth= 0.50', Capacity at Bank-Full= 49.95 cfs

54.00' x 0.50' deep Parabolic Channel, n= 0.050
Length= 53.0'   Slope= 0.0377 '/'
Inlet Invert= 88.00', Outlet Invert= 86.00'

‡

Reach 7R: Swale

Hydrograph

Inflow Area=4.555 ac
Avg. Depth=0.11'
Max Vel=0.98 fps
n=0.050
L=53.0'
S=0.0377 '/'
Capacity=49.95 cfs

Pond 3P: Site Depression

Inflow Area =   8.819 ac, Inflow Depth = 0.82"   for 2-Year Storm event
Inflow   =   5.85 cfs @   12.11 hrs, Volume=   0.605 af
Outflow   =   0.82 cfs @   13.61 hrs, Volume=   0.335 af, Atten= 86%, Lag= 90.1 min
Primary   =   0.82 cfs @   13.61 hrs, Volume=   0.335 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 86.27' @ 13.61 hrs   Surf.Area= 52,822 sf   Storage= 12,941 cf

Plug-Flow detention time= 276.9 min calculated for 0.335 af (55% of inflow)
Center-of-Mass det. time= 145.4 min (1,022.1 - 876.6)

Volume	Invert	Avail.Storage	Storage Description
#1	86.00'	58,179 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)
86.00	41,988	830.0	0	0	41,988
86.25	52,276	995.0	11,760	11,760	65,952
87.00	72,037	1,166.0	46,420	58,179	95,369

Device	Routing	Invert	Outlet Devices
#1	Primary	86.25'	**90.0' long x 30.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.81 cfs @ 13.61 hrs HW=86.27'   (Free Discharge)
1=Broad-Crested Rectangular Weir (Weir Controls 0.81 cfs @ 0.40 fps)

Existing Conditions3
Prepared by Gala Simon Associates
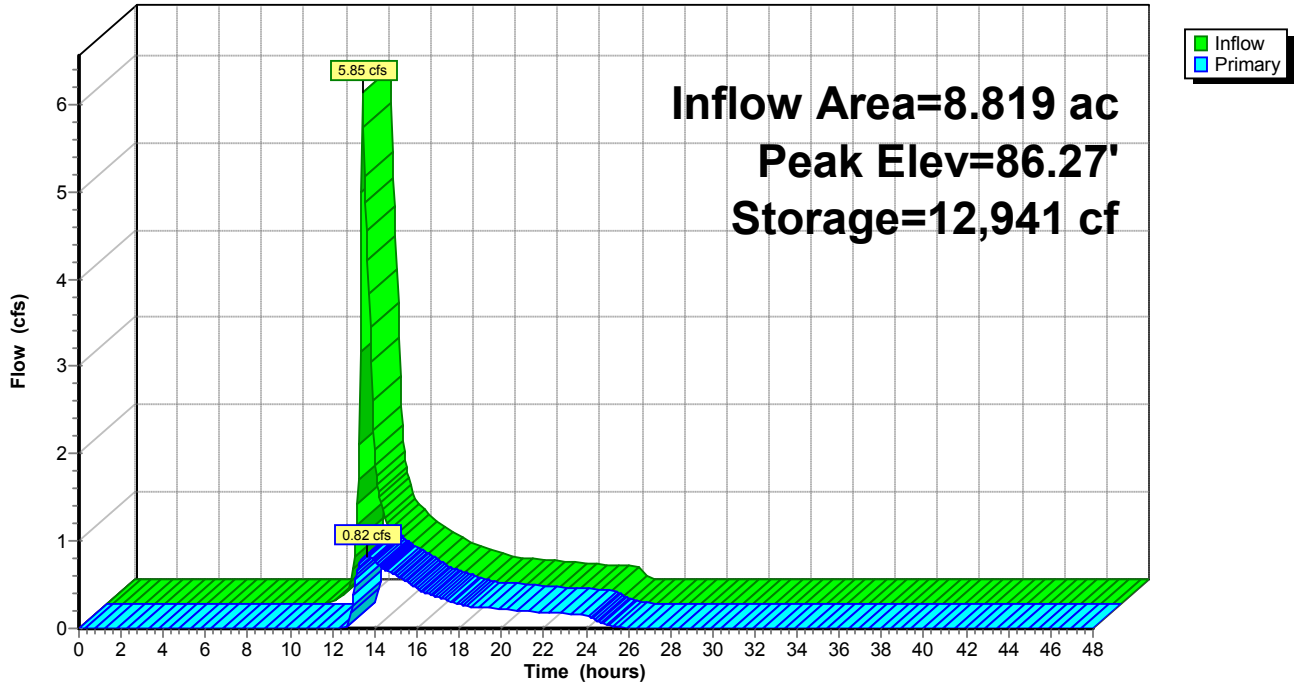HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 2-Year Storm Rainfall=3.21"
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3/17/2017

Pond 3P: Site Depression

Hydrograph

Inflow Area=8.819 ac
Peak Elev=86.27'
Storage=12,941 cf

Pond 4P: Woodbine Depression

Inflow Area =   15.014 ac, Inflow Depth = 1.17"   for 2-Year Storm event
Inflow   =   14.17 cfs @ 12.24 hrs, Volume=   1.464 af
Outflow   =   14.00 cfs @ 12.27 hrs, Volume=   1.329 af, Atten= 1%, Lag= 1.9 min
Primary   =   14.00 cfs @ 12.27 hrs, Volume=   1.329 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 88.62' @ 12.27 hrs   Surf.Area= 17,620 sf   Storage= 7,930 cf

Plug-Flow detention time= 66.1 min calculated for 1.329 af (91% of inflow)
Center-of-Mass det. time= 20.5 min (884.2 - 863.7)

Volume	Invert	Avail.Storage	Storage Description
#1	88.00'	15,739 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)
88.00	8,161	367.0	0	0	8,161
88.50	15,722	518.0	5,868	5,868	18,798
89.00	24,056	630.0	9,871	15,739	29,033

Device	Routing	Invert	Outlet Devices
#1	Primary	88.50'	**120.0' long x 97.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=13.85 cfs @ 12.27 hrs HW=88.62'   (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 13.85 cfs @ 0.94 fps)

Existing Conditions3
Prepared by Gala Simon Associates
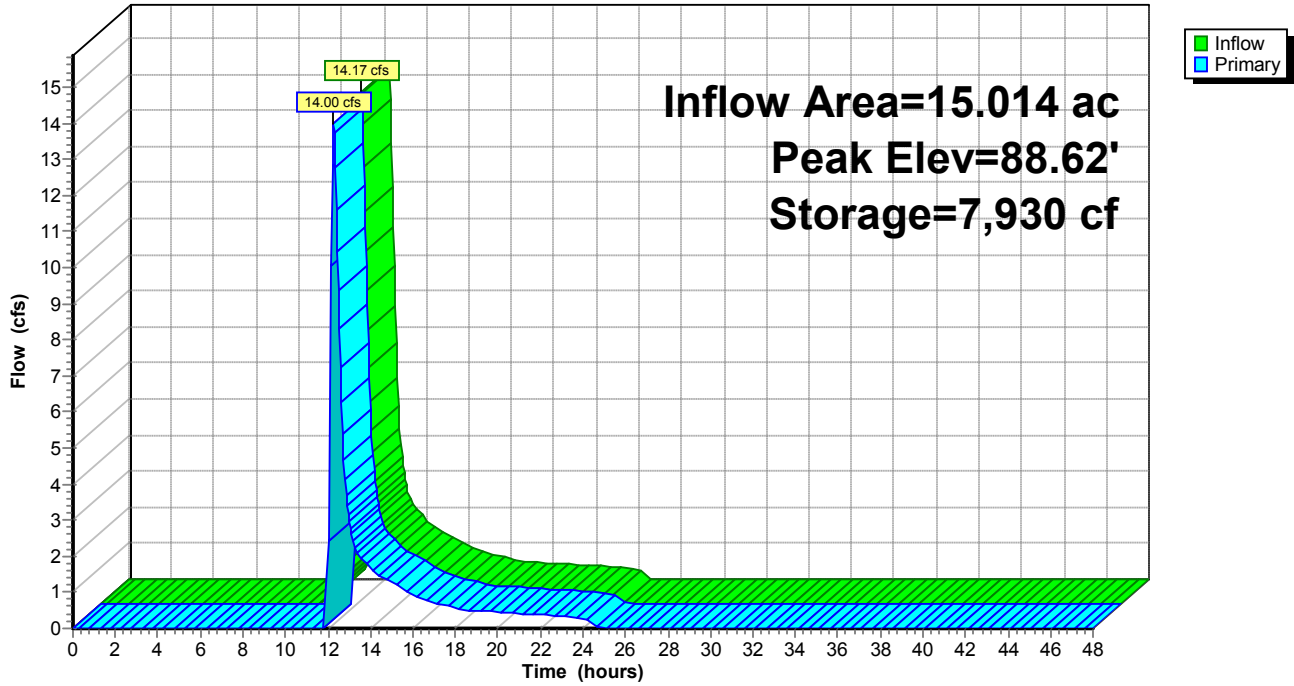HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 2-Year Storm Rainfall=3.21"
Page 13
3/17/2017

Pond 4P: Woodbine Depression

Hydrograph

Inflow Area=15.014 ac
Peak Elev=88.62'
Storage=7,930 cf

14.17 cfs
14.00 cfs

Inflow
Primary

Flow (cfs)

Time (hours)

Existing Conditions
10 Year Storm Event

Subcatchment 1S: Site to Marsh Street

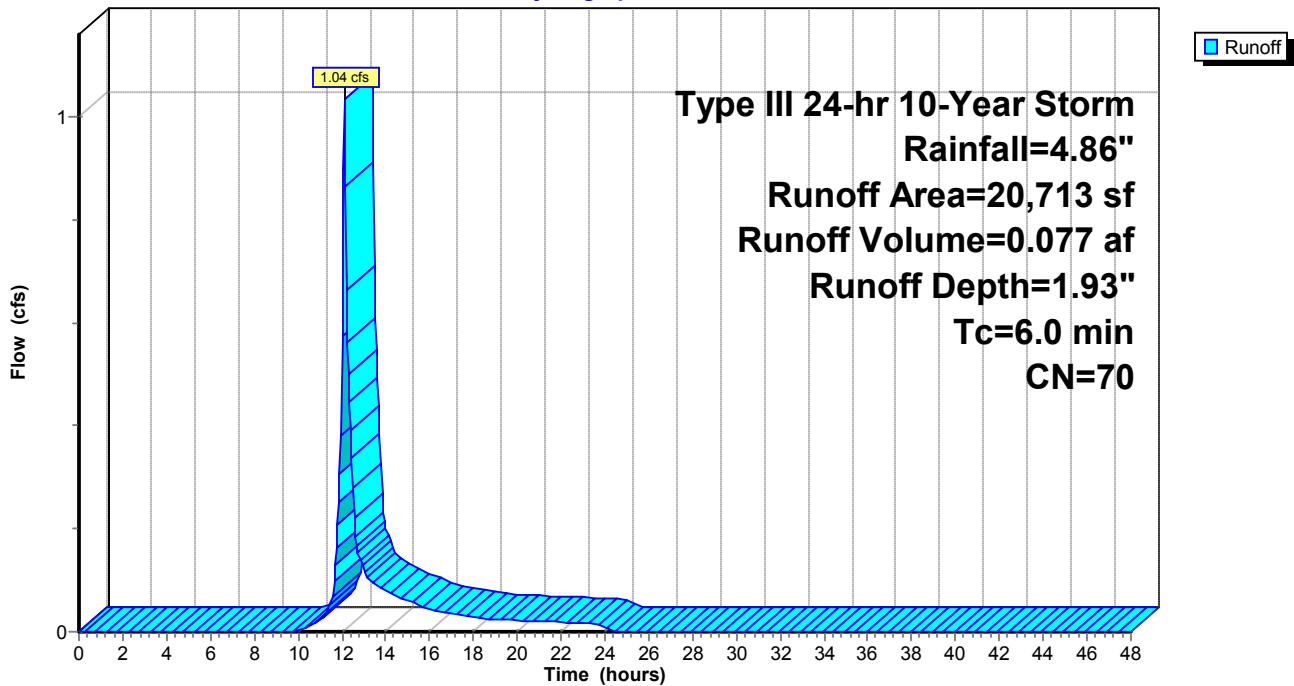Runoff   =   1.04 cfs @ 12.10 hrs, Volume=   0.077 af, Depth= 1.93"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
5,036	98	Paved parking & roofs
15,677	61	>75% Grass cover, Good, HSG B
20,713	70	Weighted Average
15,677		Pervious Area
5,036		Impervious Area

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

Subcatchment 1S: Site to Marsh Street

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=20,713 sf
Runoff Volume=0.077 af
Runoff Depth=1.93"
Tc=6.0 min
CN=70

Subcatchment 3S: Site to Depression

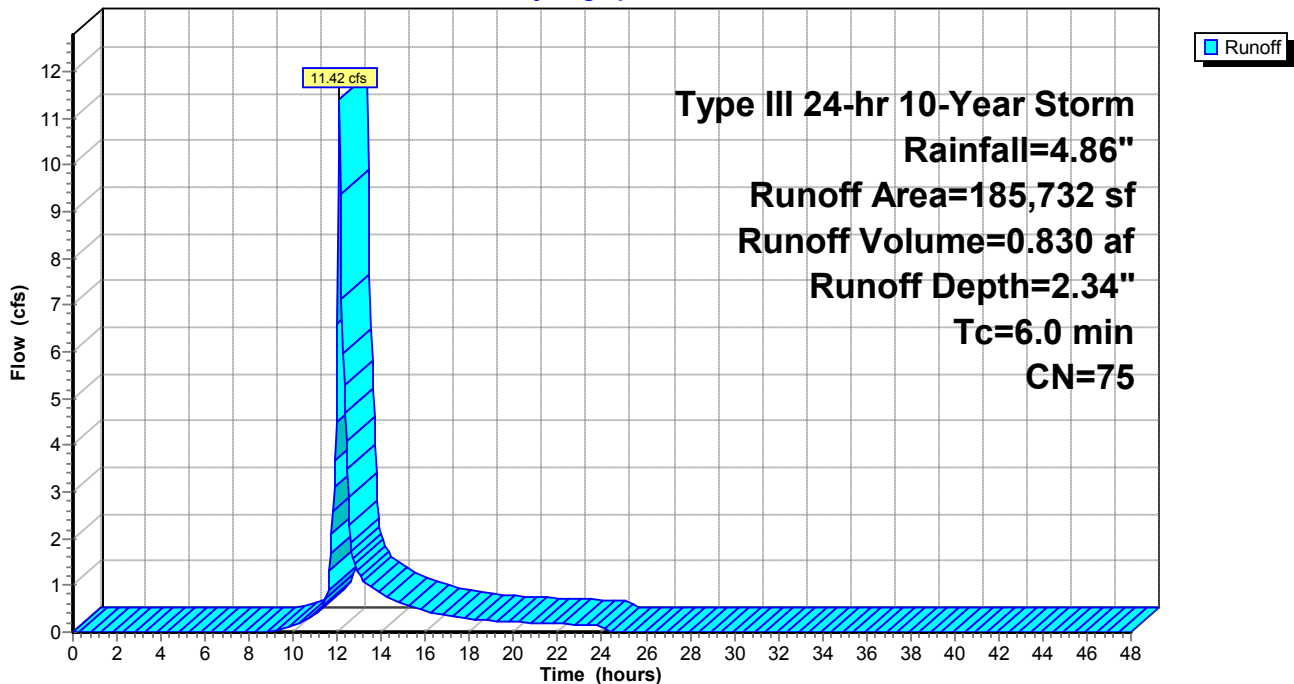Runoff   =   11.42 cfs @ 12.09 hrs, Volume=   0.830 af, Depth= 2.34"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
1,495	98	Paved roads w/curbs & sewers
13,425	39	>75% Grass cover, Good, HSG A
6,625	80	>75% Grass cover, Good, HSG D
4,530	36	Woods, Fair, HSG A
159,657	79	Woods, Fair, HSG D
185,732	75	Weighted Average
184,237		Pervious Area
1,495		Impervious Area

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

Subcatchment 3S: Site to Depression

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=185,732 sf
Runoff Volume=0.830 af
Runoff Depth=2.34"
Tc=6.0 min
CN=75

Subcatchment 4S: Offsite Properties

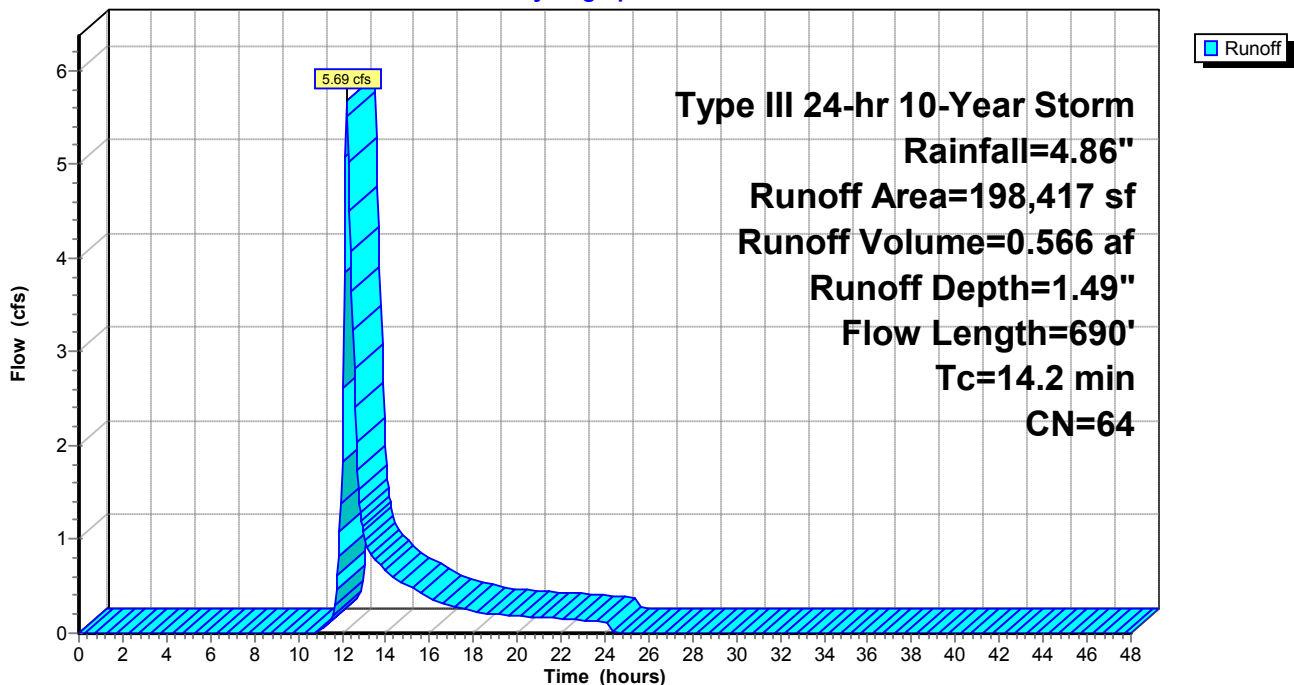Runoff   =   5.69 cfs @   12.22 hrs, Volume=   0.566 af, Depth= 1.49"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
132,278	54	1/2 acre lots, 25% imp, HSG A
41,772	85	1/2 acre lots, 25% imp, HSG D
24,367	85	1/2 acre lots, 25% imp, HSG D
198,417	64	Weighted Average
148,813		Pervious Area
49,604		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
4.3	550	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
1.7	90	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.2	690	Total			

Subcatchment 4S: Offsite Properties

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=198,417 sf
Runoff Volume=0.566 af
Runoff Depth=1.49"
Flow Length=690'
Tc=14.2 min
CN=64

Subcatchment 6S: Woodbine Road & Offsite

Runoff   =   29.09 cfs @ 12.23 hrs, Volume=   2.853 af, Depth= 2.42"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
362,024	73	Woods, Fair, HSG C
254,113	80	1/2 acre lots, 25% imp, HSG C
616,137	76	Weighted Average
552,609		Pervious Area
63,528		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	125	0.0150	0.61		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	200	0.0150	1.84		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.7	710	0.0250	3.21		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.5	100	0.0180	0.67		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
16.3	1,185	Total			

Existing Conditions3
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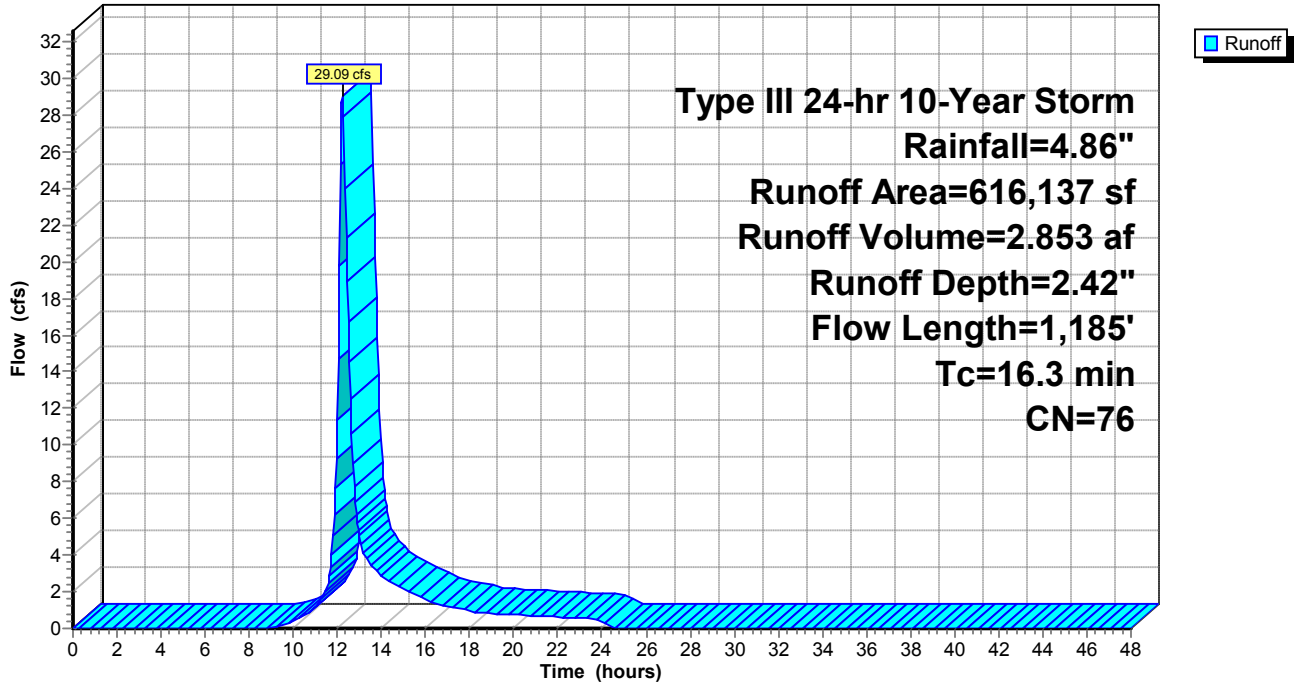HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 10-Year Storm Rainfall=4.86"
Page 5
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Subcatchment 6S: Woodbine Road & Offsite

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=616,137 sf
Runoff Volume=2.853 af
Runoff Depth=2.42"
Flow Length=1,185'
Tc=16.3 min
CN=76

29.09 cfs

Runoff

Subcatchment 7S: Site to Woodbine Depression

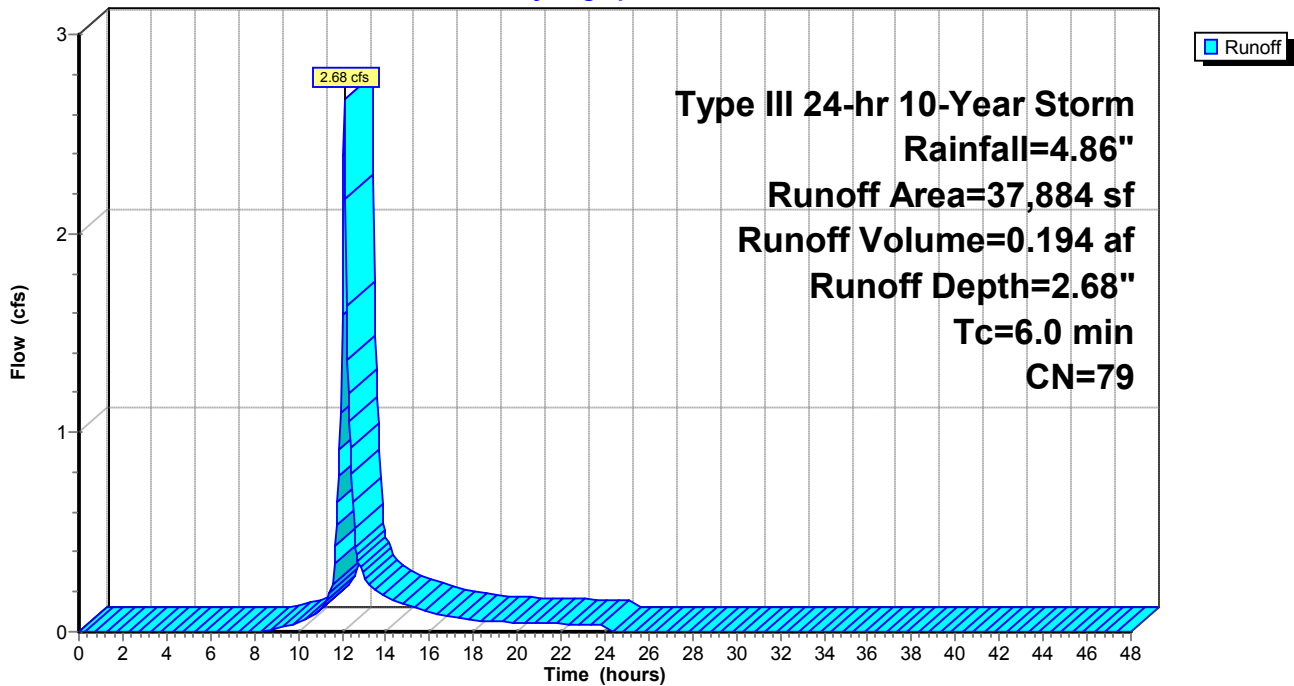Runoff   =   2.68 cfs @ 12.09 hrs, Volume=   0.194 af, Depth= 2.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
179	98	Paved parking & roofs
37,705	79	Woods, Fair, HSG D
37,884	79	Weighted Average
37,705		Pervious Area
179		Impervious Area

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

Subcatchment 7S: Site to Woodbine Depression

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=37,884 sf
Runoff Volume=0.194 af
Runoff Depth=2.68"
Tc=6.0 min
CN=79

Subcatchment 8S: Site to Wetlands

Runoff   =   3.87 cfs @ 12.09 hrs, Volume=   0.280 af, Depth= 2.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
54,672	79	Woods, Fair, HSG D
54,672		Pervious Area

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

Subcatchment 8S: Site to Wetlands

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=54,672 sf
Runoff Volume=0.280 af
Runoff Depth=2.68"
Tc=6.0 min
CN=79
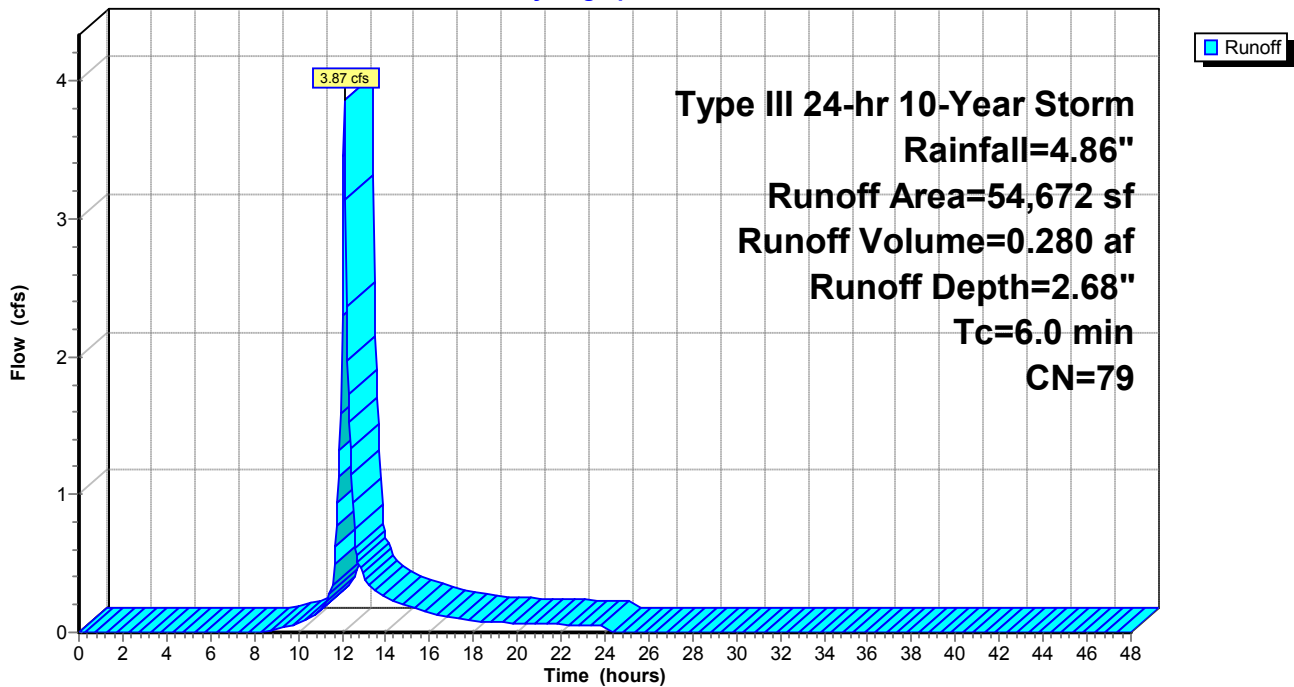
Existing Conditions3
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Type III 24-hr 10-Year Storm Rainfall=4.86"
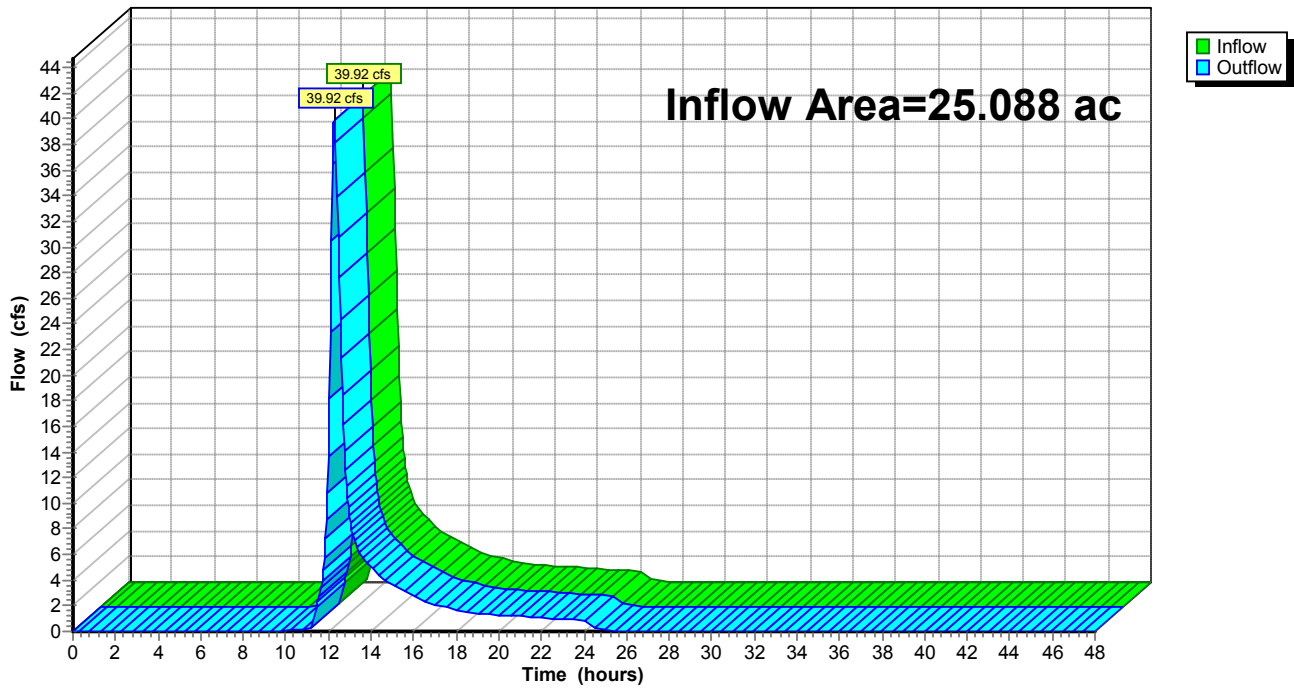Page 8
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Reach 1R: IVW

Inflow Area =   25.088 ac, Inflow Depth = 2.07"   for 10-Year Storm event
Inflow   =   39.92 cfs @   12.27 hrs, Volume=   4.319 af
Outflow   =   39.92 cfs @   12.27 hrs, Volume=   4.319 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Reach 1R: IVW

Reach 7R: Swale

Inflow Area =   4.555 ac, Inflow Depth = 1.49"   for 10-Year Storm event
Inflow   =   5.69 cfs @   12.22 hrs, Volume=   0.566 af
Outflow   =   5.60 cfs @   12.24 hrs, Volume=   0.566 af, Atten= 2%, Lag= 1.3 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 1.42 fps, Min. Travel Time= 0.6 min
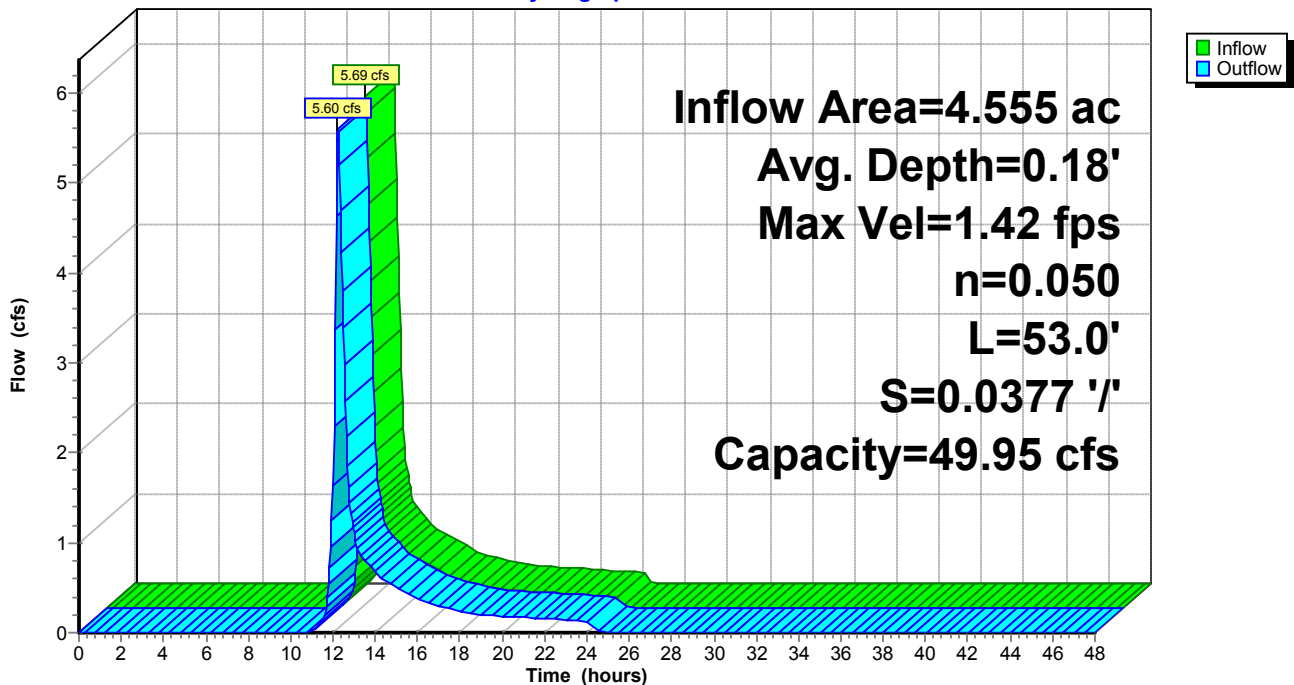Avg. Velocity = 0.56 fps, Avg. Travel Time= 1.6 min

Peak Storage= 212 cf @ 12.22 hrs, Average Depth at Peak Storage= 0.18'
Bank-Full Depth= 0.50', Capacity at Bank-Full= 49.95 cfs

54.00' x 0.50' deep Parabolic Channel, n= 0.050
Length= 53.0'   Slope= 0.0377 '/'
Inlet Invert= 88.00', Outlet Invert= 86.00'

‡

Reach 7R: Swale

Pond 3P: Site Depression

Inflow Area =   8.819 ac, Inflow Depth = 1.90"   for 10-Year Storm event
Inflow   =   14.88 cfs @   12.11 hrs, Volume=   1.396 af
Outflow   =   9.01 cfs @   12.37 hrs, Volume=   1.126 af, Atten= 39%, Lag= 15.5 min
Primary   =   9.01 cfs @   12.37 hrs, Volume=   1.126 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 86.36' @ 12.37 hrs   Surf.Area= 55,019 sf   Storage= 17,752 cf

Plug-Flow detention time= 133.4 min calculated for 1.125 af (81% of inflow)
Center-of-Mass det. time= 55.0 min (906.8 - 851.9)

Volume	Invert	Avail.Storage	Storage Description
#1	86.00'	58,179 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)
86.00	41,988	830.0	0	0	41,988
86.25	52,276	995.0	11,760	11,760	65,952
87.00	72,037	1,166.0	46,420	58,179	95,369

Device	Routing	Invert	Outlet Devices
#1	Primary	86.25'	**90.0' long x 30.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=8.94 cfs @ 12.37 hrs HW=86.36'   (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 8.94 cfs @ 0.89 fps)

Existing Conditions3
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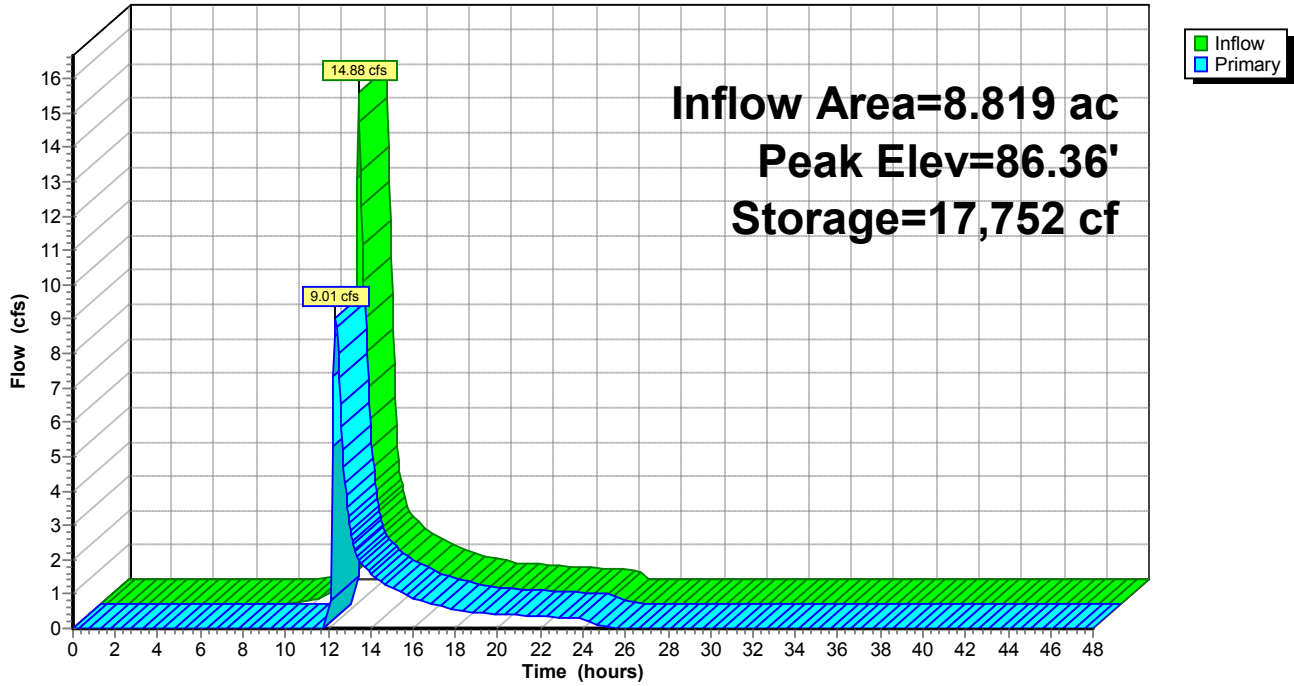
Type III 24-hr 10-Year Storm Rainfall=4.86"
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Pond 3P: Site Depression

Hydrograph

Inflow Area=8.819 ac
Peak Elev=86.36'
Storage=17,752 cf

Legend: Inflow, Primary

14.88 cfs

9.01 cfs

Pond 4P: Woodbine Depression

Inflow Area =   15.014 ac, Inflow Depth = 2.44"   for 10-Year Storm event
Inflow   =   30.66 cfs @ 12.22 hrs, Volume=   3.048 af
Outflow   =   30.33 cfs @ 12.25 hrs, Volume=   2.913 af, Atten= 1%, Lag= 1.7 min
Primary   =   30.33 cfs @ 12.25 hrs, Volume=   2.913 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 88.71' @ 12.25 hrs   Surf.Area= 18,960 sf   Storage= 9,455 cf

Plug-Flow detention time= 37.4 min calculated for 2.913 af (96% of inflow)
Center-of-Mass det. time= 13.0 min (855.0 - 842.1)

Volume	Invert	Avail.Storage	Storage Description
#1	88.00'	15,739 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)
88.00	8,161	367.0	0	0	8,161
88.50	15,722	518.0	5,868	5,868	18,798
89.00	24,056	630.0	9,871	15,739	29,033

Device	Routing	Invert	Outlet Devices
#1	Primary	88.50'	**120.0' long x 97.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=30.28 cfs @ 12.25 hrs HW=88.71'   (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 30.28 cfs @ 1.22 fps)

Existing Conditions3
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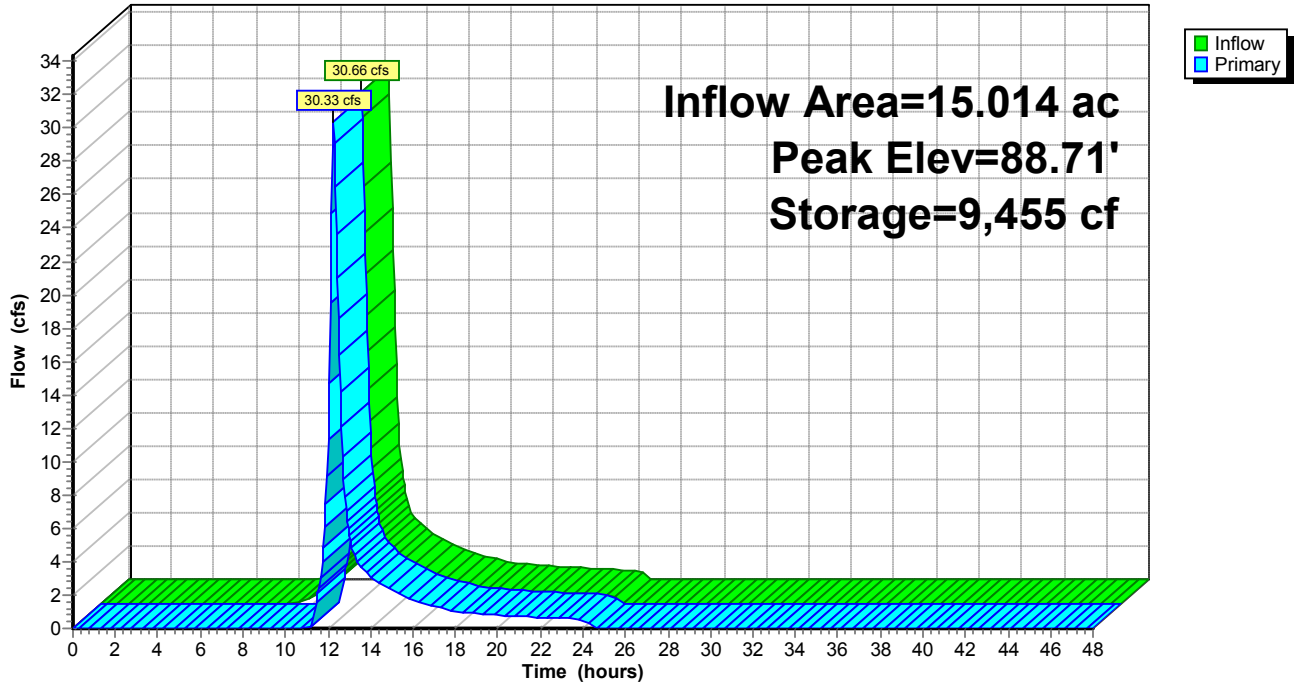
Type III 24-hr 10-Year Storm Rainfall=4.86"
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Pond 4P: Woodbine Depression

Hydrograph

Inflow Area=15.014 ac
Peak Elev=88.71'
Storage=9,455 cf

Existing Conditions
100 Year Storm Event

Subcatchment 1S: Site to Marsh Street

Runoff   =   2.84 cfs @ 12.09 hrs, Volume=   0.206 af, Depth= 5.19"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
5,036	98	Paved parking & roofs
15,677	61	>75% Grass cover, Good, HSG B
20,713	70	Weighted Average
15,677		Pervious Area
5,036		Impervious Area

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

Subcatchment 1S: Site to Marsh Street

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=20,713 sf
Runoff Volume=0.206 af
Runoff Depth=5.19"
Tc=6.0 min
CN=70

Existing Conditions3
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Type III 24-hr 100-Year Storm Rainfall=8.84"
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Subcatchment 3S: Site to Depression

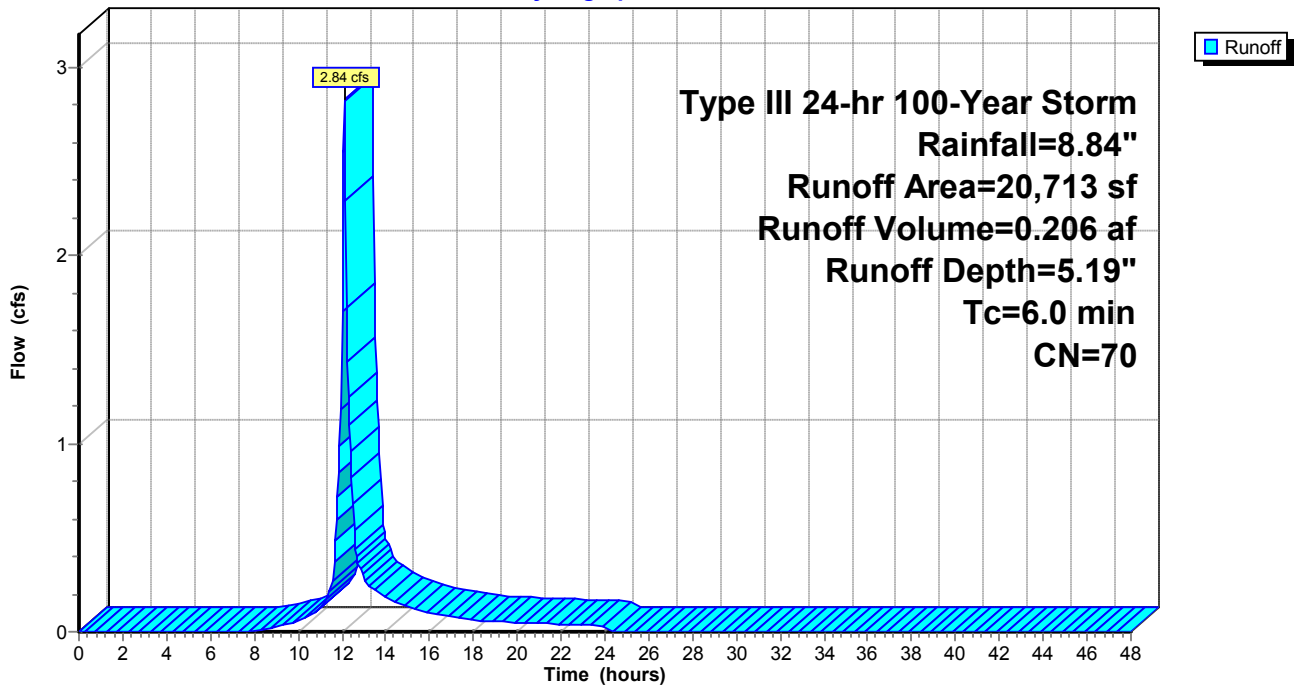Runoff   =   28.19 cfs @ 12.09 hrs, Volume=   2.063 af, Depth= 5.81"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
1,495	98	Paved roads w/curbs & sewers
13,425	39	>75% Grass cover, Good, HSG A
6,625	80	>75% Grass cover, Good, HSG D
4,530	36	Woods, Fair, HSG A
159,657	79	Woods, Fair, HSG D
185,732	75	Weighted Average
184,237		Pervious Area
1,495		Impervious Area

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

Subcatchment 3S: Site to Depression

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=185,732 sf
Runoff Volume=2.063 af
Runoff Depth=5.81"
Tc=6.0 min
CN=75

Subcatchment 4S: Offsite Properties

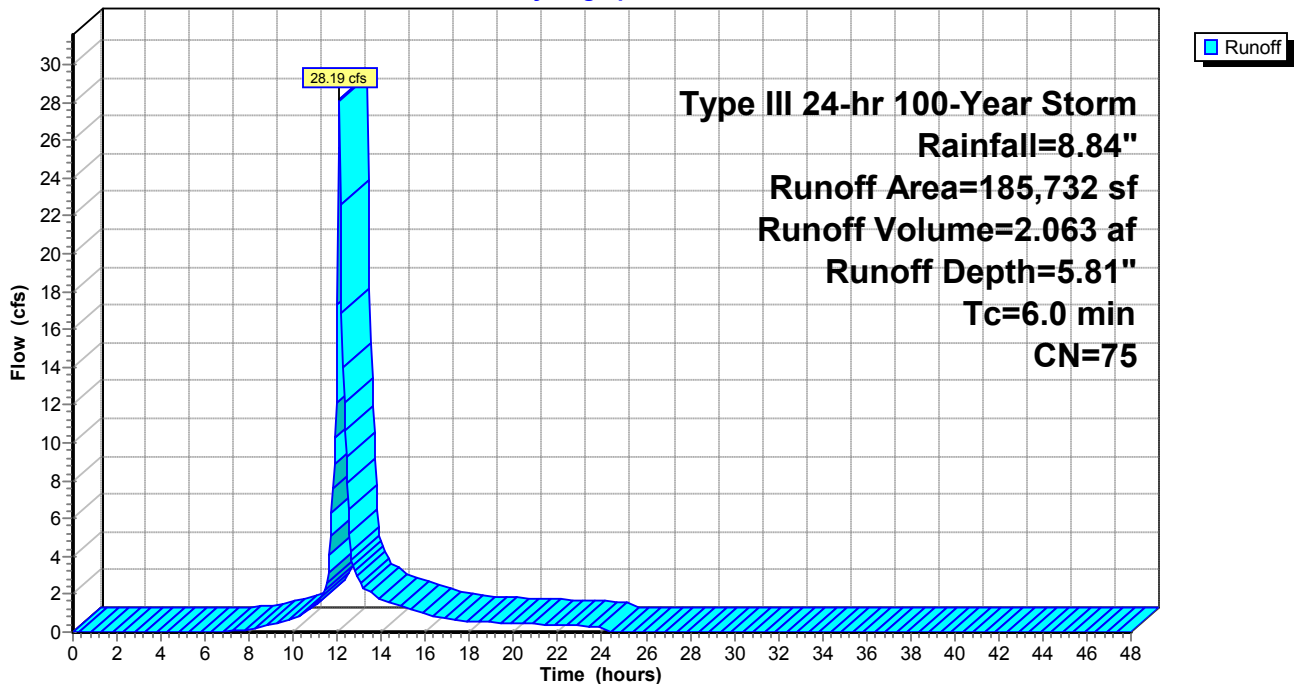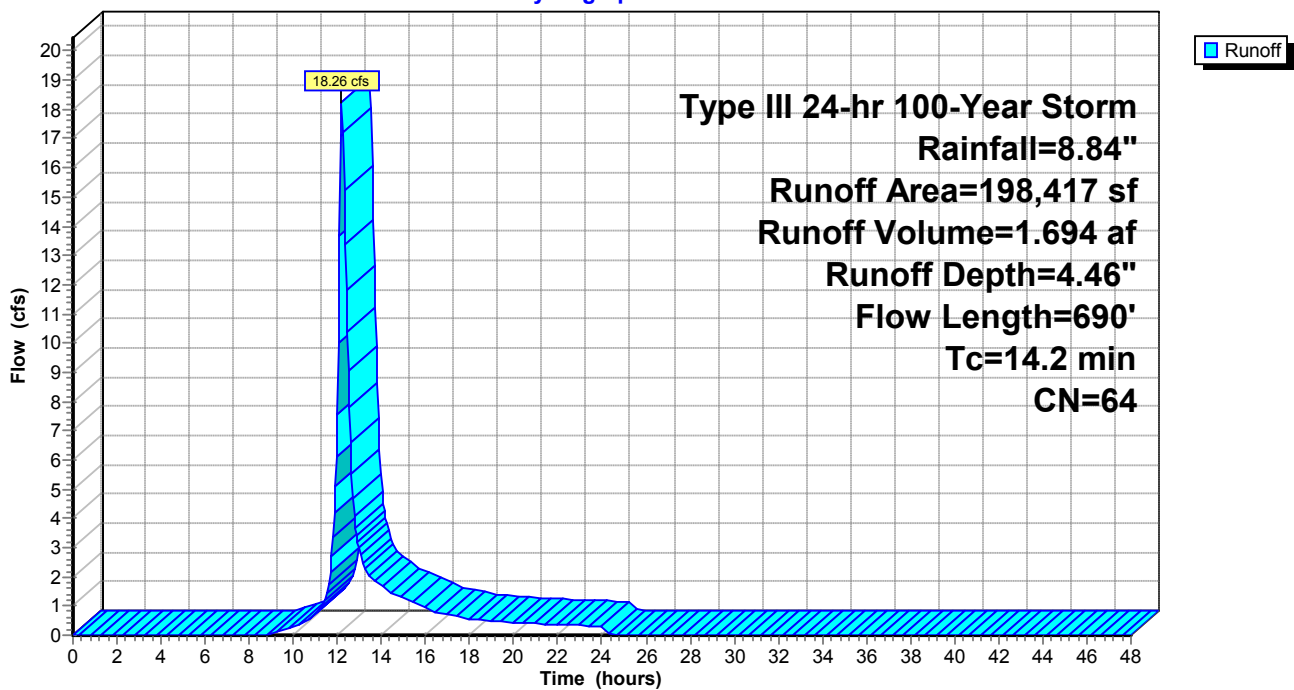Runoff   =   18.26 cfs @ 12.20 hrs, Volume=   1.694 af, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
132,278	54	1/2 acre lots, 25% imp, HSG A
41,772	85	1/2 acre lots, 25% imp, HSG D
24,367	85	1/2 acre lots, 25% imp, HSG D
198,417	64	Weighted Average
148,813		Pervious Area
49,604		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
4.3	550	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
1.7	90	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
14.2	690				Total

Subcatchment 4S: Offsite Properties

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=198,417 sf
Runoff Volume=1.694 af
Runoff Depth=4.46"
Flow Length=690'
Tc=14.2 min
CN=64

Existing Conditions3
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Type III 24-hr 100-Year Storm Rainfall=8.84"
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Subcatchment 6S: Woodbine Road & Offsite

Runoff   =   71.32 cfs @ 12.22 hrs, Volume=   6.987 af, Depth= 5.93"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
362,024	73	Woods, Fair, HSG C
254,113	80	1/2 acre lots, 25% imp, HSG C
616,137	76	Weighted Average
552,609		Pervious Area
63,528		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	125	0.0150	0.61		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	200	0.0150	1.84		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.7	710	0.0250	3.21		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.5	100	0.0180	0.67		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
16.3	1,185	Total			

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Type III 24-hr 100-Year Storm Rainfall=8.84"
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Subcatchment 6S: Woodbine Road & Offsite

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=616,137 sf
Runoff Volume=6.987 af
Runoff Depth=5.93"
Flow Length=1,185'
Tc=16.3 min
CN=76

□ Runoff

71.32 cfs

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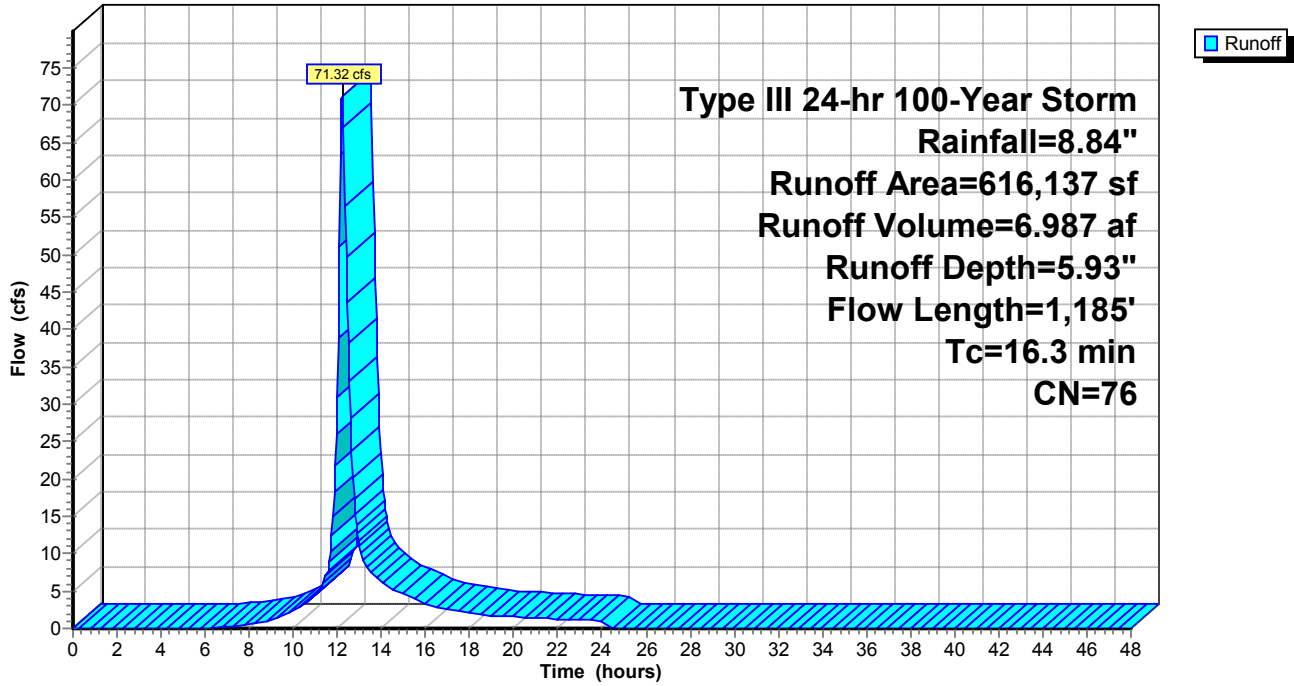*Type III 24-hr 100-Year Storm Rainfall=8.84"*
Page 6
3/17/2017

Subcatchment 7S: Site to Woodbine Depression

Runoff   =   6.17 cfs @   12.09 hrs, Volume=   0.456 af, Depth= 6.29"
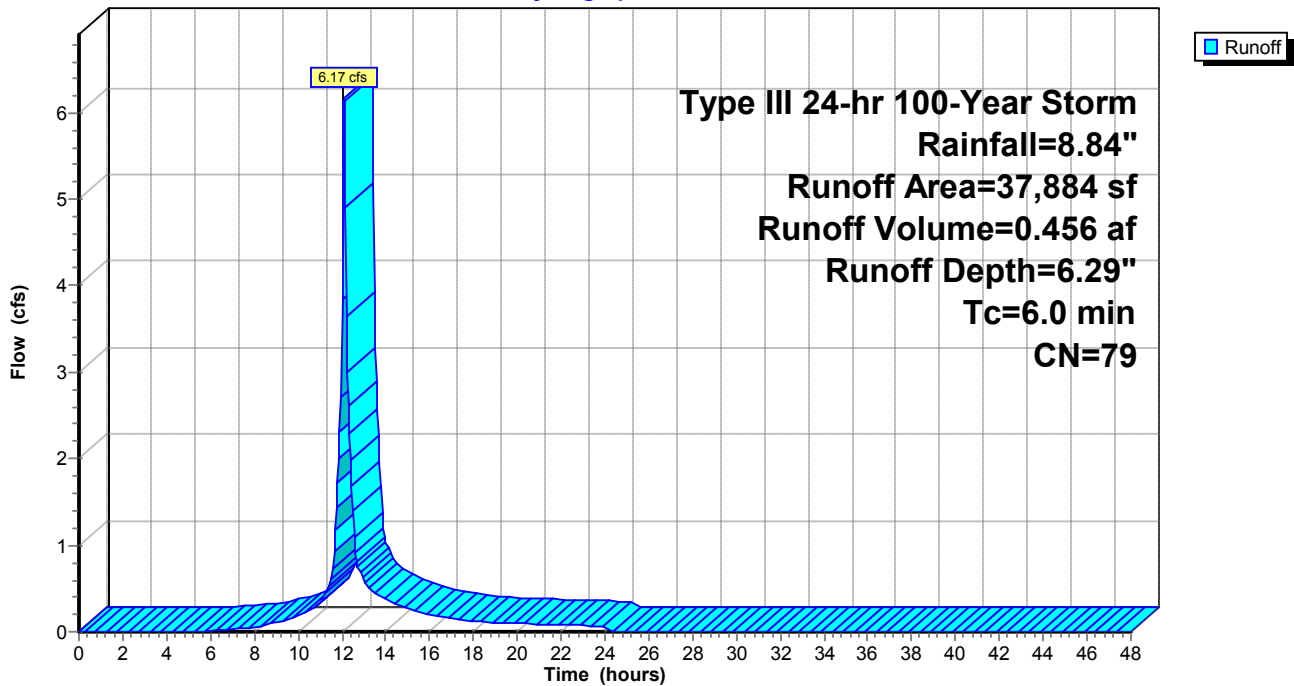
Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
179	98	Paved parking & roofs
37,705	79	Woods, Fair, HSG D
37,884	79	Weighted Average
37,705		Pervious Area
179		Impervious Area

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

Subcatchment 7S: Site to Woodbine Depression

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=37,884 sf
Runoff Volume=0.456 af
Runoff Depth=6.29"
Tc=6.0 min
CN=79

Subcatchment 8S: Site to Wetlands

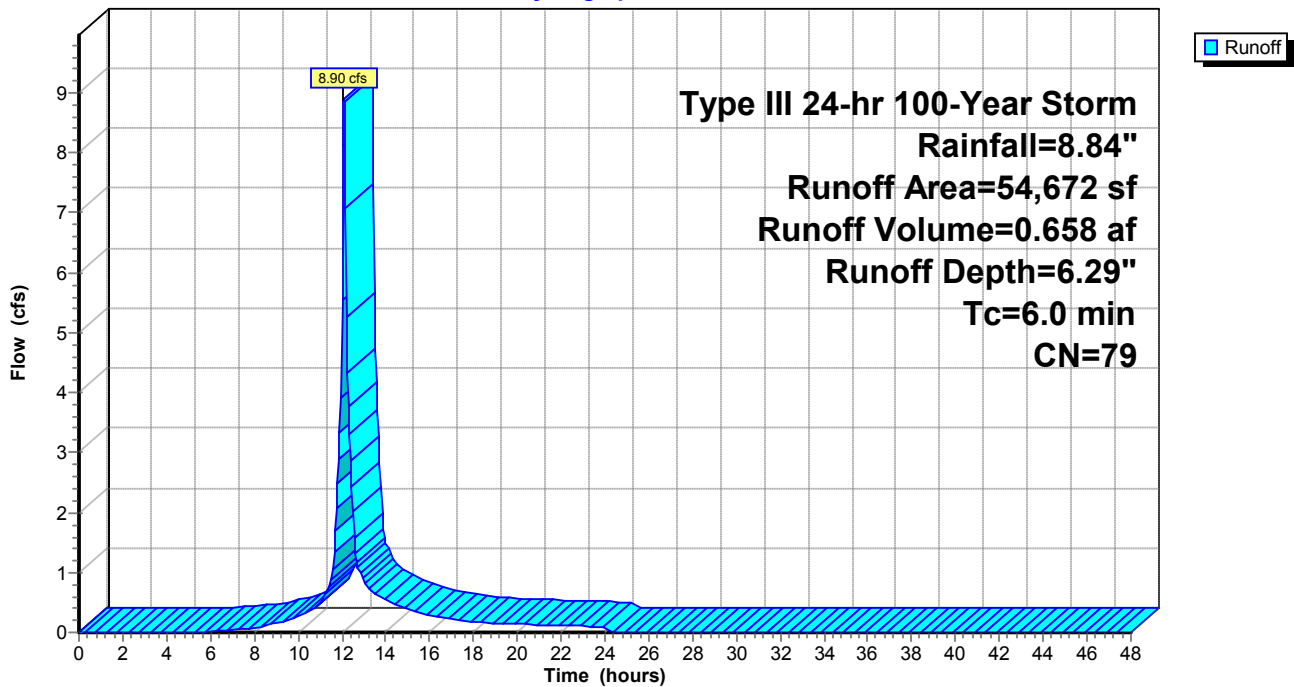Runoff   =   8.90 cfs @   12.09 hrs, Volume=   0.658 af, Depth= 6.29"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
54,672	79	Woods, Fair, HSG D
54,672		Pervious Area

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

Subcatchment 8S: Site to Wetlands

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=54,672 sf
Runoff Volume=0.658 af
Runoff Depth=6.29"
Tc=6.0 min
CN=79

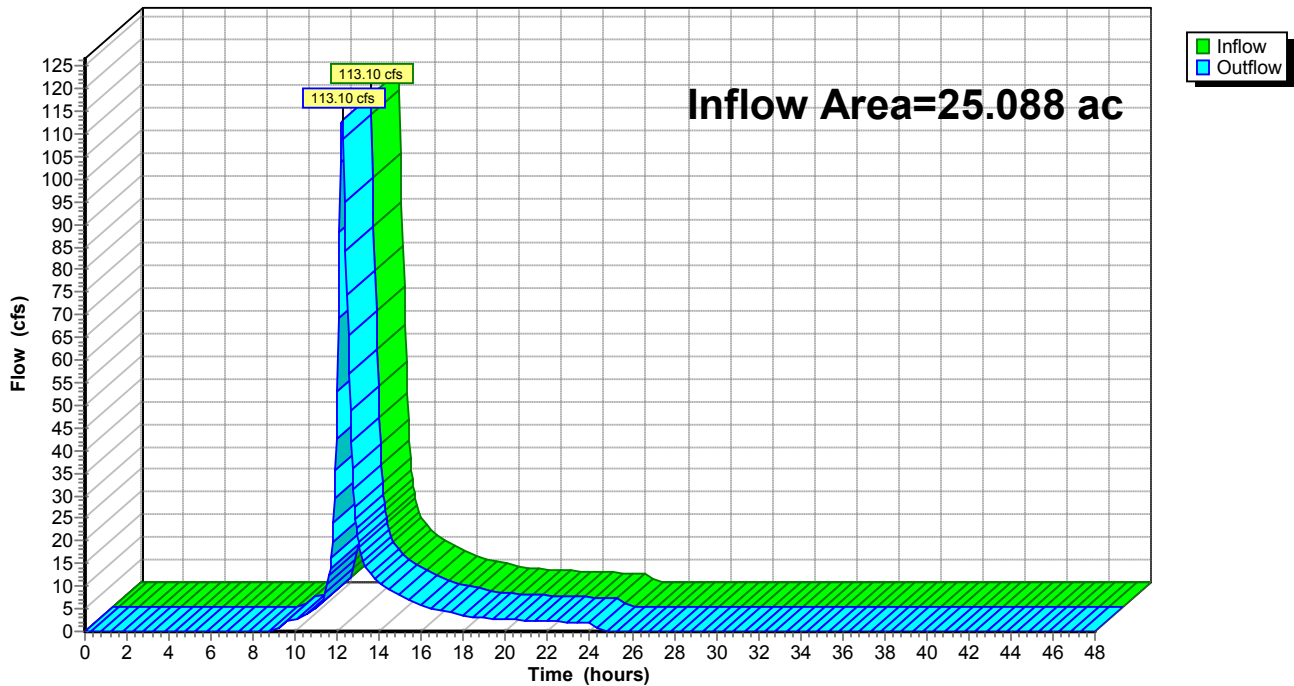## Reach 1R: IVW

Inflow Area =   25.088 ac, Inflow Depth = 5.48"   for 100-Year Storm event
Inflow   =   113.10 cfs @   12.23 hrs, Volume=   11.454 af
Outflow   =   113.10 cfs @   12.23 hrs, Volume=   11.454 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Reach 1R: IVW

Hydrograph

Inflow Area=25.088 ac

Reach 7R: Swale

Inflow Area =   4.555 ac, Inflow Depth = 4.46"   for 100-Year Storm event
Inflow   =   18.26 cfs @   12.20 hrs, Volume=   1.694 af
Outflow   =   18.12 cfs @   12.21 hrs, Volume=   1.694 af, Atten= 1%, Lag= 0.7 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Max. Velocity= 2.04 fps, Min. Travel Time= 0.4 min
Avg. Velocity = 0.73 fps, Avg. Travel Time= 1.2 min

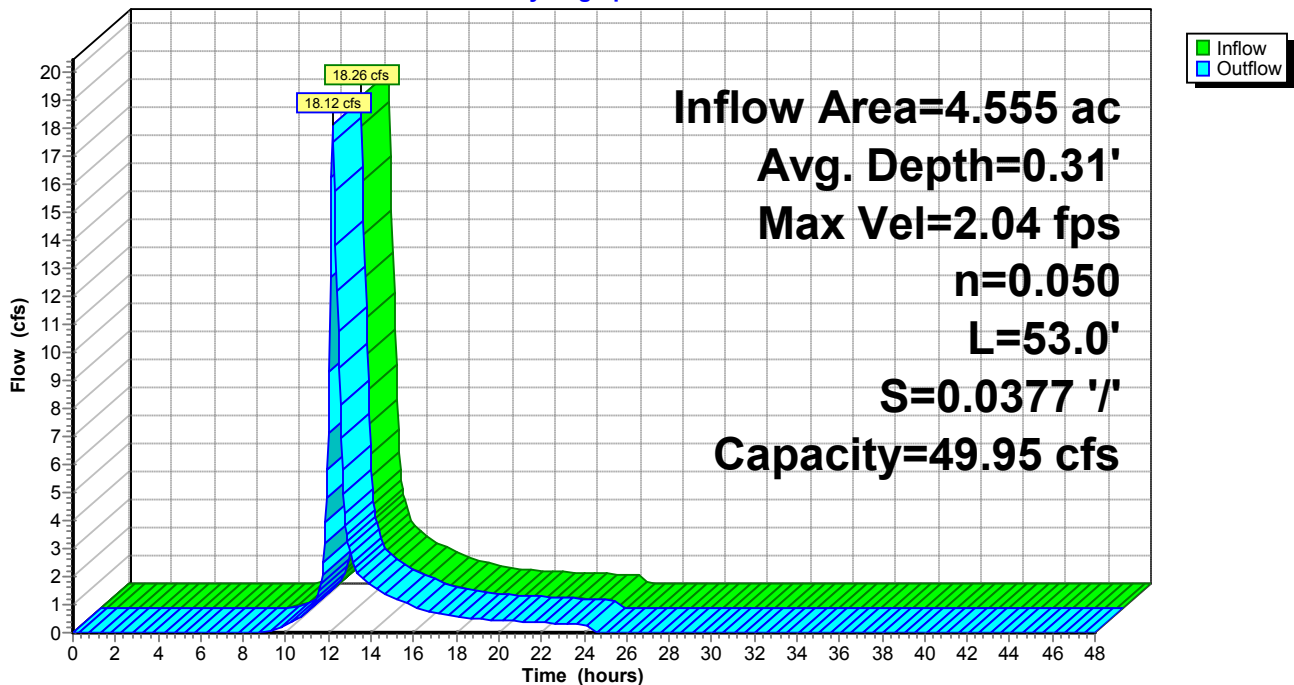Peak Storage= 475 cf @ 12.21 hrs, Average Depth at Peak Storage= 0.31'
Bank-Full Depth= 0.50', Capacity at Bank-Full= 49.95 cfs

54.00' x 0.50' deep Parabolic Channel, n= 0.050
Length= 53.0'   Slope= 0.0377 '/'
Inlet Invert= 88.00', Outlet Invert= 86.00'

‡

Reach 7R: Swale

Hydrograph

Inflow Area=4.555 ac
Avg. Depth=0.31'
Max Vel=2.04 fps
n=0.050
L=53.0'
S=0.0377 '/'
Capacity=49.95 cfs

Pond 3P: Site Depression

Inflow Area =   8.819 ac, Inflow Depth = 5.11"   for 100-Year Storm event
Inflow   =   41.00 cfs @   12.11 hrs, Volume=   3.757 af
Outflow   =   34.89 cfs @   12.21 hrs, Volume=   3.487 af, Atten= 15%, Lag= 5.8 min
Primary   =   34.89 cfs @   12.21 hrs, Volume=   3.487 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 86.53' @ 12.21 hrs   Surf.Area= 59,156 sf   Storage= 27,074 cf

Plug-Flow detention time= 67.4 min calculated for 3.487 af (93% of inflow)
Center-of-Mass det. time= 29.6 min (853.9 - 824.3)

Volume	Invert	Avail.Storage	Storage Description
#1	86.00'	58,179 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)
86.00	41,988	830.0	0	0	41,988
86.25	52,276	995.0	11,760	11,760	65,952
87.00	72,037	1,166.0	46,420	58,179	95,369

Device	Routing	Invert	Outlet Devices
#1	Primary	86.25'	**90.0' long x 30.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=34.71 cfs @ 12.21 hrs HW=86.52' (Free Discharge)
└—**1=Broad-Crested Rectangular Weir** (Weir Controls 34.71 cfs @ 1.41 fps)

Existing Conditions3
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Type III 24-hr 100-Year Storm Rainfall=8.84"
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Pond 3P: Site Depression

Hydrograph

Inflow Area=8.819 ac
Peak Elev=86.53'
Storage=27,074 cf

Pond 4P: Woodbine Depression

Inflow Area =   15.014 ac, Inflow Depth = 5.95"   for 100-Year Storm event
Inflow   =   74.65 cfs @   12.22 hrs, Volume=   7.443 af
Outflow   =   73.96 cfs @   12.24 hrs, Volume=   7.309 af, Atten= 1%, Lag= 1.4 min
Primary   =   73.96 cfs @   12.24 hrs, Volume=   7.309 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 88.87' @ 12.24 hrs   Surf.Area= 21,785 sf   Storage= 12,847 cf

Plug-Flow detention time= 19.6 min calculated for 7.309 af (98% of inflow)
Center-of-Mass det. time= 8.6 min (825.2 - 816.6)

Volume	Invert	Avail.Storage	Storage Description
#1	88.00'	15,739 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation	Surf.Area	Perim.	Inc.Store	Cum.Store	Wet.Area
(feet)	(sq-ft)	(feet)	(cubic-feet)	(cubic-feet)	(sq-ft)
88.00	8,161	367.0	0	0	8,161
88.50	15,722	518.0	5,868	5,868	18,798
89.00	24,056	630.0	9,871	15,739	29,033

Device	Routing	Invert	Outlet Devices
#1	Primary	88.50'	**120.0' long x 97.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=73.43 cfs @ 12.24 hrs HW=88.87' (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 73.43 cfs @ 1.65 fps)

Existing Conditions3
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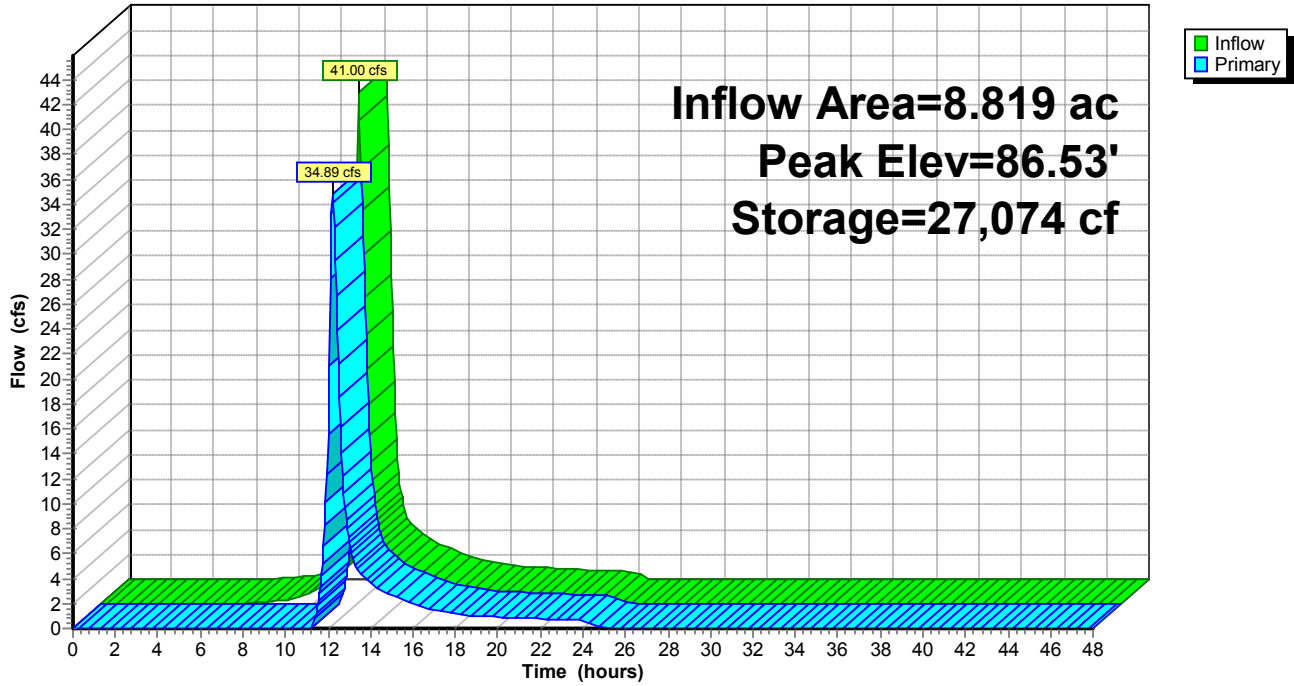HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 100-Year Storm Rainfall=8.84"
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Pond 4P: Woodbine Depression

Hydrograph

Inflow Area=15.014 ac
Peak Elev=88.87'
Storage=12,847 cf
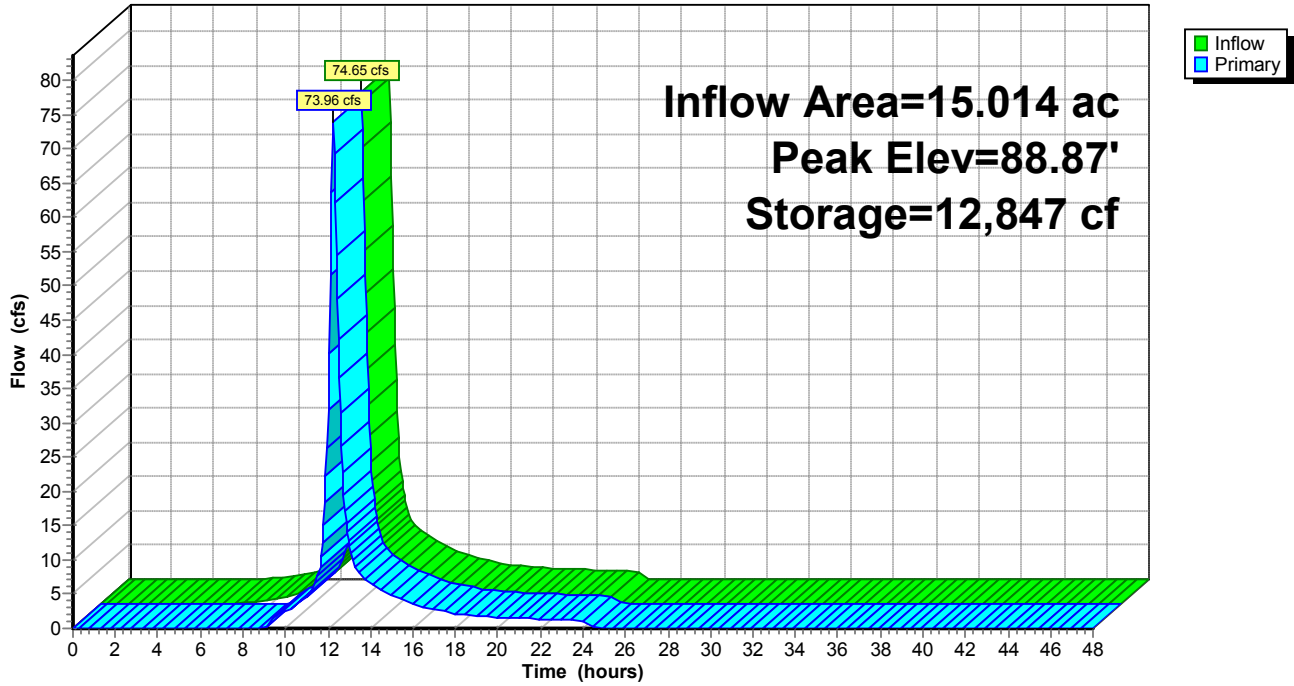
Appendix B
Proposed Conditions

Proposed Conditions
2 Year Storm Event
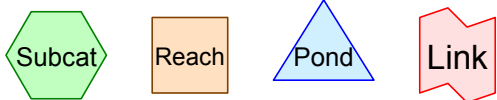
Drainage Diagram for Proposed Conditions5
Prepared by Gala Simon Associates   3/17/2017
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Subcatchment 1A: Lot 1 Infiltrated Area

Runoff   =   0.29 cfs @ 12.09 hrs, Volume=   0.024 af, Depth= 2.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
4,152	98	Paved roads w/curbs & sewers
4,152		Impervious Area

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

Subcatchment 1A: Lot 1 Infiltrated Area

Hydrograph

Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=4,152 sf
Runoff Volume=0.024 af
Runoff Depth=2.98"
Tc=6.0 min
CN=98

Subcatchment 1S: Site to Marsh Street

Runoff   =   0.32 cfs @ 12.11 hrs, Volume=   0.026 af, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
13,418	61	>75% Grass cover, Good, HSG B
3,788	98	Paved parking & roofs
17,206	69	Weighted Average
13,418		Pervious Area
3,788		Impervious Area

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

Subcatchment 1S: Site to Marsh Street

Hydrograph

Proposed Conditions5
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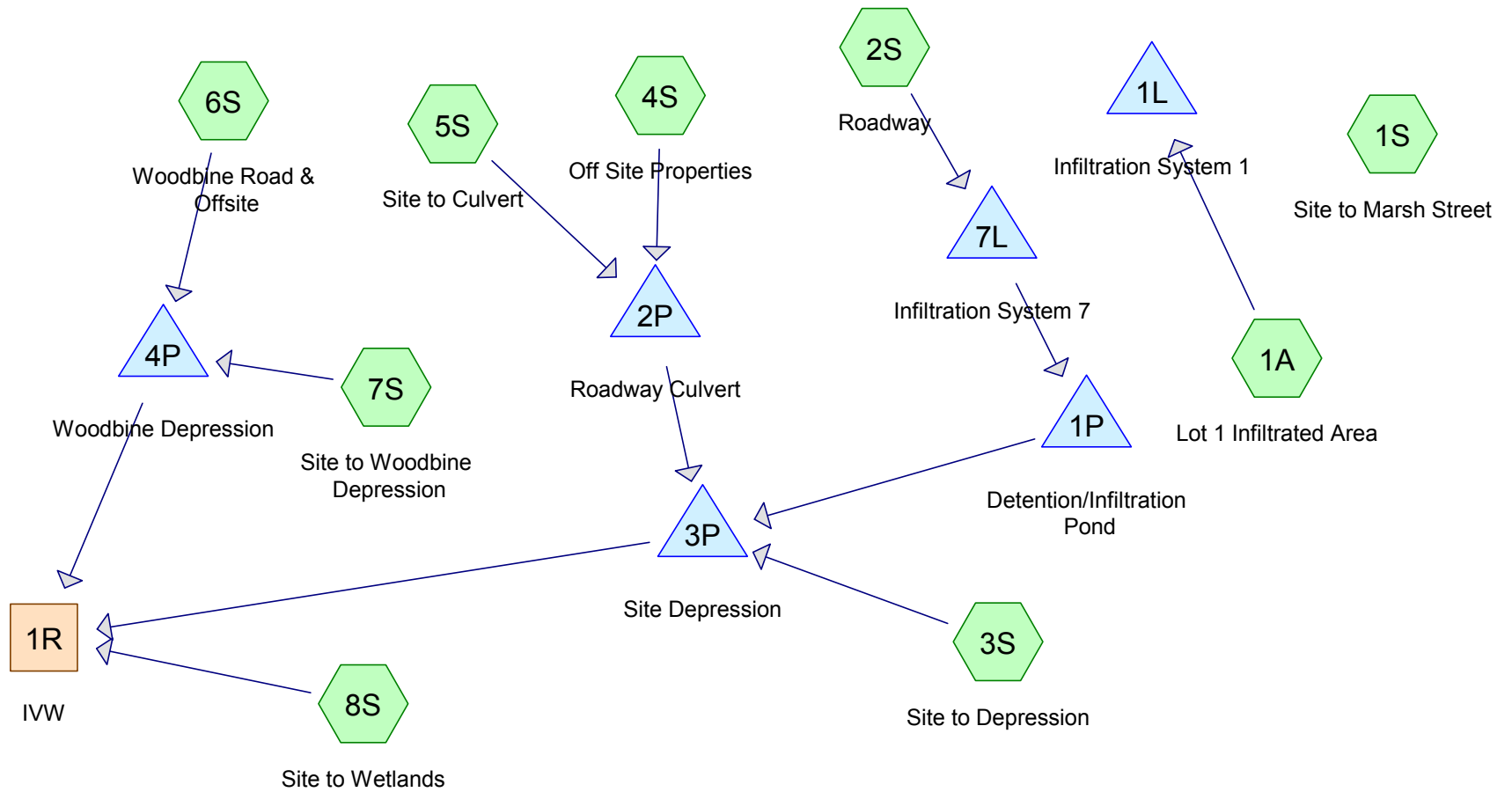*Type III 24-hr 2-Year Storm Rainfall=3.21"*
Page 3
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Subcatchment 2S: Roadway

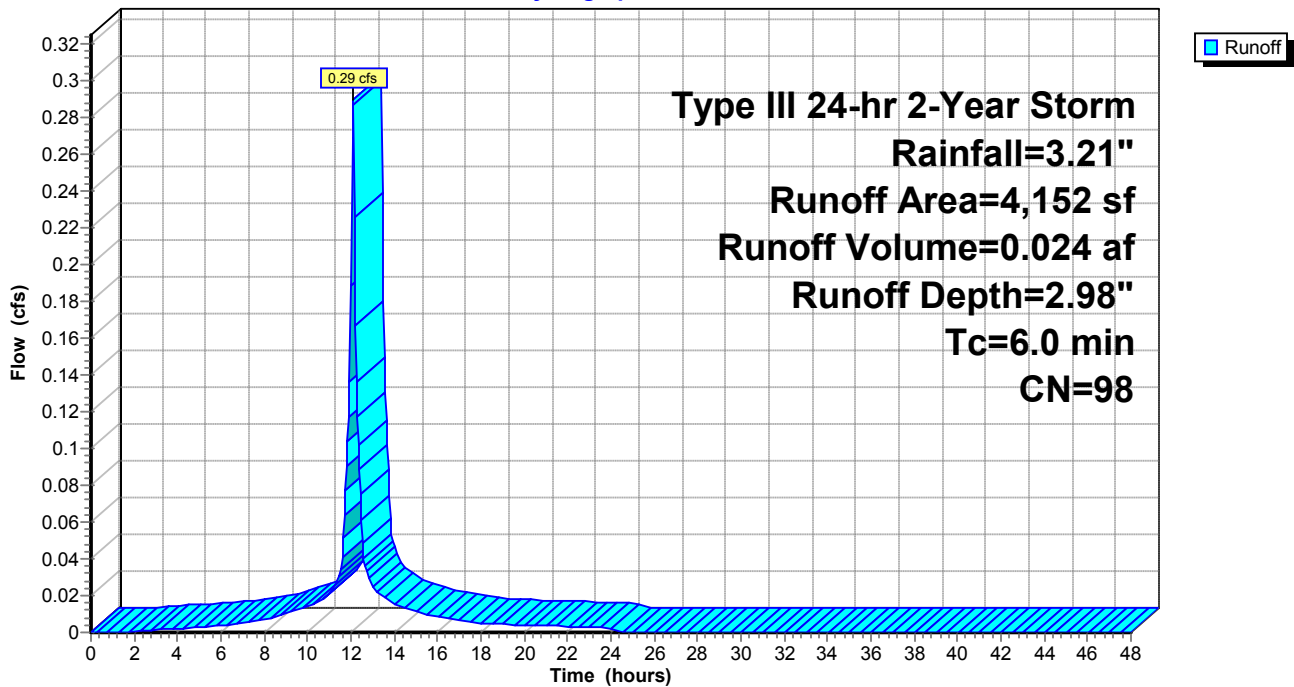Runoff   =   2.87 cfs @ 12.09 hrs, Volume=   0.211 af, Depth= 2.20"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
1,108	39	>75% Grass cover, Good, HSG A
31,026	98	Paved parking & roofs
18,080	80	>75% Grass cover, Good, HSG D
50,214	90	Weighted Average
19,188		Pervious Area
31,026		Impervious Area

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

Subcatchment 2S: Roadway

Hydrograph

Subcatchment 3S: Site to Depression

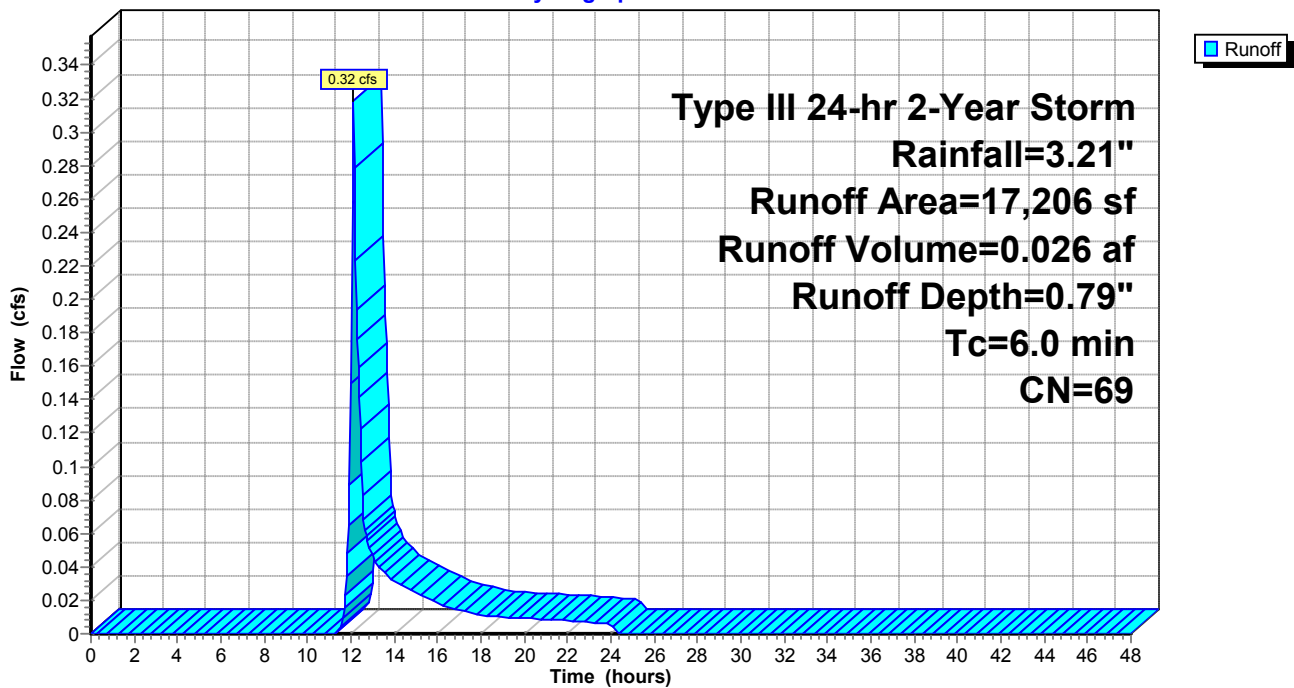Runoff   =   3.45 cfs @ 12.13 hrs, Volume=   0.282 af, Depth= 1.23"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
518	98	Paved parking & roofs
6,600	39	>75% Grass cover, Good, HSG A
25,718	80	>75% Grass cover, Good, HSG D
87,511	79	Woods, Fair, HSG D
120,347	77	Weighted Average
119,829		Pervious Area
518		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0300	0.12		**Sheet Flow,**
					Grass: Dense n= 0.240 P2= 3.20"
1.1	175	0.0300	2.60		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
0.5	35	0.0500	1.12		**Shallow Concentrated Flow,**
					Woodland Kv= 5.0 fps
8.6	260	Total			

Subcatchment 3S: Site to Depression

Hydrograph

Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=120,347 sf
Runoff Volume=0.282 af
Runoff Depth=1.23"
Flow Length=260'
Tc=8.6 min
CN=77

Subcatchment 4S: Off Site Properties

Runoff   =   1.82 cfs @ 12.23 hrs, Volume=   0.219 af, Depth= 0.58"
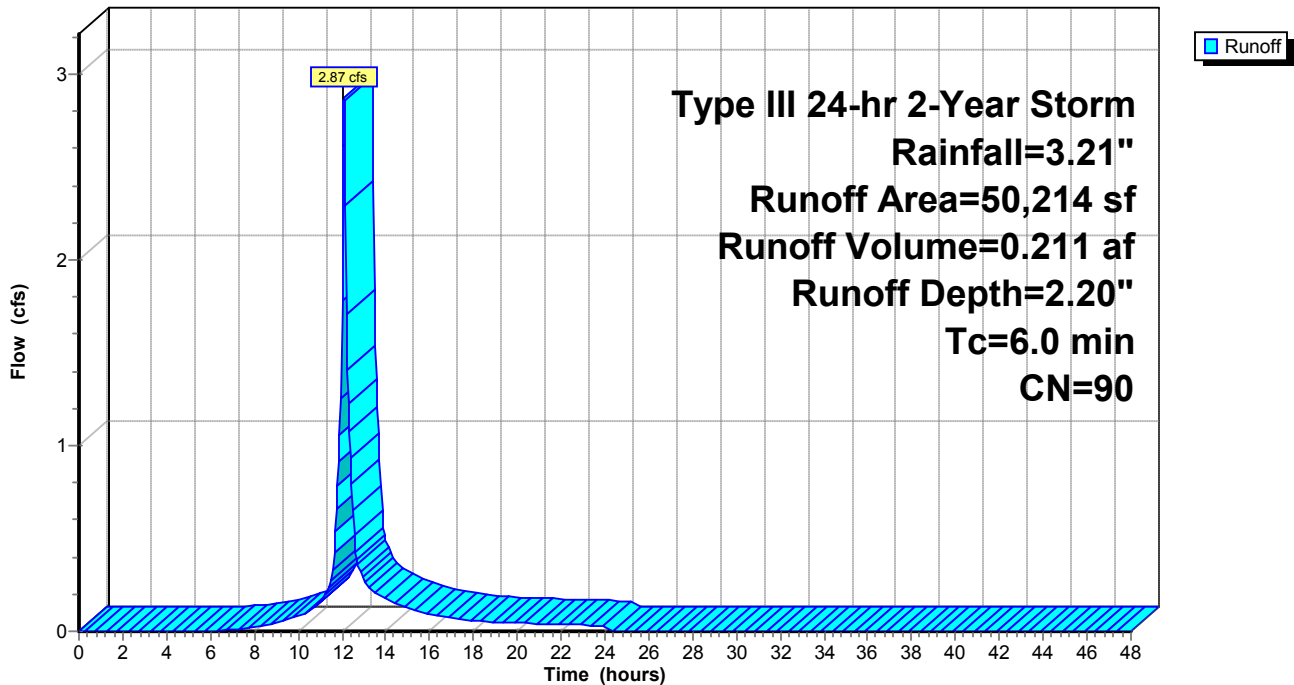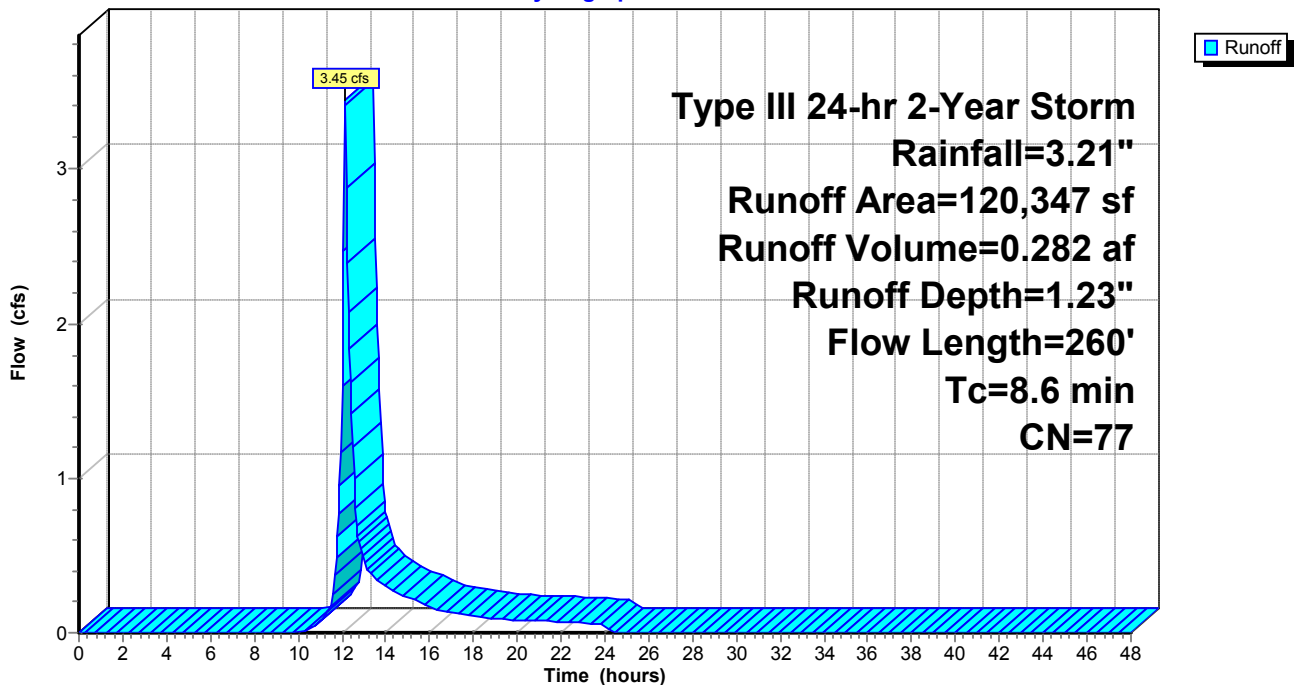
Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
132,278	54	1/2 acre lots, 25% imp, HSG A
41,772	85	1/2 acre lots, 25% imp, HSG D
24,367	85	1/2 acre lots, 25% imp, HSG D
198,417	64	Weighted Average
148,813		Pervious Area
49,604		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow,**
					Grass: Dense n= 0.240 P2= 3.20"
4.3	550	0.0200	2.12		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
0.2	16	0.0100	1.50		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
0.1	30	0.0100	6.44	11.38	**Circular Channel (pipe), Culvert**
					Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38'
					n= 0.012 Concrete pipe, finished
0.3	17	0.0300	0.87		**Shallow Concentrated Flow,**
					Woodland Kv= 5.0 fps
13.1	663	Total			

Subcatchment 4S: Off Site Properties

Hydrograph

Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=198,417 sf
Runoff Volume=0.219 af
Runoff Depth=0.58"
Flow Length=663'
Tc=13.1 min
CN=64

Proposed Conditions5
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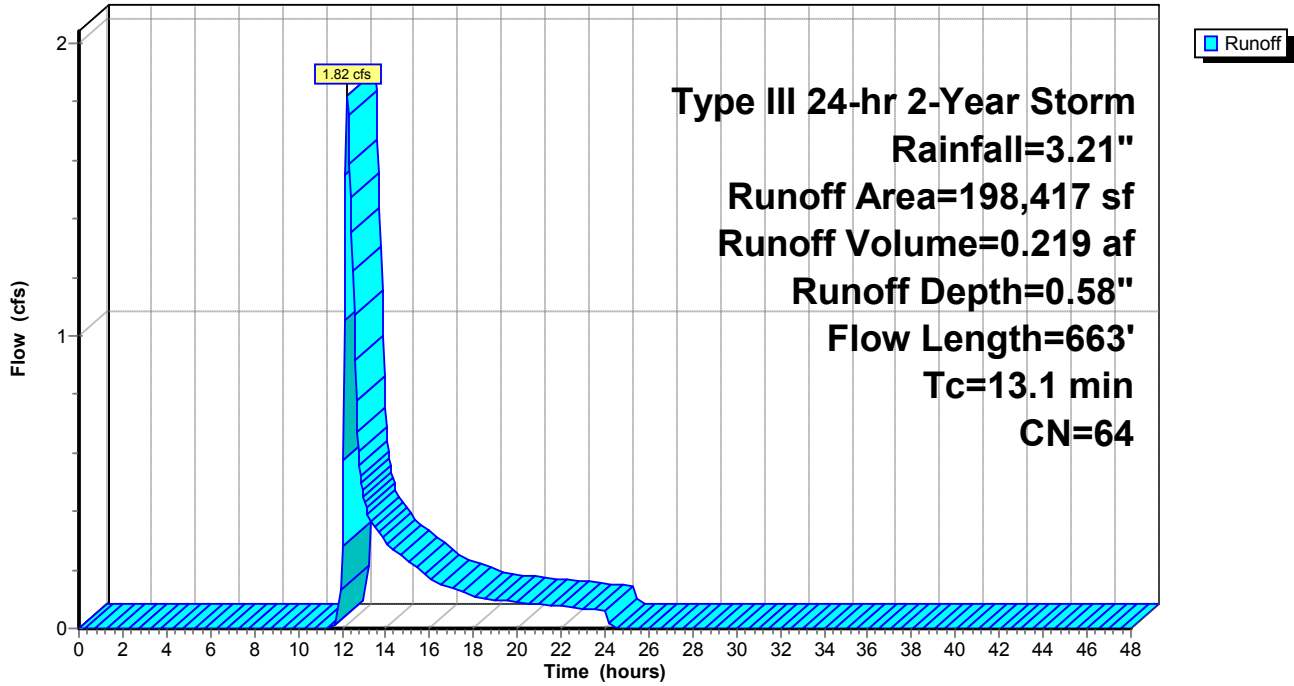*Type III 24-hr 2-Year Storm Rainfall=3.21"*
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Subcatchment 5S: Site to Culvert

Runoff   =   0.33 cfs @ 12.21 hrs, Volume=   0.032 af, Depth= 0.96"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
12,820	79	Woods, Fair, HSG D
2,936	39	>75% Grass cover, Good, HSG A
1,901	80	>75% Grass cover, Good, HSG D
17,657	72	Weighted Average
17,657		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.8	50	0.0100	0.08		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
2.6	231	0.0100	1.50		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.1	38	0.0150	7.28	12.87	**Circular Channel (pipe),** Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.013 Corrugated PE, smooth interior
0.2	14	0.0100	1.50		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
13.7	333	Total			

Subcatchment 5S: Site to Culvert

Hydrograph

Subcatchment 6S: Woodbine Road & Offsite

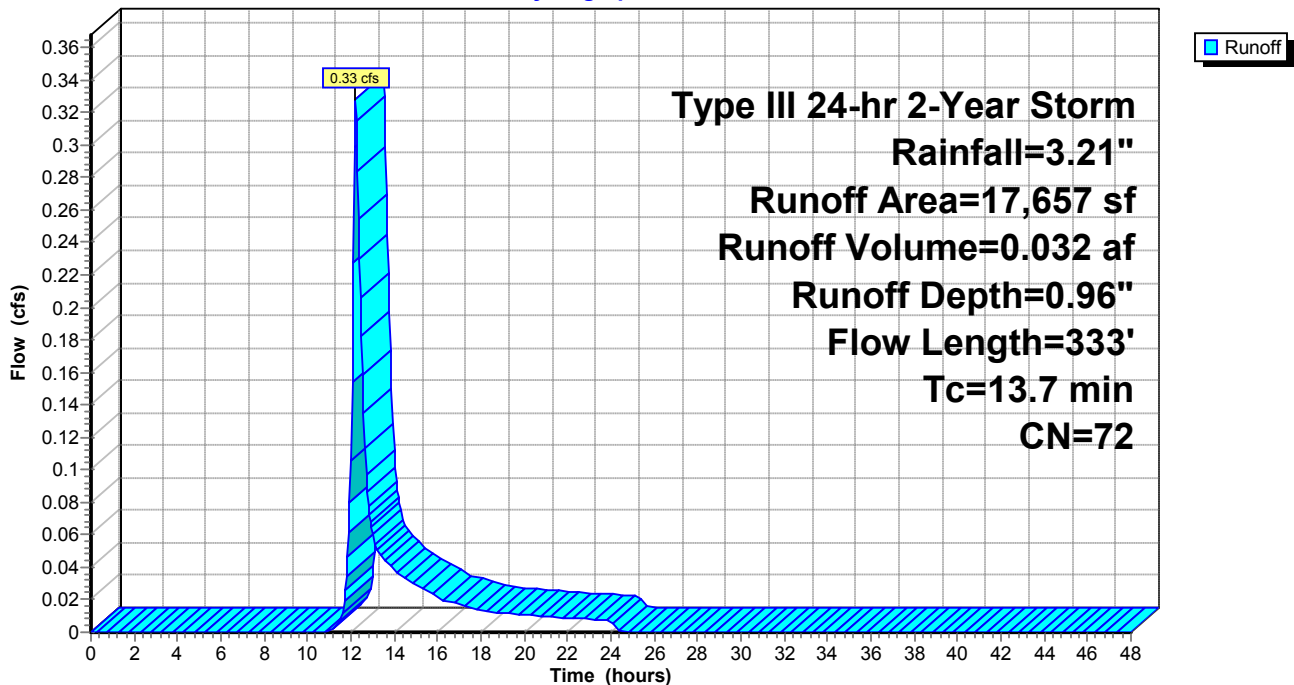Runoff   =   13.35 cfs @ 12.24 hrs, Volume=   1.358 af, Depth= 1.15"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
362,024	73	Woods, Fair, HSG C
254,113	80	1/2 acre lots, 25% imp, HSG C
616,137	76	Weighted Average
552,609		Pervious Area
63,528		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	125	0.0150	0.61		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	200	0.0150	1.84		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.7	710	0.0250	3.21		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.5	100	0.0180	0.67		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
16.3	1,185				Total

Proposed Conditions5
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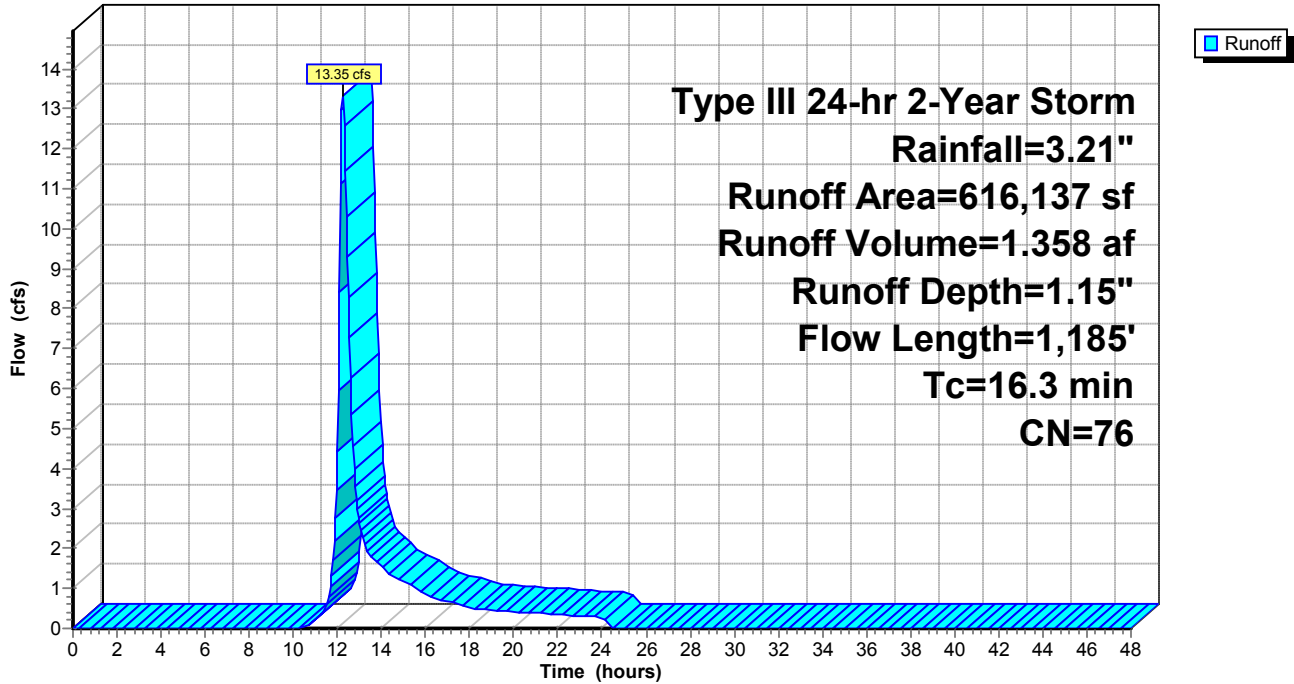HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 2-Year Storm Rainfall=3.21"
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Subcatchment 6S: Woodbine Road & Offsite

Hydrograph

Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=616,137 sf
Runoff Volume=1.358 af
Runoff Depth=1.15"
Flow Length=1,185'
Tc=16.3 min
CN=76

13.35 cfs

Runoff

Proposed Conditions5
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Type III 24-hr 2-Year Storm Rainfall=3.21"
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Subcatchment 7S: Site to Woodbine Depression

Runoff   =   1.28 cfs @ 12.10 hrs, Volume=   0.094 af, Depth= 1.36"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
179	98	Paved parking & roofs
31,805	79	Woods, Fair, HSG D
4,096	80	>75% Grass cover, Good, HSG D
36,080	79	Weighted Average
35,901		Pervious Area
179		Impervious Area

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

Subcatchment 7S: Site to Woodbine Depression

Hydrograph

□ Runoff

1.28 cfs

**Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=36,080 sf
Runoff Volume=0.094 af
Runoff Depth=1.36"
Tc=6.0 min
CN=79**

Subcatchment 8S: Site to Wetlands

Runoff   =   1.87 cfs @ 12.10 hrs, Volume=   0.137 af, Depth= 1.35"
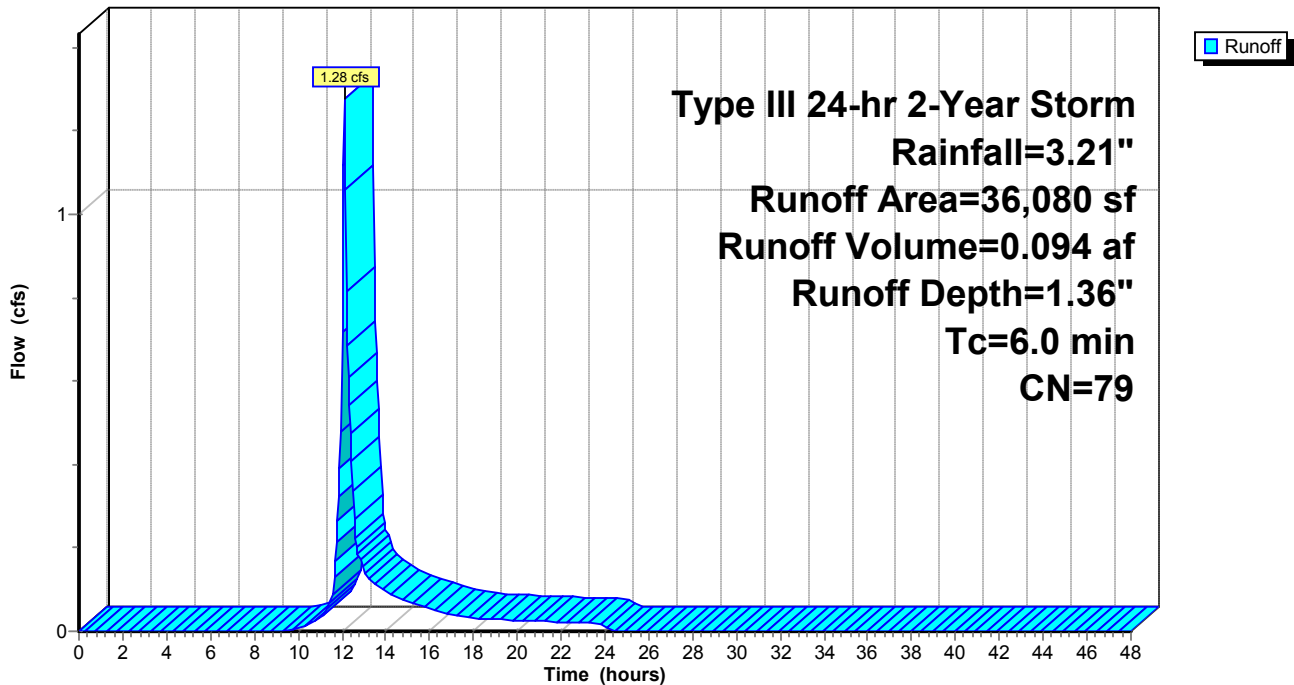
Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Storm Rainfall=3.21"

Area (sf)	CN	Description
51,265	79	Woods, Fair, HSG D
2,080	80	>75% Grass cover, Good, HSG D
53,345	79	Weighted Average
53,345		Pervious Area

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

Subcatchment 8S: Site to Wetlands

Hydrograph

Type III 24-hr 2-Year Storm
Rainfall=3.21"
Runoff Area=53,345 sf
Runoff Volume=0.137 af
Runoff Depth=1.35"
Tc=6.0 min
CN=79

Proposed Conditions5
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Type III 24-hr 2-Year Storm Rainfall=3.21"
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Reach 1R: IVW

Inflow Area =   25.073 ac, Inflow Depth = 0.82"   for 2-Year Storm event
Inflow   =   14.85 cfs @   12.26 hrs, Volume=   1.718 af
Outflow   =   14.85 cfs @   12.26 hrs, Volume=   1.718 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Reach 1R: IVW

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Type III 24-hr 2-Year Storm Rainfall=3.21"
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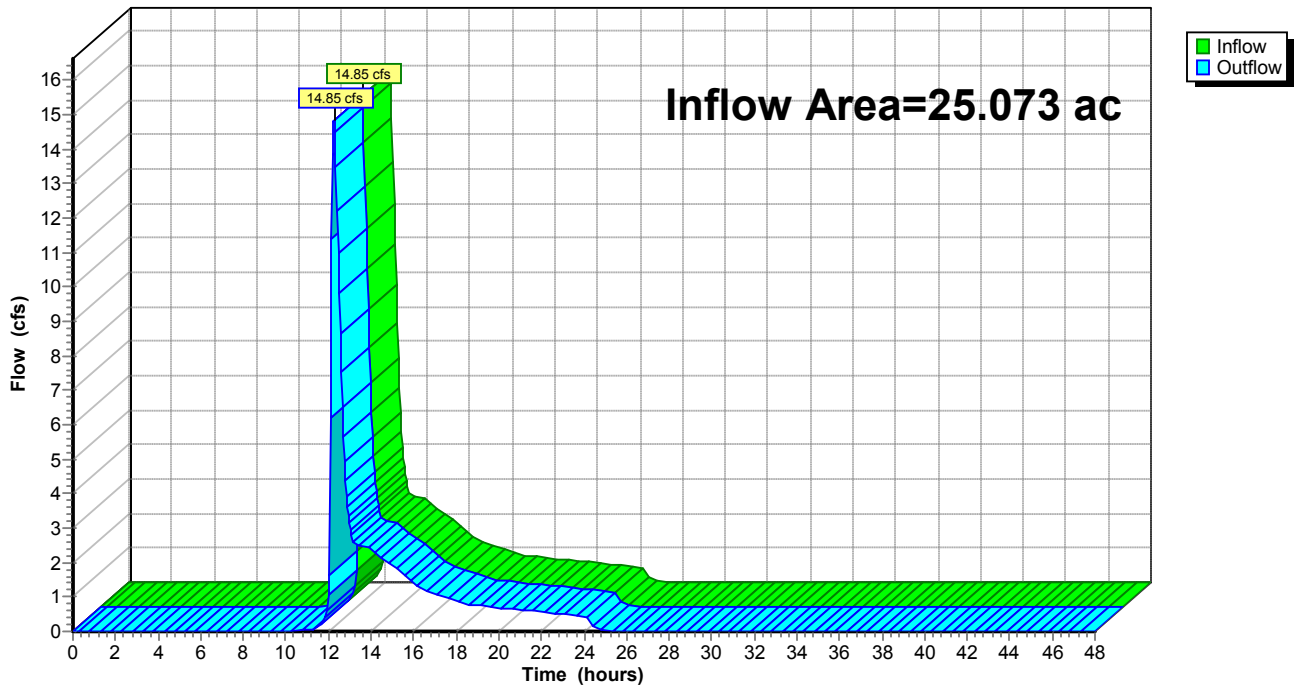3/17/2017

Pond 1L: Infiltration System 1

Inflow Area =   0.095 ac, Inflow Depth = 2.98"   for 2-Year Storm event
Inflow   =   0.29 cfs @   12.09 hrs, Volume=   0.024 af
Outflow   =   0.01 cfs @   9.60 hrs, Volume=   0.024 af, Atten= 96%, Lag= 0.0 min
Primary   =   0.01 cfs @   9.60 hrs, Volume=   0.024 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 91.46' @ 14.95 hrs   Surf.Area= 0 sf   Storage= 513 cf

Plug-Flow detention time= 363.0 min calculated for 0.024 af (100% of inflow)
Center-of-Mass det. time= 363.0 min (1,119.3 - 756.3)

Volume	Invert	Avail.Storage	Storage Description
#1	89.80'	2,159 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
89.80	0
90.30	84
95.63	2,062
95.89	2,159

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**Special & User-Defined** Elev. (feet) 89.80 89.81 90.30 95.63 95.89 Disch. (cfs) 0.000 0.012 0.012 0.012 0.012

Primary OutFlow Max=0.01 cfs @ 9.60 hrs HW=89.81'   (Free Discharge)
└─**1=Special & User-Defined** (Custom Controls 0.01 cfs)

Proposed Conditions5
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Type III 24-hr 2-Year Storm Rainfall=3.21"
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Pond 1L: Infiltration System 1

Hydrograph

Inflow Area=0.095 ac
Peak Elev=91.46'
Storage=513 cf

Legend: Inflow, Primary

0.29 cfs

0.01 cfs

Flow (cfs) vs Time (hours)

Pond 1P: Detention/Infiltration Pond

Inflow Area =   1.153 ac, Inflow Depth = 2.14"   for 2-Year Storm event
Inflow   =   2.87 cfs @ 12.09 hrs, Volume=   0.206 af
Outflow   =   0.14 cfs @ 11.05 hrs, Volume=   0.206 af, Atten= 95%, Lag= 0.0 min
Discarded =   0.14 cfs @ 11.05 hrs, Volume=   0.206 af
Primary   =   0.00 cfs @   0.00 hrs, Volume=   0.000 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 89.75' @ 14.63 hrs   Surf.Area= 3,861 sf   Storage= 4,497 cf

Plug-Flow detention time= 299.1 min calculated for 0.205 af (100% of inflow)
Center-of-Mass det. time= 299.0 min (1,108.0 - 809.0)

Volume	Invert	Avail.Storage	Storage Description
#1	88.50'	14,988 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)
88.50	3,498	238.0	0	0	3,498
89.00	3,498	238.0	1,749	1,749	3,617
90.00	3,988	251.0	3,740	5,489	4,179
91.00	4,502	263.0	4,242	9,732	4,733
92.00	6,049	329.0	5,256	14,988	7,856

Device	Routing	Invert	Outlet Devices
#1	Primary	89.80'	**8.0" Vert. Orifice** C= 0.600
#2	Primary	91.20'	**2.00' x 2.00' Horiz. Overflow Grate** Limited to weir flow C= 0.600
#3	Discarded	0.00'	**Exfiltration**
			Elev. (feet) 88.50 88.51 89.00 90.00 91.00 92.00
			Disch. (cfs) 0.000 0.143 0.143 0.143 0.143 0.143

Discarded OutFlow Max=0.14 cfs @ 11.05 hrs HW=88.51' (Free Discharge)
└─**3=Exfiltration** (Custom Controls 0.14 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=88.50' (Free Discharge)
├─**1=Orifice** (Controls 0.00 cfs)
└─**2=Overflow Grate** (Controls 0.00 cfs)

Proposed Conditions5
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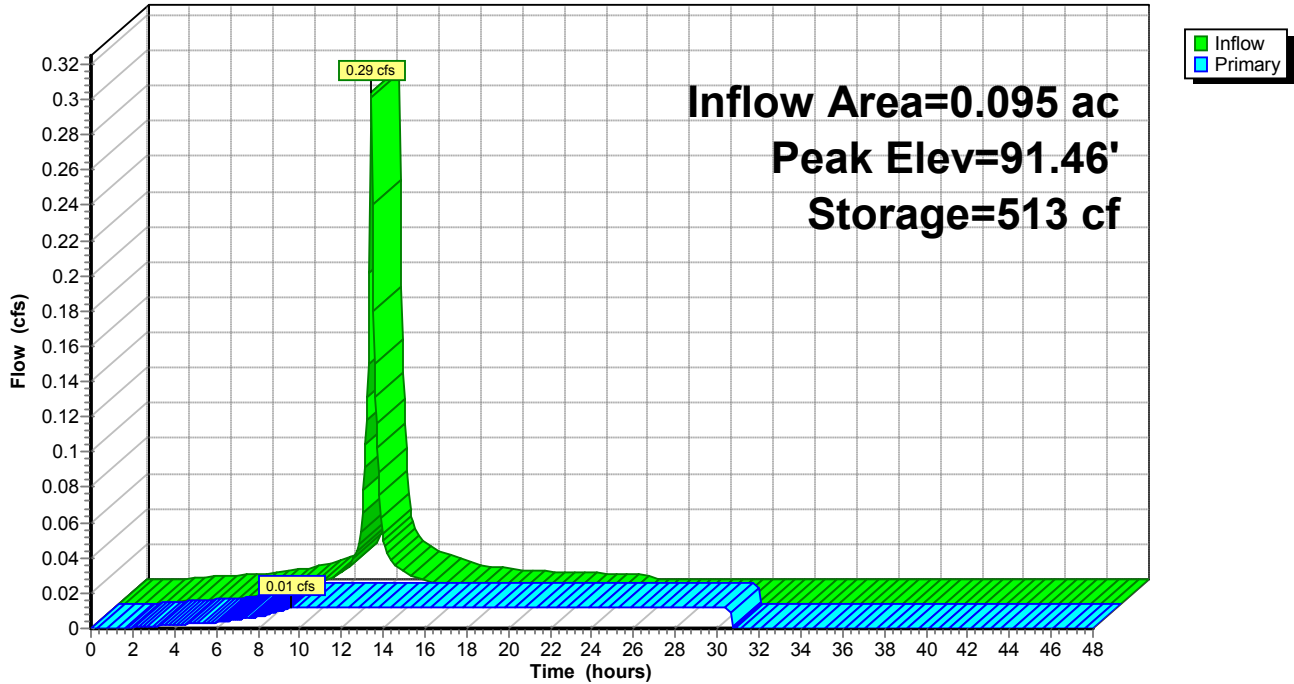HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 2-Year Storm Rainfall=3.21"
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Pond 1P: Detention/Infiltration Pond

Hydrograph

Inflow Area=1.153 ac
Peak Elev=89.75'
Storage=4,497 cf

Legend:
- Inflow
- Outflow
- Discarded
- Primary

2.87 cfs
0.14 cfs
0.14 cfs
0.00 cfs

Flow (cfs)

Time (hours)

Pond 2P: Roadway Culvert

Inflow Area =   4.960 ac, Inflow Depth = 0.61"   for 2-Year Storm event
Inflow   =   2.17 cfs @   12.22 hrs, Volume=   0.252 af
Outflow   =   2.15 cfs @   12.23 hrs, Volume=   0.252 af, Atten= 1%, Lag= 0.4 min
Primary   =   2.15 cfs @   12.23 hrs, Volume=   0.252 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 87.51' @ 12.23 hrs   Surf.Area= 0 sf   Storage= 80 cf

Plug-Flow detention time= 1.6 min calculated for 0.251 af (100% of inflow)
Center-of-Mass det. time= 1.6 min (902.3 - 900.7)

Volume	Invert	Avail.Storage	Storage Description
#1	87.25'	4,801 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
87.25	0
88.00	230
89.50	4,801

Device	Routing	Invert	Outlet Devices
#1	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#2	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#3	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#4	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#5	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#6	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished

Primary OutFlow Max=2.13 cfs @ 12.23 hrs HW=87.51'   (Free Discharge)
—**1=Culvert** (Inlet Controls 0.35 cfs @ 1.73 fps)
—**2=Culvert** (Inlet Controls 0.35 cfs @ 1.73 fps)
—**3=Culvert** (Inlet Controls 0.35 cfs @ 1.73 fps)
—**4=Culvert** (Inlet Controls 0.35 cfs @ 1.73 fps)
—**5=Culvert** (Inlet Controls 0.35 cfs @ 1.73 fps)
└—**6=Culvert** (Inlet Controls 0.35 cfs @ 1.73 fps)

Proposed Conditions5
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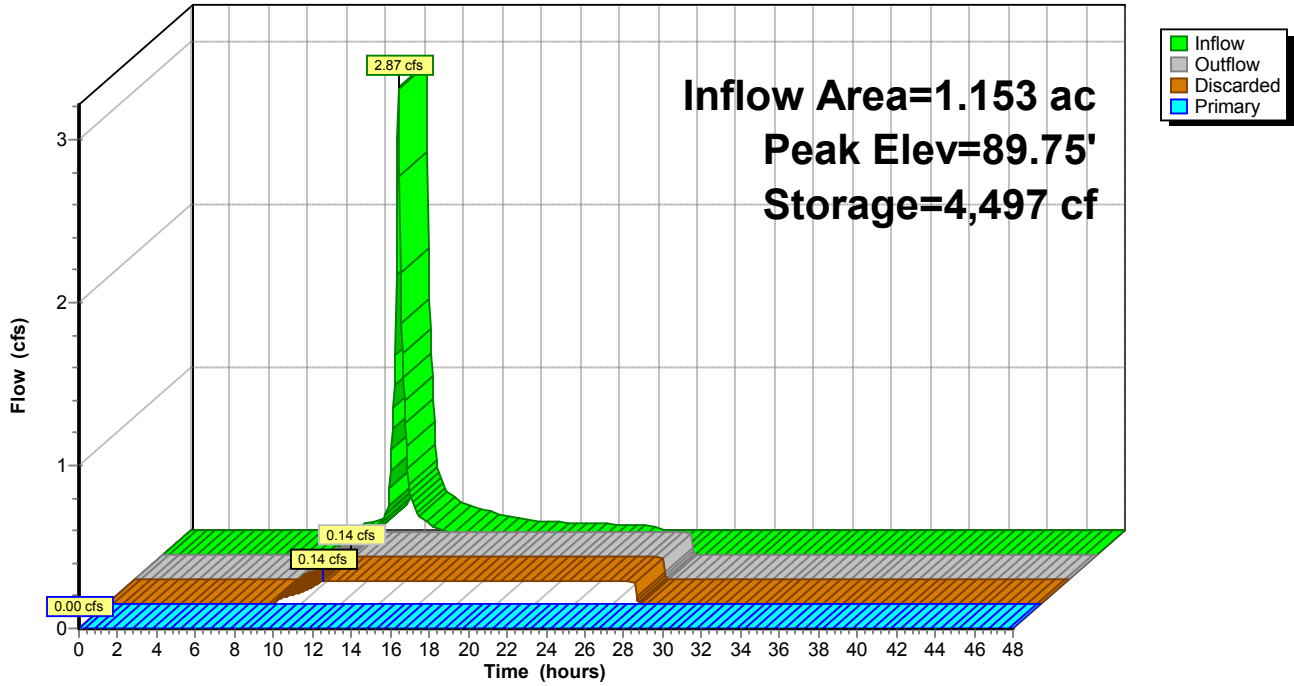HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 2-Year Storm Rainfall=3.21"
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Pond 2P: Roadway Culvert

Hydrograph

Inflow Area=4.960 ac
Peak Elev=87.51'
Storage=80 cf

2.17 cfs
2.15 cfs

Inflow
Primary

Pond 3P: Site Depression

Inflow Area =   8.876 ac, Inflow Depth = 0.72"   for 2-Year Storm event
Inflow   =   5.23 cfs @   12.16 hrs, Volume=   0.534 af
Outflow   =   0.61 cfs @   14.10 hrs, Volume=   0.264 af, Atten= 88%, Lag= 116.1 min
Primary   =   0.61 cfs @   14.10 hrs, Volume=   0.264 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 86.27' @ 14.10 hrs   Surf.Area= 52,723 sf   Storage= 12,726 cf

Plug-Flow detention time= 311.4 min calculated for 0.264 af (49% of inflow)
Center-of-Mass det. time= 172.4 min (1,049.3 - 876.9)

Volume	Invert	Avail.Storage	Storage Description
#1	86.00'	58,179 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)
86.00	41,988	830.0	0	0	41,988
86.25	52,276	995.0	11,760	11,760	65,952
87.00	72,037	1,166.0	46,420	58,179	95,369

Device	Routing	Invert	Outlet Devices
#1	Primary	86.25'	**90.0' long x 30.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=0.60 cfs @ 14.10 hrs HW=86.27'   (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 0.60 cfs @ 0.36 fps)

Proposed Conditions5
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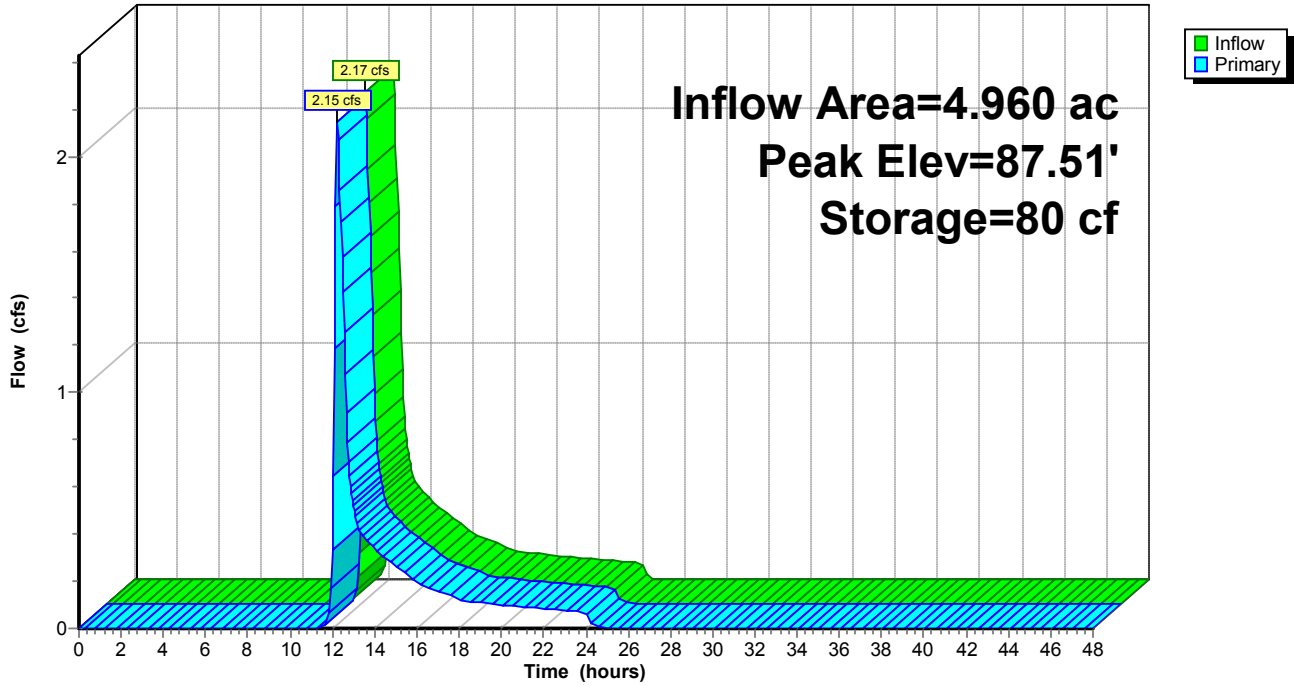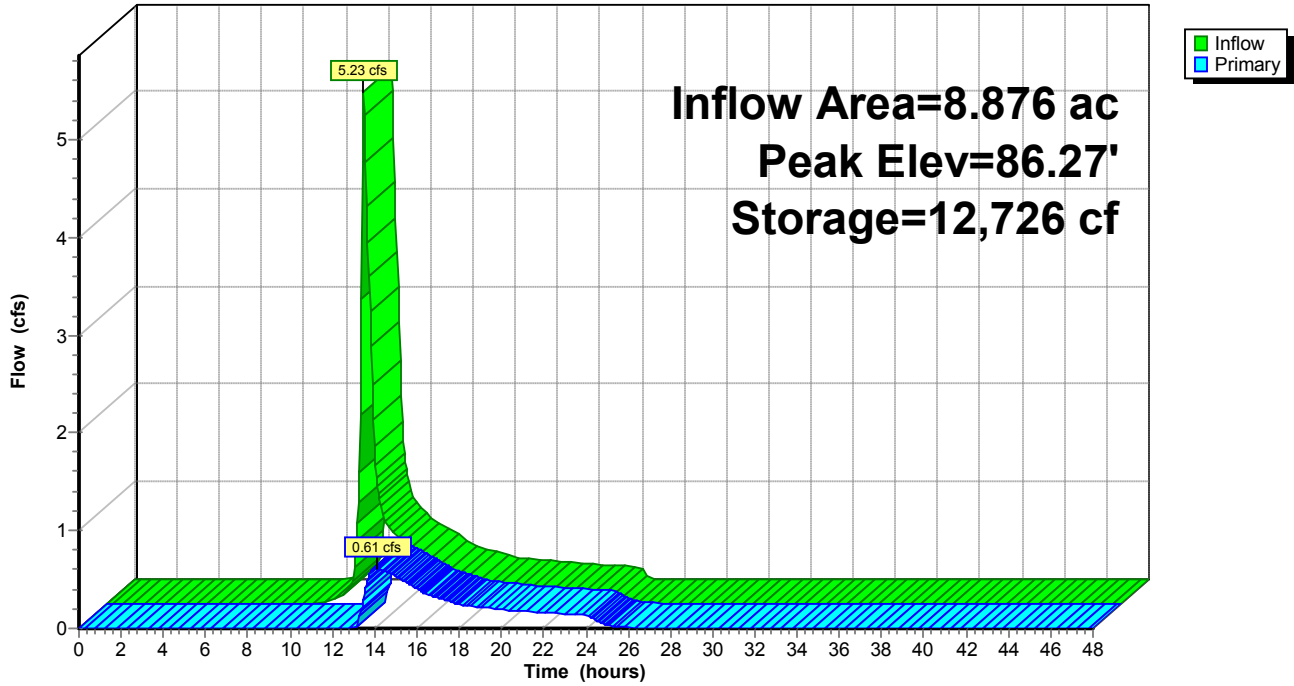HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 2-Year Storm Rainfall=3.21"
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Pond 3P: Site Depression

Hydrograph

Inflow Area=8.876 ac
Peak Elev=86.27'
Storage=12,726 cf

Pond 4P: Woodbine Depression

Inflow Area =   14.973 ac, Inflow Depth = 1.16"   for 2-Year Storm event
Inflow   =   14.05 cfs @   12.24 hrs, Volume=   1.452 af
Outflow   =   13.89 cfs @   12.27 hrs, Volume=   1.317 af, Atten= 1%, Lag= 1.9 min
Primary   =   13.89 cfs @   12.27 hrs, Volume=   1.317 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 88.62' @ 12.27 hrs   Surf.Area= 17,550 sf   Storage= 7,914 cf

Plug-Flow detention time= 66.5 min calculated for 1.317 af (91% of inflow)
Center-of-Mass det. time= 20.7 min (884.7 - 864.0)

Volume	Invert	Avail.Storage	Storage Description
#1	88.00'	15,673 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)
88.00	8,161	367.0	0	0	8,161
88.50	15,722	518.0	5,868	5,868	18,798
89.00	23,774	614.0	9,805	15,673	27,450

Device	Routing	Invert	Outlet Devices
#1	Primary	88.50'	**120.0' long x 97.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=13.73 cfs @ 12.27 hrs HW=88.62'   (Free Discharge)
⌐—**1=Broad-Crested Rectangular Weir** (Weir Controls 13.73 cfs @ 0.94 fps)

Proposed Conditions5
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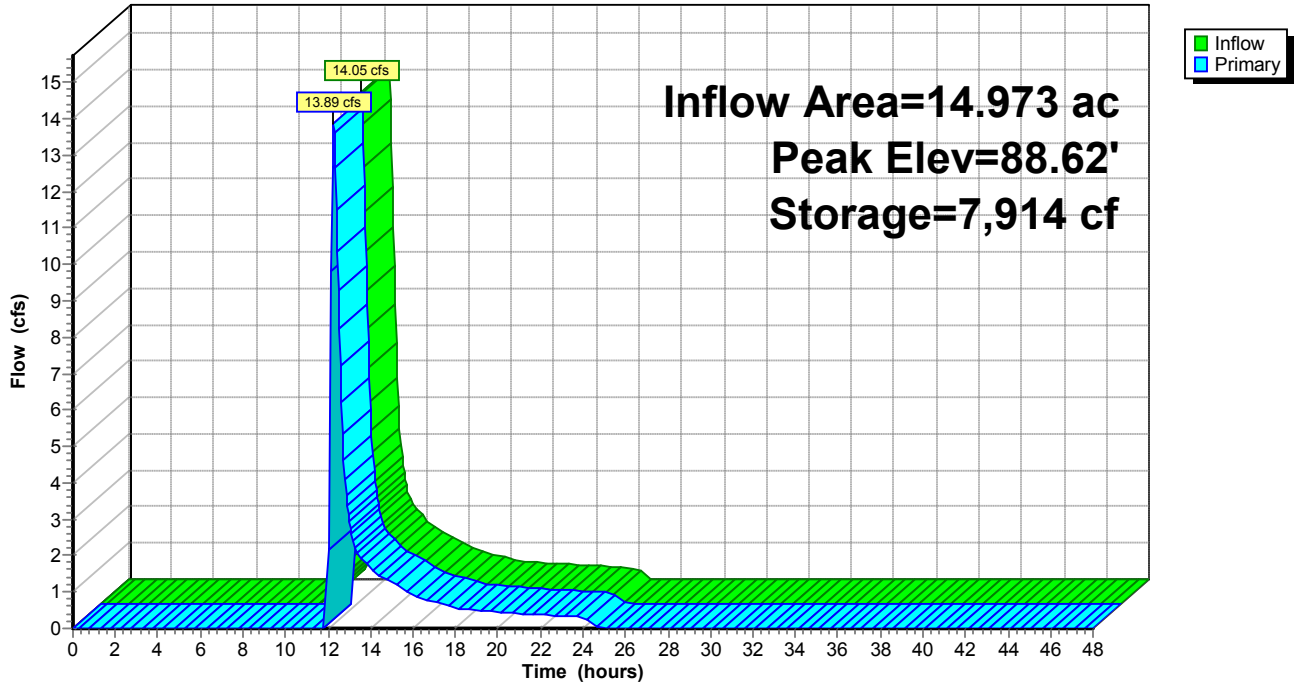HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 2-Year Storm Rainfall=3.21"
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Pond 4P: Woodbine Depression

Hydrograph

Inflow Area=14.973 ac
Peak Elev=88.62'
Storage=7,914 cf

Pond 7L: Infiltration System 7

Inflow Area =   1.153 ac, Inflow Depth = 2.20"   for 2-Year Storm event
Inflow   =   2.87 cfs @ 12.09 hrs, Volume=   0.211 af
Outflow   =   2.88 cfs @ 12.09 hrs, Volume=   0.211 af, Atten= 0%, Lag= 0.2 min
Discarded =   0.00 cfs @   6.25 hrs, Volume=   0.005 af
Primary   =   2.87 cfs @ 12.09 hrs, Volume=   0.206 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 89.61' @ 12.09 hrs   Surf.Area= 0 sf   Storage= 149 cf

Plug-Flow detention time= 15.9 min calculated for 0.211 af (100% of inflow)
Center-of-Mass det. time= 16.7 min (822.6 - 805.8)

Volume	Invert	Avail.Storage	Storage Description
#1	86.50'	247 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
86.50	0
87.00	13
91.50	247

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**Exfiltration** Elev. (feet) 86.50 86.51 87.00 91.50 Disch. (cfs) 0.000 0.002 0.002 0.002
#2	Primary	88.74'	**18.0" x 45.0' long Outlet** CPP, square edge headwall, Ke= 0.500 Outlet Invert= 88.50' S= 0.0053 '/' Cc= 0.900 n= 0.009 Corrugated PE, smooth interior

Discarded OutFlow Max=0.00 cfs @ 6.25 hrs HW=86.51' (Free Discharge)
└─**1=Exfiltration** (Custom Controls 0.00 cfs)

Primary OutFlow Max=2.82 cfs @ 12.09 hrs HW=89.60' (Free Discharge)
└─**2=Outlet** (Barrel Controls 2.82 cfs @ 3.88 fps)

Proposed Conditions5
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Type III 24-hr 2-Year Storm Rainfall=3.21"
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Pond 7L: Infiltration System 7
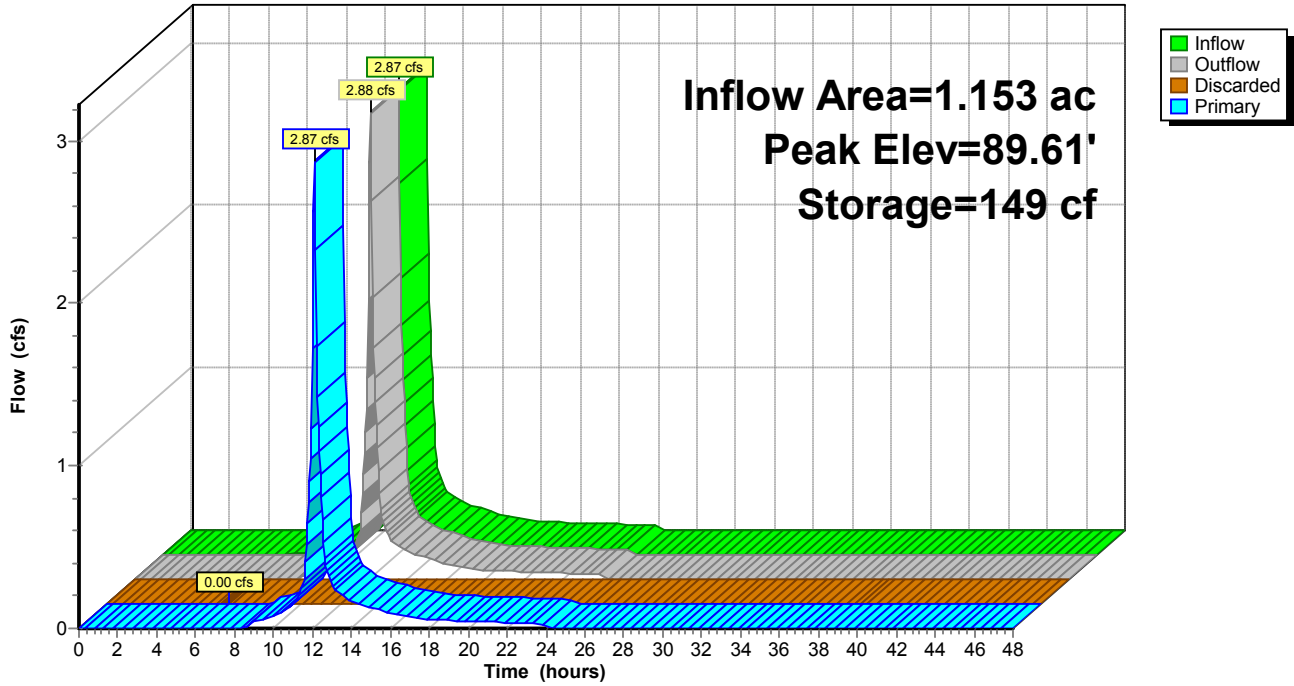
Hydrograph

Inflow Area=1.153 ac
Peak Elev=89.61'
Storage=149 cf

Legend:
- Inflow
- Outflow
- Discarded
- Primary

Labels: 2.87 cfs, 2.88 cfs, 2.87 cfs, 0.00 cfs

Axis: Flow (cfs) vs Time (hours)

Proposed Conditions
10 Year Storm Event

Subcatchment 1A: Lot 1 Infiltrated Area

Runoff   =   0.44 cfs @ 12.09 hrs, Volume=   0.037 af, Depth= 4.62"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
4,152	98	Paved roads w/curbs & sewers
4,152		Impervious Area

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

Subcatchment 1A: Lot 1 Infiltrated Area

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=4,152 sf
Runoff Volume=0.037 af
Runoff Depth=4.62"
Tc=6.0 min
CN=98

0.44 cfs

Subcatchment 1S: Site to Marsh Street

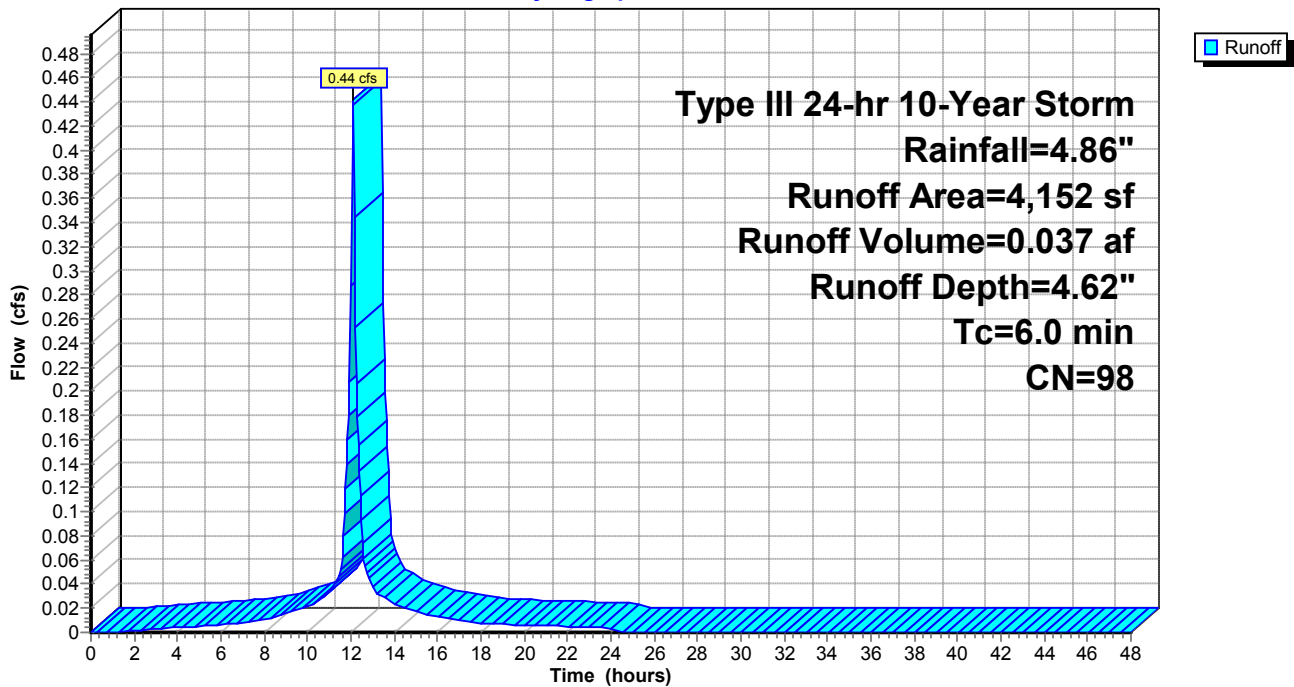Runoff   =   0.83 cfs @ 12.10 hrs, Volume=   0.061 af, Depth= 1.87"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
13,418	61	>75% Grass cover, Good, HSG B
3,788	98	Paved parking & roofs
17,206	69	Weighted Average
13,418		Pervious Area
3,788		Impervious Area

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

Subcatchment 1S: Site to Marsh Street

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=17,206 sf
Runoff Volume=0.061 af
Runoff Depth=1.87"
Tc=6.0 min
CN=69

Subcatchment 2S: Roadway

Runoff   =   4.80 cfs @ 12.09 hrs, Volume=   0.362 af, Depth= 3.76"
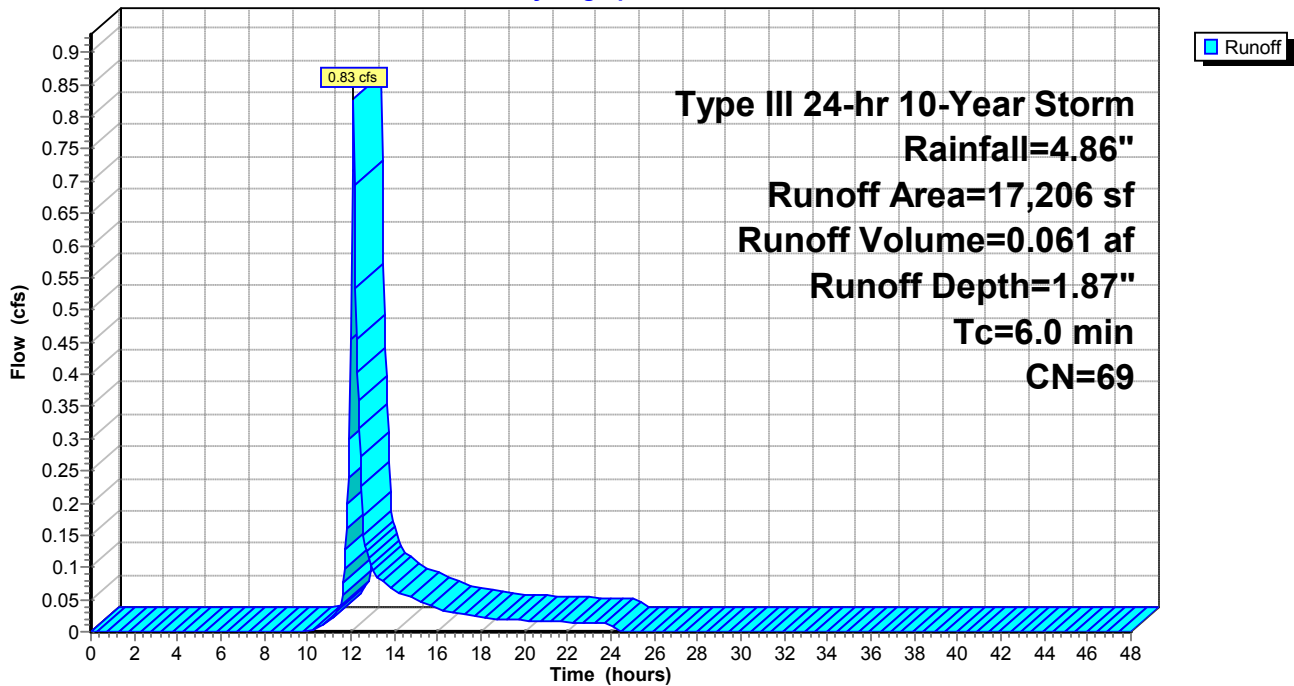
Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
1,108	39	>75% Grass cover, Good, HSG A
31,026	98	Paved parking & roofs
18,080	80	>75% Grass cover, Good, HSG D
50,214	90	Weighted Average
19,188		Pervious Area
31,026		Impervious Area

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

Subcatchment 2S: Roadway

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=50,214 sf
Runoff Volume=0.362 af
Runoff Depth=3.76"
Tc=6.0 min
CN=90

Subcatchment 3S: Site to Depression

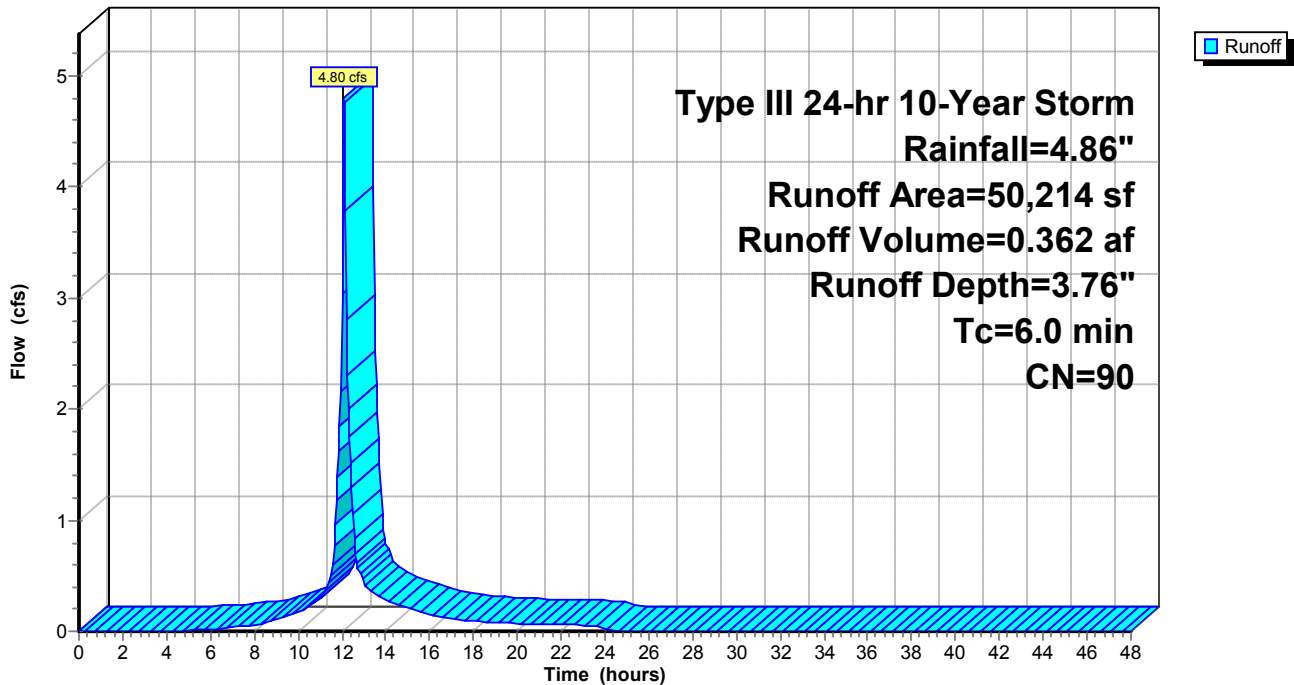Runoff   =   7.33 cfs @ 12.12 hrs, Volume=   0.579 af, Depth= 2.52"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
518	98	Paved parking & roofs
6,600	39	>75% Grass cover, Good, HSG A
25,718	80	>75% Grass cover, Good, HSG D
87,511	79	Woods, Fair, HSG D
120,347	77	Weighted Average
119,829		Pervious Area
518		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
1.1	175	0.0300	2.60		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.5	35	0.0500	1.12		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.6	260	Total			

Subcatchment 3S: Site to Depression

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=120,347 sf
Runoff Volume=0.579 af
Runoff Depth=2.52"
Flow Length=260'
Tc=8.6 min
CN=77

Subcatchment 4S: Off Site Properties

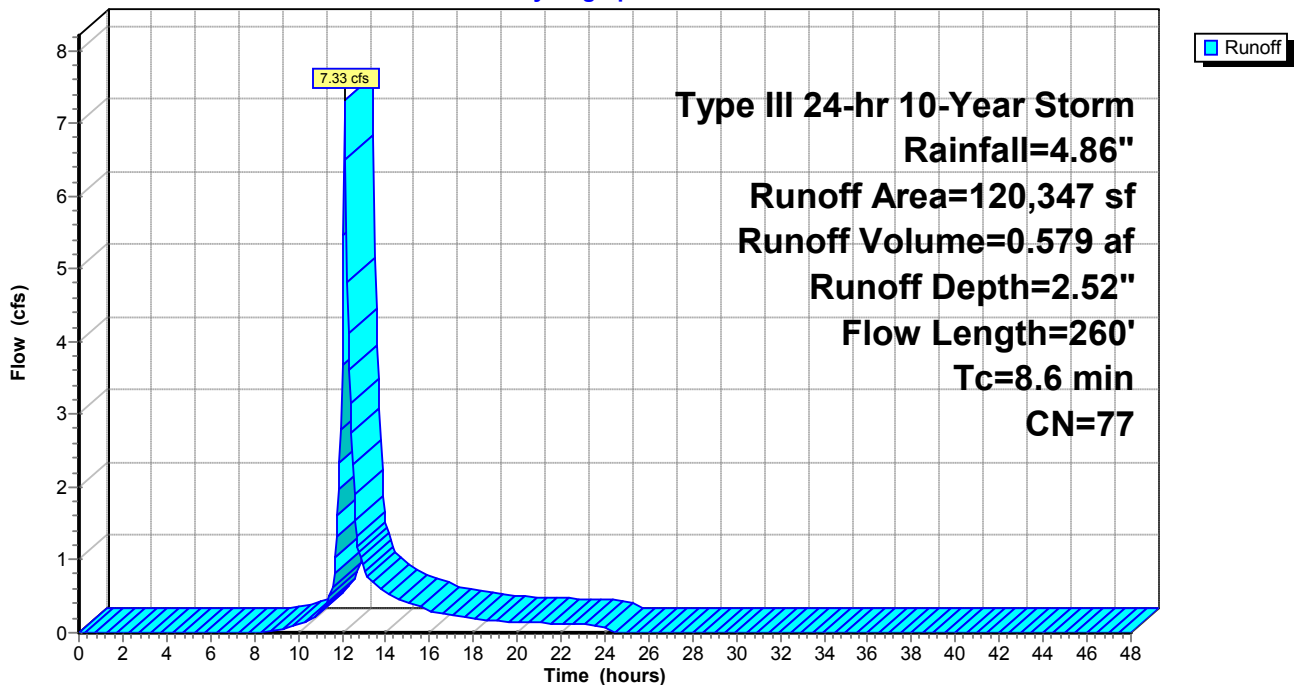Runoff   =   5.96 cfs @ 12.20 hrs, Volume=   0.575 af, Depth= 1.51"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
132,278	54	1/2 acre lots, 25% imp, HSG A
41,772	85	1/2 acre lots, 25% imp, HSG D
24,367	85	1/2 acre lots, 25% imp, HSG D
198,417	64	Weighted Average
148,813		Pervious Area
49,604		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
4.3	550	0.0200	2.12		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.2	16	0.0100	1.50		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.1	30	0.0100	6.44	11.38	**Circular Channel (pipe), Culvert** Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38' n= 0.012 Concrete pipe, finished
0.3	17	0.0300	0.87		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
13.1	663	Total			

Proposed Conditions5
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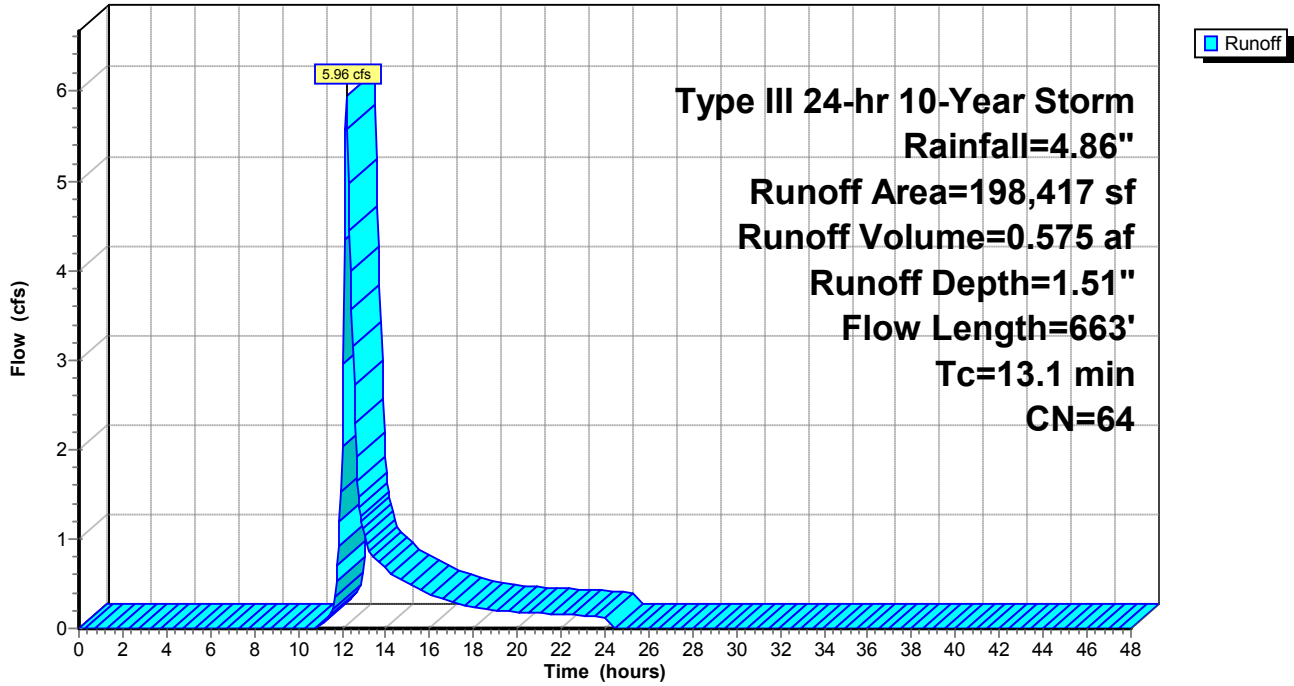HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 10-Year Storm Rainfall=4.86"
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Subcatchment 4S: Off Site Properties

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=198,417 sf
Runoff Volume=0.575 af
Runoff Depth=1.51"
Flow Length=663'
Tc=13.1 min
CN=64

Subcatchment 5S: Site to Culvert

Runoff   =   0.78 cfs @ 12.20 hrs, Volume=   0.072 af, Depth= 2.13"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
12,820	79	Woods, Fair, HSG D
2,936	39	>75% Grass cover, Good, HSG A
1,901	80	>75% Grass cover, Good, HSG D
17,657	72	Weighted Average
17,657		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.8	50	0.0100	0.08		**Sheet Flow,**
					Grass: Dense n= 0.240 P2= 3.20"
2.6	231	0.0100	1.50		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
0.1	38	0.0150	7.28	12.87	**Circular Channel (pipe),**
					Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38'
					n= 0.013 Corrugated PE, smooth interior
0.2	14	0.0100	1.50		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
13.7	333				Total

Subcatchment 5S: Site to Culvert

Hydrograph

Subcatchment 6S: Woodbine Road & Offsite

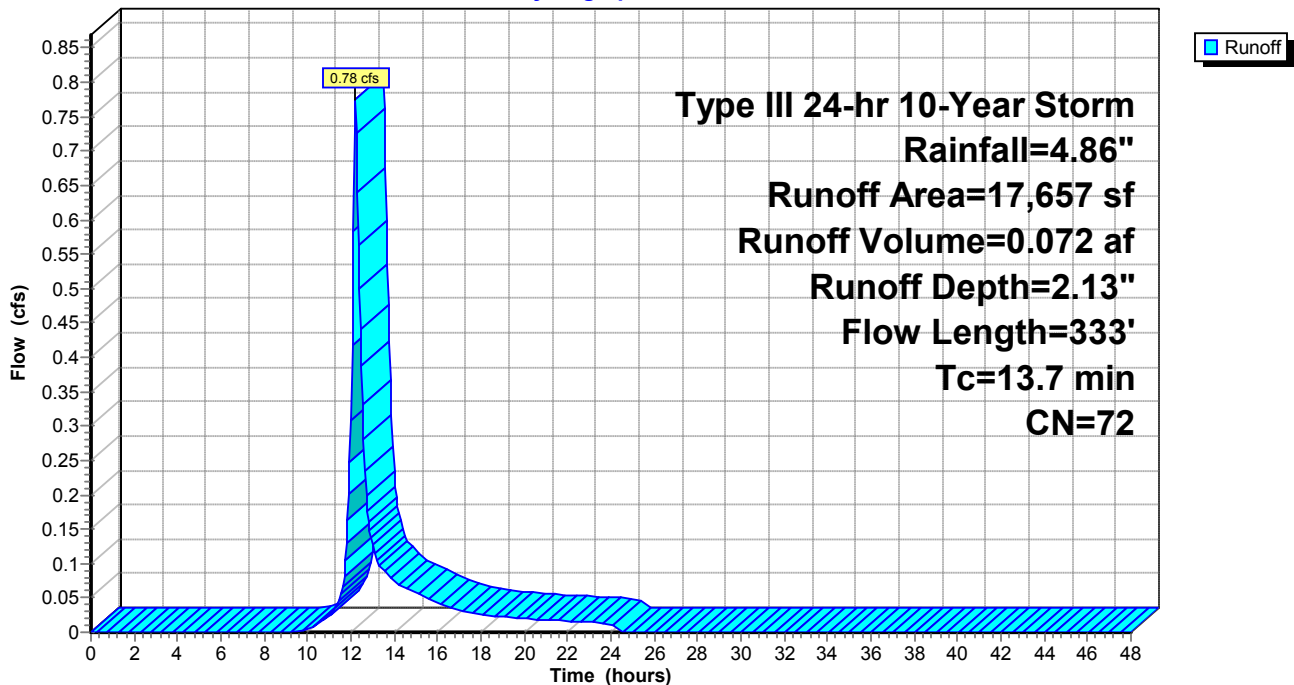Runoff   =   28.97 cfs @ 12.23 hrs, Volume=   2.842 af, Depth= 2.41"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
362,024	73	Woods, Fair, HSG C
254,113	80	1/2 acre lots, 25% imp, HSG C
616,137	76	Weighted Average
552,609		Pervious Area
63,528		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.2000	0.17		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	125	0.0150	0.61		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.8	200	0.0150	1.84		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
3.7	710	0.0250	3.21		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
2.5	100	0.0180	0.67		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
16.3	1,185	Total			

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Type III 24-hr 10-Year Storm Rainfall=4.86"
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Subcatchment 6S: Woodbine Road & Offsite

Hydrograph

Chart annotations:
- 28.97 cfs
- Runoff
- Type III 24-hr 10-Year Storm
- Rainfall=4.86"
- Runoff Area=616,137 sf
- Runoff Volume=2.842 af
- Runoff Depth=2.41"
- Flow Length=1,185'
- Tc=16.3 min
- CN=76

X-axis: Time (hours)
Y-axis: Flow (cfs)

Subcatchment 7S: Site to Woodbine Depression

Runoff   =   2.57 cfs @ 12.09 hrs, Volume=   0.186 af, Depth= 2.70"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
179	98	Paved parking & roofs
31,805	79	Woods, Fair, HSG D
4,096	80	>75% Grass cover, Good, HSG D
36,080	79	Weighted Average
35,901		Pervious Area
179		Impervious Area

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

Subcatchment 7S: Site to Woodbine Depression

Hydrograph

Type III 24-hr 10-Year Storm
Rainfall=4.86"
Runoff Area=36,080 sf
Runoff Volume=0.186 af
Runoff Depth=2.70"
Tc=6.0 min
CN=79

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Type III 24-hr 10-Year Storm Rainfall=4.86"
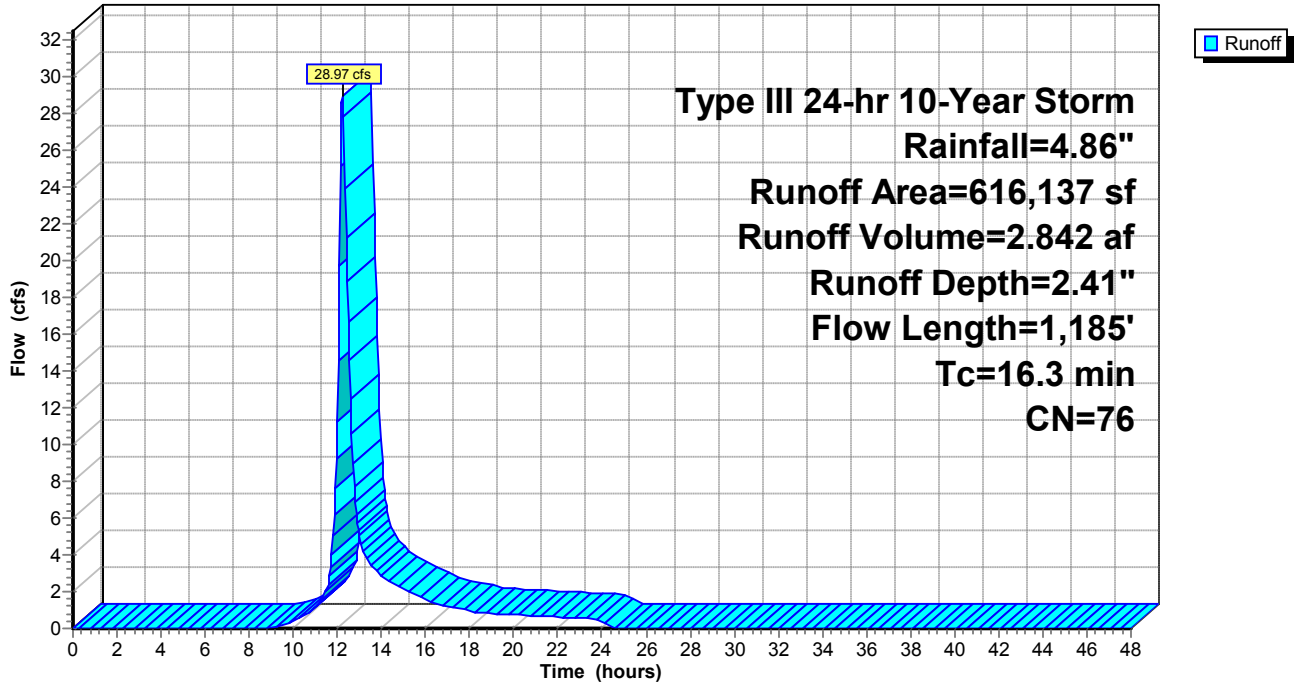Page 11
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Subcatchment 8S: Site to Wetlands

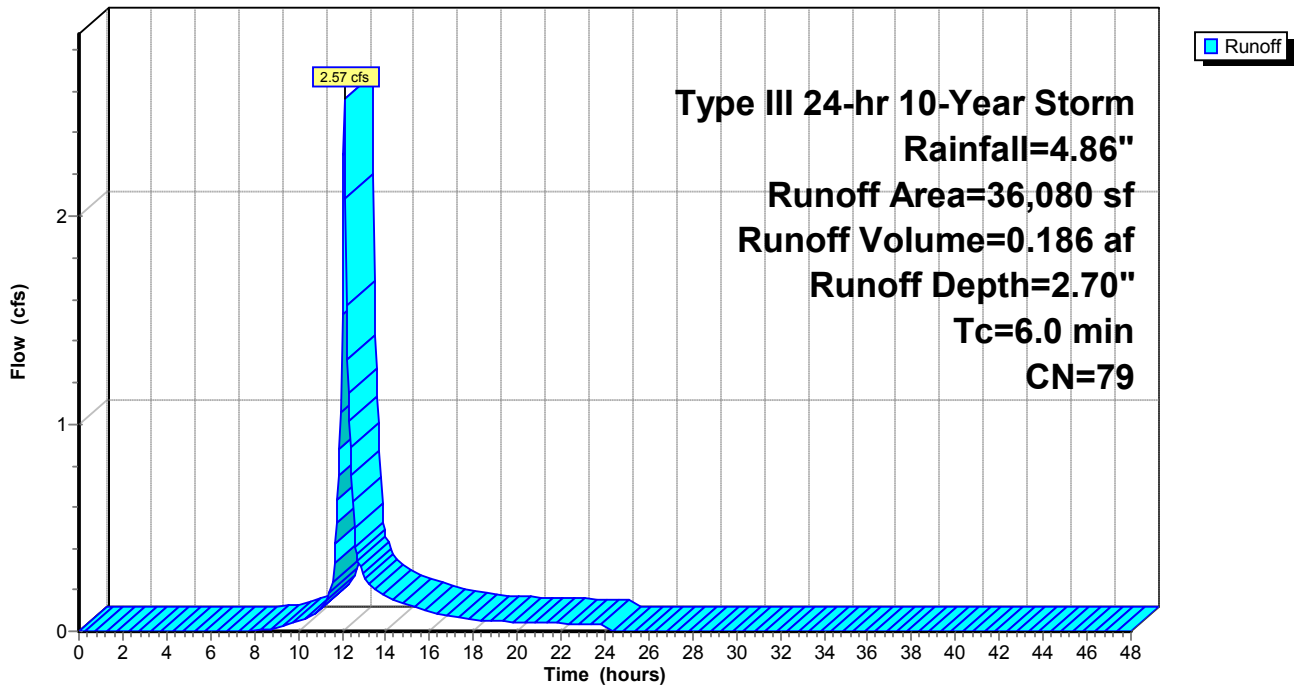Runoff   =   3.78 cfs @ 12.09 hrs, Volume=   0.274 af, Depth= 2.68"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Storm Rainfall=4.86"

Area (sf)	CN	Description
51,265	79	Woods, Fair, HSG D
2,080	80	>75% Grass cover, Good, HSG D
53,345	79	Weighted Average
53,345		Pervious Area

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

Subcatchment 8S: Site to Wetlands

Hydrograph

Reach 1R: IVW

Inflow Area =   25.073 ac, Inflow Depth = 2.02"   for 10-Year Storm event
Inflow   =   36.90 cfs @   12.29 hrs, Volume=   4.221 af
Outflow   =   36.90 cfs @   12.29 hrs, Volume=   4.221 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Reach 1R: IVW

Pond 1L: Infiltration System 1

Inflow Area =   0.095 ac, Inflow Depth = 4.62"   for 10-Year Storm event
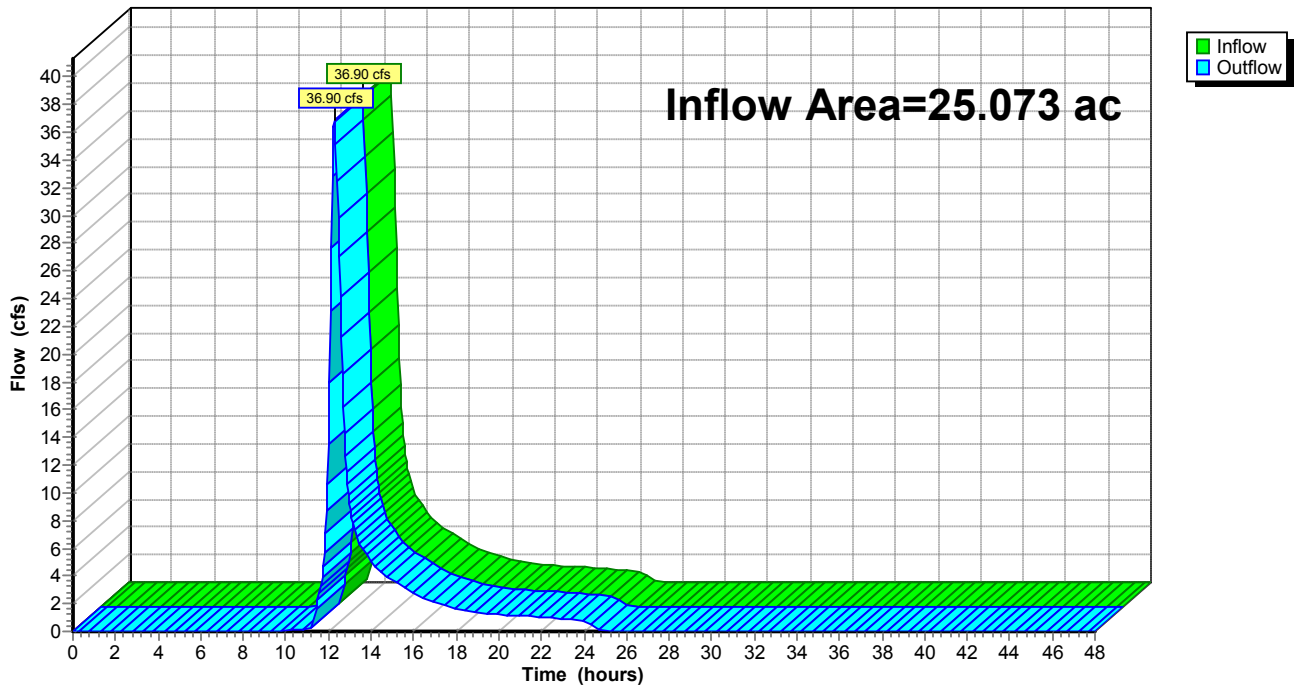Inflow   =   0.44 cfs @   12.09 hrs, Volume=   0.037 af
Outflow   =   0.01 cfs @   8.30 hrs, Volume=   0.037 af, Atten= 97%, Lag= 0.0 min
Primary   =   0.01 cfs @   8.30 hrs, Volume=   0.037 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 92.60' @ 16.15 hrs   Surf.Area= 0 sf   Storage= 938 cf

Plug-Flow detention time= 669.7 min calculated for 0.037 af (100% of inflow)
Center-of-Mass det. time= 669.7 min (1,418.2 - 748.5)

Volume	Invert	Avail.Storage	Storage Description
#1	89.80'	2,159 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
89.80	0
90.30	84
95.63	2,062
95.89	2,159

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**Special & User-Defined**
			Elev. (feet) 89.80 89.81 90.30 95.63 95.89
			Disch. (cfs) 0.000 0.012 0.012 0.012 0.012

Primary OutFlow Max=0.01 cfs @ 8.30 hrs HW=89.81'   (Free Discharge)
└─**1=Special & User-Defined** (Custom Controls 0.01 cfs)

Proposed Conditions5
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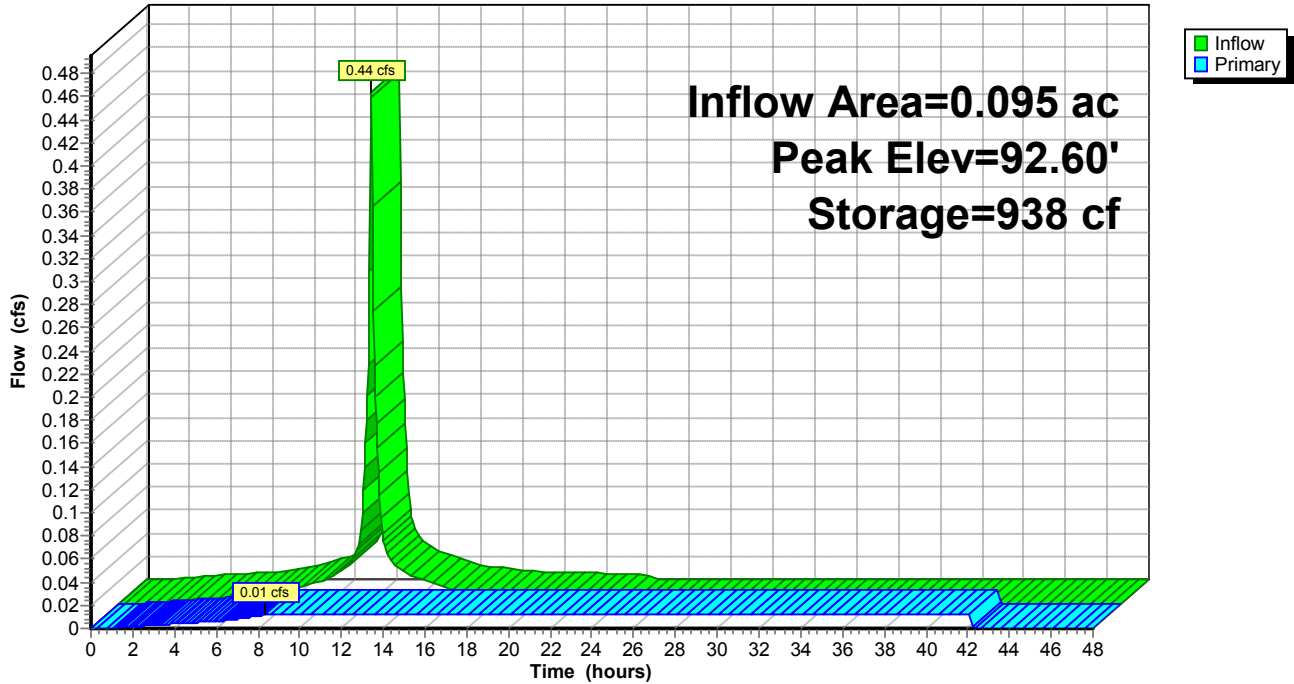HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 10-Year Storm Rainfall=4.86"
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Pond 1L: Infiltration System 1

Inflow Area=0.095 ac
Peak Elev=92.60'
Storage=938 cf

Pond 1P: Detention/Infiltration Pond

Inflow Area =   1.153 ac, Inflow Depth = 3.70"   for 10-Year Storm event
Inflow   =   4.81 cfs @ 12.09 hrs, Volume=   0.356 af
Outflow   =   0.86 cfs @ 12.55 hrs, Volume=   0.356 af, Atten= 82%, Lag= 27.8 min
Discarded   =   0.14 cfs @   9.75 hrs, Volume=   0.258 af
Primary   =   0.71 cfs @ 12.55 hrs, Volume=   0.098 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 90.32' @ 12.55 hrs   Surf.Area= 4,148 sf   Storage= 6,785 cf

Plug-Flow detention time= 263.8 min calculated for 0.356 af (100% of inflow)
Center-of-Mass det. time= 263.9 min (1,057.6 - 793.7)

Volume	Invert	Avail.Storage	Storage Description
#1	88.50'	14,988 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)
88.50	3,498	238.0	0	0	3,498
89.00	3,498	238.0	1,749	1,749	3,617
90.00	3,988	251.0	3,740	5,489	4,179
91.00	4,502	263.0	4,242	9,732	4,733
92.00	6,049	329.0	5,256	14,988	7,856

Device	Routing	Invert	Outlet Devices
#1	Primary	89.80'	**8.0" Vert. Orifice** C= 0.600
#2	Primary	91.20'	**2.00' x 2.00' Horiz. Overflow Grate** Limited to weir flow C= 0.600
#3	Discarded	0.00'	**Exfiltration**
			Elev. (feet) 88.50 88.51 89.00 90.00 91.00 92.00
			Disch. (cfs) 0.000 0.143 0.143 0.143 0.143 0.143

Discarded OutFlow Max=0.14 cfs @ 9.75 hrs HW=88.51' (Free Discharge)
└─**3=Exfiltration** (Custom Controls 0.14 cfs)

Primary OutFlow Max=0.71 cfs @ 12.55 hrs HW=90.32' (Free Discharge)
├─**1=Orifice** (Orifice Controls 0.71 cfs @ 2.45 fps)
└─**2=Overflow Grate** (Controls 0.00 cfs)

Pond 1P: Detention/Infiltration Pond

Hydrograph

Inflow Area=1.153 ac
Peak Elev=90.32'
Storage=6,785 cf

Legend:
- Inflow
- Outflow
- Discarded
- Primary

4.81 cfs
0.86 cfs
0.71 cfs
0.14 cfs

Pond 2P: Roadway Culvert

Inflow Area = 4.960 ac, Inflow Depth = 1.56" for 10-Year Storm event
Inflow = 6.73 cfs @ 12.20 hrs, Volume= 0.646 af
Outflow = 6.74 cfs @ 12.20 hrs, Volume= 0.646 af, Atten= 0%, Lag= 0.2 min
Primary = 6.74 cfs @ 12.20 hrs, Volume= 0.646 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 87.72' @ 12.20 hrs Surf.Area= 0 sf Storage= 145 cf

Plug-Flow detention time= 1.1 min calculated for 0.646 af (100% of inflow)
Center-of-Mass det. time= 1.0 min (869.8 - 868.8)

Volume	Invert	Avail.Storage	Storage Description
#1	87.25'	4,801 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
87.25	0
88.00	230
89.50	4,801

Device	Routing	Invert	Outlet Devices
#1	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#2	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#3	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#4	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#5	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#6	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished

Primary OutFlow Max=6.71 cfs @ 12.20 hrs HW=87.72' (Free Discharge)
—**1=Culvert** (Inlet Controls 1.12 cfs @ 2.34 fps)
—**2=Culvert** (Inlet Controls 1.12 cfs @ 2.34 fps)
—**3=Culvert** (Inlet Controls 1.12 cfs @ 2.34 fps)
—**4=Culvert** (Inlet Controls 1.12 cfs @ 2.34 fps)
—**5=Culvert** (Inlet Controls 1.12 cfs @ 2.34 fps)
—**6=Culvert** (Inlet Controls 1.12 cfs @ 2.34 fps)

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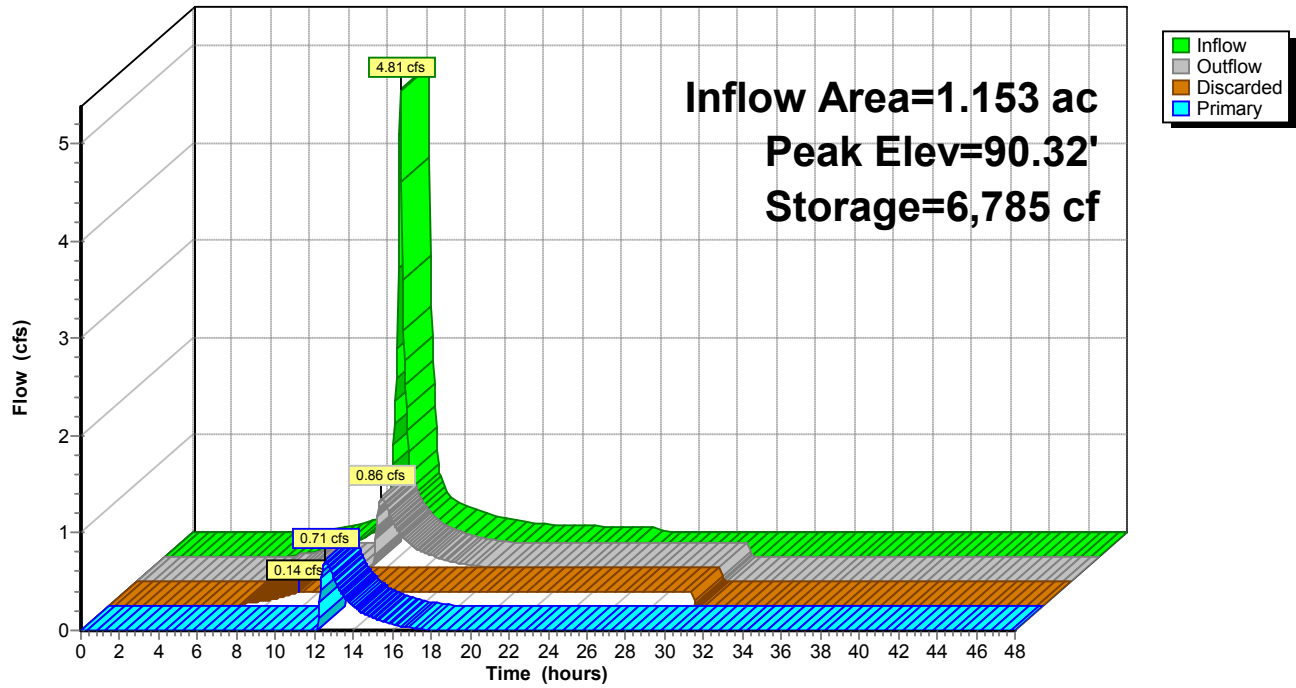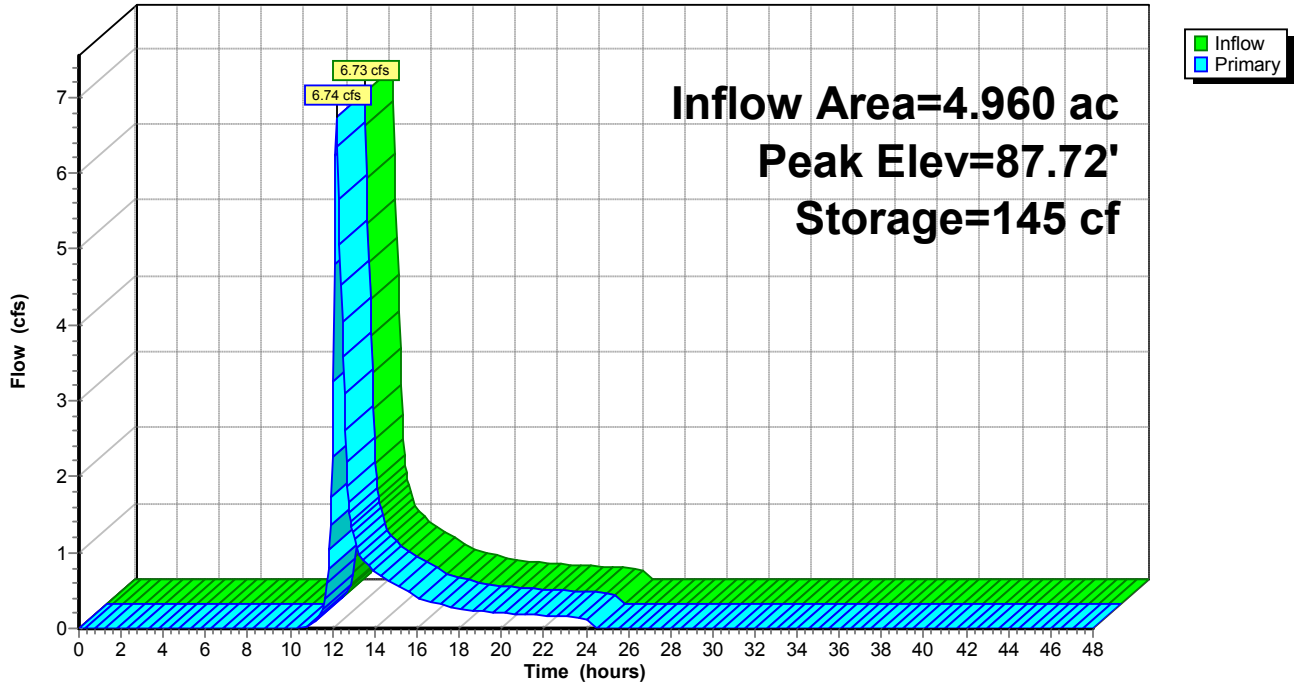*Type III 24-hr 10-Year Storm Rainfall=4.86"*
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Pond 2P: Roadway Culvert

Hydrograph

Inflow
Primary

6.73 cfs
6.74 cfs

Inflow Area=4.960 ac
Peak Elev=87.72'
Storage=145 cf

Flow (cfs)

Time (hours)

Pond 3P: Site Depression

Inflow Area =   8.876 ac, Inflow Depth = 1.79"   for 10-Year Storm event
Inflow   =   13.41 cfs @   12.16 hrs, Volume=   1.323 af
Outflow   =   7.78 cfs @   12.43 hrs, Volume=   1.053 af, Atten= 42%, Lag= 16.4 min
Primary   =   7.78 cfs @   12.43 hrs, Volume=   1.053 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 86.35' @ 12.43 hrs   Surf.Area= 54,761 sf   Storage= 17,183 cf

Plug-Flow detention time= 135.4 min calculated for 1.053 af (80% of inflow)
Center-of-Mass det. time= 56.4 min (906.2 - 849.8)

Volume	Invert	Avail.Storage	Storage Description
#1	86.00'	58,179 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)
86.00	41,988	830.0	0	0	41,988
86.25	52,276	995.0	11,760	11,760	65,952
87.00	72,037	1,166.0	46,420	58,179	95,369

Device	Routing	Invert	Outlet Devices
#1	Primary	86.25'	**90.0' long x 30.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=7.75 cfs @ 12.43 hrs HW=86.35'   (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 7.75 cfs @ 0.85 fps)

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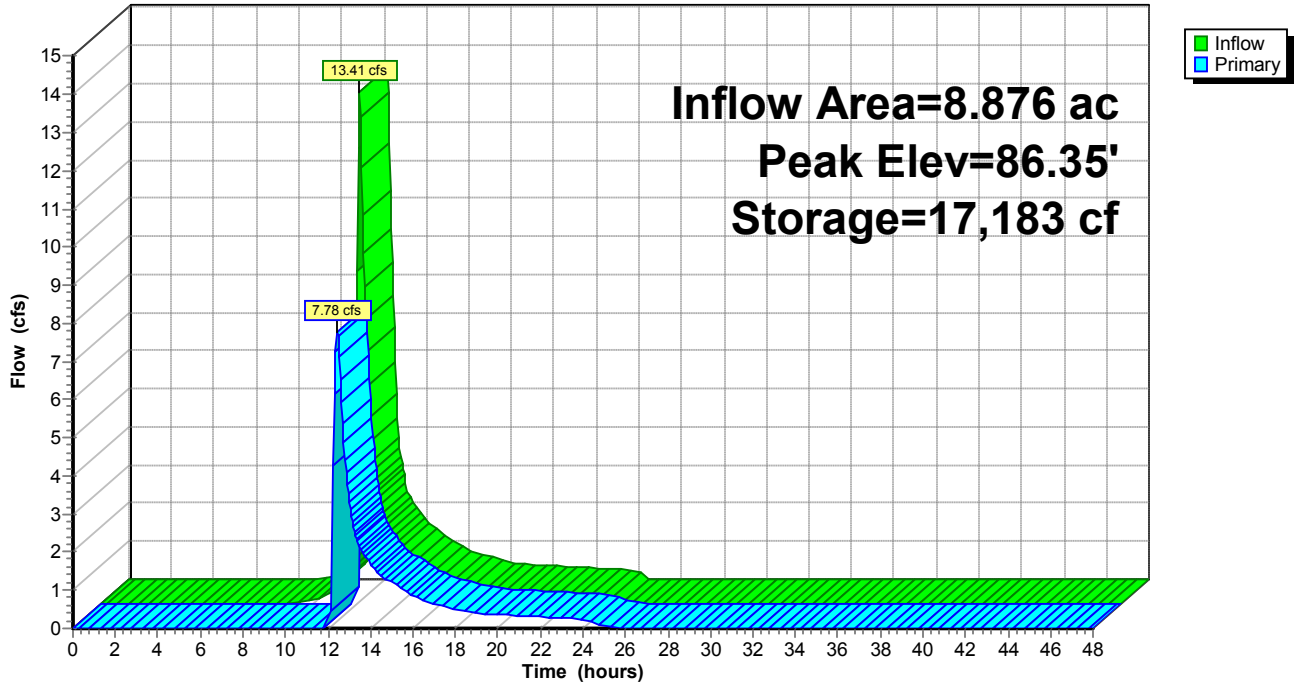
Type III 24-hr 10-Year Storm Rainfall=4.86"
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Pond 3P: Site Depression

Hydrograph

Inflow Area=8.876 ac
Peak Elev=86.35'
Storage=17,183 cf

Legend: Inflow, Primary

13.41 cfs

7.78 cfs

Pond 4P: Woodbine Depression

Inflow Area =   14.973 ac, Inflow Depth = 2.43"   for 10-Year Storm event
Inflow   =   30.48 cfs @ 12.22 hrs, Volume=   3.028 af
Outflow   =   30.15 cfs @ 12.25 hrs, Volume=   2.894 af, Atten= 1%, Lag= 1.7 min
Primary   =   30.15 cfs @ 12.25 hrs, Volume=   2.894 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 88.71' @ 12.25 hrs   Surf.Area= 18,843 sf   Storage= 9,429 cf

Plug-Flow detention time= 37.5 min calculated for 2.894 af (96% of inflow)
Center-of-Mass det. time= 13.0 min (855.4 - 842.4)

Volume	Invert	Avail.Storage	Storage Description
#1	88.00'	15,673 cf	**Custom Stage Data (Irregular)** Listed below (Recalc)

Elevation	Surf.Area	Perim.	Inc.Store	Cum.Store	Wet.Area
(feet)	(sq-ft)	(feet)	(cubic-feet)	(cubic-feet)	(sq-ft)
88.00	8,161	367.0	0	0	8,161
88.50	15,722	518.0	5,868	5,868	18,798
89.00	23,774	614.0	9,805	15,673	27,450

Device	Routing	Invert	Outlet Devices
#1	Primary	88.50'	**120.0' long x 97.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=30.09 cfs @ 12.25 hrs HW=88.71'   (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 30.09 cfs @ 1.22 fps)

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Type III 24-hr 10-Year Storm Rainfall=4.86"
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Pond 4P: Woodbine Depression

Hydrograph

Inflow Area=14.973 ac
Peak Elev=88.71'
Storage=9,429 cf

30.48 cfs
30.15 cfs

Legend: Inflow / Primary

Pond 7L: Infiltration System 7

Inflow Area =   1.153 ac, Inflow Depth = 3.76"   for 10-Year Storm event
Inflow   =   4.80 cfs @   12.09 hrs, Volume=   0.362 af
Outflow   =   4.81 cfs @   12.09 hrs, Volume=   0.362 af, Atten= 0%, Lag= 0.2 min
Discarded =   0.00 cfs @   4.50 hrs, Volume=   0.006 af
Primary   =   4.81 cfs @   12.09 hrs, Volume=   0.356 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 89.94' @ 12.09 hrs   Surf.Area= 0 sf   Storage= 166 cf

Plug-Flow detention time= 10.7 min calculated for 0.362 af (100% of inflow)
Center-of-Mass det. time= 10.7 min (801.5 - 790.9)

Volume	Invert	Avail.Storage	Storage Description
#1	86.50'	247 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
86.50	0
87.00	13
91.50	247

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**Exfiltration** Elev. (feet) 86.50 86.51 87.00 91.50 Disch. (cfs) 0.000 0.002 0.002 0.002
#2	Primary	88.74'	**18.0" x 45.0' long Outlet** CPP, square edge headwall, Ke= 0.500 Outlet Invert= 88.50' S= 0.0053 '/' Cc= 0.900 n= 0.009 Corrugated PE, smooth interior

Discarded OutFlow Max=0.00 cfs @ 4.50 hrs HW=86.51' (Free Discharge)
└─**1=Exfiltration** (Custom Controls 0.00 cfs)

Primary OutFlow Max=4.71 cfs @ 12.09 hrs HW=89.92' (Free Discharge)
└─**2=Outlet** (Barrel Controls 4.71 cfs @ 4.32 fps)

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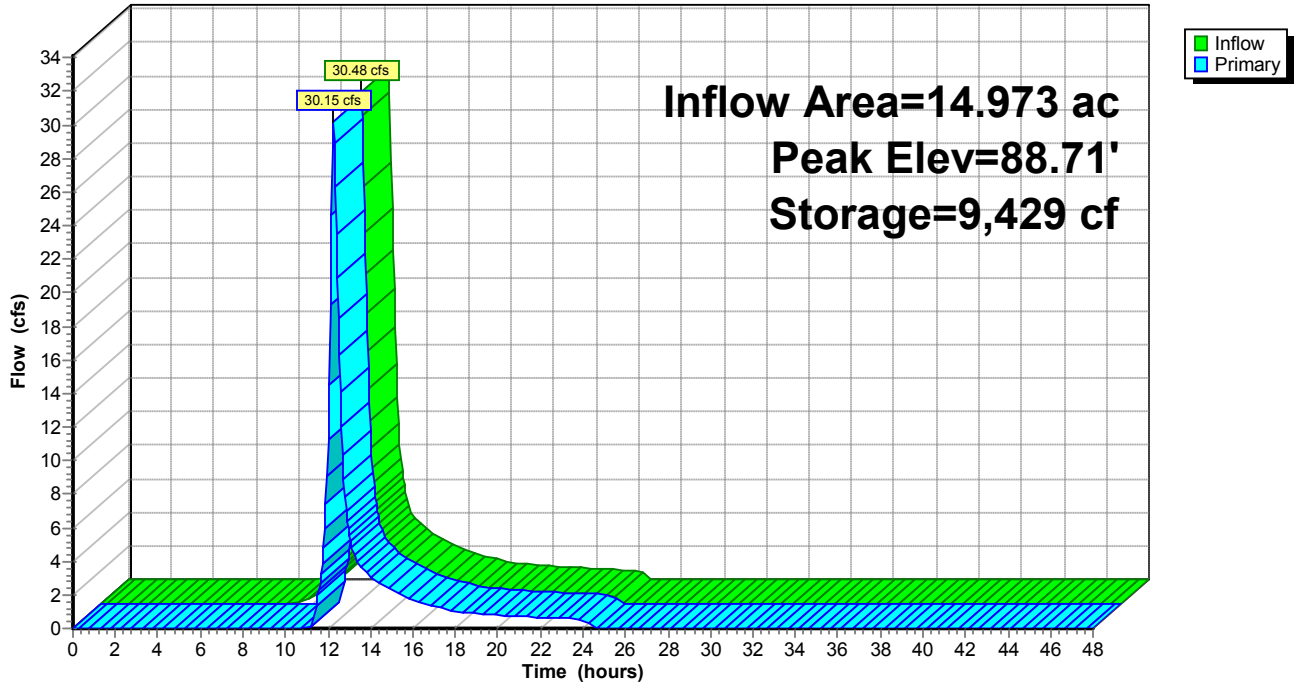
Type III 24-hr 10-Year Storm Rainfall=4.86"
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Pond 7L: Infiltration System 7

Hydrograph

Inflow Area=1.153 ac
Peak Elev=89.94'
Storage=166 cf

Legend:
- Inflow
- Outflow
- Discarded
- Primary

Data labels on chart: 4.80 cfs, 4.81 cfs, 4.81 cfs, 0.00 cfs

Y-axis: Flow (cfs)
X-axis: Time (hours)

Proposed Conditions
100 Year Storm Event

Subcatchment 1A: Lot 1 Infiltrated Area

Runoff   =   0.81 cfs @ 12.09 hrs, Volume=   0.068 af, Depth= 8.60"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
4,152	98	Paved roads w/curbs & sewers
4,152		Impervious Area

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

Subcatchment 1A: Lot 1 Infiltrated Area

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=4,152 sf
Runoff Volume=0.068 af
Runoff Depth=8.60"
Tc=6.0 min
CN=98

Subcatchment 1S: Site to Marsh Street

Runoff   =   2.31 cfs @ 12.09 hrs, Volume=   0.168 af, Depth= 5.09"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
13,418	61	>75% Grass cover, Good, HSG B
3,788	98	Paved parking & roofs
17,206	69	Weighted Average
13,418		Pervious Area
3,788		Impervious Area

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

Subcatchment 1S: Site to Marsh Street

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=17,206 sf
Runoff Volume=0.168 af
Runoff Depth=5.09"
Tc=6.0 min
CN=69

Subcatchment 2S: Roadway

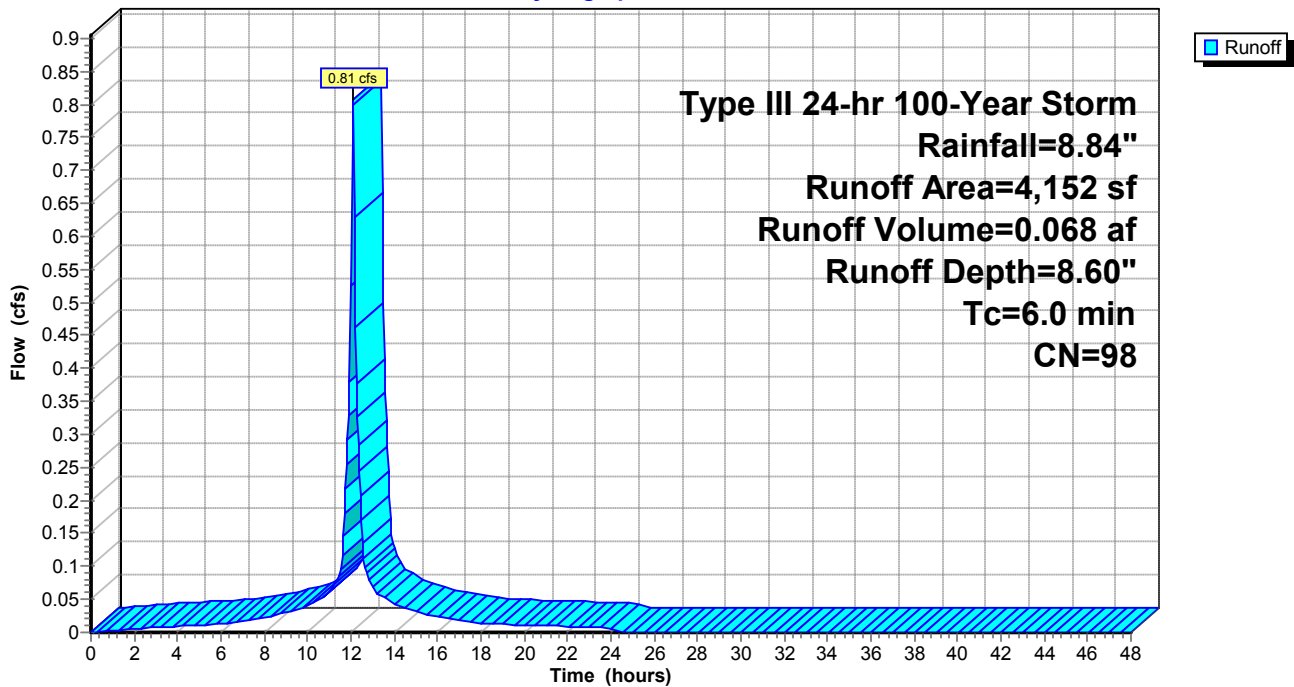Runoff   =   9.38 cfs @ 12.09 hrs, Volume=   0.736 af, Depth= 7.66"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
1,108	39	>75% Grass cover, Good, HSG A
31,026	98	Paved parking & roofs
18,080	80	>75% Grass cover, Good, HSG D
50,214	90	Weighted Average
19,188		Pervious Area
31,026		Impervious Area

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

Subcatchment 2S: Roadway

Hydrograph

Subcatchment 3S: Site to Depression

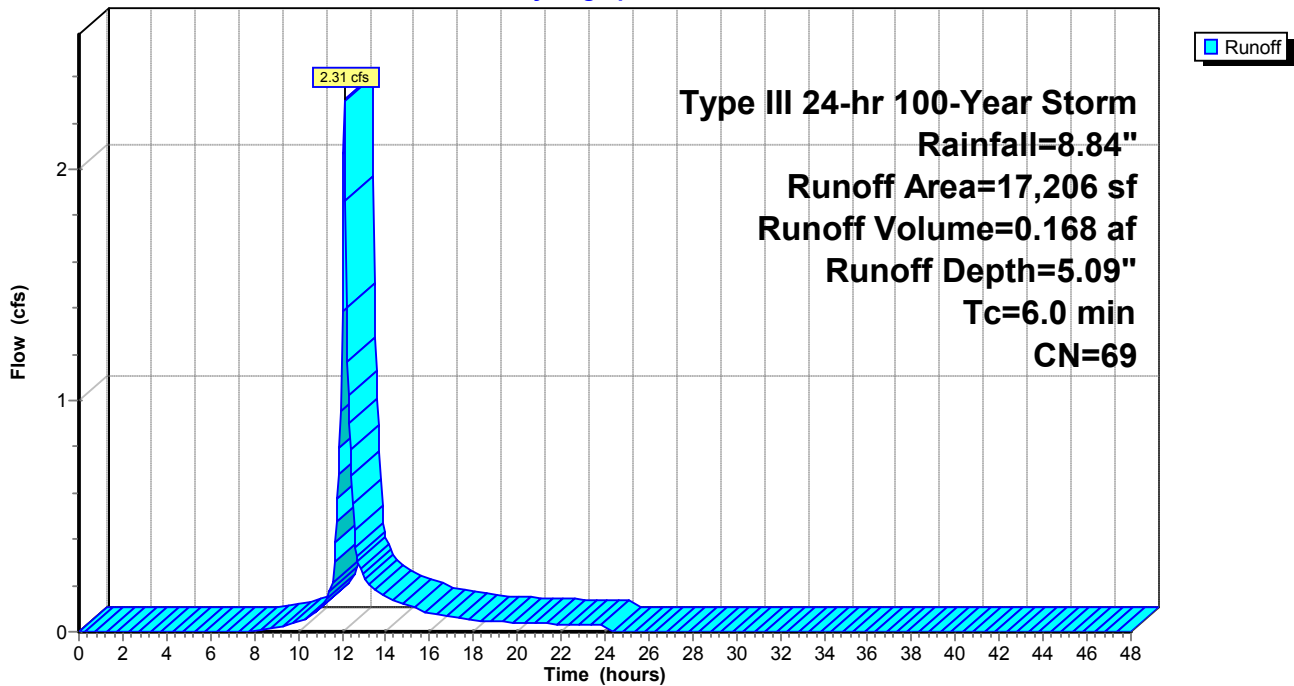Runoff   =   17.51 cfs @   12.12 hrs, Volume=   1.396 af, Depth= 6.06"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
518	98	Paved parking & roofs
6,600	39	>75% Grass cover, Good, HSG A
25,718	80	>75% Grass cover, Good, HSG D
87,511	79	Woods, Fair, HSG D
120,347	77	Weighted Average
119,829		Pervious Area
518		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0300	0.12		**Sheet Flow,** Grass: Dense n= 0.240 P2= 3.20"
1.1	175	0.0300	2.60		**Shallow Concentrated Flow,** Grassed Waterway Kv= 15.0 fps
0.5	35	0.0500	1.12		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
8.6	260	Total			

Subcatchment 3S: Site to Depression

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=120,347 sf
Runoff Volume=1.396 af
Runoff Depth=6.06"
Flow Length=260'
Tc=8.6 min
CN=77

Subcatchment 4S: Off Site Properties

Runoff   =   18.91 cfs @ 12.19 hrs, Volume=   1.709 af, Depth= 4.50"
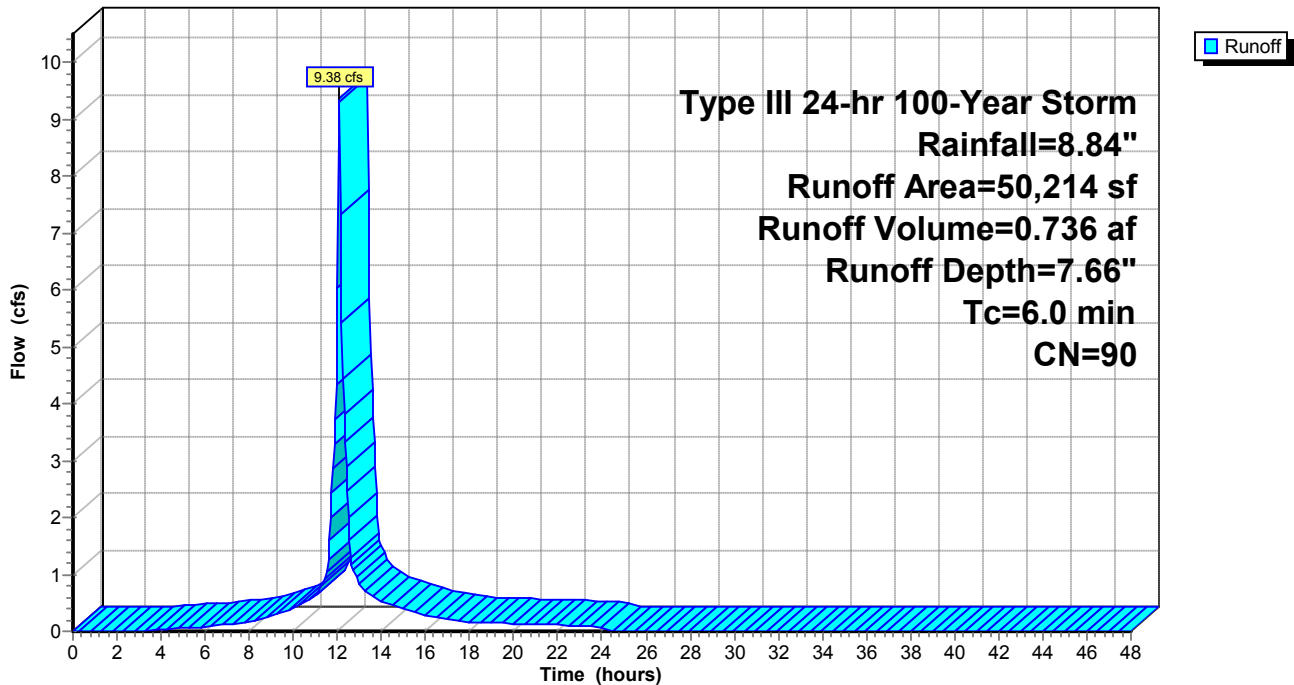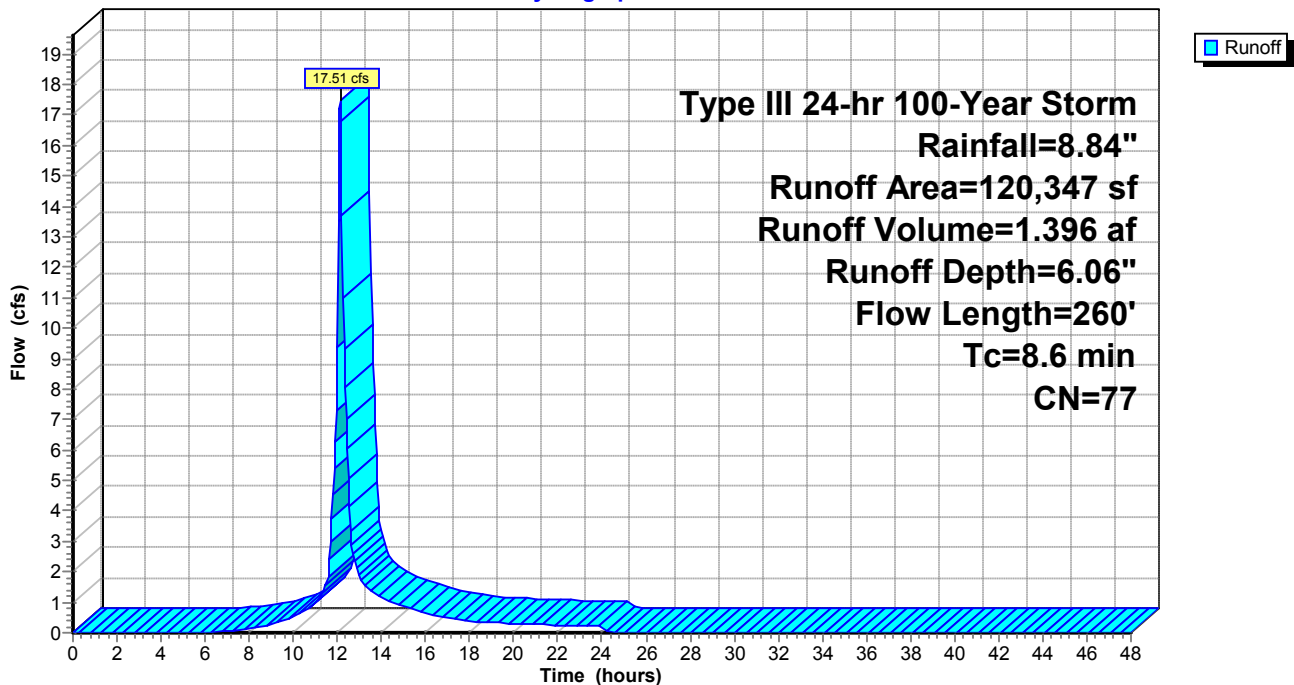
Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
132,278	54	1/2 acre lots, 25% imp, HSG A
41,772	85	1/2 acre lots, 25% imp, HSG D
24,367	85	1/2 acre lots, 25% imp, HSG D
198,417	64	Weighted Average
148,813		Pervious Area
49,604		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0200	0.10		**Sheet Flow,**
					Grass: Dense n= 0.240 P2= 3.20"
4.3	550	0.0200	2.12		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
0.2	16	0.0100	1.50		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
0.1	30	0.0100	6.44	11.38	**Circular Channel (pipe), Culvert**
					Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38'
					n= 0.012 Concrete pipe, finished
0.3	17	0.0300	0.87		**Shallow Concentrated Flow,**
					Woodland Kv= 5.0 fps
13.1	663	Total			

Proposed Conditions5
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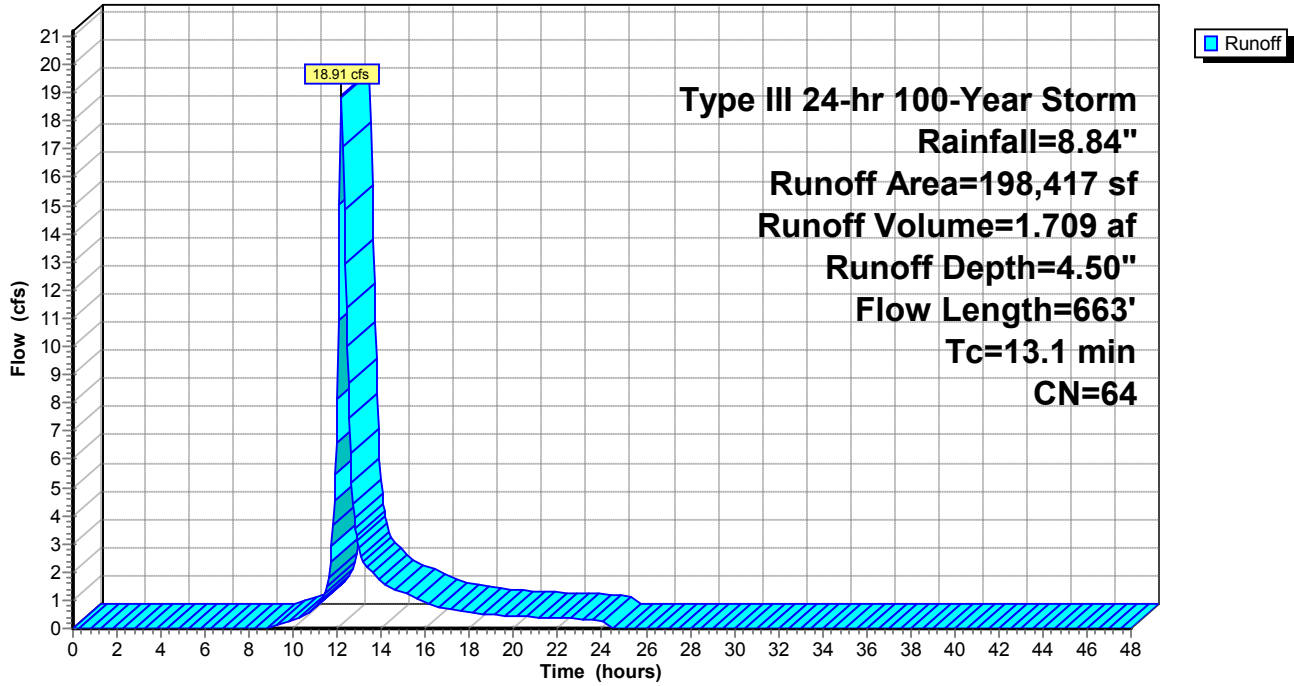HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 100-Year Storm Rainfall=8.84"
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Subcatchment 4S: Off Site Properties

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=198,417 sf
Runoff Volume=1.709 af
Runoff Depth=4.50"
Flow Length=663'
Tc=13.1 min
CN=64

Subcatchment 5S: Site to Culvert

Runoff   =   2.03 cfs @ 12.19 hrs, Volume=   0.186 af, Depth= 5.49"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
12,820	79	Woods, Fair, HSG D
2,936	39	>75% Grass cover, Good, HSG A
1,901	80	>75% Grass cover, Good, HSG D
17,657	72	Weighted Average
17,657		Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.8	50	0.0100	0.08		**Sheet Flow,**
					Grass: Dense n= 0.240 P2= 3.20"
2.6	231	0.0100	1.50		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
0.1	38	0.0150	7.28	12.87	**Circular Channel (pipe),**
					Diam= 18.0" Area= 1.8 sf Perim= 4.7' r= 0.38'
					n= 0.013 Corrugated PE, smooth interior
0.2	14	0.0100	1.50		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
13.7	333	Total			

Subcatchment 5S: Site to Culvert

Hydrograph

Subcatchment 6S: Woodbine Road & Offsite

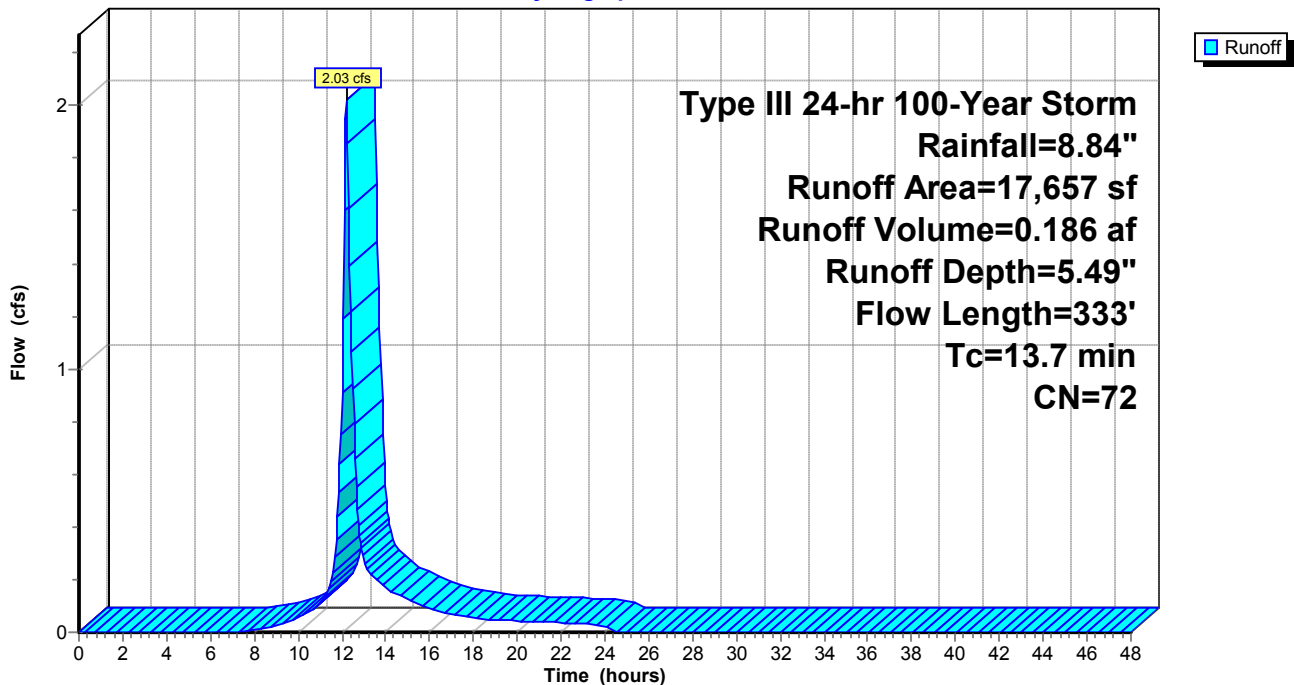Runoff   =   71.17 cfs @ 12.22 hrs, Volume=   6.971 af, Depth= 5.91"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
362,024	73	Woods, Fair, HSG C
254,113	80	1/2 acre lots, 25% imp, HSG C
616,137	76	Weighted Average
552,609		Pervious Area
63,528		Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.2000	0.17		**Sheet Flow,**
					Woods: Light underbrush n= 0.400 P2= 3.20"
3.4	125	0.0150	0.61		**Shallow Concentrated Flow,**
					Woodland Kv= 5.0 fps
1.8	200	0.0150	1.84		**Shallow Concentrated Flow,**
					Grassed Waterway Kv= 15.0 fps
3.7	710	0.0250	3.21		**Shallow Concentrated Flow,**
					Paved Kv= 20.3 fps
2.5	100	0.0180	0.67		**Shallow Concentrated Flow,**
					Woodland Kv= 5.0 fps
16.3	1,185	Total			

Subcatchment 6S: Woodbine Road & Offsite

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=616,137 sf
Runoff Volume=6.971 af
Runoff Depth=5.91"
Flow Length=1,185'
Tc=16.3 min
CN=76

Subcatchment 7S: Site to Woodbine Depression

Runoff   =   5.89 cfs @   12.09 hrs, Volume=   0.436 af, Depth= 6.32"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
179	98	Paved parking & roofs
31,805	79	Woods, Fair, HSG D
4,096	80	>75% Grass cover, Good, HSG D
36,080	79	Weighted Average
35,901		Pervious Area
179		Impervious Area

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

Subcatchment 7S: Site to Woodbine Depression

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=36,080 sf
Runoff Volume=0.436 af
Runoff Depth=6.32"
Tc=6.0 min
CN=79

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Type III 24-hr 100-Year Storm Rainfall=8.84"
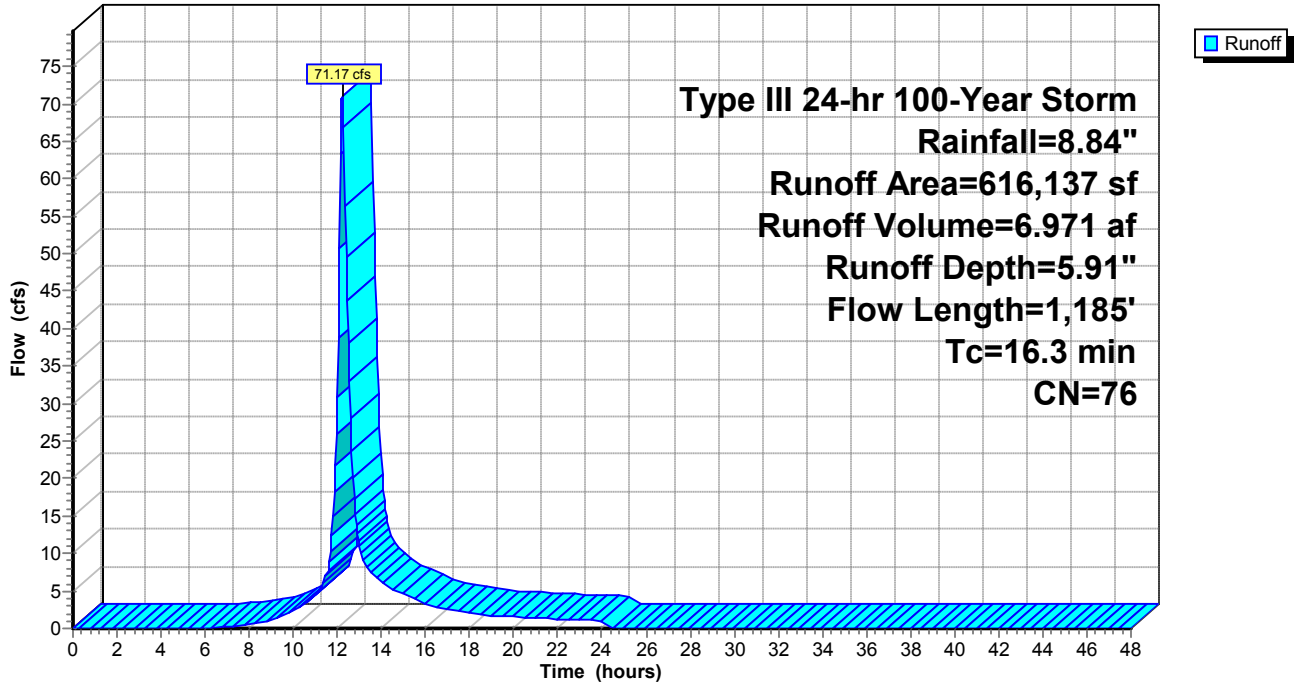Page 11
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Subcatchment 8S: Site to Wetlands

Runoff   =   8.69 cfs @   12.09 hrs, Volume=   0.643 af, Depth= 6.30"
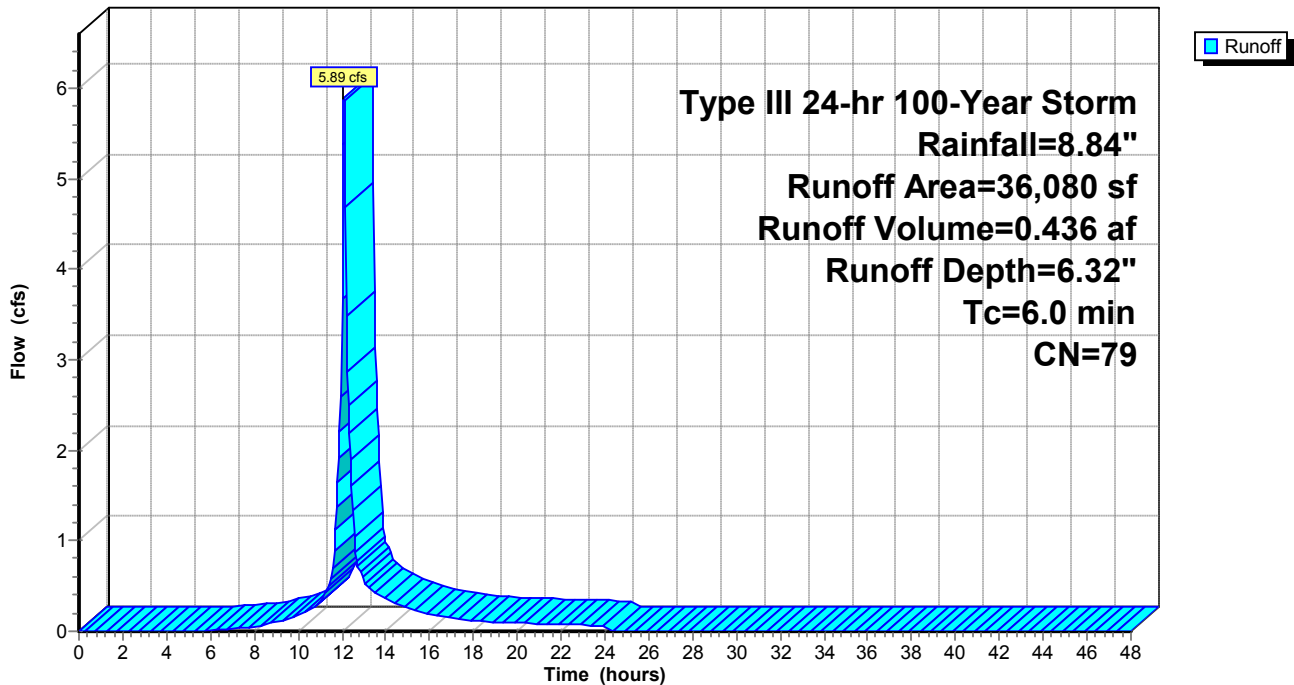
Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Storm Rainfall=8.84"

Area (sf)	CN	Description
51,265	79	Woods, Fair, HSG D
2,080	80	>75% Grass cover, Good, HSG D
53,345	79	Weighted Average
53,345		Pervious Area

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

Subcatchment 8S: Site to Wetlands

Hydrograph

Type III 24-hr 100-Year Storm
Rainfall=8.84"
Runoff Area=53,345 sf
Runoff Volume=0.643 af
Runoff Depth=6.30"
Tc=6.0 min
CN=79

Reach 1R: IVW

Inflow Area =   25.073 ac, Inflow Depth = 5.43"   for 100-Year Storm event
Inflow   =   112.34 cfs @   12.24 hrs, Volume=   11.348 af
Outflow   =   112.34 cfs @   12.24 hrs, Volume=   11.348 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Reach 1R: IVW
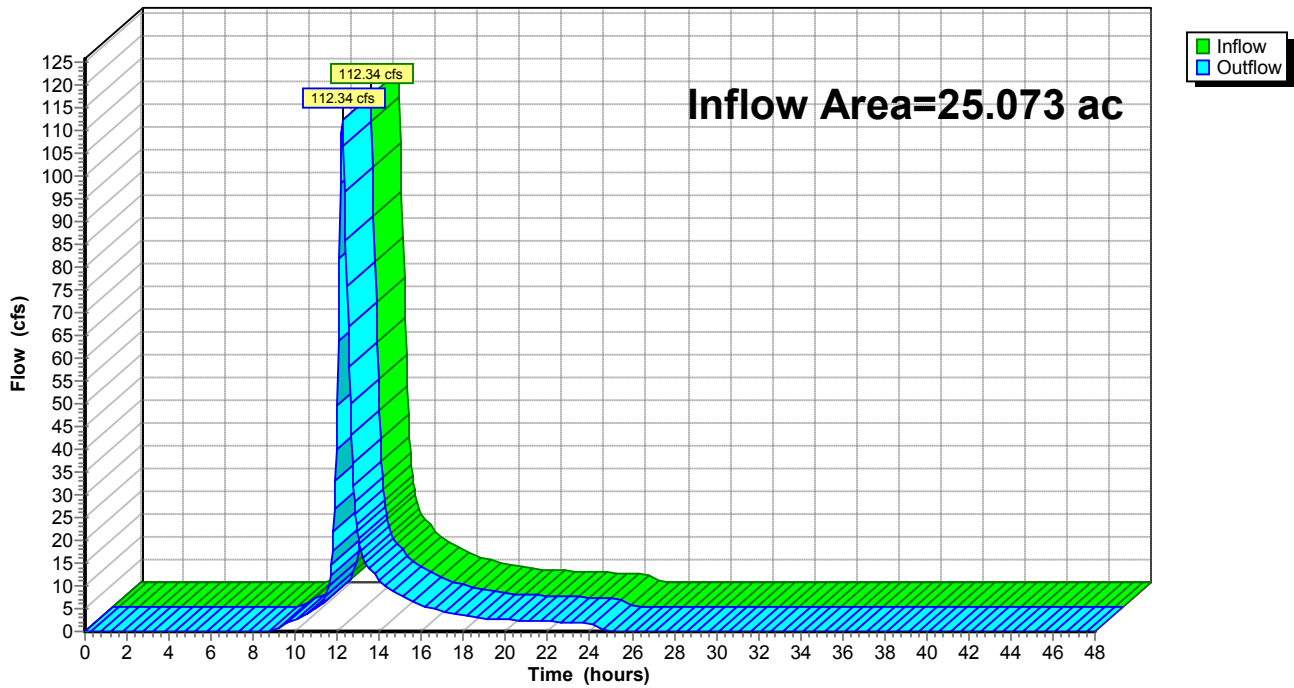
Pond 1L: Infiltration System 1

Inflow Area =   0.095 ac, Inflow Depth = 8.60"   for 100-Year Storm event
Inflow   =   0.81 cfs @   12.09 hrs, Volume=   0.068 af
Outflow   =   0.01 cfs @   5.70 hrs, Volume=   0.045 af, Atten= 99%, Lag= 0.0 min
Primary   =   0.01 cfs @   5.70 hrs, Volume=   0.045 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 95.70' @ 19.34 hrs   Surf.Area= 0 sf   Storage= 2,089 cf

Plug-Flow detention time= 879.2 min calculated for 0.045 af (66% of inflow)
Center-of-Mass det. time= 777.0 min (1,517.0 - 740.0)

Volume	Invert	Avail.Storage	Storage Description
#1	89.80'	2,159 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
89.80	0
90.30	84
95.63	2,062
95.89	2,159

Device	Routing	Invert	Outlet Devices
#1	Primary	0.00'	**Special & User-Defined**
			Elev. (feet) 89.80 89.81 90.30 95.63 95.89
			Disch. (cfs) 0.000 0.012 0.012 0.012 0.012

Primary OutFlow Max=0.01 cfs @ 5.70 hrs HW=89.81'   (Free Discharge)
└─**1=Special & User-Defined** (Custom Controls 0.01 cfs)

Proposed Conditions5
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Type III 24-hr 100-Year Storm Rainfall=8.84"
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Pond 1L: Infiltration System 1

Hydrograph

Inflow Area=0.095 ac
Peak Elev=95.70'
Storage=2,089 cf

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Type III 24-hr 100-Year Storm Rainfall=8.84"
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Pond 1P: Detention/Infiltration Pond
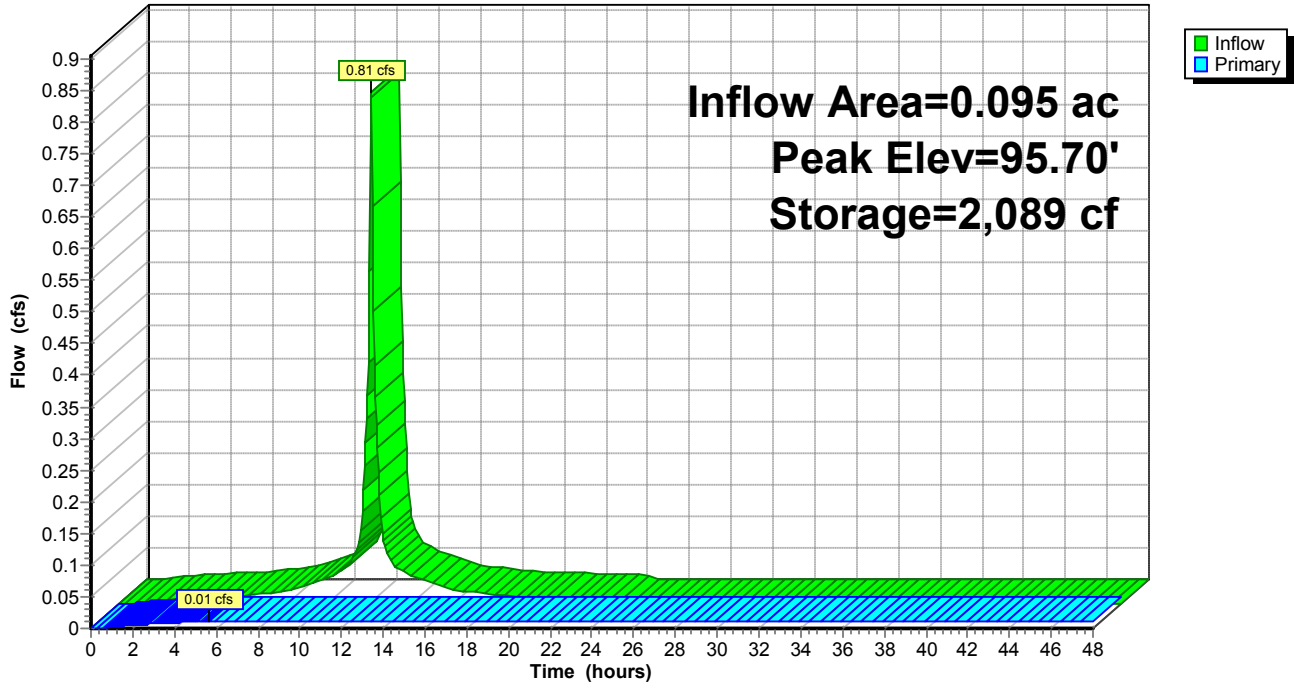
Inflow Area =   1.153 ac, Inflow Depth = 7.60"   for 100-Year Storm event
Inflow   =   9.36 cfs @ 12.09 hrs, Volume=   0.730 af
Outflow   =   4.61 cfs @ 12.26 hrs, Volume=   0.730 af, Atten= 51%, Lag= 9.9 min
Discarded =   0.14 cfs @   7.60 hrs, Volume=   0.317 af
Primary   =   4.46 cfs @ 12.26 hrs, Volume=   0.413 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 91.41' @ 12.26 hrs   Surf.Area= 5,112 sf   Storage= 11,712 cf

Plug-Flow detention time= 183.2 min calculated for 0.729 af (100% of inflow)
Center-of-Mass det. time= 183.6 min (958.0 - 774.5)

Volume	Invert	Avail.Storage	Storage Description
#1	88.50'	14,988 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)
88.50	3,498	238.0	0	0	3,498
89.00	3,498	238.0	1,749	1,749	3,617
90.00	3,988	251.0	3,740	5,489	4,179
91.00	4,502	263.0	4,242	9,732	4,733
92.00	6,049	329.0	5,256	14,988	7,856

Device	Routing	Invert	Outlet Devices
#1	Primary	89.80'	**8.0" Vert. Orifice** C= 0.600
#2	Primary	91.20'	**2.00' x 2.00' Horiz. Overflow Grate** Limited to weir flow C= 0.600
#3	Discarded	0.00'	**Exfiltration**
			Elev. (feet) 88.50 88.51 89.00 90.00 91.00 92.00
			Disch. (cfs) 0.000 0.143 0.143 0.143 0.143 0.143

Discarded OutFlow Max=0.14 cfs @ 7.60 hrs HW=88.51' (Free Discharge)
└─**3=Exfiltration** (Custom Controls 0.14 cfs)

Primary OutFlow Max=4.43 cfs @ 12.26 hrs HW=91.41' (Free Discharge)
├─**1=Orifice** (Orifice Controls 1.90 cfs @ 5.44 fps)
└─**2=Overflow Grate** (Weir Controls 2.53 cfs @ 1.50 fps)

Proposed Conditions5
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Type III 24-hr 100-Year Storm Rainfall=8.84"
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Pond 1P: Detention/Infiltration Pond

Hydrograph

Inflow Area=1.153 ac
Peak Elev=91.41'
Storage=11,712 cf

Legend: Inflow, Outflow, Discarded, Primary

9.36 cfs
4.61 cfs
4.46 cfs
0.14 cfs

Pond 2P: Roadway Culvert

Inflow Area =   4.960 ac, Inflow Depth = 4.58"   for 100-Year Storm event
Inflow   =   20.94 cfs @ 12.19 hrs, Volume=   1.895 af
Outflow   =   20.77 cfs @ 12.21 hrs, Volume=   1.895 af, Atten= 1%, Lag= 1.4 min
Primary   =   20.77 cfs @ 12.21 hrs, Volume=   1.895 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 88.13' @ 12.21 hrs   Surf.Area= 0 sf   Storage= 635 cf

Plug-Flow detention time= 0.7 min calculated for 1.893 af (100% of inflow)
Center-of-Mass det. time= 0.7 min (837.7 - 837.0)

Volume	Invert	Avail.Storage	Storage Description
#1	87.25'	4,801 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
87.25	0
88.00	230
89.50	4,801

Device	Routing	Invert	Outlet Devices
#1	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#2	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#3	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#4	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#5	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished
#6	Primary	87.25'	**18.0" x 37.5' long Culvert** RCP, square edge headwall, Ke= 0.500 Outlet Invert= 86.69' S= 0.0149 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished

Primary OutFlow Max=20.52 cfs @ 12.21 hrs HW=88.13' (Free Discharge)
—**1=Culvert** (Inlet Controls 3.42 cfs @ 3.19 fps)
—**2=Culvert** (Inlet Controls 3.42 cfs @ 3.19 fps)
—**3=Culvert** (Inlet Controls 3.42 cfs @ 3.19 fps)
—**4=Culvert** (Inlet Controls 3.42 cfs @ 3.19 fps)
—**5=Culvert** (Inlet Controls 3.42 cfs @ 3.19 fps)
—**6=Culvert** (Inlet Controls 3.42 cfs @ 3.19 fps)

Proposed Conditions5
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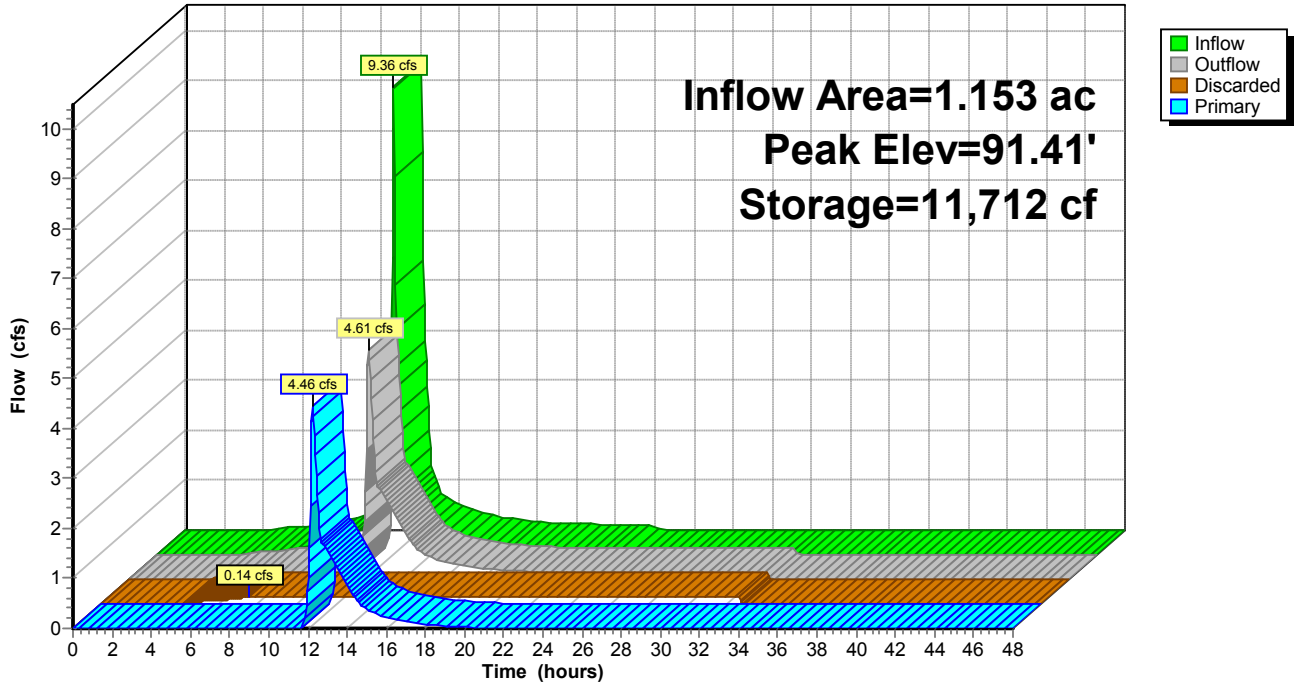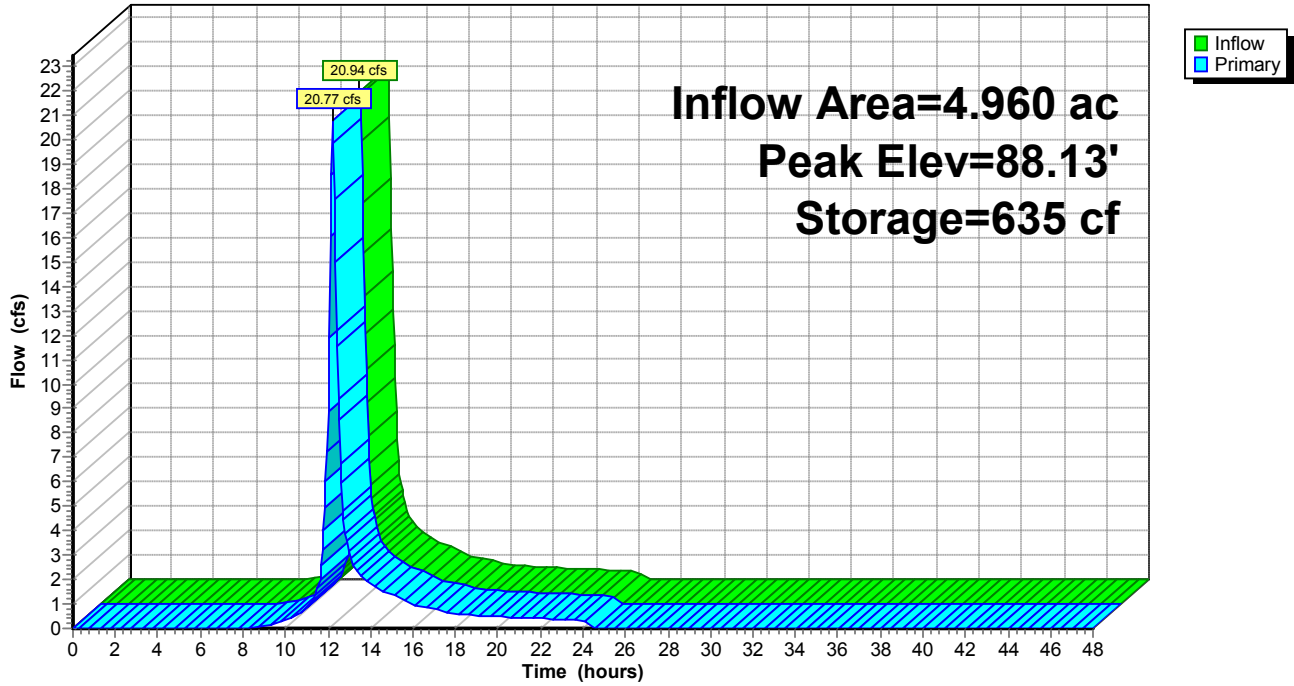HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 100-Year Storm Rainfall=8.84"
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Pond 2P: Roadway Culvert

Hydrograph

Inflow Area=4.960 ac
Peak Elev=88.13'
Storage=635 cf

Pond 3P: Site Depression

Inflow Area =   8.876 ac, Inflow Depth = 5.01"   for 100-Year Storm event
Inflow   =   38.73 cfs @   12.18 hrs, Volume=   3.703 af
Outflow   =   34.57 cfs @   12.26 hrs, Volume=   3.433 af, Atten= 11%, Lag= 4.8 min
Primary   =   34.57 cfs @   12.26 hrs, Volume=   3.433 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 86.52' @ 12.26 hrs   Surf.Area= 59,113 sf   Storage= 26,975 cf

Plug-Flow detention time= 66.4 min calculated for 3.433 af (93% of inflow)
Center-of-Mass det. time= 29.1 min (852.3 - 823.2)

Volume	Invert	Avail.Storage	Storage Description
#1	86.00'	58,179 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)
86.00	41,988	830.0	0	0	41,988
86.25	52,276	995.0	11,760	11,760	65,952
87.00	72,037	1,166.0	46,420	58,179	95,369

Device	Routing	Invert	Outlet Devices
#1	Primary	86.25'	**90.0' long x 30.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=34.31 cfs @ 12.26 hrs HW=86.52'   (Free Discharge)
└—**1=Broad-Crested Rectangular Weir** (Weir Controls 34.31 cfs @ 1.40 fps)

Proposed Conditions5
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Type III 24-hr 100-Year Storm Rainfall=8.84"
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Pond 3P: Site Depression

Hydrograph

Inflow Area=8.876 ac
Peak Elev=86.52'
Storage=26,975 cf

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Pond 4P: Woodbine Depression

Inflow Area =   14.973 ac, Inflow Depth = 5.94"   for 100-Year Storm event
Inflow   =   74.35 cfs @   12.22 hrs, Volume=   7.407 af
Outflow   =   73.66 cfs @   12.24 hrs, Volume=   7.272 af, Atten= 1%, Lag= 1.4 min
Primary   =   73.66 cfs @   12.24 hrs, Volume=   7.272 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 88.87' @ 12.24 hrs   Surf.Area= 21,568 sf   Storage= 12,790 cf

Plug-Flow detention time= 19.5 min calculated for 7.265 af (98% of inflow)
Center-of-Mass det. time= 8.6 min (825.5 - 816.8)

Volume	Invert	Avail.Storage	Storage Description
#1	88.00'	15,673 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)
88.00	8,161	367.0	0	0	8,161
88.50	15,722	518.0	5,868	5,868	18,798
89.00	23,774	614.0	9,805	15,673	27,450

Device	Routing	Invert	Outlet Devices
#1	Primary	88.50'	**120.0' long x 97.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Primary OutFlow Max=73.14 cfs @ 12.24 hrs HW=88.87'   (Free Discharge)
└─**1=Broad-Crested Rectangular Weir** (Weir Controls 73.14 cfs @ 1.64 fps)

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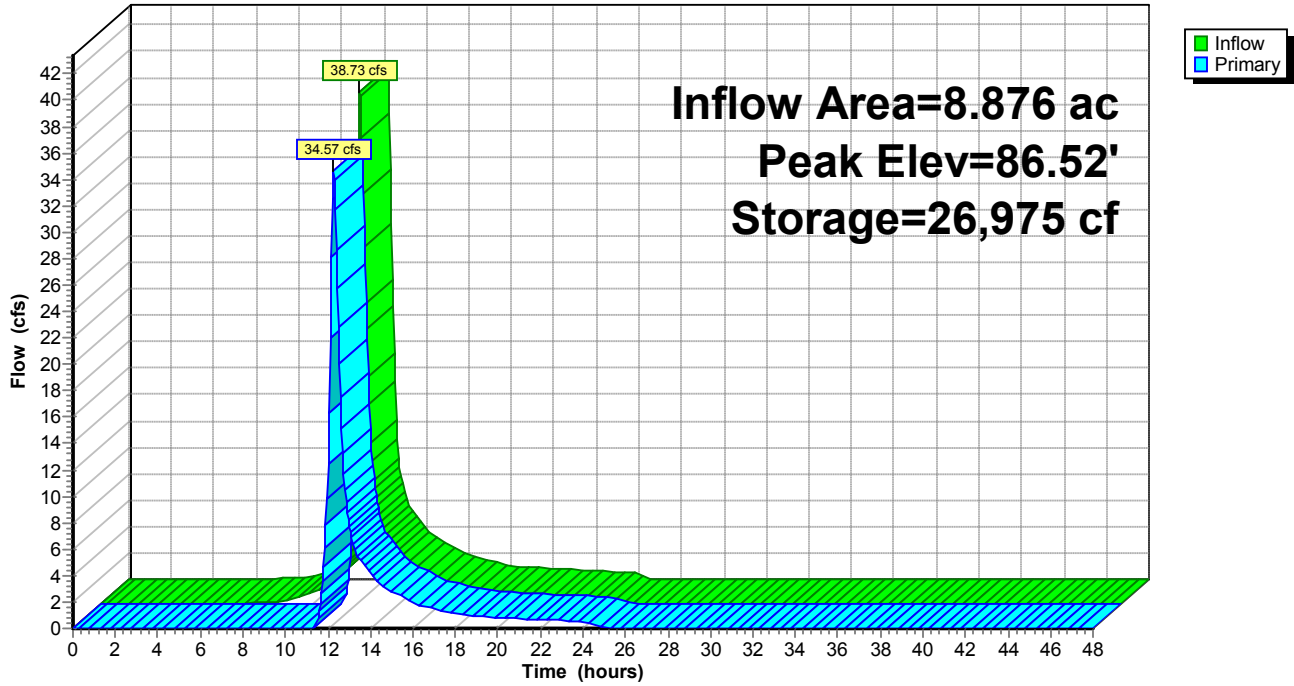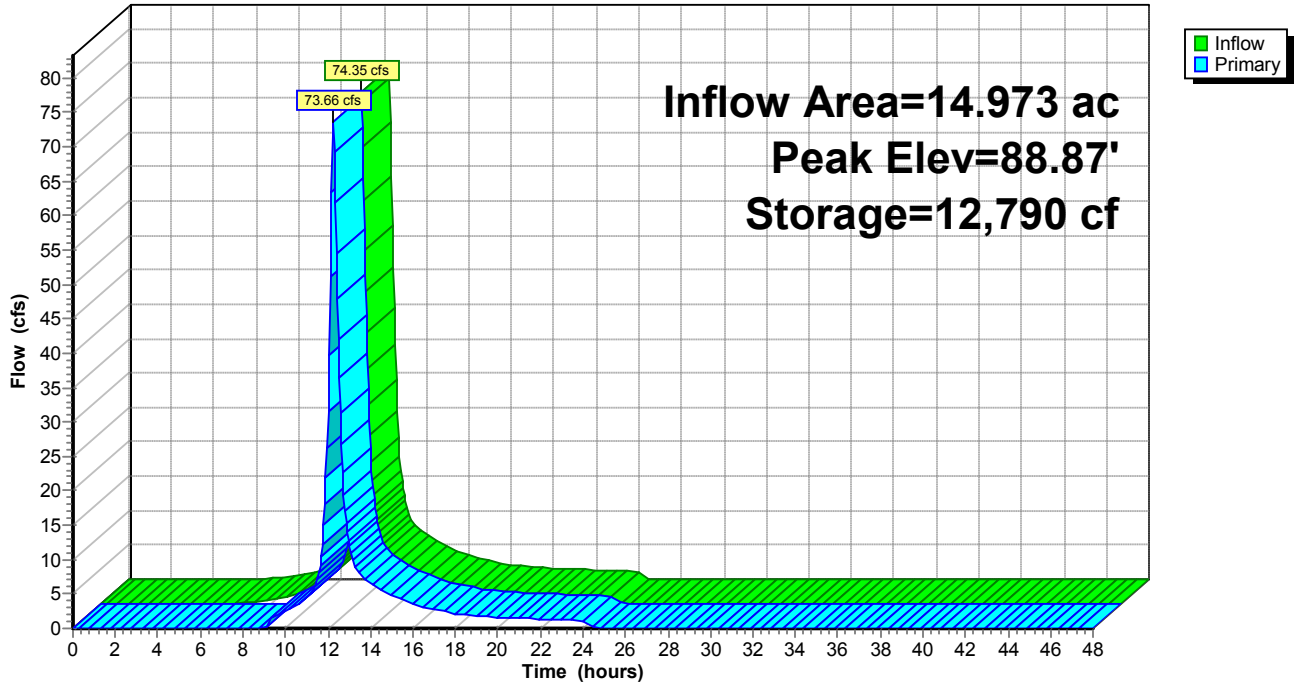HydroCAD® 8.00 s/n 004688 © 2006 HydroCAD Software Solutions LLC

Type III 24-hr 100-Year Storm Rainfall=8.84"
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Pond 4P: Woodbine Depression

Inflow Area=14.973 ac
Peak Elev=88.87'
Storage=12,790 cf

Pond 7L: Infiltration System 7

Inflow Area =   1.153 ac, Inflow Depth = 7.66"   for 100-Year Storm event
Inflow   =   9.38 cfs @   12.09 hrs, Volume=   0.736 af
Outflow   =   9.36 cfs @   12.09 hrs, Volume=   0.736 af, Atten= 0%, Lag= 0.2 min
Discarded =   0.00 cfs @   2.70 hrs, Volume=   0.006 af
Primary   =   9.36 cfs @   12.09 hrs, Volume=   0.730 af

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 90.82' @ 12.09 hrs   Surf.Area= 0 sf   Storage= 212 cf

Plug-Flow detention time= 5.9 min calculated for 0.736 af (100% of inflow)
Center-of-Mass det. time= 5.9 min (778.2 - 772.4)

Volume	Invert	Avail.Storage	Storage Description
#1	86.50'	247 cf	**Custom Stage Data** Listed below

Elevation (feet)	Cum.Store (cubic-feet)
86.50	0
87.00	13
91.50	247

Device	Routing	Invert	Outlet Devices
#1	Discarded	0.00'	**Exfiltration** Elev. (feet) 86.50 86.51 87.00 91.50 Disch. (cfs) 0.000 0.002 0.002 0.002
#2	Primary	88.74'	**18.0" x 45.0' long Outlet** CPP, square edge headwall, Ke= 0.500 Outlet Invert= 88.50' S= 0.0053 '/' Cc= 0.900 n= 0.009 Corrugated PE, smooth interior

Discarded OutFlow Max=0.00 cfs @ 2.70 hrs HW=86.51' (Free Discharge)
└—**1=Exfiltration** (Custom Controls 0.00 cfs)

Primary OutFlow Max=9.07 cfs @ 12.09 hrs HW=90.78' (Free Discharge)
└—**2=Outlet** (Barrel Controls 9.07 cfs @ 5.13 fps)

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Pond 7L: Infiltration System 7

Hydrograph

Legend:
- Inflow
- Outflow
- Discarded
- Primary

9.38 cfs
9.36 cfs
9.36 cfs
0.00 cfs

Inflow Area=1.153 ac
Peak Elev=90.82'
Storage=212 cf

Flow (cfs)

Time (hours)
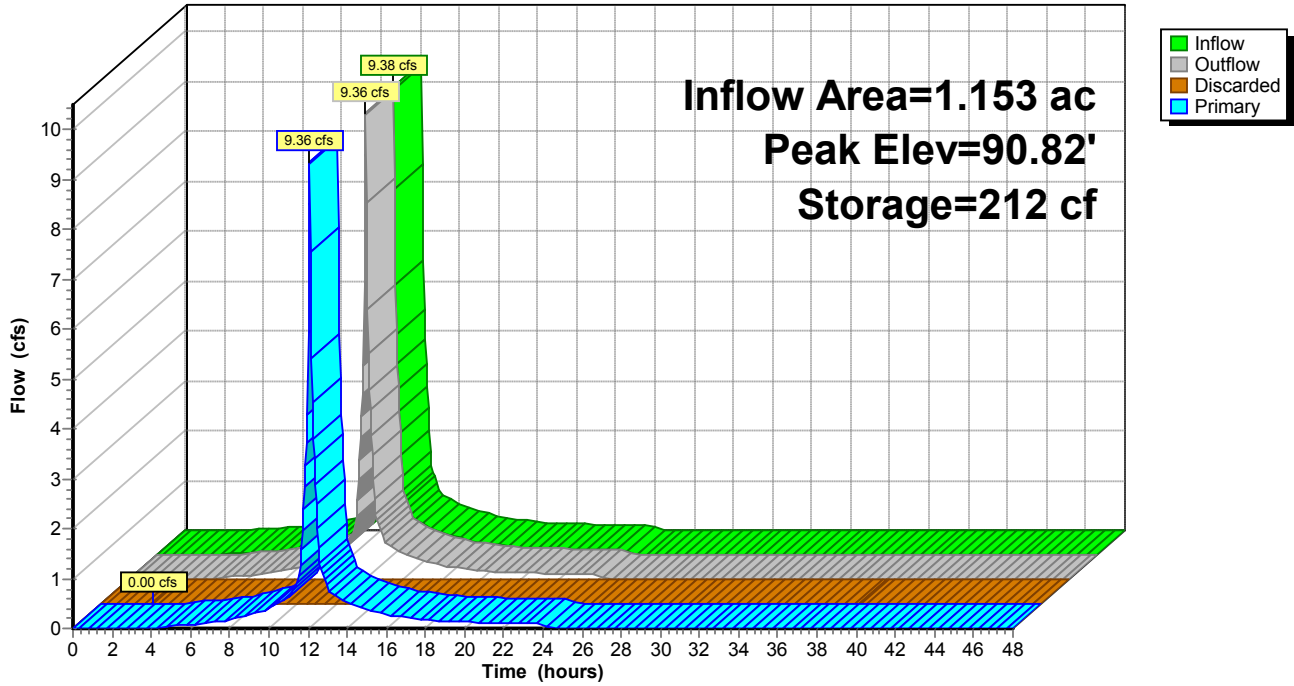
Appendix C
Groundwater Mounding Analysis
(Hantush Method)

Test Hole	Evidence of GW/Ledge	Elevation (ft.)
1	Mottling	84.4
2	Mottling	84.5
3	Boulder Refusal	83.7
4	None, depth to bottom of test pit	82.4

Infiltration System	ESGWT (ft.)	Bottom of System (ft.)	Δ (ft.)
1	84.5	89.8	5.3
7	84.5	86.5	2.0*
Detention/Infiltration Pond	84.4	88.5	4.1

Infiltration system 7, is within four feet of the estimated seasonal high groundwater table, therefore they require a groundwater mounding analysis per the Massachusetts Stormwater Handbook.

Infiltration System 7

This spreadsheet will calculate the height of a groundwater mound beneath a stormwater infiltration basin. More information can be found in the U.S. Geological Survey Scientific Investigations Report 2010-5102 "Simulation of groundwater mounding beneath hypothetical stormwater infiltration basins".

The user must specify infiltration rate (R), specific yield (Sy), horizontal hydraulic conductivity (Kh), basin dimensions (x, y), duration of infiltration period (t), and the initial thickness of the saturated zone (hi(0), height of the water table if the bottom of the aquifer is the datum). For a square basin the half width equals the half length (x = y). For a rectangular basin, if the user wants the water-table changes perpendicular to the long side, specify x as the short dimension and y as the long dimension. Conversely, if the user wants the values perpendicular to the short side, specify y as the short dimension, x as the long dimension. All distances are from the center of the basin. Users can change the distances from the center of the basin at which water-table aquifer thickness are calculated.

Cells highlighted in yellow are values that can be changed by the user. Cells highlighted in red are output values based on user-specified inputs. The user MUST click the blue "Re-Calculate Now" button each time ANY of the user-specified inputs are changed otherwise necessary iterations to converge on the correct solution will not be done and values shown will be incorrect. Use consistent units for all input values (for example, feet and days)

use consistent units (e.g. feet & days **or** inches & hours)

Conversion Table

	inch/hour	feet/day
	0.67	1.33
	2.00	4.00

In the report accompanying this spreadsheet (USGS SIR 2010-5102), vertical soil permeability (ft/d) is assumed to be one-tenth horizontal hydraulic conductivity (ft/d).

hours	days
36	1.50

Input Values

Value	Symbol	Description
4.2000	R	Recharge (infiltration) rate (feet/day)
0.330	Sy	Specific yield, Sy (dimensionless, between 0 and 1)
45.00	K	Horizontal hydraulic conductivity, Kh (feet/day)*
4.000	x	1/2 length of basin (x direction, in feet)
4.000	y	1/2 width of basin (y direction, in feet)
1.000	t	duration of infiltration period (days)
2.000	hi(0)	initial thickness of saturated zone (feet)

Value	Symbol	Description
2.892	h(max)	maximum thickness of saturated zone (beneath center of basin at end of infiltration period)
0.892	Δh(max)	maximum groundwater mounding (beneath center of basin at end of infiltration period)

Ground-water Mounding, in feet	Distance from center of basin in x direction, in feet
0.892	0
0.186	20
0.030	40
0.012	50
0.006	60
0.005	70
0.004	80
0.004	90
0.004	100
0.004	120

Re-Calculate Now

Groundwater Mounding, in feet
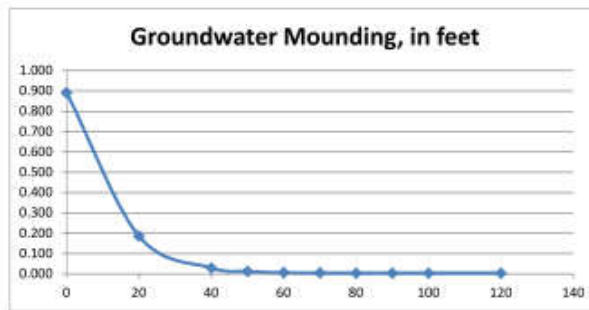
Disclaimer

This spreadsheet solving the Hantush (1967) equation for ground-water mounding beneath an infiltration basin is made available to the general public as a convenience for those wishing to replicate values documented in the USGS Scientific Investigations Report 2010-5102 "Groundwater mounding beneath hypothetical stormwater infiltration basins" or to calculate values based on user-specified site conditions. Any changes made to the spreadsheet (other than values identified as user-specified) after transmission from the USGS could have unintended, undesirable consequences. These consequences could include, but may not be limited to: erroneous output, numerical instabilities, and violations of underlying assumptions that are inherent in results presented in the accompanying USGS published report. The USGS assumes no responsibility for the consequences of any changes made to the spreadsheet. If changes are made to the spreadsheet, the user is responsible for documenting the changes and justifying the results and conclusions.

Results from the Hantush analysis for Infiltration System 7, shown above, reveal that ground water will rise 0.892 feet beneath the system. Therefore, even though the system is less than four feet from the ESGWT, the groundwater will not reach the bottom of the infiltration system via mounding.

Appendix D
Rip-Rap Sizing Calculations

Rip-Rap Protection at Detention Pond Outlet

Outlet Elevation = 87.9
100-year elevation of isolated area = 86.5
$TW_{min} = 0$

$D_o = 18" = 1.5'$

$W_1 = 3D_o = \textbf{4.5}$

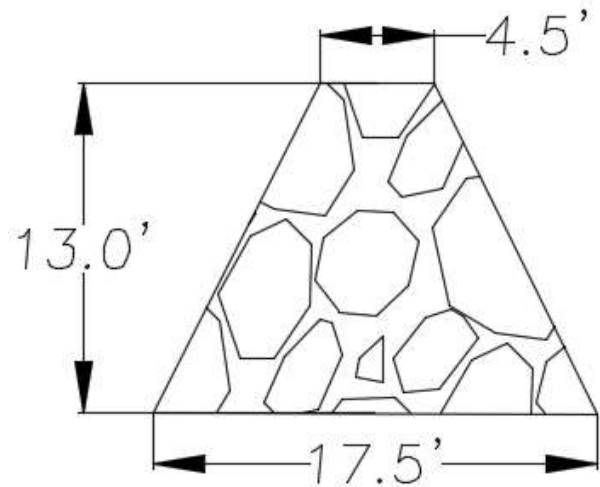$D_o/2 = 0.75'$

Since, $TW < D_o/2 = 0.75'$

$L_a = ((1.8)*Q)/(D_o{}^\wedge 3/2) + 7D_o$

$Q = 2.52$ cfs

$L_a = ((1.8*2.52)/(1.5^\wedge 1.5)) + 7 * 1.5 = \textbf{13.0}$

Since, $TW < D_o/2 = 0.75'$

$W_2 = 3D_o + L_a = 3(1.5) + 13 = \textbf{17.5}$

Rip-Rap Protection at Detention Pond Inlet

Inlet Elevation = 88.5
100-year elevation of isolated area = 91.6
TW = 3.1

D_o = 18" = 1.5'

$W_1 = 3D_o$ = **4.5**

$D_o/2 = 0.75'$

Since, TW > $D_o/2$

$L_a = (3Q)/(D_o^{3/2}) + 7D_o$

Q = 9.74 cfs

$L_a = ((3*9.74)/(1.5^{1.5})) + 7 * 1.5$ = **26.4**

Since, TW > $D_o/2$

$W_2 = 3D_o + 0.4 * L_a = 3(1.5) + 0.4(26.4)$ = **15.1**
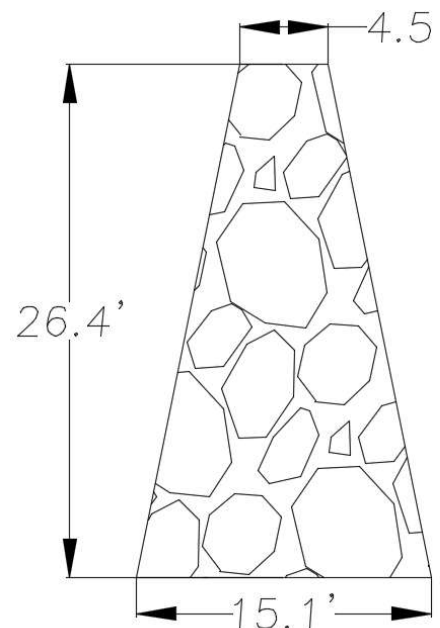
Apron Material

d_{50} = median stone diameter

$d_{50} = (0.02 * Q^{4/3}) / (TW * (D_o))$

$d_{50} = (0.02 * 9.74^{4/3}) / (3.1 * (1.5))$

$d_{50} = 0.089' = 1.07"$

Use 6" diameter stone, minimum on rip-rap aprons

*Empirical equations obtained from, *Design and Construction of Urban Stormwater Management Systems*.
New York: American Society of Civil Engineers, 1993. p 351-354. Print.

Rip-Rap Basin for Cuvert Outlet

$D_o = 18'' = 1.5'$

Minimum Dissipator Pool Length $= 3D_o = 4.5'$

Minimum Apron Length $= D_o = 1.5'$

Basin Material

d_{50} = median stone diameter

$Q = 20.46$ cfs

$TW = 88.13 - 85.70 = 2.43$

$d_{50} = (0.02 * Q^{(4/3)}) / (TW * (D_o))$

$d_{50} = (0.02 * 20.46^{(4/3)}) / (2.43 * (1.5))$

$d_{50} = 0.31' = 3.73''$

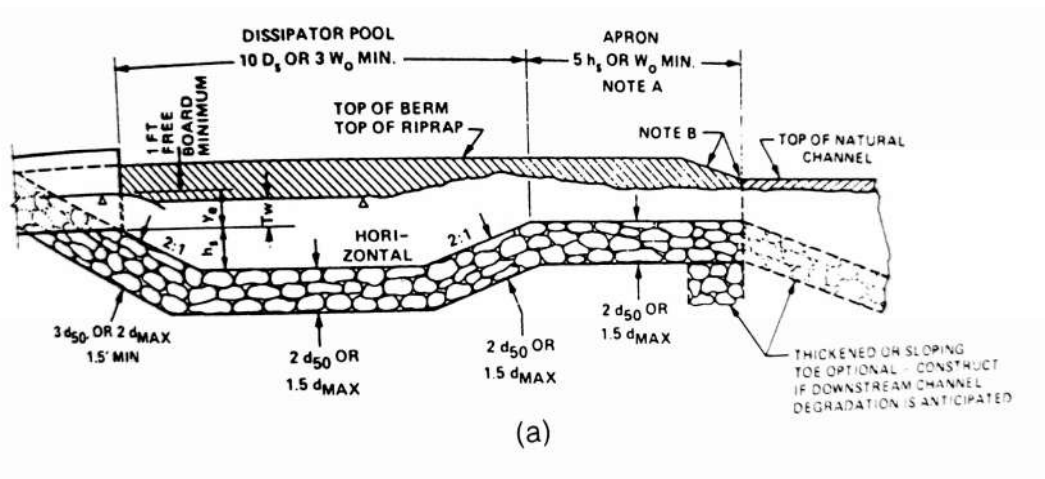Use 6" diameter stone, minimum

h_s / d_{50} must be $>/= 2$

$h_s = 1.0'$; $h_s / d_{50} = 2$

Minimum thickness of rip-rap base $= 3d_{50} = 1.5'$

(a)

Figure 9.18 from, *Design and Construction of Urban Stormwater Management Systems*. New York: American Society of Civil Engineers, 1993. p 354, 360-361. Print.

Appendix E
Stormwater Pipe Sizing Calculations

TABLE 1: PIPE SIZING (10 YEAR RETURN PERIOD)

From	To	A(ac.)	C	CA	ΣCA	Tc	ΣTc	I	Q	D	s	n	Qf	Vf	L	Fall	Iup	Ilow	Rim
CB1	DMH1	0.19	0.9	0.17		10		4.3	0.73	12	0.01	0.011	4.2	5.4	12	0.12	91.69	91.57	95.10
CB2	DMH1	0.19	0.9	0.17		10		4.3	0.73	12	0.012	0.011	4.6	5.9	10	0.10	91.69	91.57	95.10
DMH1	DMH2				0.34	10.7		4.3	1.46	12	0.01	0.011	4.2	5.4	233	2.23	91.57	89.34	95.30
CB3	DMH2	0.21	0.9	0.19		10		4.3		12	0.016	0.011	5.3	6.8	9	0.14	89.48	89.34	91.92
CB4	DMH2	0.18	0.9	0.16		10		4.3		12	0.01	0.011	4.2	5.4	15	0.14	89.48	89.34	91.92
DMH2	SED.				0.69	10.9		4.3	2.97	18	0.005	0.01	8.8	5.0	50	0.25	89.34	89.09	92.00

SMOOTH PIPE
==========

V(full) = Sqrt Slope * V(chart)

Q(full) = Sqrt Slope * Q(chart)

MANNING FLOW FORMULA
    V = 1.486 * R(2/3) * S(1/2) / n
    Q = 1.486 * A * R(2/3) * S(1/2) / n

DIA in.	n = 0.011 V	n = 0.011 Q	n = 0.012 V	n = 0.012 Q	n = 0.013 V	n = 0.013 Q	AREA sf	DIA in.
3	21.3	1.04	19.5	0.96	18.0	0.88	0.049	3
4	25.8	2.25	23.6	2.06	21.8	1.90	0.087	4
5	29.9	4.08	27.4	3.74	25.3	3.45	0.136	5
6	33.8	6.63	31.0	6.08	28.6	5.61	0.196	6
8	40.9	14.3	37.5	13.1	34.6	12.1	0.349	8
10	47.5	25.9	43.5	23.7	40.2	21.9	0.545	10
12	53.6	42.1	49.1	38.6	45.4	35.6	0.785	12
15	62.2	76.3	57.0	70.0	52.6	64.6	1.23	15
18	70.3	124	64.4	114	59.4	105	1.77	18
21	77.9	187	71.4	172	65.9	158	2.41	21
24	85.1	267	78.0	245	72.0	226	3.14	24
27	92.1	366	84.4	336	77.9	310	3.98	27
30	98.8	485	90.5	444	83.6	410	4.91	30
33	105	625	96.5	573	89.0	529	5.94	33
36	112	788	102	723	94.4	667	7.07	36
42	124	1,189	113	1,090	105	1,006	9.62	42
48	135	1,698	124	1,556	114	1,436	12.6	48
54	146	2,324	134	2,130	124	1,966	15.9	54
60	157	3,078	144	2,821	133	2,604	19.6	60
66	167	3,969	153	3,638	141	3,358	23.8	66
72	177	5,005	162	4,588	150	4,235	28.3	72
78	187	6,196	171	5,680	158	5,243	33.2	78
84	196	7,550	180	6,921	166	6,388	38.5	84
90	205	9,075	188	8,319	174	7,679	44.2	90
96	214	10,779	197	9,881	181	9,121	50.3	96
108	232	14,757	213	13,527	196	12,486	63.6	108
120	249	19,544	228	17,915	211	16,537	78.5	120
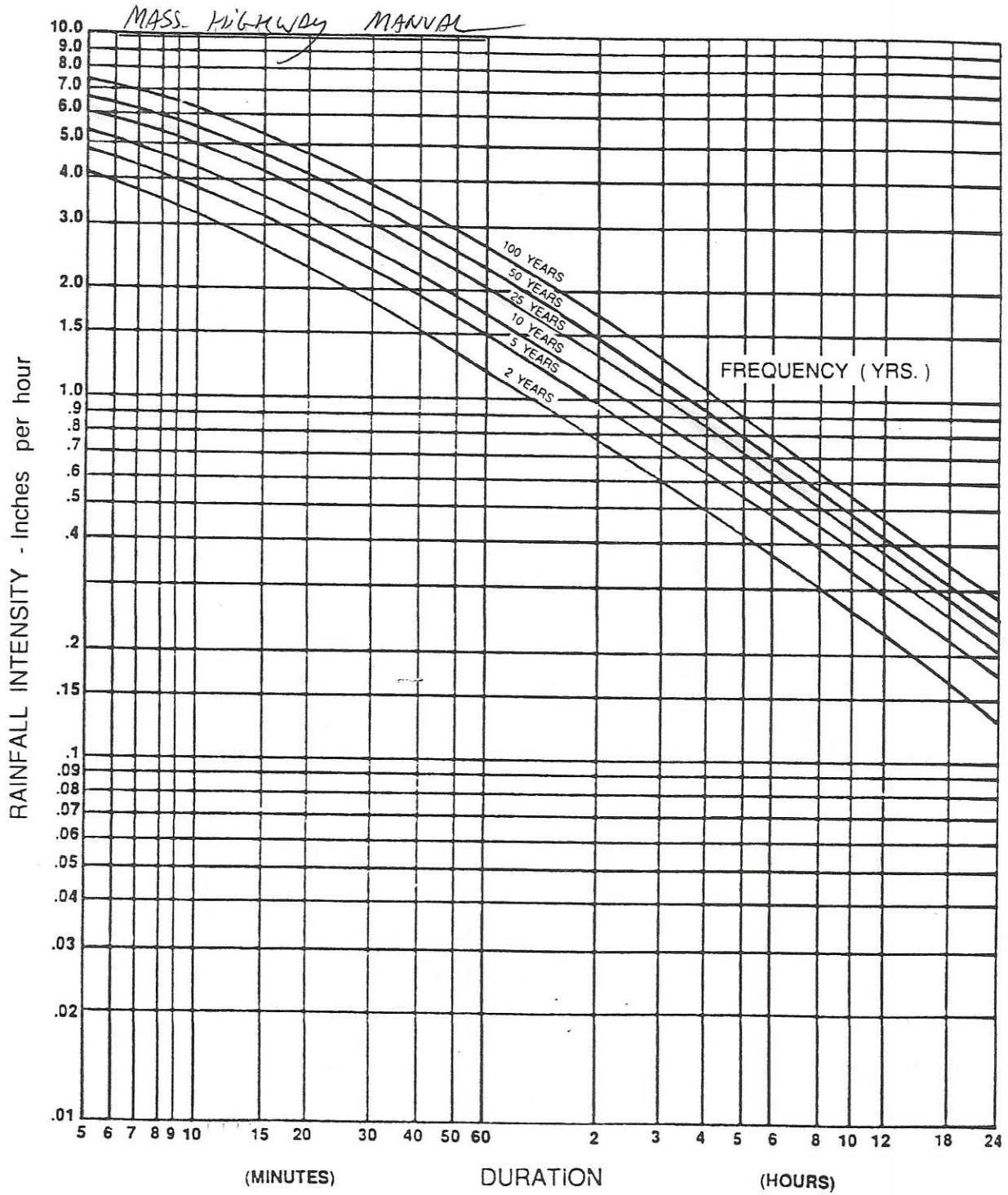
Intensity — Duration — Frequency
Curve for Boston, MA