TOWN OF WAKEFIELD

DEPARTMENT OF PUBLIC WORKS
Engineering Division

NOTICE OF INTENT

for

Quannapowitt Parkway Roadway Improvements

Wakefield, MA

April 2024

PREPARED BY:

Wakefield Department of Public Works
Engineering Division
1 Lafayette Street
Wakefield, MA 01880

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WPA Form 3
Notice of Intent Application

Filed online

Checklist for Stormwater Report

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

Checklist for Stormwater 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 Report must be submitted with the Notice of Intent permit application to document compliance with the Stormwater Management Standards. The following checklist is NOT a substitute for the Stormwater Report (which should provide more substantive and detailed information) but is offered here as a tool to help the applicant organize their Stormwater Management documentation for their Report and for the reviewer to assess this information in a consistent format. As noted in the Checklist, the Stormwater 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 Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.[1] This Checklist is to be used as the cover for the completed Stormwater 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 Stormwater 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 Stormwater Management 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.

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

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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 an Order of Conditions 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. Stormwater Checklist and Certification

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

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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature

COMMONWEALTH OF MASSACHUSETTS
WILLIAM J. RENAULT, JR.
CIVIL
No. 48185
REGISTERED PROFESSIONAL ENGINEER

4/4/24
Signature and Date

Checklist

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

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist (continued)

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

☐ No disturbance to any Wetland Resource Areas

☐ Site Design Practices (e.g. clustered development, reduced frontage setbacks)

☒ Reduced Impervious Area (Redevelopment Only)

☐ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

- ☐ Credit 1
- ☐ Credit 2
- ☐ Credit 3

☐ Use of "country drainage" versus curb and gutter conveyance and pipe

☐ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☐ Grass Channel

☐ Green Roof

☒ Other (describe): Hydrodynamic Separators, deep sump catch basins, Rain Gaurdian Foxholes

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

☒ Outlets have been designed so there is no erosion or scour to wetlands and waters of the Commonwealth

☒ Supporting calculations specified in Volume 3 of the Massachusetts Stormwater Handbook included.

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist (continued)

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

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

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

Standard 9: Operation and Maintenance Plan

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

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

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

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

Standard 10: Prohibition of Illicit Discharges

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

☒ An Illicit Discharge Compliance Statement is attached;

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

Project Narrative

Background

This Notice of Intent (NOI) application is for a limited project which proposes the rehabilitation of Quannapowitt Parkway. The project proposes the reconfiguration of the existing roadway cross-section within the current impervious limits and the replacement and expansion of an existing underground infiltration system. The roadway cross-section reconfiguration proposes to widen the sidewalk and create a shared-use-path. The current roadway footprint will be maintained with the wider shared-use-path by relocating the curb line closer to the center of the road. The treatment and infiltration systems will reduce nitrogen, phosphorus and total suspended solid (TSS) entering Lake Quannapowitt.

Quannapowitt Parkway is of poor quality with significant cracking in the pavement surface and sub-grade degradation. The project proposes full depth reclamation of the roadway to fix the sub-grade, reconfigure the cross-section and regrade the road to facilitate control of the stormwater runoff. Further, the existing sidewalk is inadequate to handle the pedestrian traffic through the area. Lake Quannapowitt is a popular location for recreational purposes including walking, biking, and rolling around the lake. The new cross-section will widen the sidewalk to a 12 foot shared-use-path that will increase available space for walkers, rollers and bicyclists.

Figure 1 - Cracking/potholes in the pavement

The existing drainage infrastructure along Quannapowitt Parkway is in disrepair and requires replacement. The catch basins on the southern end of the roadway drain to an underground infiltration system, but the system appears to be clogged. During rainfall events greater than the 2-year storm, stormwater in the roadway often overtops the sidewalk and flows untreated overland to bordering vegetated wetlands. The system cannot be inspected or cleaned as there aren't any inspection ports. There are several sections of the roadway on the northern end of the road that drain untreated to the lake. The project will direct the stormwater from the roadway into treatment BMPs prior to outletting to the lake or wetlands.

The project also proposes the replacement of the culvert connecting the wetlands to the lake on the northern end of the roadway. Currently, the culvert starts as an 18-inch diameter pipe on the wetland side of the road and transitions to a 2-foot high by 4-foot wide 3-sided box culvert before daylighting on the lake side. The crossing doesn't qualify as a stream however, the stream crossing standards were evaluated and it was determined it would be infeasible to construct a new culvert according to the standards. Should the crossing be constructed based on the general standards, the new culvert would need to be 4-feet high and 14.5-feet wide. Based on the elevations of the roadway, a new culvert cannot be constructed with 4-feet of interior height. Additionally, upsizing the culvert to these dimensions would drastically change the hydrology of the wetlands. The project proposes replacing the existing culvert with a new 2-foot high by 4-foot wide 3-sided box culvert with a natural stream bottom for the entire length of the culvert.

Figure 2 - Stormwater runoff overflowing untreated to BVW – March 14, 2023

Stormwater Design

The general topography of the road is relatively flat which has led to water ponding within the roadway. The project proposes a slight decrease of impervious area and proposes rehabilitation and retrofitting of the existing roadway and drainage infrastructure within the current impervious area. The current drainage infrastructure no longer functions as designed and is inadequate to handle the stormwater runoff. The project will regrade the roadway to eliminate flat areas and direct runoff to BMPs prior to outletting to Lake Quannapowitt.

Existing Conditions

On the southern end of Quannapowitt Parkway stormwater runoff drains to one of three catch basins which are routed to an underground infiltration system consisting of five – 70 foot long, 12" diameter perforated PVC pipes surrounded by washed stone. When the system overflows it is intended to bubble up through the washed stone and flow overland to the bordering vegetated wetlands (BVW). The conditions of the system are unknown and unable to be inspected as no inspection ports can be found to check sediment levels. Additionally, the crushed stone that was originally designed to be exposed to the surface is no longer visible and there is grass cover is the whole area. Actual conditions show in less than the 2-yr storm events, stormwater overflows the catch basins and spills over the sidewalk to the BVW without getting into the underground system. The overflow is at the low point in the roadway and flows to the BVW untreated.

On the northern end of the road, half of the road drains to a catch basin routed to a bio-retention area. This system was constructed in 2020 and is designed to treat 1" of runoff. The other half of the road drains untreated directly to Lake Quannapowitt through openings in the gutter. The openings are 4-inch PVC pipes installed directly under the sidewalk pavement which outlet directly to the lake without treatment. The pipes often fill with leaves and debris which allows ponding in the roadway and in large rain events the water overtops the sidewalk and flows directly to the lake.

Proposed Conditions

The first 500-feet of the southern end of the road will be graded to two catch basins routed through an underground infiltration system which will replace the existing system. As-builts for the existing system show that it was installed with less than 2-feet of separation to groundwater. The proposed system will be installed at the same elevation as the current system and extended an additional 20-feet to provide greater water quality and recharge volume. Since it is being replaced with the same elevations, mounding calculations are not included in the report. The underground system will overflow through an outlet control structure with a riprap apron to the grass area eventually flowing to a wetland system upstream of Lake Quannapowitt.

The next 725-feet of roadway will be graded to three new gutter inlet/trench drain structures that are routed under the sidewalk to a riprap spillway flowing to the BVW. The trench drain structures include removable filters to treat runoff prior to discharge. Several alternative drainage and BMP designs were reviewed in an attempt to maximize the treatment prior to discharge to the BVW. Existing grades of the roadway, abutting properties, the average elevation of Lake Quannapowitt and inability to infiltrate due to the surface water setback requirement eliminated many of the standard options.

On the northern end of the roadway the road will be regraded to direct most of the runoff to the existing bio-retention area. There will be a 225-foot segment in the middle that will be directed to a new gutter inlet/trench drain system as described above. An additional lined bio-retention area was analyzed as part of the design process, however the same restrictions that prohibited installation of a BMP on the southern end of the roadway were present on the northern end. Pretreatment will be provided through deep sump catch basins, proprietary hydrodynamic separators and/or forebays prior to runoff entering the treatment systems.

The proposed treatment BMPs will remove 90% TSS. The proposed BMPs have been sized to the maximum extent possible with 45% nitrogen and 31% phosphorus reduction as the primary consideration given this proposal is a drainage retrofit of a pre-existing design. Evaluation of Nitrogen and Phosphorus removal has been conducted via the methodology outlined in "MA Exhibit A: Proposed Permit Modifications to Appendix F, Att. 3, December 9, 2019, EPA NDPES MS4 Permit"

Construction of the proposed ADA compliant shared-use-path will necessitate filling in 5.4 cubic yards of floodplain storage. The project will provide 6 cubic yards of compensatory storage at the same elevation. Attachment 7 includes compensatory storage calculations as required.

Responses to the Stormwater Management Standards

1. *"No new stormwater conveyances (e.g. outfalls) may discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth."*

   New stormwater outfalls being proposed as part of the project include treatment by using the Rain Guardian Foxhole system. The outfalls will have riprap aprons to ensure the discharges won't cause erosion in the BVW. The southern end of the road currently overtops the sidewalk and outlets directly to the BVW untreated and segments of the northern end outlet untreated through scuppers under the sidewalk, so proposed changes will provide treatment where current conditions provide none. Calculations are provided showing how the riprap for the new outfall and the reconstructed outfall were sized.

   Existing discharges which currently have no treatment will be routed through BMPs such as hydrodynamic separators, underground infiltration system, or bio-retention areas prior to discharge to the wetlands. The existing outfall on the southern end of the roadway will have a riprap apron at the discharge point to prevent erosion.

2. *"Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for discharges to land subject to coastal storm flowage as defined in 310 CMR 10.04."*

   Post-development peak discharge rates and volumes will be reduced for all rainfall events.

Peak Flow and Volume Comparisons at 1L (Lake Quannapowitt)

Storm	2-year (3.16-in)		10-year (4.77-in)		25-year (6.03-in)		100-year (8.62-in)	
	Peak Flow (cfs)	Volume (cf)	Peak Flow (cfs)	Volume (cf)	Peak Flow (cfs)	Volume (cf)	Peak Flow (cfs)	Volume (cf)
Pre-development	8.32	26,815	14.07	47,917	20.28	65,166	31.36	101,767
Post-development	8.22	24,316	12.66	44,906	17.69	61,909	31.17	98,125

3. *"Loss of annual recharge to groundwater shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, stormwater best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development site shall approximate the annual recharge from pre-development conditions based on soil type. This Standard is met when the stormwater management system is designed to infiltrate the required recharge volume as determined in accordance with the Massachusetts Stormwater Handbook."*

   Due to the existing site constraints with the elevations of roadway, groundwater/average lake elevation and abutting properties and the required setback to surface waters, the limited project/ redevelopment cannot meet the required groundwater recharge. The design proposes a reduction in total impervious area as well as an increase in the size of the reconstructed underground infiltration system. Both of these measures provide an increased recharge volume when compared to the existing condition.

4. *"Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS). This Standard is met when:*
   - ***a.*** *Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained;*
   - ***b.*** *Structural stormwater best management practices are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and*
   - ***c.*** *Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook."*

   The proposed drainage structures and infiltration BMP chain will provide 90% TSS removal.

5. *"For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable…"*

   Non-applicable

6. *"Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices…"*

   The project has discharges to outstanding resource water and the Zone A for the Lynn Water/Sewer District. This limited project/redevelopment incorporates retrofit BMPs to improve on the existing condition. The proposed BMPs are consistent with the list of BMPs for discharges to critical areas recommended in the Stormwater Handbook.

7. *"A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable: Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions."*

   This is a limited project/redevelopment. Standards 2, 4 and 6 are met fully as outlined above. Standard 3 is met to the maximum extent practicable and improves on the existing condition. Standard 5 is not applicable to the proposed project.

8. *"A plan to control construction-related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented."*

   Erosion Control plans, means and methods during construction are included with the attached plans herein as well as explained below in "Erosion Control" section of this NOI submittal.

9. *A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.*

   An operations and maintenance plan has been included with this submittal.

10. *All illicit discharges to the stormwater management system are prohibited.*

    No illicit connections will be made to this drainage system.

EROSION CONTROL

Proposed erosion control measures will include the deployment of straw wattles (as shown on the attached plans), tuff matts or spread slat marsh hay to prevent washout of newly disturbed soils until lawn turf growth is established.

DEWATERING

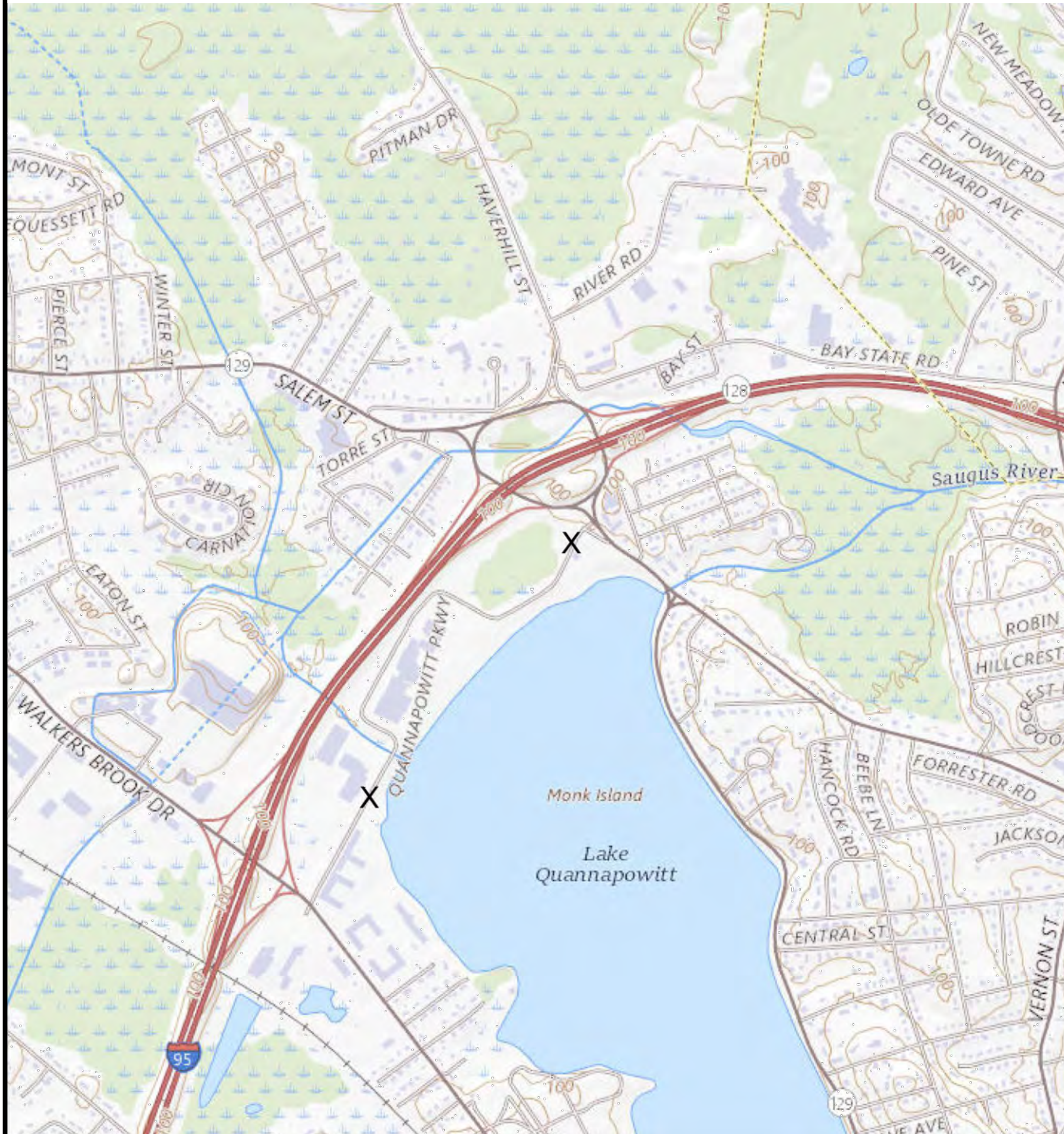
In order to properly replace the culvert dewatering activities are anticipated. The attached plan shows the dewatering activity plan. Temporary sandbag coffer dams shall block the upstream and downstream side of the culvert where the water will be pumped via a flexible pump hose to a crushed stone filtration device. If needed, the hose will be placed in a ductile iron sleeve imbedded in the road surface to allow traffic to pass, if road closure is not possible. The dewatering hoses will discharge to a sedimentation basin consisting of a precast catch basin sump (3' tall) filled with crushed stone. The pumping action will force the water through the crushed stone which will act as a filter media ensuring clean water to overflow the rim. In addition to the crushed stone, straw bales surrounding the catch basin sump will act as a secondary filter media. See the attached plan for further dewatering notes.

Any other de-watering required of the project will utilize large capacity dewatering sediment bags surrounded by haybales deployed near the embankment of Lake Quannapowitt with plastic sheeting or tarpaulins placed underneath the bags to prevent erosion of the embankment during use.

FLOW CONTROL

The project will use a 12" flume pipe pushed through the existing culvert during the construction phase to allow continued flow connecting the wetlands and the lake. The flume pipe will be removed after the construction of the box culvert.

Attachment 1: Maps



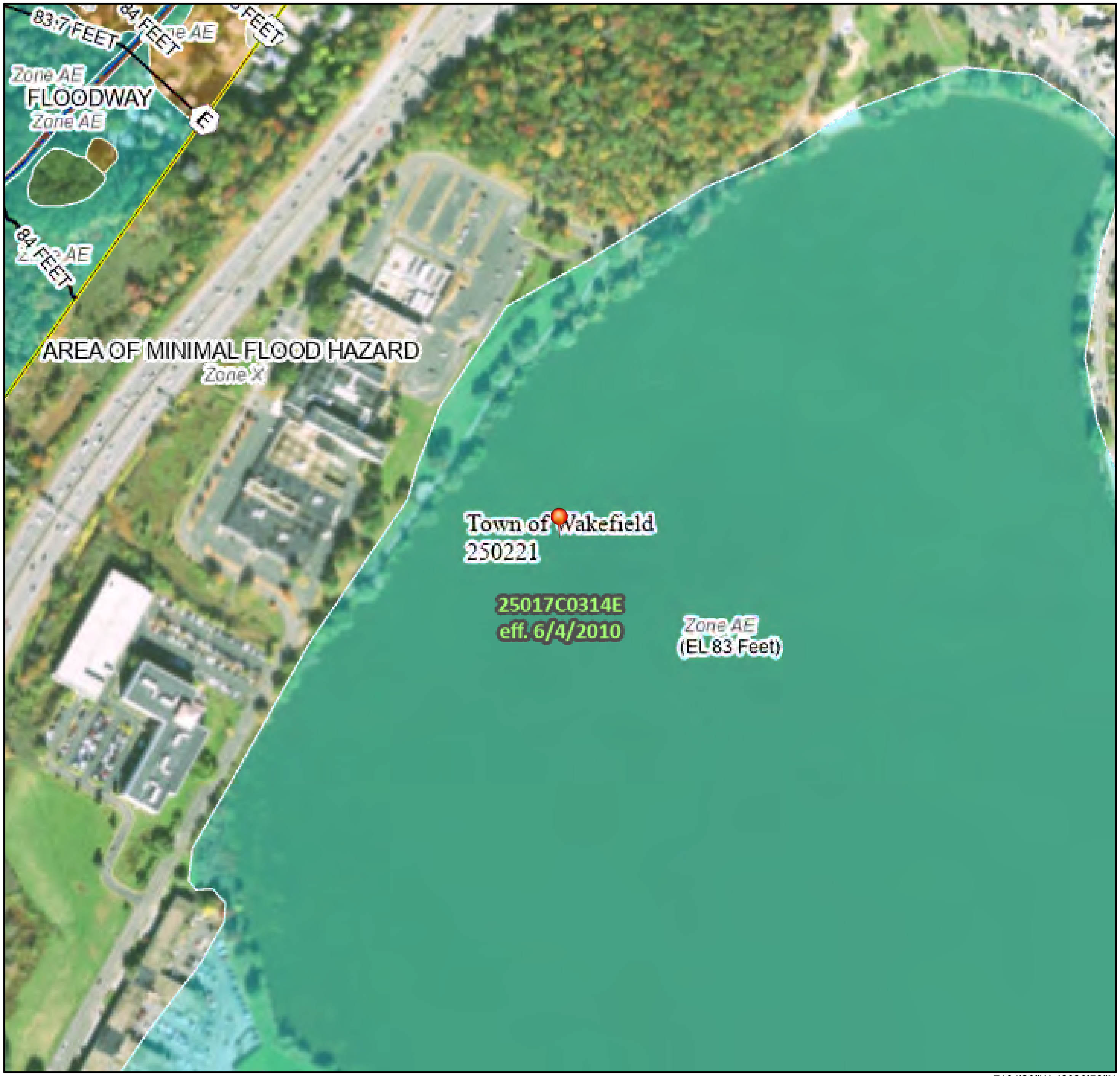
ENGINEERING DIVISION - WAKEFIELD PUBLIC WORKS	
QUANNAPOWITT PARKWAY ACCESS ROAD IMPROVEMENTS	
SCALE: N.T.S.	DATE: MAR 01 2023

TOWN OF WAKEFIELD

National Flood Hazard Layer FIRMette

FEMA

71°5'17"W 42°31'24"N



71°4'39"W 42°30'58"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

Basemap: USGS National Map: Orthoimagery: Data refreshed October, 2020

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS	Without Base Flood Elevation (BFE) *Zone A, V, A99*	
	With BFE or Depth *Zone AE, AO, AH, VE, AR*	
	Regulatory Floodway	
OTHER AREAS OF FLOOD HAZARD	0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*	
	Future Conditions 1% Annual Chance Flood Hazard *Zone X*	
	Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*	
	Area with Flood Risk due to Levee *Zone D*	
OTHER AREAS	NO SCREEN	Area of Minimal Flood Hazard *Zone X*
		Effective LOMRs
		Area of Undetermined Flood Hazard *Zone D*
GENERAL STRUCTURES		Channel, Culvert, or Storm Sewer
		Levee, Dike, or Floodwall
OTHER FEATURES	B 20.2 / 17.5	Cross Sections with 1% Annual Chance Water Surface Elevation
	8	Coastal Transect
	513	Base Flood Elevation Line (BFE)
		Limit of Study
		Jurisdiction Boundary
		Coastal Transect Baseline
		Profile Baseline
		Hydrographic Feature
MAP PANELS		Digital Data Available
		No Digital Data Available
		Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 3/1/2023 at 2:08 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Attachment 2: Notification of Abutters

AFFIDAVIT OF SERVICE

Under the Massachusetts Wetlands Protection Act

I, William J. Renault, PE hereby certify under the pains and penalties of perjury that on April 4, 2024 I gave notification to abutters in compliance with the second paragraph of the Massachusetts General Laws, Chapter 131, Section 40 and the DEP Guide to Abutter Notification in connection with the following matter:

A(n) Notice of Intent application was filed under the Massachusetts Wetlands Protection Act by

Wakefield DPW - Engineering Div. with the Wakefield Conservation Commission on
name

April 4, 2024 for a property located at
date

Quannapowitt Parkway, Wakefield, MA

The form of notification and the list of abutters to whom it was given and their addresses are attached to this Affidavit of Service.

[signature]
signature

4/4/24
date

WAKEFIELD
Abutters List

Subject Parcel ID: ***SEE NOTES***

Subject Property Location: ***SEE NOTES***

ParcelID	Location	Owner	Co-Owner	Mailing Address	City	State	Zip
01-003-011	147 LOWELL ST	TOWN OF WAKEFIELD	CONSERVATION COMMISS	1 LAFAYETTE ST	WAKEFIELD	MA	01880
01-004-010	LOWELL ST	TOWN OF WAKEFIELD DPW	PARK DEPT	1 LAFAYETTE ST	WAKEFIELD	MA	01880
01-034-001	QUANNAPOWITT PKWY	TOWN OF WAKEFIELD	BOARD OF SELECTMEN	1 LAFAYETTE ST	WAKEFIELD	MA	01880
01-36A-AM2	100 QUANNAPOWITT PKWY	100 Q OWNER LLC		55 CAMBRIDGE ST	BURLINGTON	MA	01803
01-36-AM1	200 -400 QUANNAPOWITT PKWY	200 QUANNAPOWITT OWNER LLC	c/o EQR-RE TAX DEPT	PO BOX 87407	CHICAGO	IL	60680
01-36B-AM3	50 QUANNAPOWITT PKWY	WAKEFIELD 200 LLC	%THE BEAL COMPANIES L	177 MILK ST	BOSTON	MA	02109
2A-023-47C	610 NORTH AVE	335 WASHINGTON STREET LLC		394 WASHINGTON ST	WOBURN	MA	01801
2A-024-PAM	607 NORTH AVE	QP 607 LLC	c/o QP HOLDINGS LLC	PO BOX 2037	WAKEFIELD	MA	01880
2A-025-PHB	599 NORTH AVE	LAKESIDE VISTA LLC	c/o QP HOLDING LLC	PO BOX 2037	WAKEFIELD	MA	01880
2A-027-0PH	595 NORTH AVE	QP 595 LLC	c/o QP HOLDING LLC	PO BOX 2037	WAKEFIELD	MA	01880
2B-004-44A+	618 NORTH AVE	335 WASHINGTON STREET LLC		394 WASHINGTON ST	WOBURN	MA	01801

Parcel Count: **11**

End of Report

100ft Abutters List of the Subject Parcel IDs
Requested by: Timothy Wilson, Senior Civil Engineer
Wakefield Public Works – Engineering Division
1 Lafayette Street
Wakefield, MA 01880
Ph: 781-246-6308

Parcel ID: 01-034-001
Location: Quannapowitt Pkwy

Parcel ID: 2A-024-PAM
Location: 607 North Ave

Scott W. Morrison

BOARD OF ASSESSORS

TOWN OF WAKEFIELD

CONSERVATION COMMISSION

Notification to Abutters: Under the Massachusetts Wetlands Protection Act

In accordance with the second paragraph of Massachusetts General Laws, Chapter 131, Section 40, you are hereby notified of the following:

The name of the applicant is Town of Wakefield

The applicant has filed with the Wakefield Conservation Commission for a (please check applicable filing):

- [x] Notice of Intent, seeking permission to alter an Area Subject to Protection
- [ ] Request to amend an existing Order of Conditions
- [ ] Notice of Resource Area Delineation, seeking to determine the extent of Areas Subject to Protection

The proposed work includes:

The project will include stormwater quality and drainage improvements and upgrading existing pedestrian sidewalk to a shared-use-path.

Site location: Quannapowitt Parkway right-of-way - Assessors Property ID 01-034-001

Copies may be examined or obtained (for a fee) from:

(Check all that apply)

- [ ] Applicant at
- [x] Representative at office of Town of Wakefield DPW Engineering Division at 1 Lafayette St, Wakefield MA

  between the hours of 8:00am and 4:30pm on the following days: Monday through Thursday.
- [ ] Conservation Department in Wakefield Town Hall, 1 Lafayette Street, 2nd floor, Wakefield, MA on Tuesdays and Thursdays between 10:00 a.m. and 2:00 p.m. Please call the Conservation office at 781-224-5015 to verify arrangements prior to visiting.

Electronic copies of these filings may also be available through the Conservation Department. To request an e-copy, please email concom@wakefield.ma.us or call the Conservation Office directly at 781-224-5015. Copies may also be examined at www.wakefield.ma.us/conservation-commission/pages/current-projects.

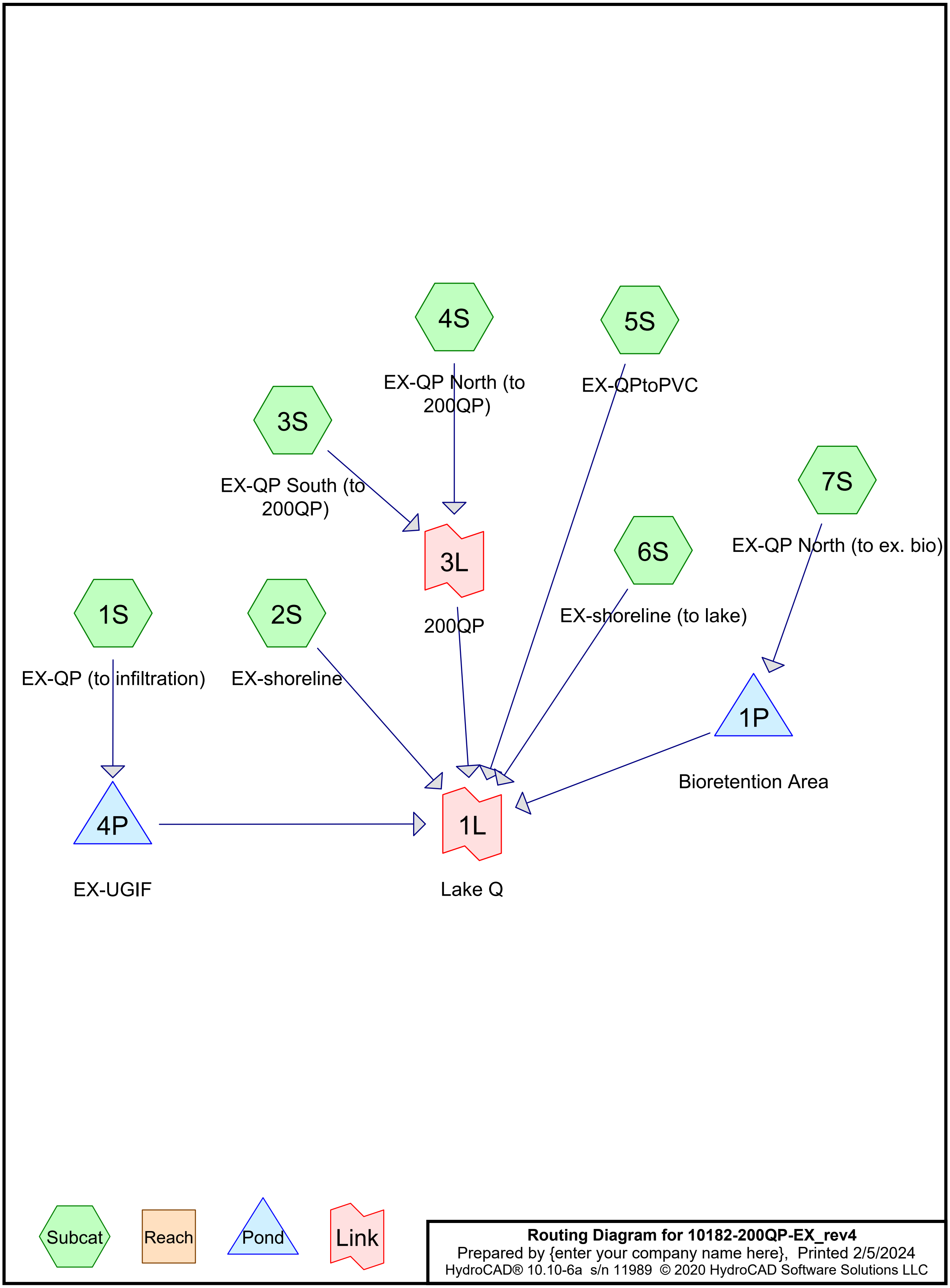
Information regarding the date, time, and place of the public hearing may be obtained on the Wakefield Conservation Commission website at www.wakefield.ma.us/calendar.

Notice of the public hearing, including its date, time, and place will be published in the Wakefield Daily Item at least five business days prior to the public hearing date.

Notice of the public hearing, including its date, time, and place will be posted in Wakefield Town Hall at least 48 hours prior to the public hearing date. This information will be listed at www.wakefield.ma.us on the public meeting calendar.

You may contact the Department of Environmental Protection (DEP) Regional Office for more information about this application or the Wetlands Protection Act. To contact the DEP, Northeast Region, call (978) 694-3200.

Attachment 3: Stormwater Report



Routing Diagram for 10182-200QP-EX_rev4
Prepared by {enter your company name here}, Printed 2/5/2024
HydroCAD® 10.10-6a s/n 11989 © 2020 HydroCAD Software Solutions LLC

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	Type III 24-hr		Default	24.00	1	3.16	2
2	10-Year	Type III 24-hr		Default	24.00	1	4.77	2
3	25-Year	Type III 24-hr		Default	24.00	1	6.03	2
4	100-Year	Type III 24-hr		Default	24.00	1	8.62	2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
45,200	61	>75% Grass cover, Good, HSG B (1S, 2S, 6S)
120,699	98	Paved parking, HSG B (1S, 3S, 4S, 5S, 7S)
18,440	98	Roofs, HSG B (1S)
1,646	98	Unconnected roofs, HSG B (2S)
185,985	**89**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
185,985	HSG B	1S, 2S, 3S, 4S, 5S, 6S, 7S
0	HSG C	
0	HSG D	
0	Other	
185,985		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Sub Num
0	45,200	0	0	0	45,200	>75% Grass cover, Good	
0	120,699	0	0	0	120,699	Paved parking	
0	18,440	0	0	0	18,440	Roofs	
0	1,646	0	0	0	1,646	Unconnected roofs	
0	**185,985**	**0**	**0**	**0**	**185,985**	**TOTAL AREA**	

Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: EX-QP (to infiltration) Runoff Area=104,650 sf 85.86% Impervious Runoff Depth=2.41"
Tc=6.0 min CN=93 Runoff=6.42 cfs 20,994 cf

Subcatchment 2S: EX-shoreline Runoff Area=18,000 sf 9.14% Impervious Runoff Depth=0.50"
Tc=6.0 min UI Adjusted CN=63 Runoff=0.17 cfs 752 cf

Subcatchment 3S: EX-QP South (to 200QP) Runoff Area=7,828 sf 100.00% Impervious Runoff Depth=2.93"
Tc=6.0 min CN=98 Runoff=0.54 cfs 1,910 cf

Subcatchment 4S: EX-QP North (to Runoff Area=10,214 sf 100.00% Impervious Runoff Depth=2.93"
Tc=6.0 min CN=98 Runoff=0.70 cfs 2,492 cf

Subcatchment 5S: EX-QPtoPVC Runoff Area=6,447 sf 100.00% Impervious Runoff Depth=2.93"
Tc=6.0 min CN=98 Runoff=0.44 cfs 1,573 cf

Subcatchment 6S: EX-shoreline (to lake) Runoff Area=14,048 sf 0.00% Impervious Runoff Depth=0.43"
Tc=6.0 min CN=61 Runoff=0.10 cfs 501 cf

Subcatchment 7S: EX-QP North (to ex. Runoff Area=24,798 sf 100.00% Impervious Runoff Depth=2.93"
Tc=6.0 min CN=98 Runoff=1.70 cfs 6,050 cf

Pond 1P: Bioretention Area Peak Elev=83.03' Storage=2,407 cf Inflow=1.70 cfs 6,050 cf
Discarded=0.16 cfs 5,944 cf Primary=0.07 cfs 106 cf Outflow=0.23 cfs 6,050 cf

Pond 4P: EX-UGIF Peak Elev=83.29' Storage=976 cf Inflow=6.42 cfs 20,994 cf
Discarded=0.01 cfs 1,028 cf Primary=6.39 cfs 19,481 cf Outflow=6.40 cfs 20,509 cf

Link 1L: Lake Q Inflow=8.32 cfs 26,815 cf
Primary=8.32 cfs 26,815 cf

Link 3L: 200QP Inflow=1.24 cfs 4,402 cf
Primary=1.24 cfs 4,402 cf

Total Runoff Area = 185,985 sf Runoff Volume = 34,272 cf Average Runoff Depth = 2.21"
24.30% Pervious = 45,200 sf 75.70% Impervious = 140,785 sf

Summary for Subcatchment 1S: EX-QP (to infiltration)

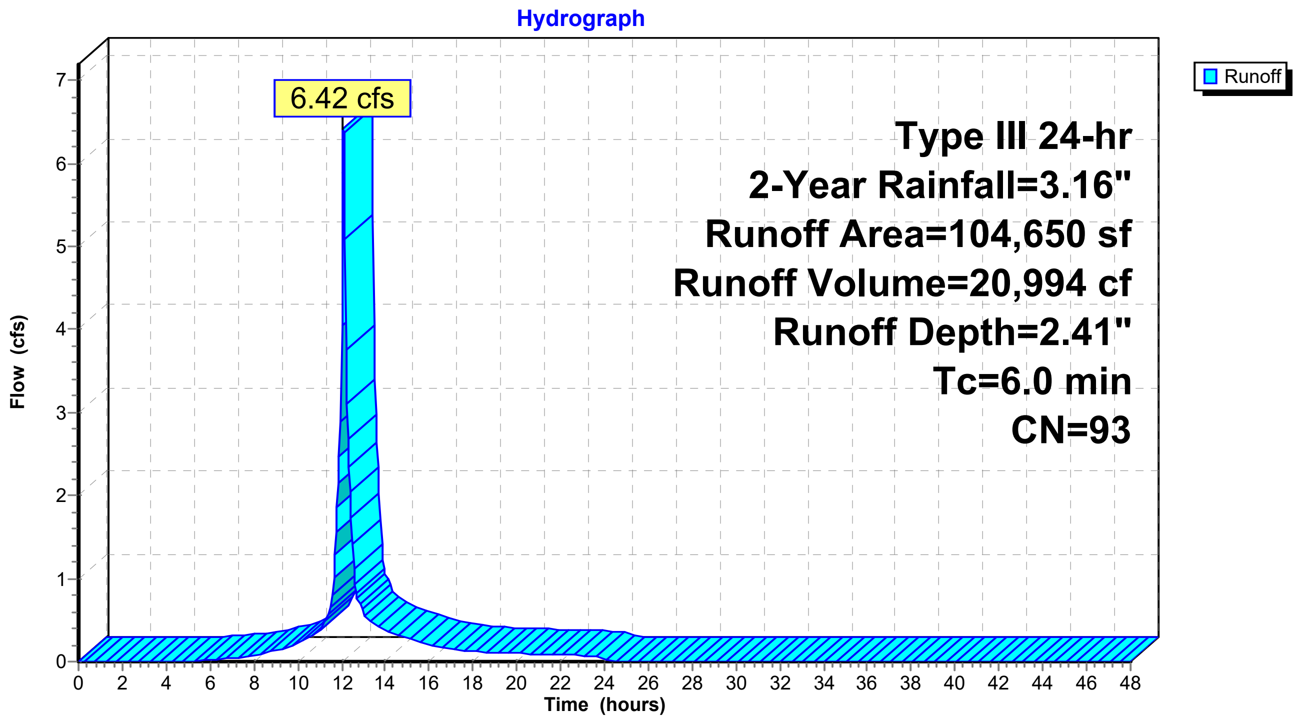
Runoff = 6.42 cfs @ 12.09 hrs, Volume= 20,994 cf, Depth= 2.41"
Routed to Pond 4P : EX-UGIF

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
71,412	98	Paved parking, HSG B
18,440	98	Roofs, HSG B
14,798	61	>75% Grass cover, Good, HSG B
104,650	93	Weighted Average
14,798		14.14% Pervious Area
89,852		85.86% Impervious Area

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

Subcatchment 1S: EX-QP (to infiltration)



Summary for Subcatchment 2S: EX-shoreline

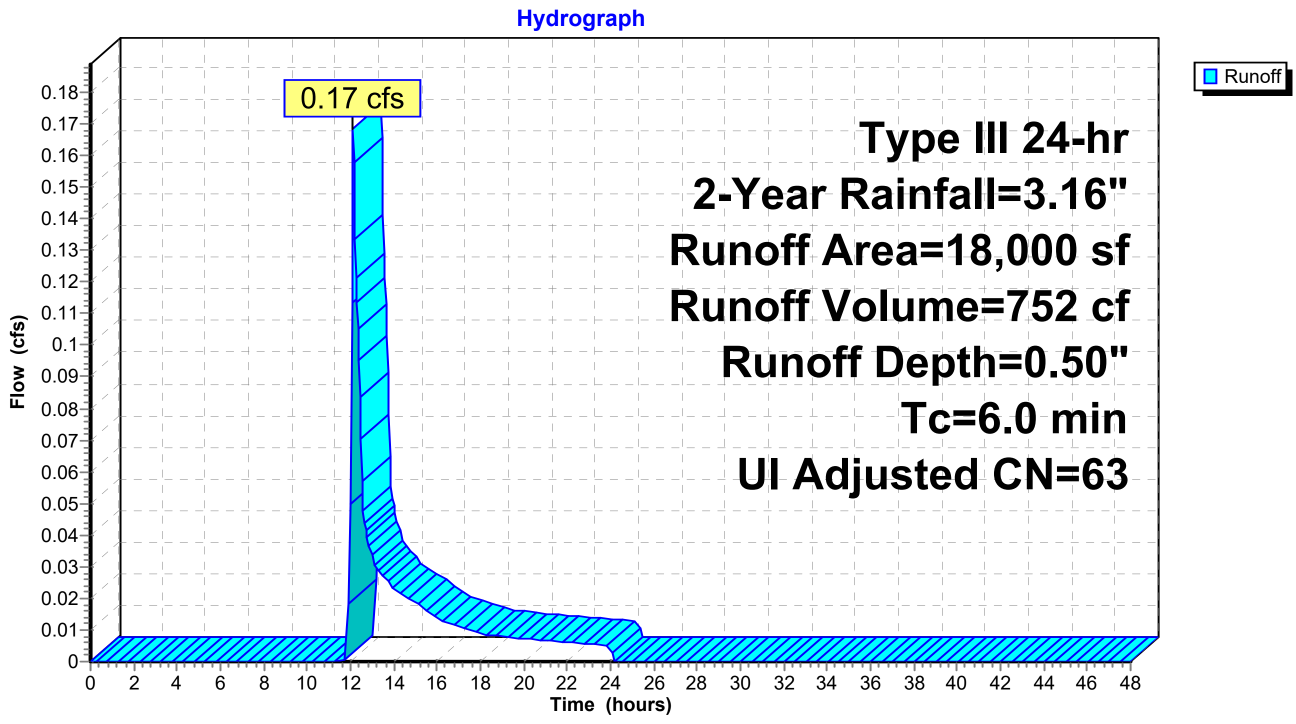
Runoff = 0.17 cfs @ 12.12 hrs, Volume= 752 cf, Depth= 0.50"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Adj	Description
1,646	98		Unconnected roofs, HSG B
16,354	61		>75% Grass cover, Good, HSG B
18,000	64	63	Weighted Average, UI Adjusted
16,354			90.86% Pervious Area
1,646			9.14% Impervious Area
1,646			100.00% Unconnected

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

Subcatchment 2S: EX-shoreline



Summary for Subcatchment 3S: EX-QP South (to 200QP)

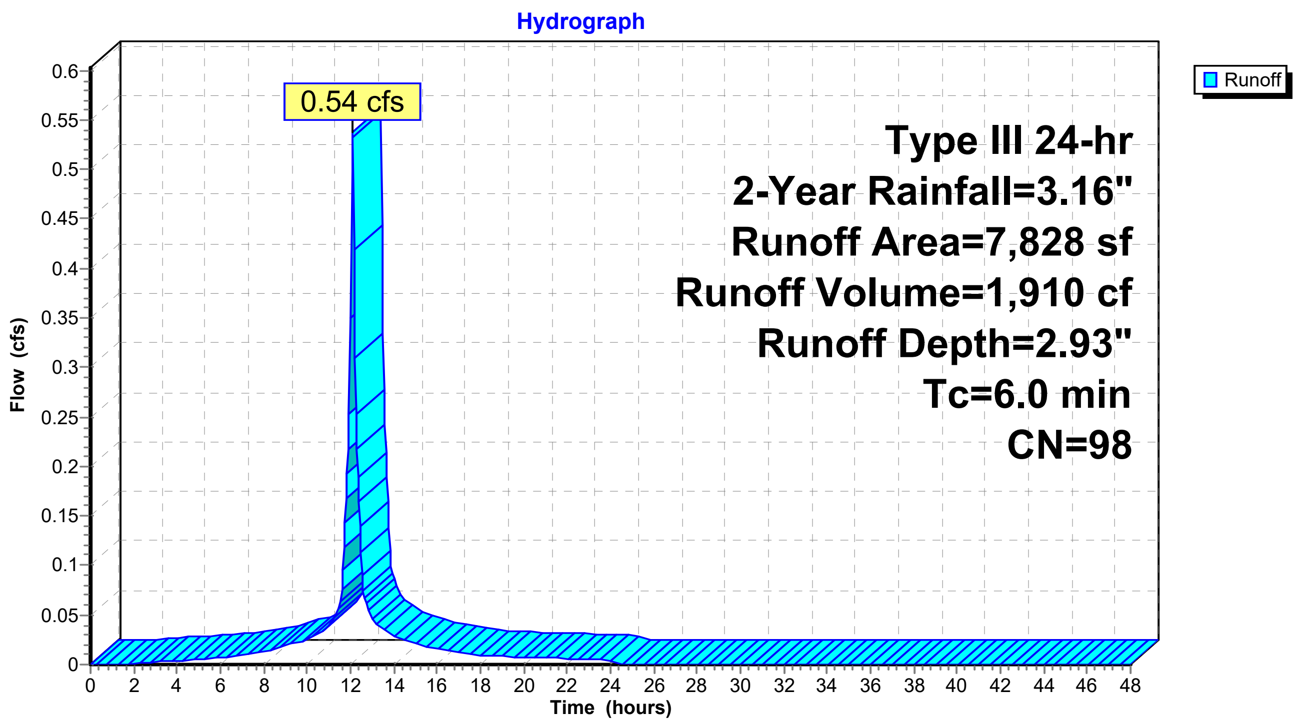
Runoff = 0.54 cfs @ 12.09 hrs, Volume= 1,910 cf, Depth= 2.93"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
7,828	98	Paved parking, HSG B
7,828		100.00% Impervious Area

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

Subcatchment 3S: EX-QP South (to 200QP)



Summary for Subcatchment 4S: EX-QP North (to 200QP)

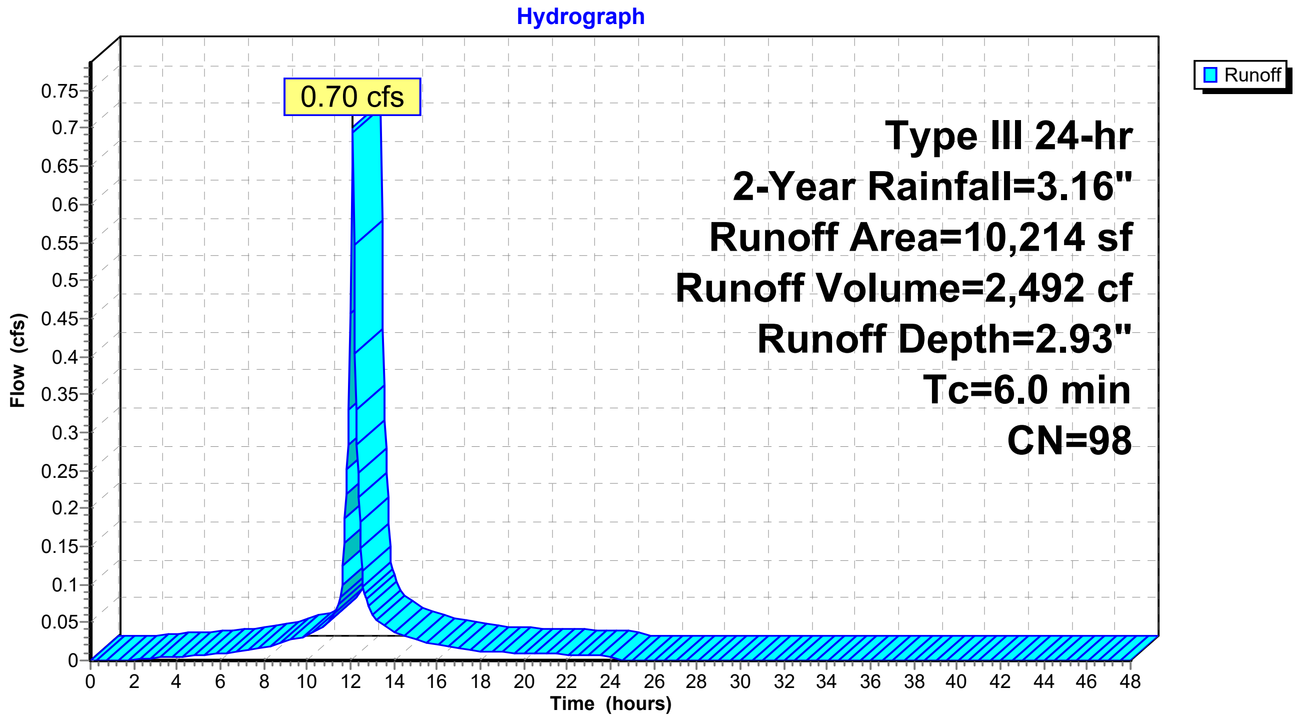
Runoff = 0.70 cfs @ 12.09 hrs, Volume= 2,492 cf, Depth= 2.93"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
10,214	98	Paved parking, HSG B
10,214		100.00% Impervious Area

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

Subcatchment 4S: EX-QP North (to 200QP)



Summary for Subcatchment 5S: EX-QPtoPVC

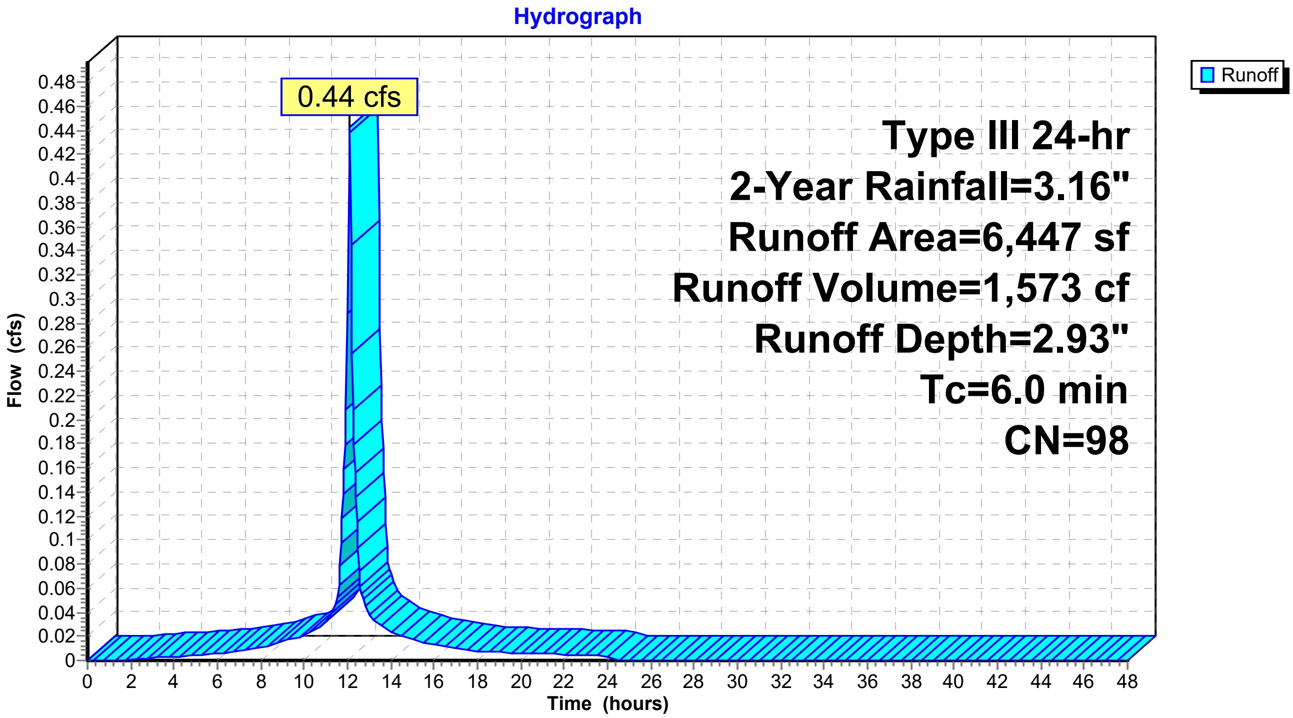
Runoff = 0.44 cfs @ 12.09 hrs, Volume= 1,573 cf, Depth= 2.93"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
6,447	98	Paved parking, HSG B
6,447		100.00% Impervious Area

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

Subcatchment 5S: EX-QPtoPVC



Summary for Subcatchment 6S: EX-shoreline (to lake)

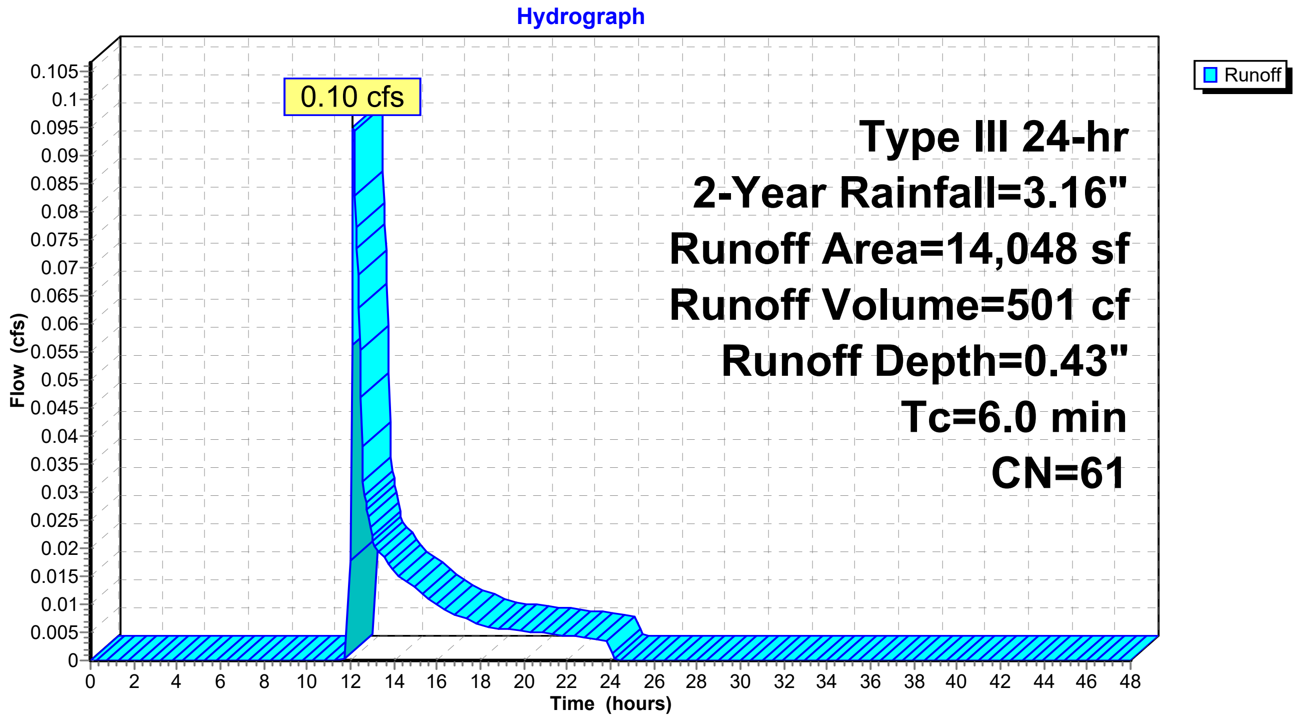
Runoff = 0.10 cfs @ 12.13 hrs, Volume= 501 cf, Depth= 0.43"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
14,048	61	>75% Grass cover, Good, HSG B
14,048		100.00% Pervious Area

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

Subcatchment 6S: EX-shoreline (to lake)



Summary for Subcatchment 7S: EX-QP North (to ex. bio)

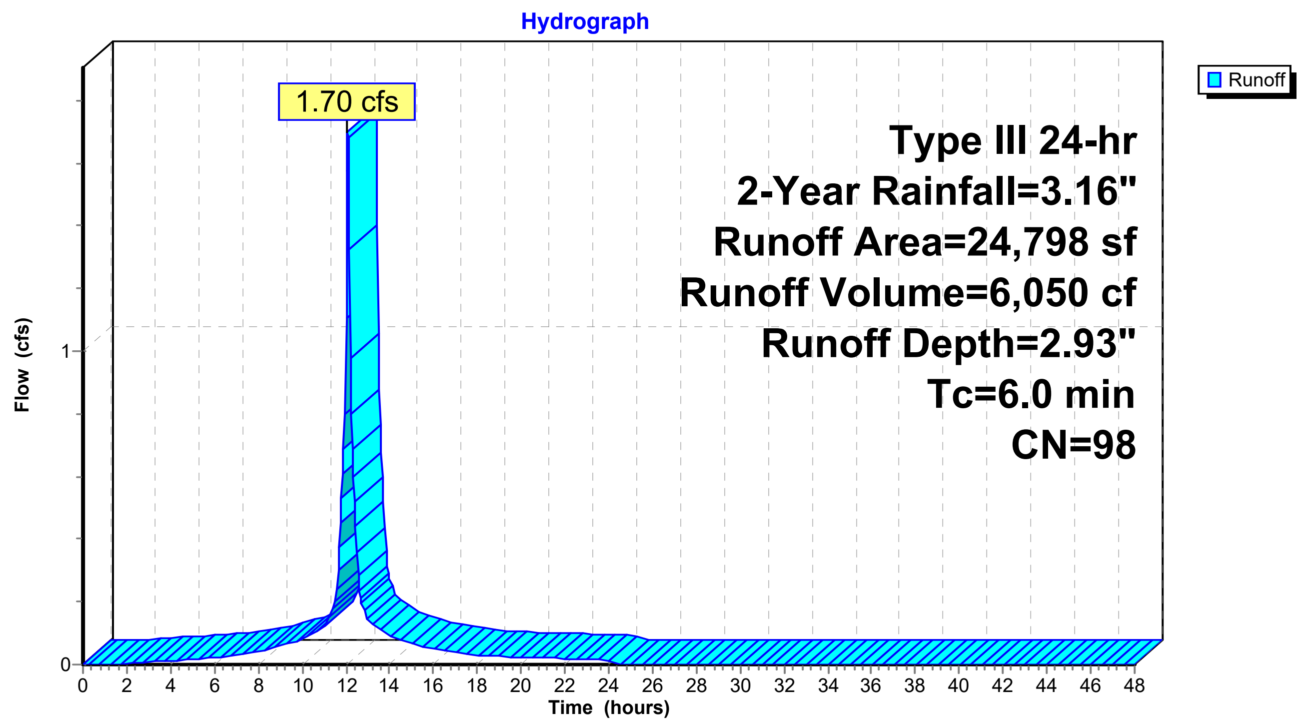
Runoff = 1.70 cfs @ 12.09 hrs, Volume= 6,050 cf, Depth= 2.93"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
24,798	98	Paved parking, HSG B
24,798		100.00% Impervious Area

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

Subcatchment 7S: EX-QP North (to ex. bio)



Summary for Pond 1P: Bioretention Area

Inflow Area = 24,798 sf,100.00% Impervious, Inflow Depth = 2.93" for 2-Year event
Inflow = 1.70 cfs @ 12.09 hrs, Volume= 6,050 cf
Outflow = 0.23 cfs @ 12.62 hrs, Volume= 6,050 cf, Atten= 87%, Lag= 32.1 min
Discarded = 0.16 cfs @ 12.62 hrs, Volume= 5,944 cf
Primary = 0.07 cfs @ 12.62 hrs, Volume= 106 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 83.03' @ 12.62 hrs Surf.Area= 2,514 sf Storage= 2,407 cf

Plug-Flow detention time= 130.1 min calculated for 6,050 cf (100% of inflow)
Center-of-Mass det. time= 130.0 min (886.7 - 756.7)

Volume	Invert	Avail.Storage	Storage Description
#1	81.80'	4,840 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

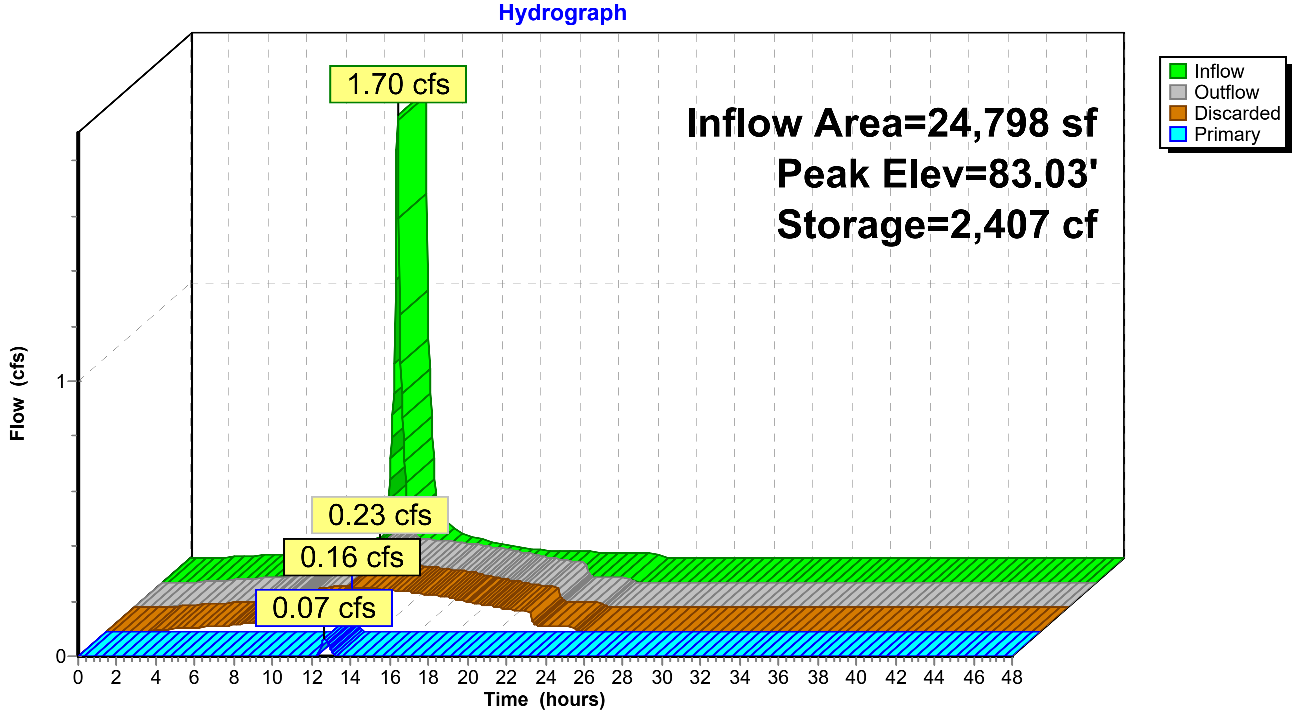
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
81.80	1,293	0	0
82.00	1,441	273	273
82.50	2,115	889	1,162
83.00	2,548	1,166	2,328
83.50	2,006	1,139	3,467
84.00	3,489	1,374	4,840

Device	Routing	Invert	Outlet Devices
#1	Discarded	81.80'	**2.400 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 75.00'
#2	Primary	83.00'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Discarded OutFlow Max=0.16 cfs @ 12.62 hrs HW=83.03' (Free Discharge)
↑—**1=Exfiltration** (Controls 0.16 cfs)

Primary OutFlow Max=0.06 cfs @ 12.62 hrs HW=83.03' (Free Discharge)
↑—**2=Broad-Crested Rectangular Weir** (Weir Controls 0.06 cfs @ 0.42 fps)

Pond 1P: Bioretention Area



Summary for Pond 4P: EX-UGIF

Inflow Area = 104,650 sf, 85.86% Impervious, Inflow Depth = 2.41" for 2-Year event
Inflow = 6.42 cfs @ 12.09 hrs, Volume= 20,994 cf
Outflow = 6.40 cfs @ 12.09 hrs, Volume= 20,509 cf, Atten= 0%, Lag= 0.0 min
Discarded = 0.01 cfs @ 12.09 hrs, Volume= 1,028 cf
Primary = 6.39 cfs @ 12.09 hrs, Volume= 19,481 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 83.29' @ 12.09 hrs Surf.Area= 854 sf Storage= 976 cf

Plug-Flow detention time= 56.9 min calculated for 20,487 cf (98% of inflow)
Center-of-Mass det. time= 44.4 min (837.5 - 793.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	80.65'	557 cf	**12.13'W x 70.45'L x 2.06'H Field A**
			1,758 cf Overall - 365 cf Embedded = 1,394 cf x 40.0% Voids
#2A	81.07'	364 cf	**CPP single-wall 12"** x 15 Inside #1
			Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
			Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
			Row Length Adjustment= +6.00' x 1.04 sf x 5 rows
			10.13' Header x 1.04 sf x 2 = 21.1 cf Inside
#3	81.15'	101 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder** x 2 -Impervious
		1,022 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	80.80'	**1.020 in/hr Exfiltration over Wetted area above 80.80'**
			Conductivity to Groundwater Elevation = 79.00'
			Excluded Wetted area = 879 sf Phase-In= 0.01'
#2	Primary	82.50'	**999.000 in/hr Exfiltration over Wetted area above 82.50'**
			Conductivity to Groundwater Elevation = 75.00'
			Excluded Wetted area = 1,160 sf Phase-In= 0.10'
#3	Primary	83.00'	**10.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
			0.5' Crest Height

Discarded OutFlow Max=0.01 cfs @ 12.09 hrs HW=83.29' (Free Discharge)
└─**1=Exfiltration** (Controls 0.01 cfs)

Primary OutFlow Max=6.22 cfs @ 12.09 hrs HW=83.29' (Free Discharge)
├─**2=Exfiltration** (Controls 0.87 cfs)
└─**3=Sharp-Crested Rectangular Weir** (Weir Controls 5.35 cfs @ 1.87 fps)

Pond 4P: EX-UGIF - Chamber Wizard Field A

Chamber Model = CPP single-wall 12" (Single-wall corrugated HDPE pipe)
Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
Row Length Adjustment= +6.00' x 1.04 sf x 5 rows

14.7" Wide + 12.0" Spacing = 26.7" C-C Row Spacing

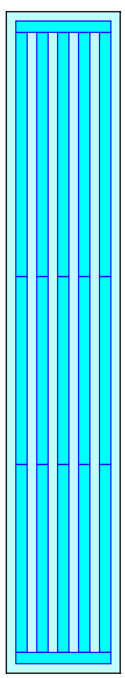
3 Chambers/Row x 20.00' Long +6.00' Row Adjustment +1.23' Header x 2 = 68.45' Row Length +12.0" End Stone x 2 = 70.45' Base Length
5 Rows x 14.7" Wide + 12.0" Spacing x 4 + 12.0" Side Stone x 2 = 12.13' Base Width
5.0" Stone Base + 14.7" Chamber Height + 5.0" Stone Cover = 2.06' Field Height

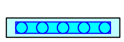
15 Chambers x 20.8 cf +6.00' Row Adjustment x 1.04 sf x 5 Rows + 10.13' Header x 1.04 sf x 2 = 364.5 cf Chamber Storage

1,758.2 cf Field - 364.5 cf Chambers = 1,393.8 cf Stone x 40.0% Voids = 557.5 cf Stone Storage

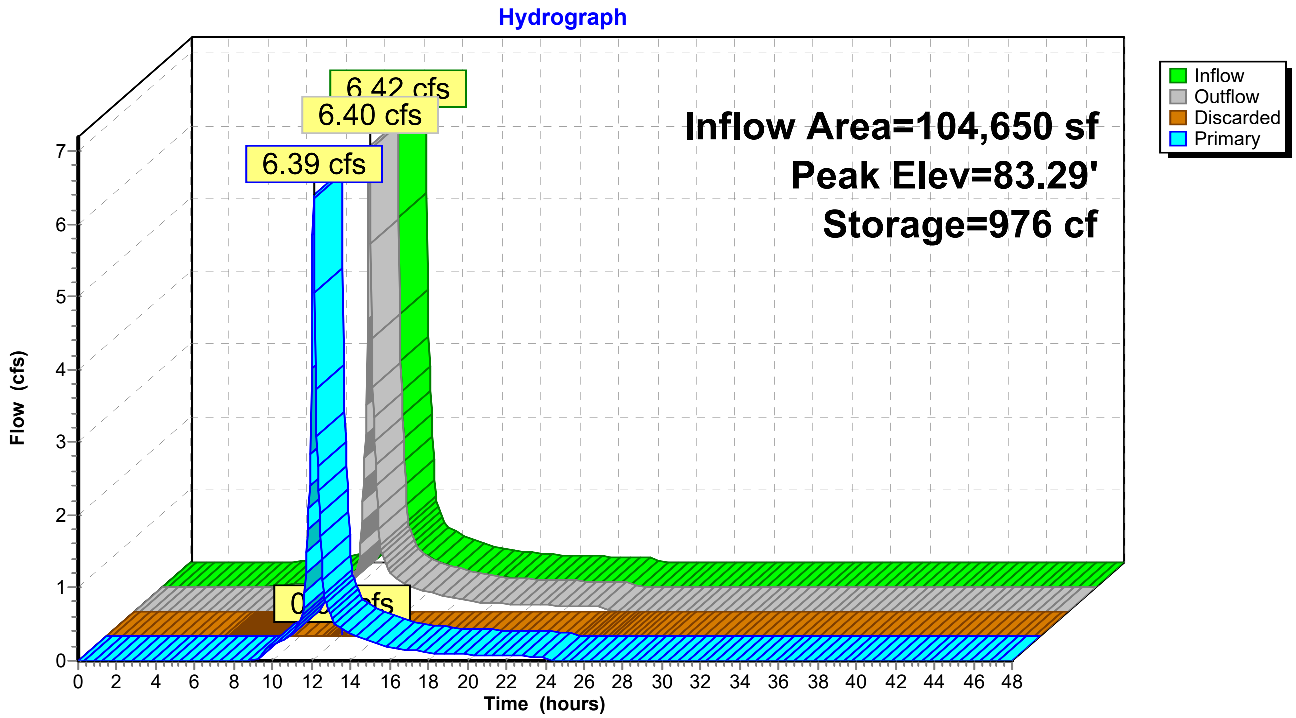
Chamber Storage + Stone Storage = 922.0 cf = 0.021 af
Overall Storage Efficiency = 52.4%
Overall System Size = 70.45' x 12.13' x 2.06'

15 Chambers
65.1 cy Field
51.6 cy Stone





Pond 4P: EX-UGIF

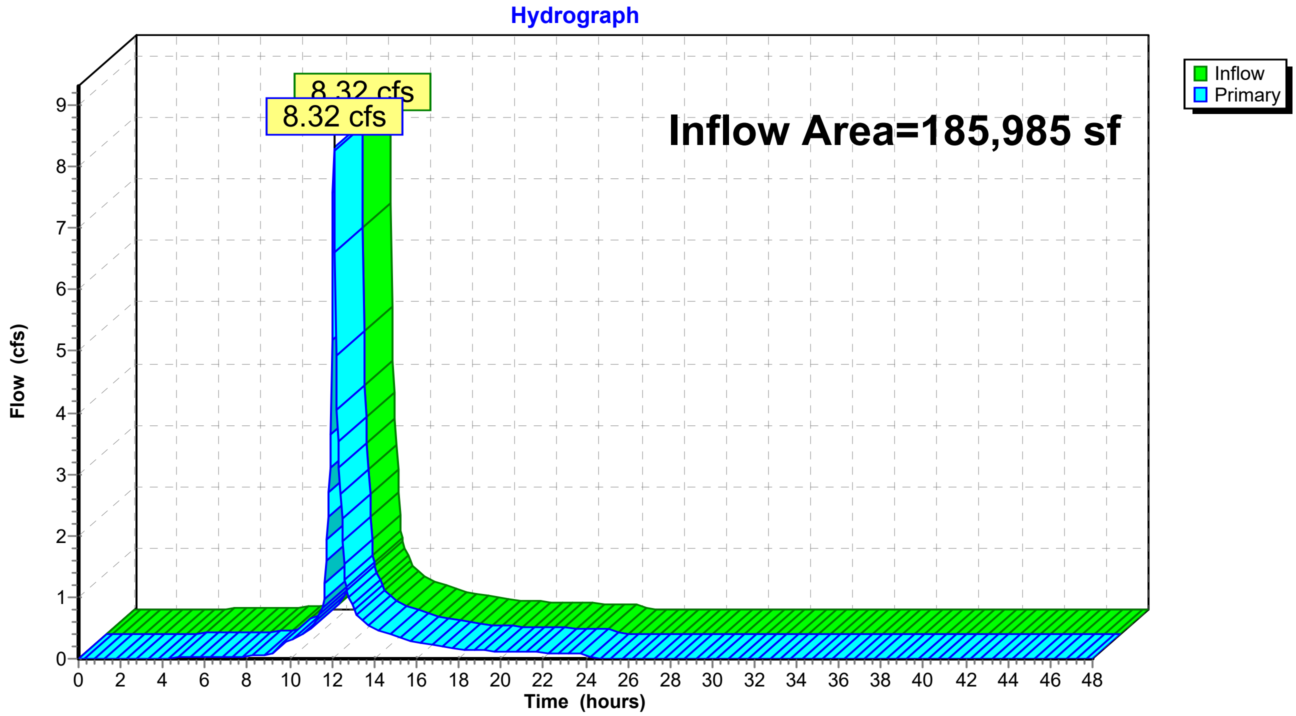


Summary for Link 1L: Lake Q

Inflow Area =	185,985 sf,	75.70% Impervious,	Inflow Depth = 1.73"	for 2-Year event	
Inflow =	8.32 cfs @	12.09 hrs,	Volume=	26,815 cf	
Primary =	8.32 cfs @	12.09 hrs,	Volume=	26,815 cf,	Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

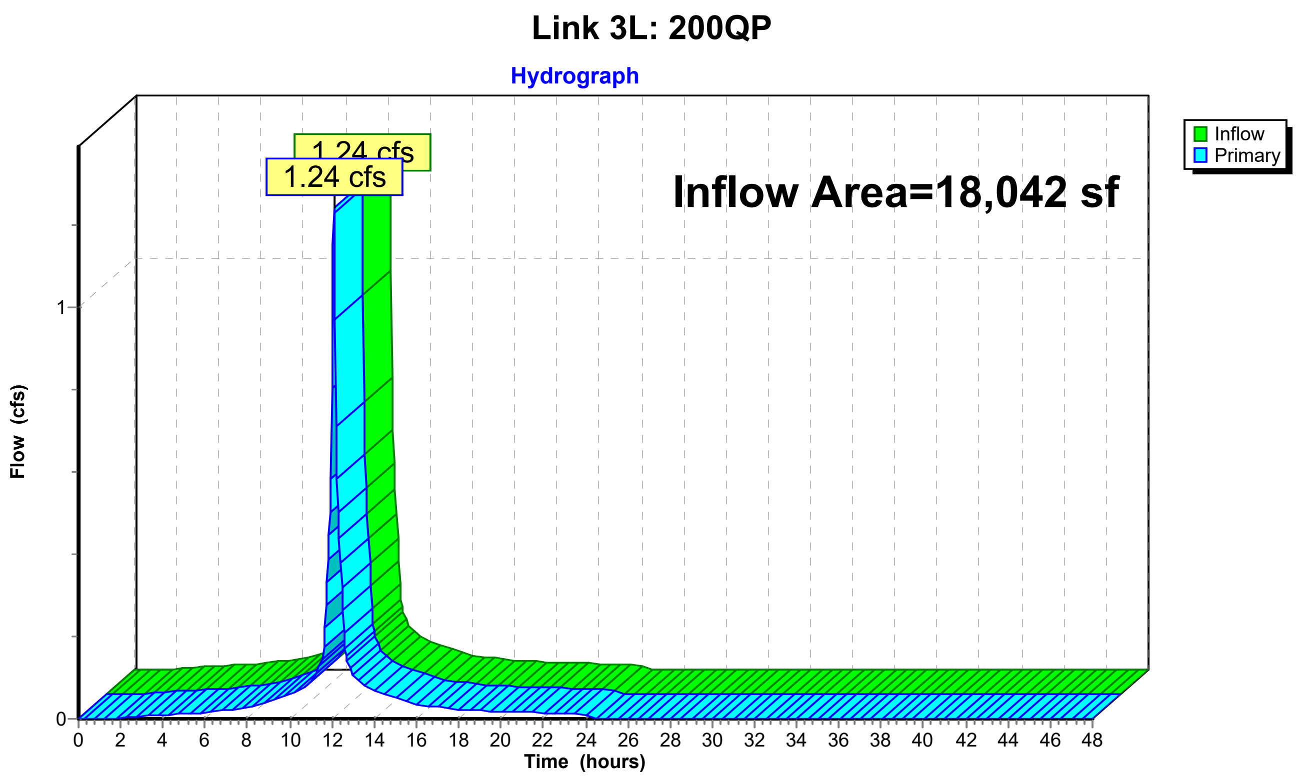
Link 1L: Lake Q



Summary for Link 3L: 200QP

Inflow Area = 18,042 sf,100.00% Impervious, Inflow Depth = 2.93" for 2-Year event
Inflow = 1.24 cfs @ 12.09 hrs, Volume= 4,402 cf
Primary = 1.24 cfs @ 12.09 hrs, Volume= 4,402 cf, Atten= 0%, Lag= 0.0 min
Routed to Link 1L : Lake Q

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs



Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: EX-QP (to infiltration) Runoff Area=104,650 sf 85.86% Impervious Runoff Depth=3.97"
Tc=6.0 min CN=93 Runoff=10.31 cfs 34,641 cf

Subcatchment 2S: EX-shoreline Runoff Area=18,000 sf 9.14% Impervious Runoff Depth=1.37"
Tc=6.0 min UI Adjusted CN=63 Runoff=0.60 cfs 2,048 cf

Subcatchment 3S: EX-QP South (to 200QP) Runoff Area=7,828 sf 100.00% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=98 Runoff=0.82 cfs 2,957 cf

Subcatchment 4S: EX-QP North (to Runoff Area=10,214 sf 100.00% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=98 Runoff=1.07 cfs 3,859 cf

Subcatchment 5S: EX-QPtoPVC Runoff Area=6,447 sf 100.00% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=98 Runoff=0.67 cfs 2,436 cf

Subcatchment 6S: EX-shoreline (to lake) Runoff Area=14,048 sf 0.00% Impervious Runoff Depth=1.23"
Tc=6.0 min CN=61 Runoff=0.41 cfs 1,444 cf

Subcatchment 7S: EX-QP North (to ex. Runoff Area=24,798 sf 100.00% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=98 Runoff=2.59 cfs 9,369 cf

Pond 1P: Bioretention Area Peak Elev=83.23' Storage=2,885 cf Inflow=2.59 cfs 9,369 cf
Discarded=0.16 cfs 7,315 cf Primary=1.32 cfs 2,054 cf Outflow=1.49 cfs 9,369 cf

Pond 4P: EX-UGIF Peak Elev=83.41' Storage=979 cf Inflow=10.31 cfs 34,641 cf
Discarded=0.01 cfs 1,100 cf Primary=10.29 cfs 33,120 cf Outflow=10.31 cfs 34,219 cf

Link 1L: Lake Q Inflow=14.07 cfs 47,917 cf
Primary=14.07 cfs 47,917 cf

Link 3L: 200QP Inflow=1.89 cfs 6,816 cf
Primary=1.89 cfs 6,816 cf

Total Runoff Area = 185,985 sf Runoff Volume = 56,753 cf Average Runoff Depth = 3.66"
24.30% Pervious = 45,200 sf 75.70% Impervious = 140,785 sf

Summary for Subcatchment 1S: EX-QP (to infiltration)

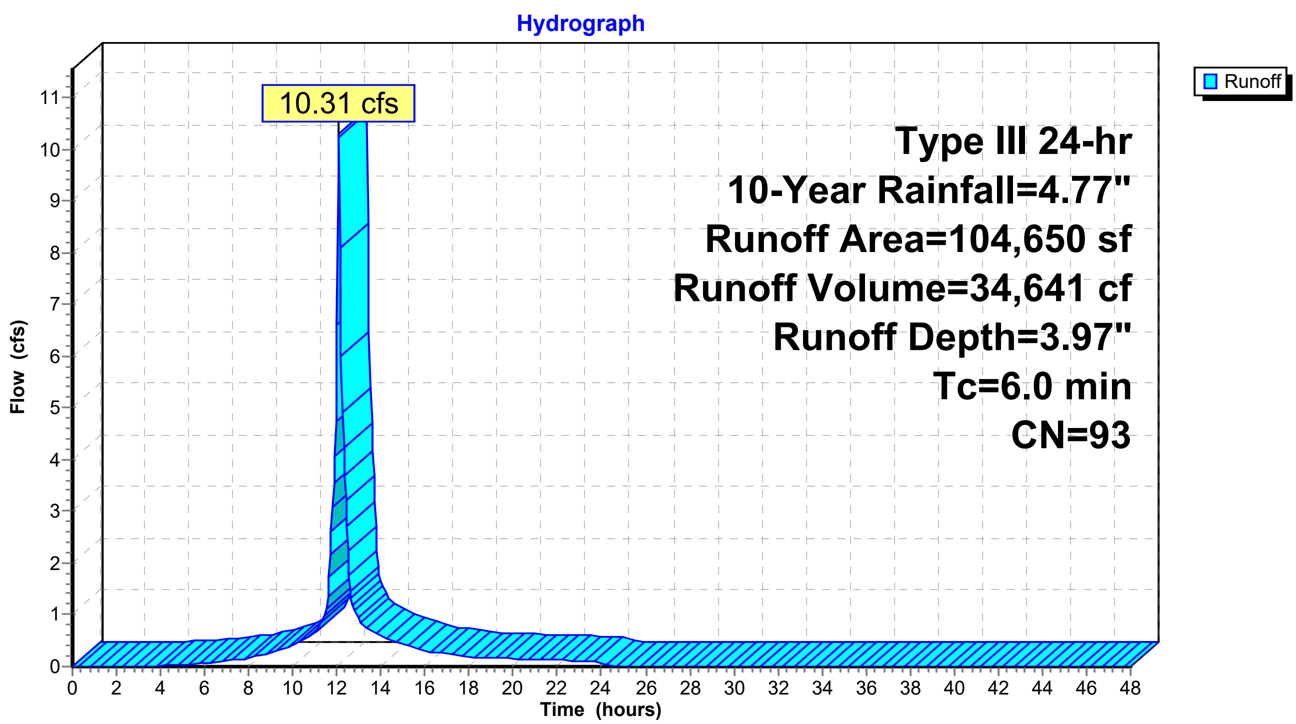
Runoff = 10.31 cfs @ 12.09 hrs, Volume= 34,641 cf, Depth= 3.97"
Routed to Pond 4P : EX-UGIF

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
71,412	98	Paved parking, HSG B
18,440	98	Roofs, HSG B
14,798	61	>75% Grass cover, Good, HSG B
104,650	93	Weighted Average
14,798		14.14% Pervious Area
89,852		85.86% Impervious Area

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

Subcatchment 1S: EX-QP (to infiltration)



Summary for Subcatchment 2S: EX-shoreline

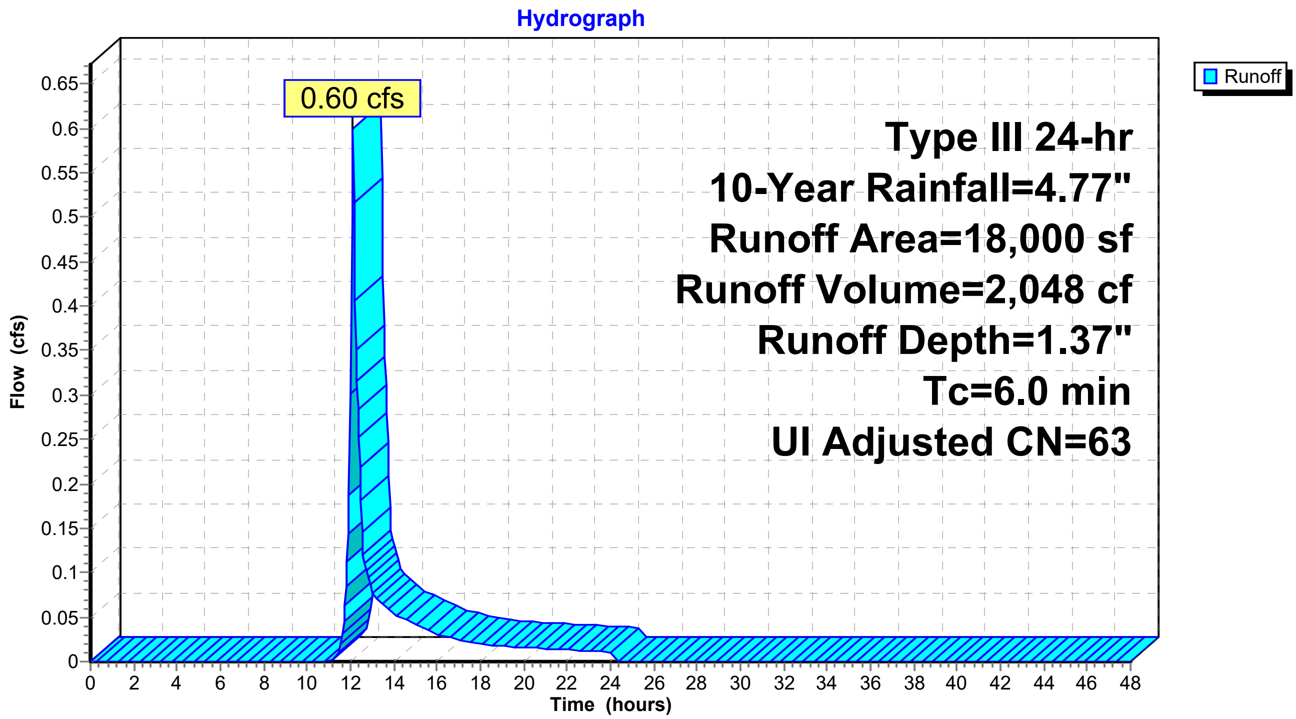
Runoff = 0.60 cfs @ 12.10 hrs, Volume= 2,048 cf, Depth= 1.37"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Adj	Description
1,646	98		Unconnected roofs, HSG B
16,354	61		>75% Grass cover, Good, HSG B
18,000	64	63	Weighted Average, UI Adjusted
16,354			90.86% Pervious Area
1,646			9.14% Impervious Area
1,646			100.00% Unconnected

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

Subcatchment 2S: EX-shoreline



Summary for Subcatchment 3S: EX-QP South (to 200QP)

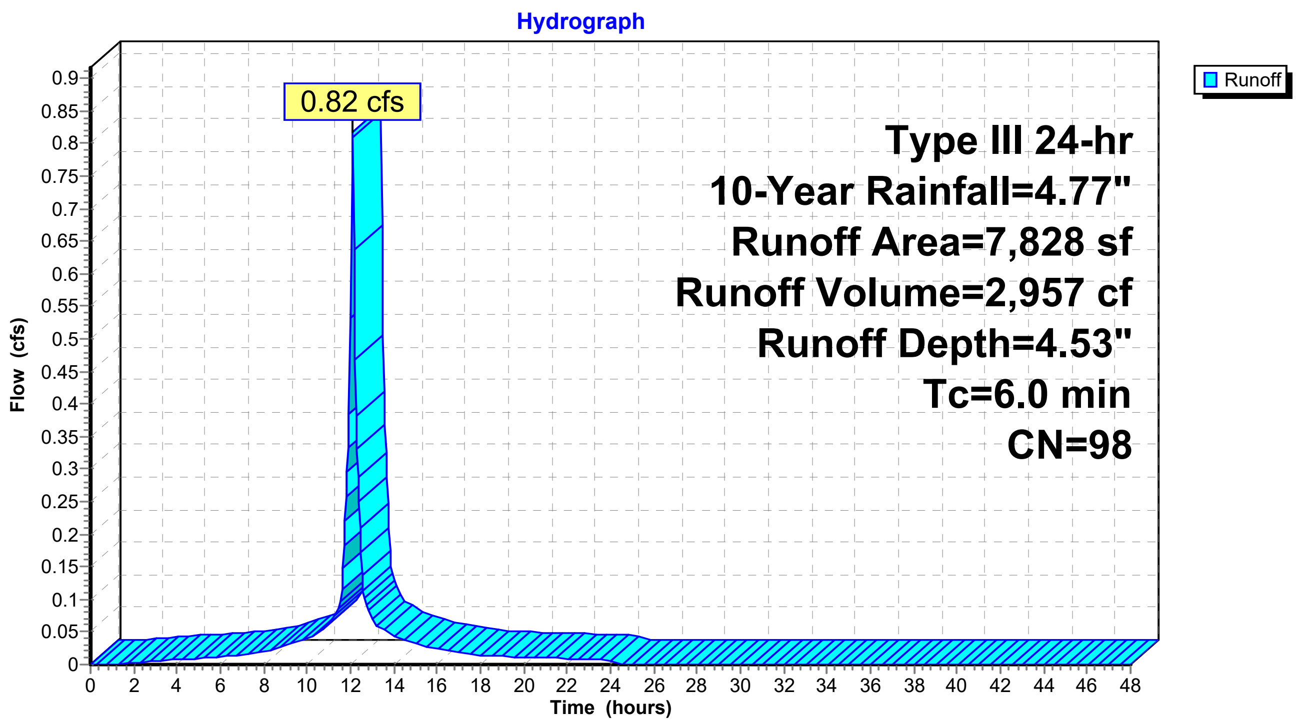
Runoff = 0.82 cfs @ 12.09 hrs, Volume= 2,957 cf, Depth= 4.53"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
7,828	98	Paved parking, HSG B
7,828		100.00% Impervious Area

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

Subcatchment 3S: EX-QP South (to 200QP)



Summary for Subcatchment 4S: EX-QP North (to 200QP)

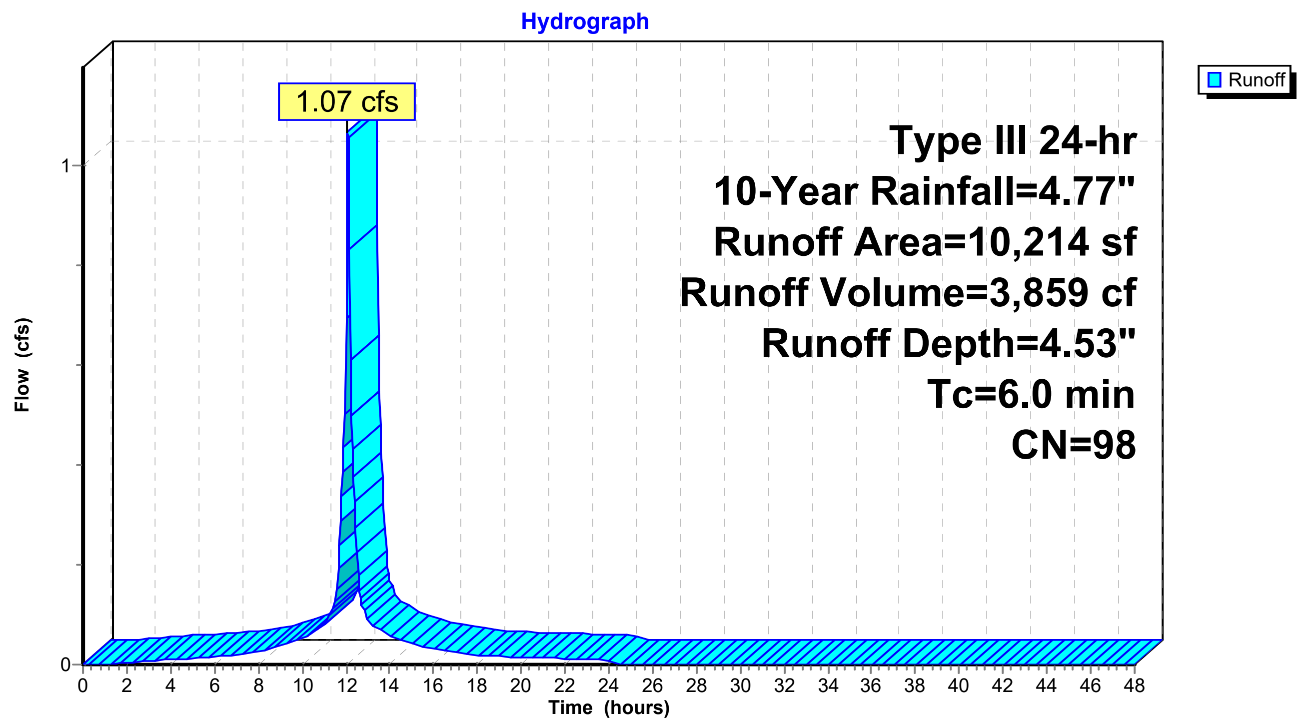
Runoff = 1.07 cfs @ 12.09 hrs, Volume= 3,859 cf, Depth= 4.53"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
10,214	98	Paved parking, HSG B
10,214		100.00% Impervious Area

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

Subcatchment 4S: EX-QP North (to 200QP)



Summary for Subcatchment 5S: EX-QPtoPVC

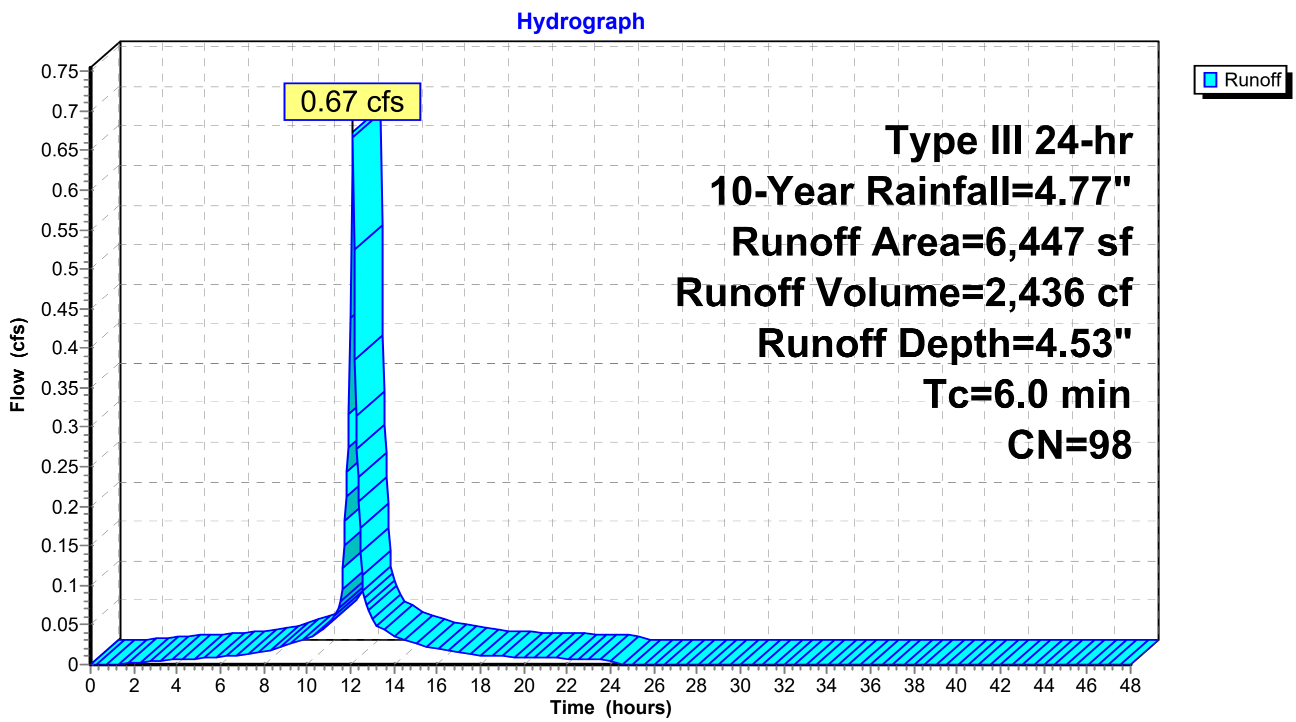
Runoff = 0.67 cfs @ 12.09 hrs, Volume= 2,436 cf, Depth= 4.53"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
6,447	98	Paved parking, HSG B
6,447		100.00% Impervious Area

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

Subcatchment 5S: EX-QPtoPVC



Summary for Subcatchment 6S: EX-shoreline (to lake)

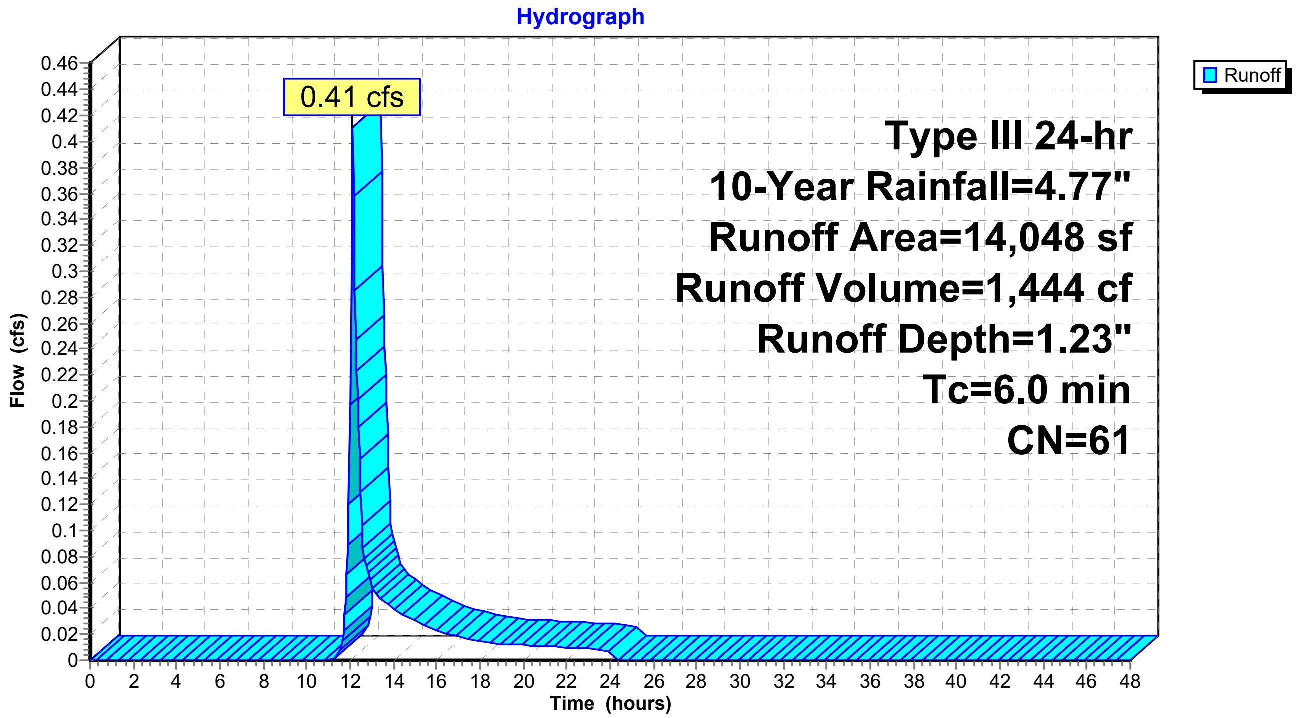
Runoff = 0.41 cfs @ 12.10 hrs, Volume= 1,444 cf, Depth= 1.23"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
14,048	61	>75% Grass cover, Good, HSG B
14,048		100.00% Pervious Area

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

Subcatchment 6S: EX-shoreline (to lake)



Summary for Subcatchment 7S: EX-QP North (to ex. bio)

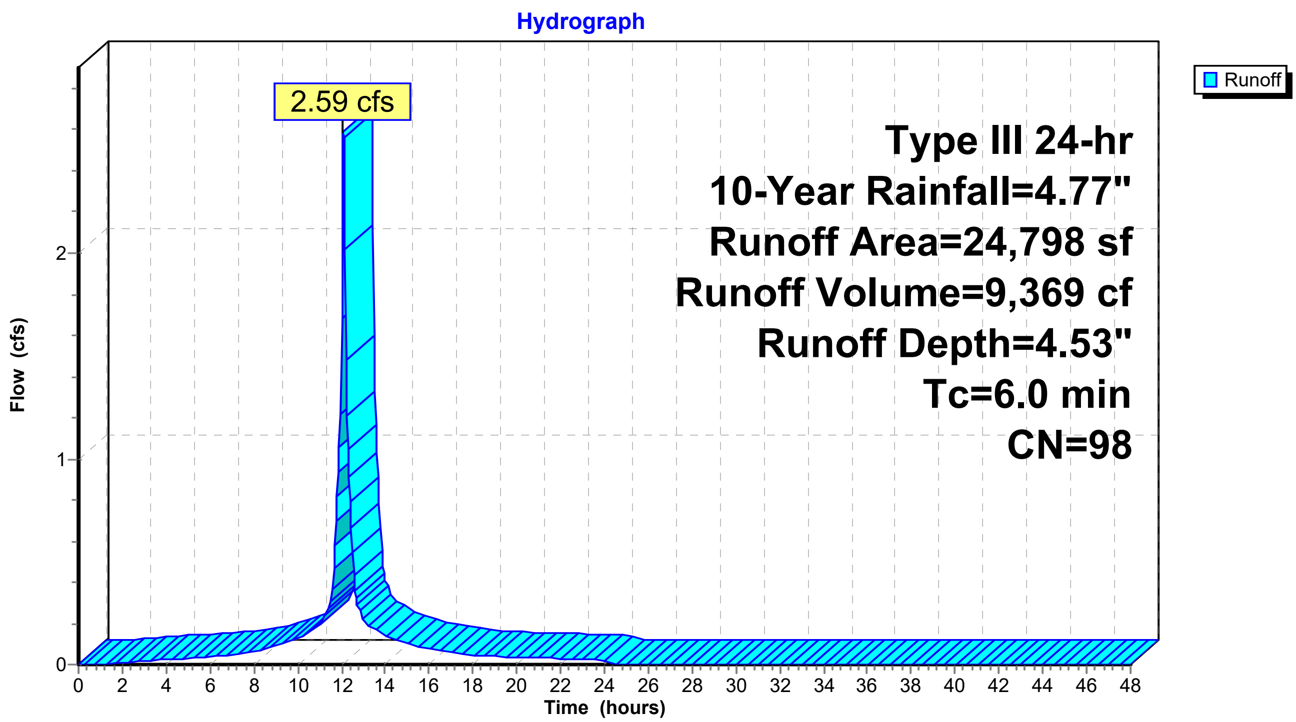
Runoff = 2.59 cfs @ 12.09 hrs, Volume= 9,369 cf, Depth= 4.53"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
24,798	98	Paved parking, HSG B
24,798		100.00% Impervious Area

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

Subcatchment 7S: EX-QP North (to ex. bio)



Summary for Pond 1P: Bioretention Area

Inflow Area = 24,798 sf,100.00% Impervious, Inflow Depth = 4.53" for 10-Year event
Inflow = 2.59 cfs @ 12.09 hrs, Volume= 9,369 cf
Outflow = 1.49 cfs @ 12.22 hrs, Volume= 9,369 cf, Atten= 43%, Lag= 7.8 min
Discarded = 0.16 cfs @ 12.22 hrs, Volume= 7,315 cf
Primary = 1.32 cfs @ 12.22 hrs, Volume= 2,054 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 83.23' @ 12.22 hrs Surf.Area= 2,299 sf Storage= 2,885 cf

Plug-Flow detention time= 112.1 min calculated for 9,369 cf (100% of inflow)
Center-of-Mass det. time= 112.1 min (860.9 - 748.8)

Volume	Invert	Avail.Storage	Storage Description
#1	81.80'	4,840 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

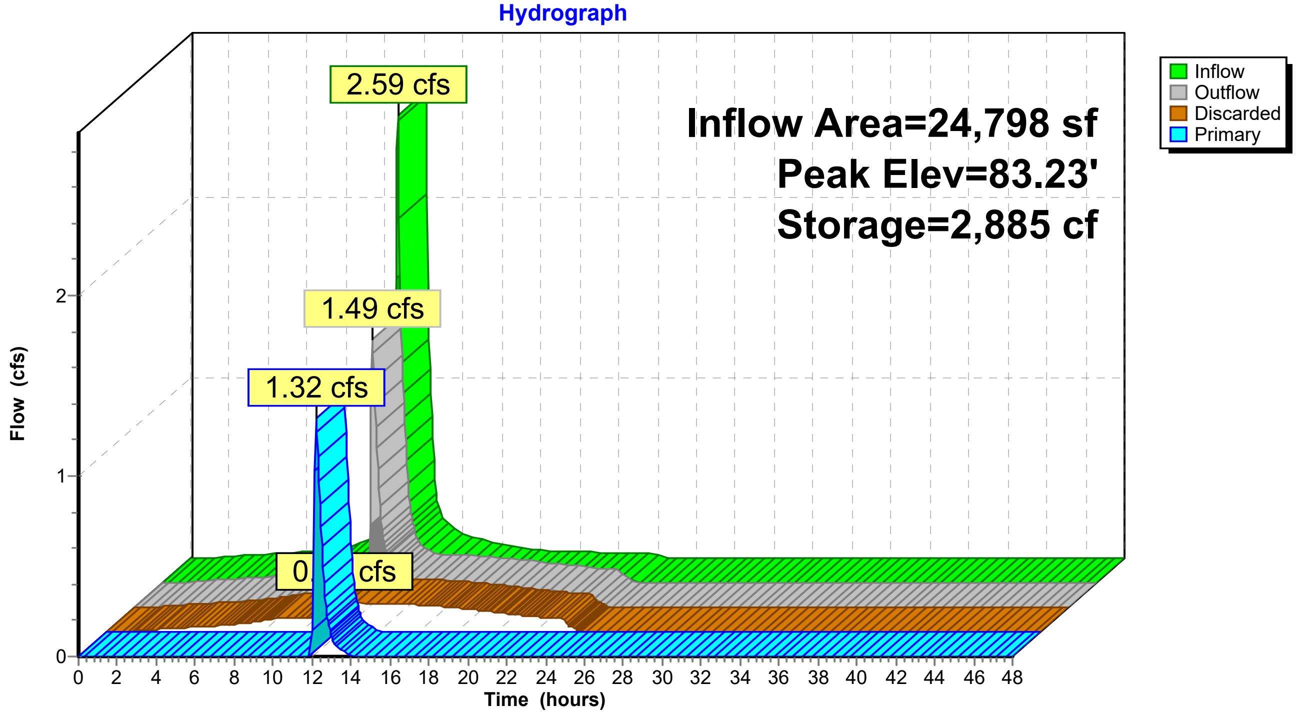
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
81.80	1,293	0	0
82.00	1,441	273	273
82.50	2,115	889	1,162
83.00	2,548	1,166	2,328
83.50	2,006	1,139	3,467
84.00	3,489	1,374	4,840

Device	Routing	Invert	Outlet Devices
#1	Discarded	81.80'	**2.400 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 75.00'
#2	Primary	83.00'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Discarded OutFlow Max=0.16 cfs @ 12.22 hrs HW=83.23' (Free Discharge)
└─**1=Exfiltration** (Controls 0.16 cfs)

Primary OutFlow Max=1.29 cfs @ 12.22 hrs HW=83.23' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 1.29 cfs @ 1.14 fps)

Pond 1P: Bioretention Area



Summary for Pond 4P: EX-UGIF

Inflow Area = 104,650 sf, 85.86% Impervious, Inflow Depth = 3.97" for 10-Year event
Inflow = 10.31 cfs @ 12.09 hrs, Volume= 34,641 cf
Outflow = 10.31 cfs @ 12.09 hrs, Volume= 34,219 cf, Atten= 0%, Lag= 0.0 min
Discarded = 0.01 cfs @ 12.09 hrs, Volume= 1,100 cf
Primary = 10.29 cfs @ 12.09 hrs, Volume= 33,120 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 83.41' @ 12.09 hrs Surf.Area= 854 sf Storage= 979 cf

Plug-Flow detention time= 35.7 min calculated for 34,184 cf (99% of inflow)
Center-of-Mass det. time= 29.4 min (809.1 - 779.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	80.65'	557 cf	**12.13'W x 70.45'L x 2.06'H Field A**
			1,758 cf Overall - 365 cf Embedded = 1,394 cf x 40.0% Voids
#2A	81.07'	364 cf	**CPP single-wall 12"** x 15 Inside #1
			Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
			Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
			Row Length Adjustment= +6.00' x 1.04 sf x 5 rows
			10.13' Header x 1.04 sf x 2 = 21.1 cf Inside
#3	81.15'	101 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder** x 2 -Impervious
		1,022 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	80.80'	**1.020 in/hr Exfiltration over Wetted area above 80.80'**
			Conductivity to Groundwater Elevation = 79.00'
			Excluded Wetted area = 879 sf Phase-In= 0.01'
#2	Primary	82.50'	**999.000 in/hr Exfiltration over Wetted area above 82.50'**
			Conductivity to Groundwater Elevation = 75.00'
			Excluded Wetted area = 1,160 sf Phase-In= 0.10'
#3	Primary	83.00'	**10.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s)
			0.5' Crest Height

Discarded OutFlow Max=0.01 cfs @ 12.09 hrs HW=83.40' (Free Discharge)
└─**1=Exfiltration** (Controls 0.01 cfs)

Primary OutFlow Max=10.02 cfs @ 12.09 hrs HW=83.40' (Free Discharge)
├─**2=Exfiltration** (Controls 0.88 cfs)
└─**3=Sharp-Crested Rectangular Weir** (Weir Controls 9.14 cfs @ 2.28 fps)

Pond 4P: EX-UGIF - Chamber Wizard Field A

Chamber Model = CPP single-wall 12" (Single-wall corrugated HDPE pipe)
Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
Row Length Adjustment= +6.00' x 1.04 sf x 5 rows

14.7" Wide + 12.0" Spacing = 26.7" C-C Row Spacing

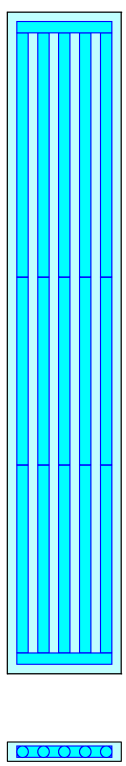
3 Chambers/Row x 20.00' Long +6.00' Row Adjustment +1.23' Header x 2 = 68.45' Row Length +12.0" End Stone x 2 = 70.45' Base Length
5 Rows x 14.7" Wide + 12.0" Spacing x 4 + 12.0" Side Stone x 2 = 12.13' Base Width
5.0" Stone Base + 14.7" Chamber Height + 5.0" Stone Cover = 2.06' Field Height

15 Chambers x 20.8 cf +6.00' Row Adjustment x 1.04 sf x 5 Rows + 10.13' Header x 1.04 sf x 2 = 364.5 cf Chamber Storage

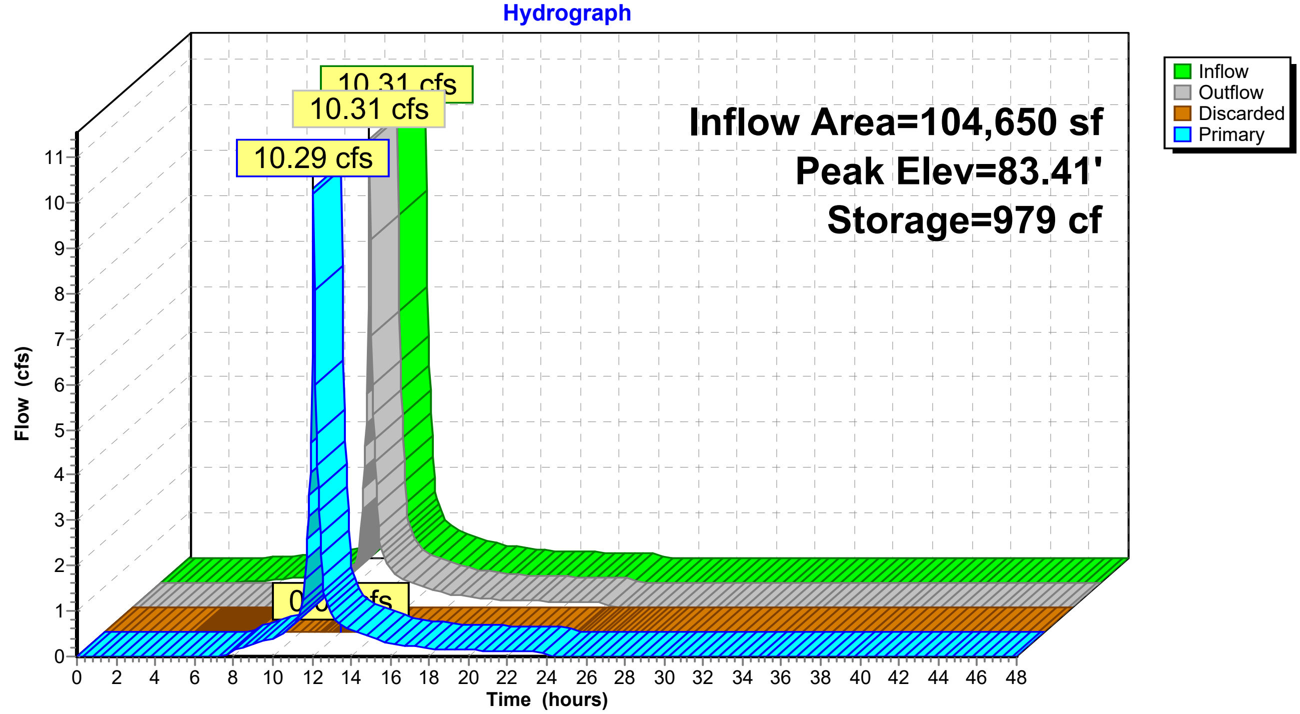
1,758.2 cf Field - 364.5 cf Chambers = 1,393.8 cf Stone x 40.0% Voids = 557.5 cf Stone Storage

Chamber Storage + Stone Storage = 922.0 cf = 0.021 af
Overall Storage Efficiency = 52.4%
Overall System Size = 70.45' x 12.13' x 2.06'

15 Chambers
65.1 cy Field
51.6 cy Stone



Pond 4P: EX-UGIF

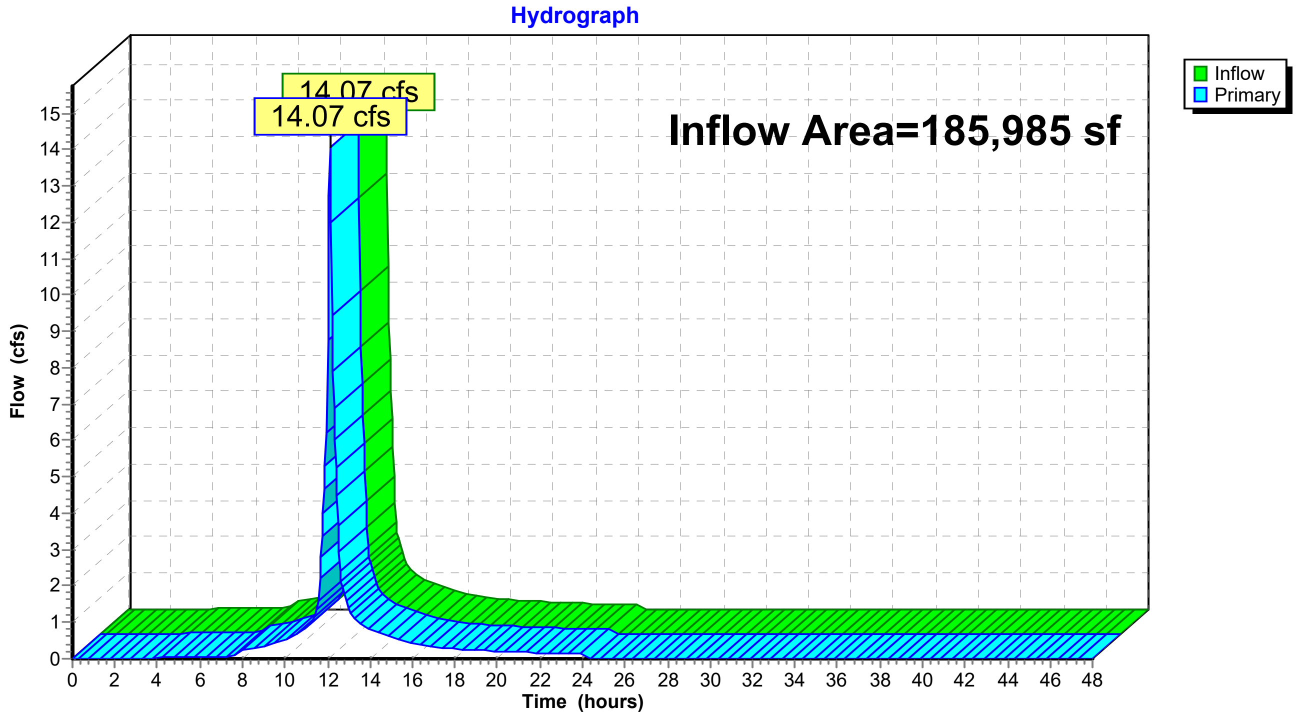


Summary for Link 1L: Lake Q

Inflow Area =	185,985 sf,	75.70% Impervious,	Inflow Depth = 3.09"	for 10-Year event
Inflow =	14.07 cfs @	12.09 hrs, Volume=	47,917 cf	
Primary =	14.07 cfs @	12.09 hrs, Volume=	47,917 cf, Atten= 0%, Lag= 0.0 min	

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Link 1L: Lake Q

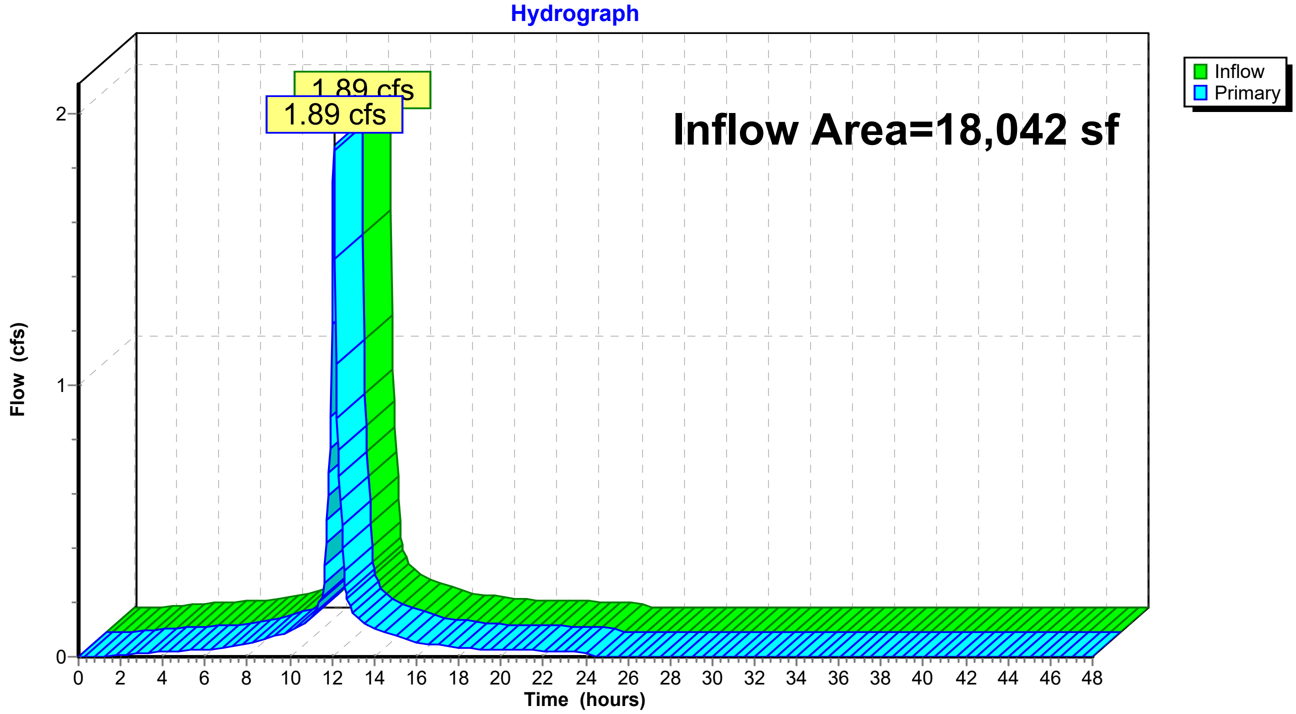


Summary for Link 3L: 200QP

Inflow Area = 18,042 sf,100.00% Impervious, Inflow Depth = 4.53" for 10-Year event
Inflow = 1.89 cfs @ 12.09 hrs, Volume= 6,816 cf
Primary = 1.89 cfs @ 12.09 hrs, Volume= 6,816 cf, Atten= 0%, Lag= 0.0 min
Routed to Link 1L : Lake Q

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

Link 3L: 200QP



Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: EX-QP (to infiltration) Runoff Area=104,650 sf 85.86% Impervious Runoff Depth=5.21"
Tc=6.0 min CN=93 Runoff=13.31 cfs 45,455 cf

Subcatchment 2S: EX-shoreline Runoff Area=18,000 sf 9.14% Impervious Runoff Depth=2.20"
Tc=6.0 min UI Adjusted CN=63 Runoff=1.01 cfs 3,296 cf

Subcatchment 3S: EX-QP South (to 200QP) Runoff Area=7,828 sf 100.00% Impervious Runoff Depth=5.79"
Tc=6.0 min CN=98 Runoff=1.04 cfs 3,778 cf

Subcatchment 4S: EX-QP North (to Runoff Area=10,214 sf 100.00% Impervious Runoff Depth=5.79"
Tc=6.0 min CN=98 Runoff=1.35 cfs 4,930 cf

Subcatchment 5S: EX-QPtoPVC Runoff Area=6,447 sf 100.00% Impervious Runoff Depth=5.79"
Tc=6.0 min CN=98 Runoff=0.85 cfs 3,112 cf

Subcatchment 6S: EX-shoreline (to lake) Runoff Area=14,048 sf 0.00% Impervious Runoff Depth=2.03"
Tc=6.0 min CN=61 Runoff=0.72 cfs 2,371 cf

Subcatchment 7S: EX-QP North (to ex. Runoff Area=24,798 sf 100.00% Impervious Runoff Depth=5.79"
Tc=6.0 min CN=98 Runoff=3.29 cfs 11,969 cf

Pond 1P: Bioretention Area Peak Elev=83.34' Storage=3,141 cf Inflow=3.29 cfs 11,969 cf
Discarded=0.17 cfs 8,219 cf Primary=2.52 cfs 3,750 cf Outflow=2.69 cfs 11,969 cf

Pond 4P: EX-UGIF Peak Elev=83.49' Storage=981 cf Inflow=13.31 cfs 45,455 cf
Discarded=0.01 cfs 1,143 cf Primary=13.30 cfs 43,929 cf Outflow=13.31 cfs 45,072 cf

Link 1L: Lake Q Inflow=20.28 cfs 65,166 cf
Primary=20.28 cfs 65,166 cf

Link 3L: 200QP Inflow=2.39 cfs 8,708 cf
Primary=2.39 cfs 8,708 cf

Total Runoff Area = 185,985 sf Runoff Volume = 74,911 cf Average Runoff Depth = 4.83"
24.30% Pervious = 45,200 sf 75.70% Impervious = 140,785 sf

Summary for Subcatchment 1S: EX-QP (to infiltration)

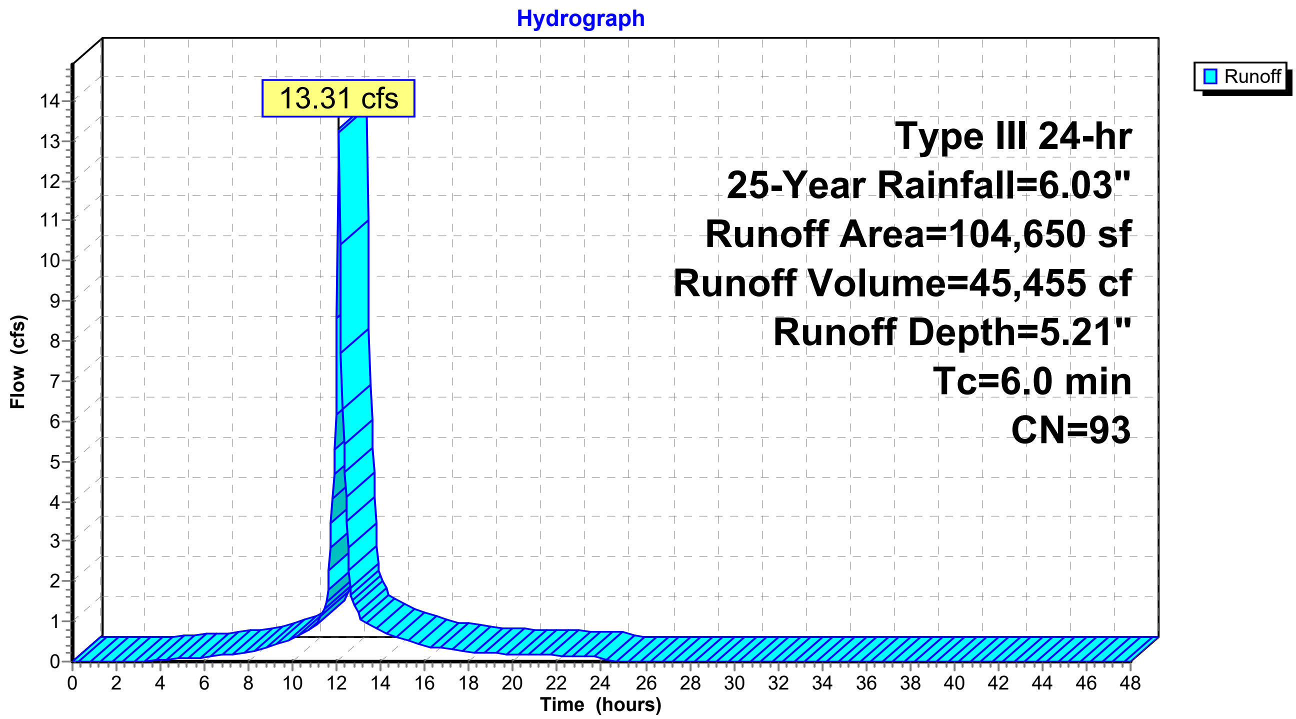
Runoff = 13.31 cfs @ 12.09 hrs, Volume= 45,455 cf, Depth= 5.21"
Routed to Pond 4P : EX-UGIF

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
71,412	98	Paved parking, HSG B
18,440	98	Roofs, HSG B
14,798	61	>75% Grass cover, Good, HSG B
104,650	93	Weighted Average
14,798		14.14% Pervious Area
89,852		85.86% Impervious Area

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

Subcatchment 1S: EX-QP (to infiltration)



Summary for Subcatchment 2S: EX-shoreline

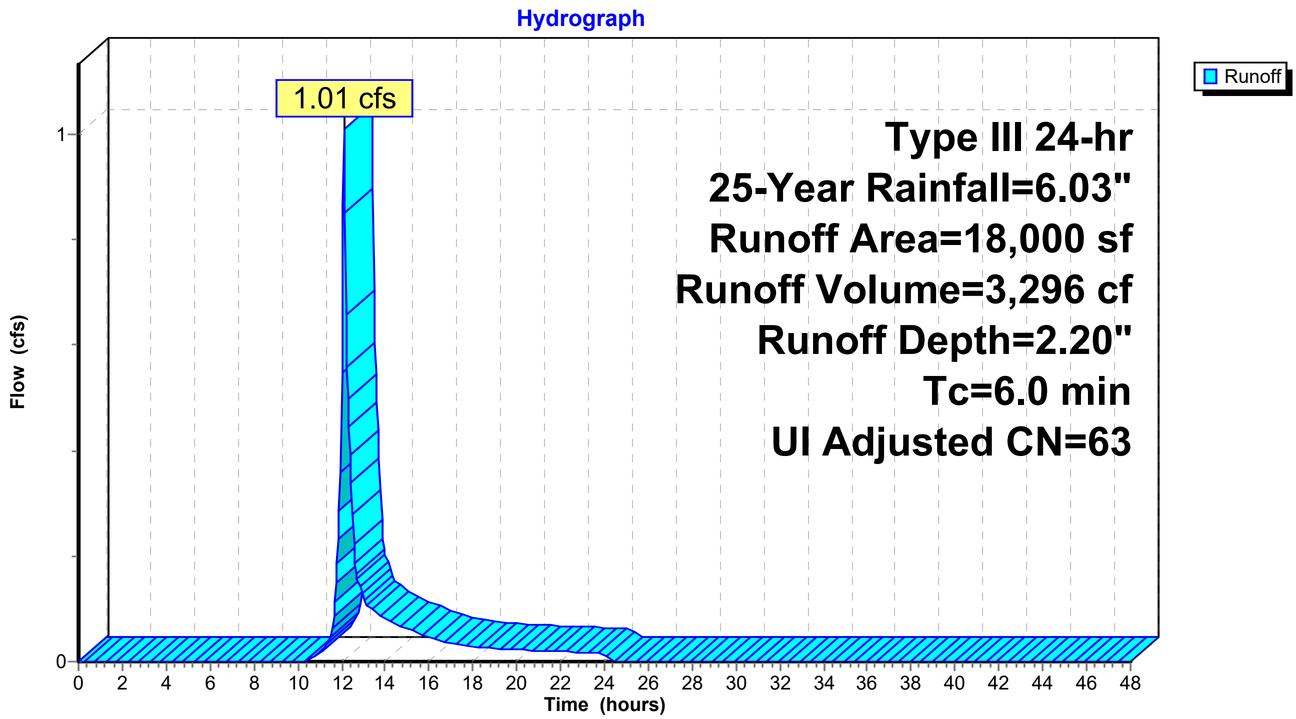
Runoff = 1.01 cfs @ 12.10 hrs, Volume= 3,296 cf, Depth= 2.20"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Adj	Description
1,646	98		Unconnected roofs, HSG B
16,354	61		>75% Grass cover, Good, HSG B
18,000	64	63	Weighted Average, UI Adjusted
16,354			90.86% Pervious Area
1,646			9.14% Impervious Area
1,646			100.00% Unconnected

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

Subcatchment 2S: EX-shoreline



Summary for Subcatchment 3S: EX-QP South (to 200QP)

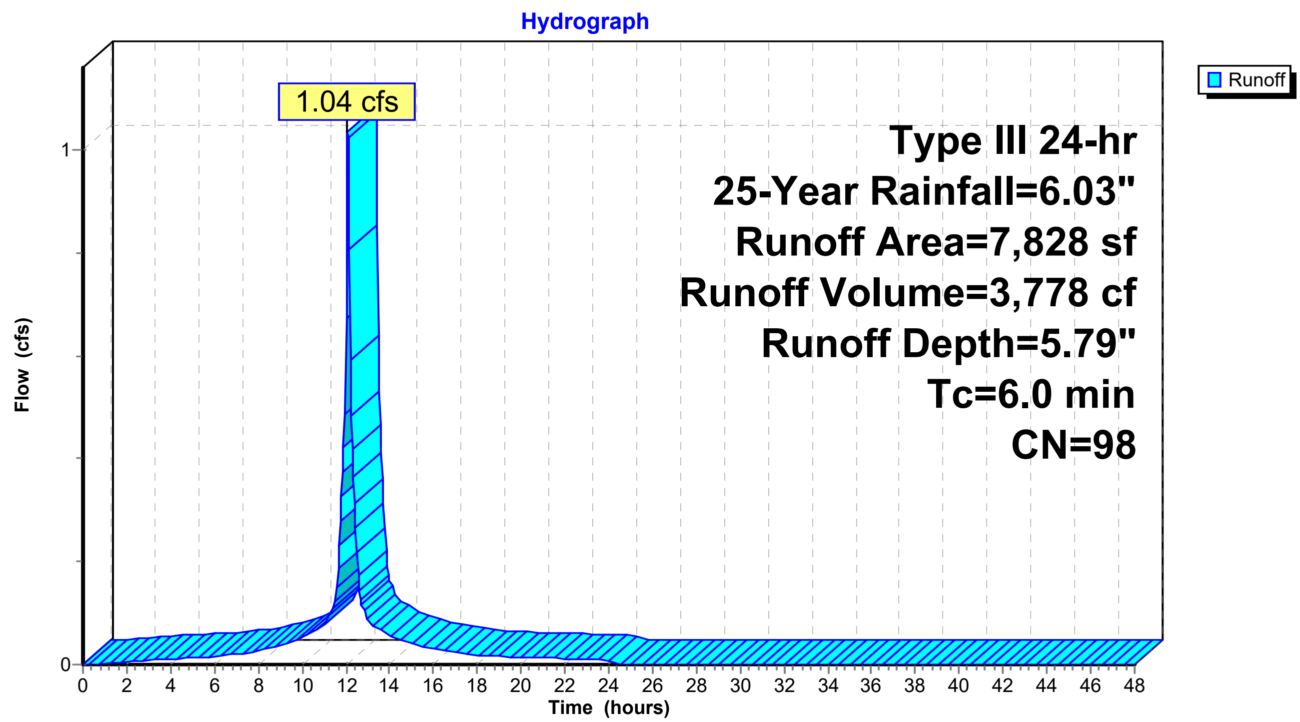
Runoff = 1.04 cfs @ 12.09 hrs, Volume= 3,778 cf, Depth= 5.79"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
7,828	98	Paved parking, HSG B
7,828		100.00% Impervious Area

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

Subcatchment 3S: EX-QP South (to 200QP)



Summary for Subcatchment 4S: EX-QP North (to 200QP)

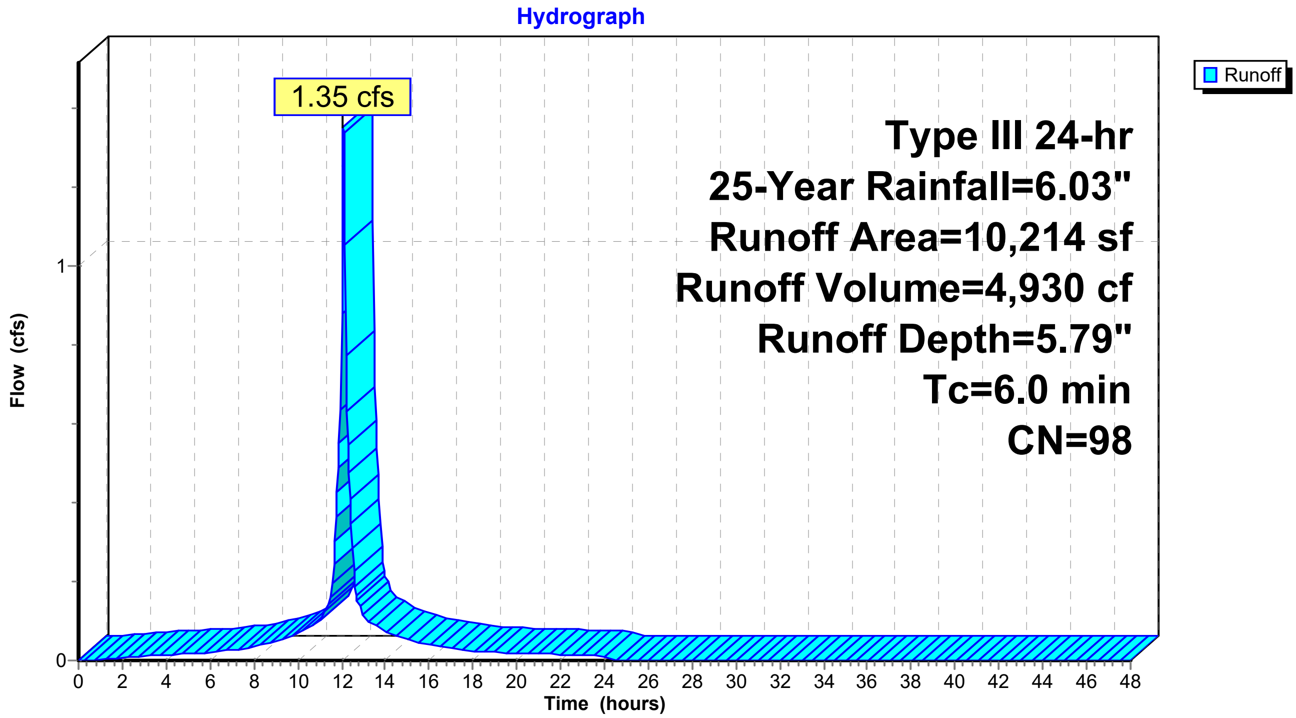
Runoff = 1.35 cfs @ 12.09 hrs, Volume= 4,930 cf, Depth= 5.79"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
10,214	98	Paved parking, HSG B
10,214		100.00% Impervious Area

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

Subcatchment 4S: EX-QP North (to 200QP)



Summary for Subcatchment 5S: EX-QPtoPVC

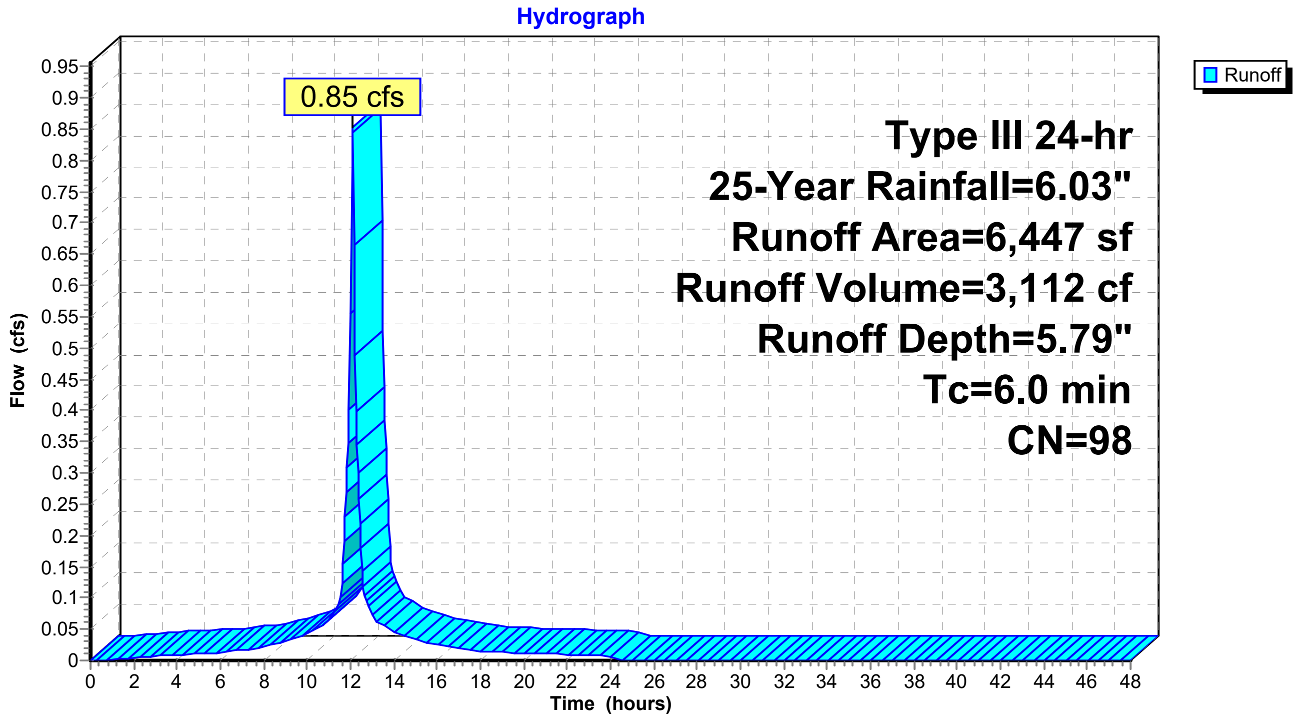
Runoff = 0.85 cfs @ 12.09 hrs, Volume= 3,112 cf, Depth= 5.79"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
6,447	98	Paved parking, HSG B
6,447		100.00% Impervious Area

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

Subcatchment 5S: EX-QPtoPVC



Summary for Subcatchment 6S: EX-shoreline (to lake)

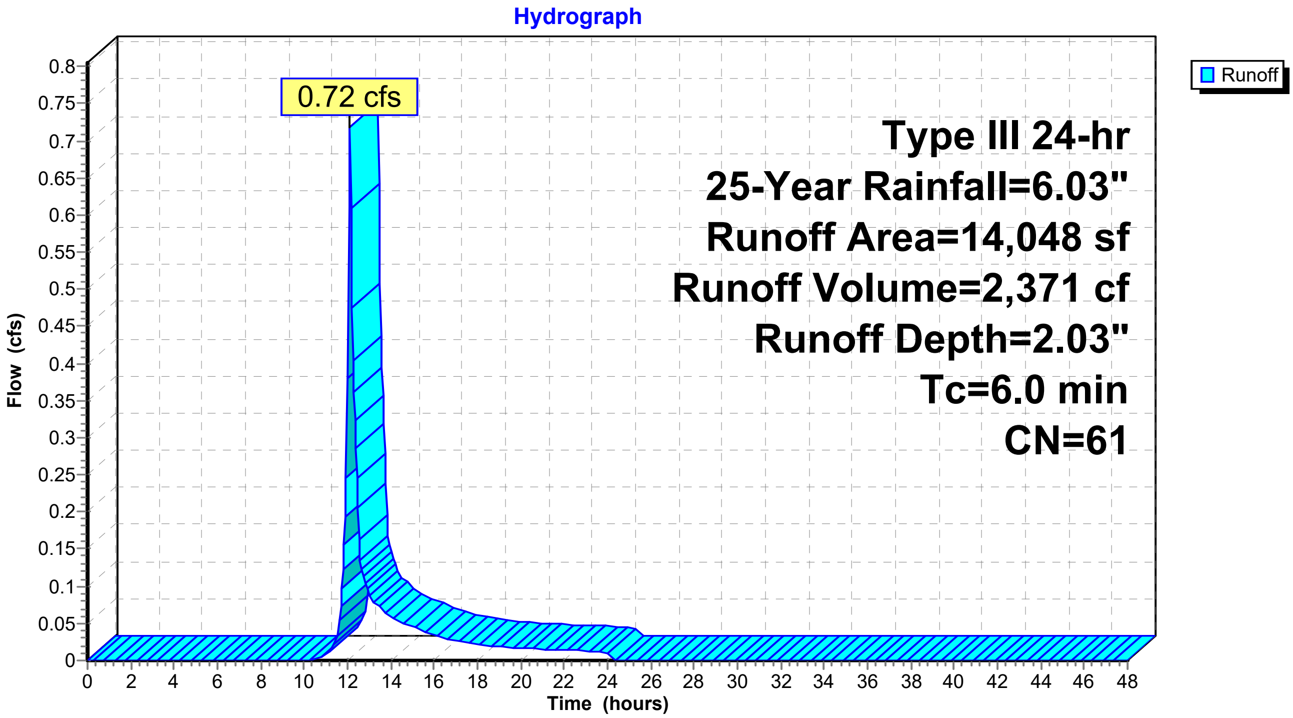
Runoff = 0.72 cfs @ 12.10 hrs, Volume= 2,371 cf, Depth= 2.03"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
14,048	61	>75% Grass cover, Good, HSG B
14,048		100.00% Pervious Area

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

Subcatchment 6S: EX-shoreline (to lake)



Summary for Subcatchment 7S: EX-QP North (to ex. bio)

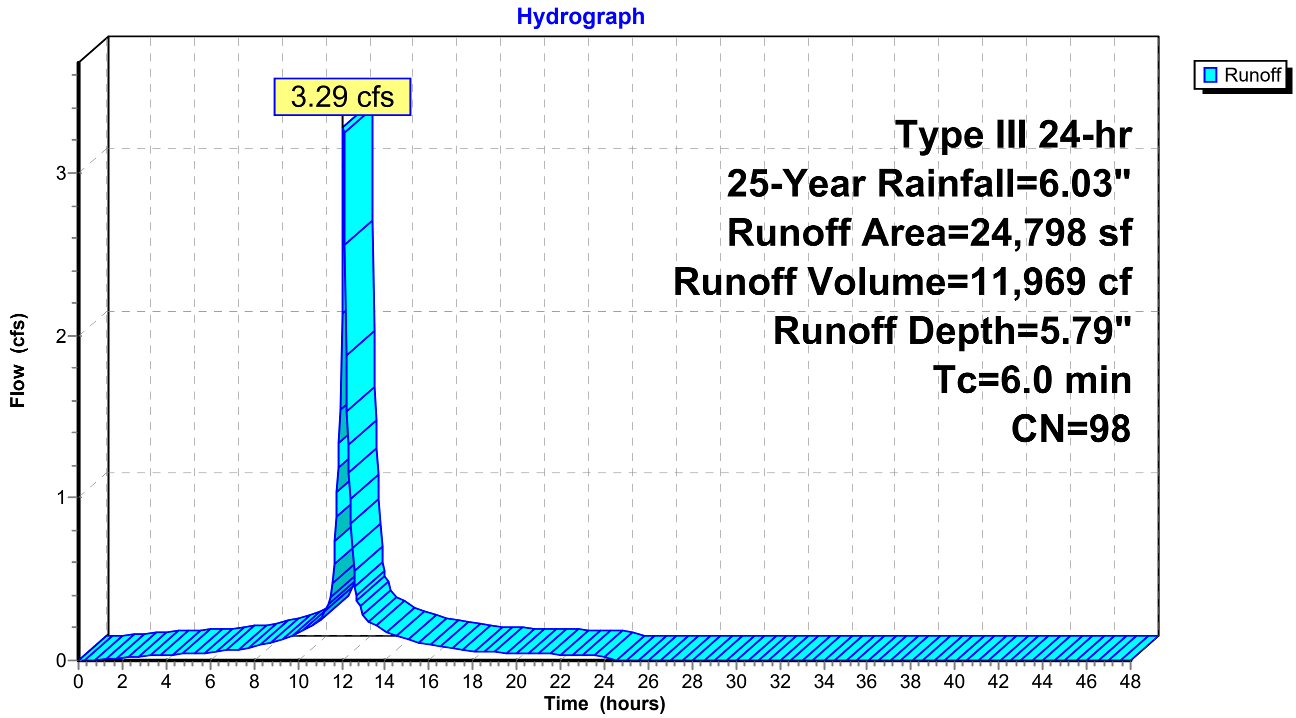
Runoff = 3.29 cfs @ 12.09 hrs, Volume= 11,969 cf, Depth= 5.79"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
24,798	98	Paved parking, HSG B
24,798		100.00% Impervious Area

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

Subcatchment 7S: EX-QP North (to ex. bio)



Summary for Pond 1P: Bioretention Area

Inflow Area = 24,798 sf,100.00% Impervious, Inflow Depth = 5.79" for 25-Year event
Inflow = 3.29 cfs @ 12.09 hrs, Volume= 11,969 cf
Outflow = 2.69 cfs @ 12.15 hrs, Volume= 11,969 cf, Atten= 18%, Lag= 4.0 min
Discarded = 0.17 cfs @ 12.15 hrs, Volume= 8,219 cf
Primary = 2.52 cfs @ 12.15 hrs, Volume= 3,750 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 83.34' @ 12.15 hrs Surf.Area= 2,175 sf Storage= 3,141 cf

Plug-Flow detention time= 103.7 min calculated for 11,956 cf (100% of inflow)
Center-of-Mass det. time= 103.6 min (848.7 - 745.1)

Volume	Invert	Avail.Storage	Storage Description
#1	81.80'	4,840 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

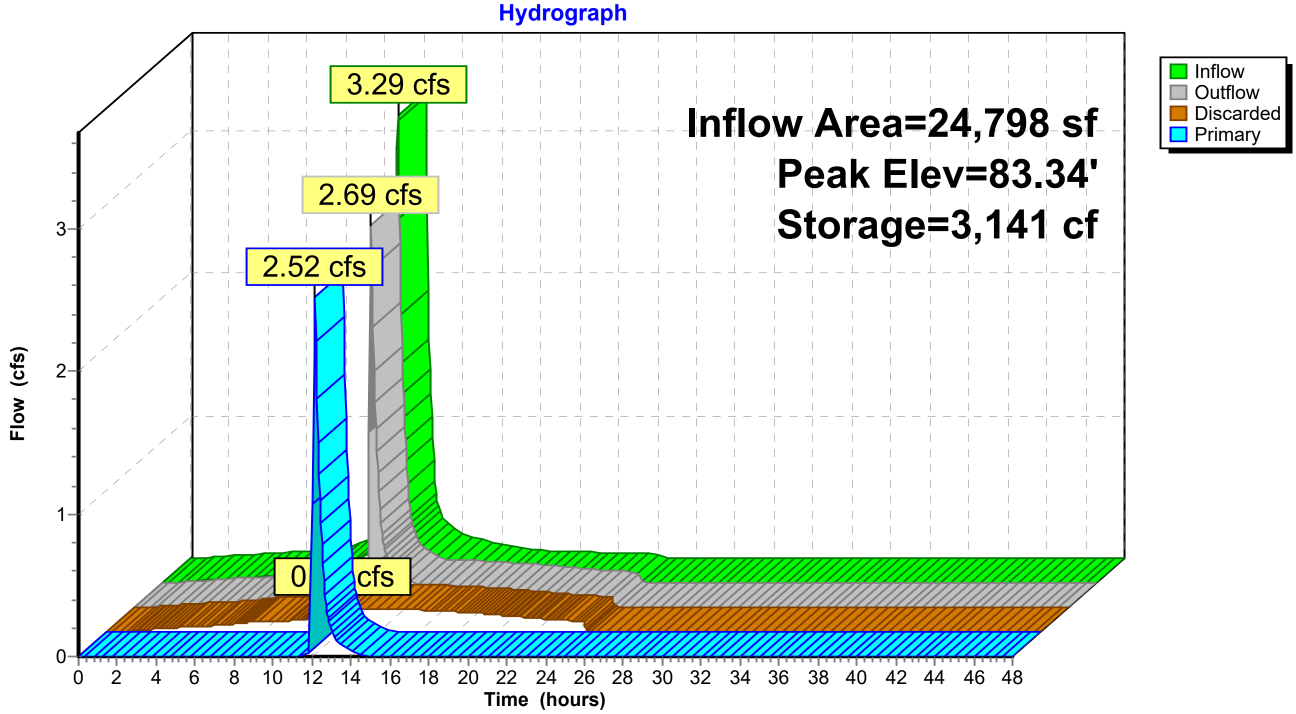
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
81.80	1,293	0	0
82.00	1,441	273	273
82.50	2,115	889	1,162
83.00	2,548	1,166	2,328
83.50	2,006	1,139	3,467
84.00	3,489	1,374	4,840

Device	Routing	Invert	Outlet Devices
#1	Discarded	81.80'	**2.400 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 75.00'
#2	Primary	83.00'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Discarded OutFlow Max=0.17 cfs @ 12.15 hrs HW=83.34' (Free Discharge)
1=Exfiltration (Controls 0.17 cfs)

Primary OutFlow Max=2.50 cfs @ 12.15 hrs HW=83.34' (Free Discharge)
2=Broad-Crested Rectangular Weir (Weir Controls 2.50 cfs @ 1.46 fps)

Pond 1P: Bioretention Area



Summary for Pond 4P: EX-UGIF

Inflow Area = 104,650 sf, 85.86% Impervious, Inflow Depth = 5.21" for 25-Year event
Inflow = 13.31 cfs @ 12.09 hrs, Volume= 45,455 cf
Outflow = 13.31 cfs @ 12.09 hrs, Volume= 45,072 cf, Atten= 0%, Lag= 0.0 min
Discarded = 0.01 cfs @ 12.09 hrs, Volume= 1,143 cf
Primary = 13.30 cfs @ 12.09 hrs, Volume= 43,929 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 83.49' @ 12.09 hrs Surf.Area= 854 sf Storage= 981 cf

Plug-Flow detention time= 28.9 min calculated for 45,072 cf (99% of inflow)
Center-of-Mass det. time= 23.5 min (796.3 - 772.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	80.65'	557 cf	**12.13'W x 70.45'L x 2.06'H Field A** 1,758 cf Overall - 365 cf Embedded = 1,394 cf x 40.0% Voids
#2A	81.07'	364 cf	**CPP single-wall 12"** x 15 Inside #1 Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf Row Length Adjustment= +6.00' x 1.04 sf x 5 rows 10.13' Header x 1.04 sf x 2 = 21.1 cf Inside
#3	81.15'	101 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder** x 2 -Impervious
		1,022 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	80.80'	**1.020 in/hr Exfiltration over Wetted area above 80.80'** Conductivity to Groundwater Elevation = 79.00' Excluded Wetted area = 879 sf Phase-In= 0.01'
#2	Primary	82.50'	**999.000 in/hr Exfiltration over Wetted area above 82.50'** Conductivity to Groundwater Elevation = 75.00' Excluded Wetted area = 1,160 sf Phase-In= 0.10'
#3	Primary	83.00'	**10.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 0.5' Crest Height

Discarded OutFlow Max=0.01 cfs @ 12.09 hrs HW=83.48' (Free Discharge)
└─**1=Exfiltration** (Controls 0.01 cfs)

Primary OutFlow Max=12.95 cfs @ 12.09 hrs HW=83.48' (Free Discharge)
├─**2=Exfiltration** (Controls 0.89 cfs)
└─**3=Sharp-Crested Rectangular Weir** (Weir Controls 12.06 cfs @ 2.53 fps)

Pond 4P: EX-UGIF - Chamber Wizard Field A

Chamber Model = CPP single-wall 12" (Single-wall corrugated HDPE pipe)
Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
Row Length Adjustment= +6.00' x 1.04 sf x 5 rows

14.7" Wide + 12.0" Spacing = 26.7" C-C Row Spacing

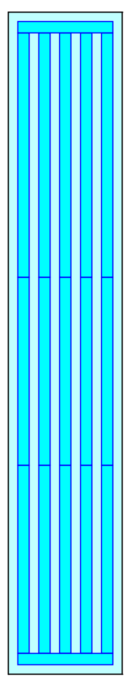
3 Chambers/Row x 20.00' Long +6.00' Row Adjustment +1.23' Header x 2 = 68.45' Row Length +12.0" End Stone x 2 = 70.45' Base Length
5 Rows x 14.7" Wide + 12.0" Spacing x 4 + 12.0" Side Stone x 2 = 12.13' Base Width
5.0" Stone Base + 14.7" Chamber Height + 5.0" Stone Cover = 2.06' Field Height

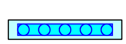
15 Chambers x 20.8 cf +6.00' Row Adjustment x 1.04 sf x 5 Rows + 10.13' Header x 1.04 sf x 2 = 364.5 cf Chamber Storage

1,758.2 cf Field - 364.5 cf Chambers = 1,393.8 cf Stone x 40.0% Voids = 557.5 cf Stone Storage

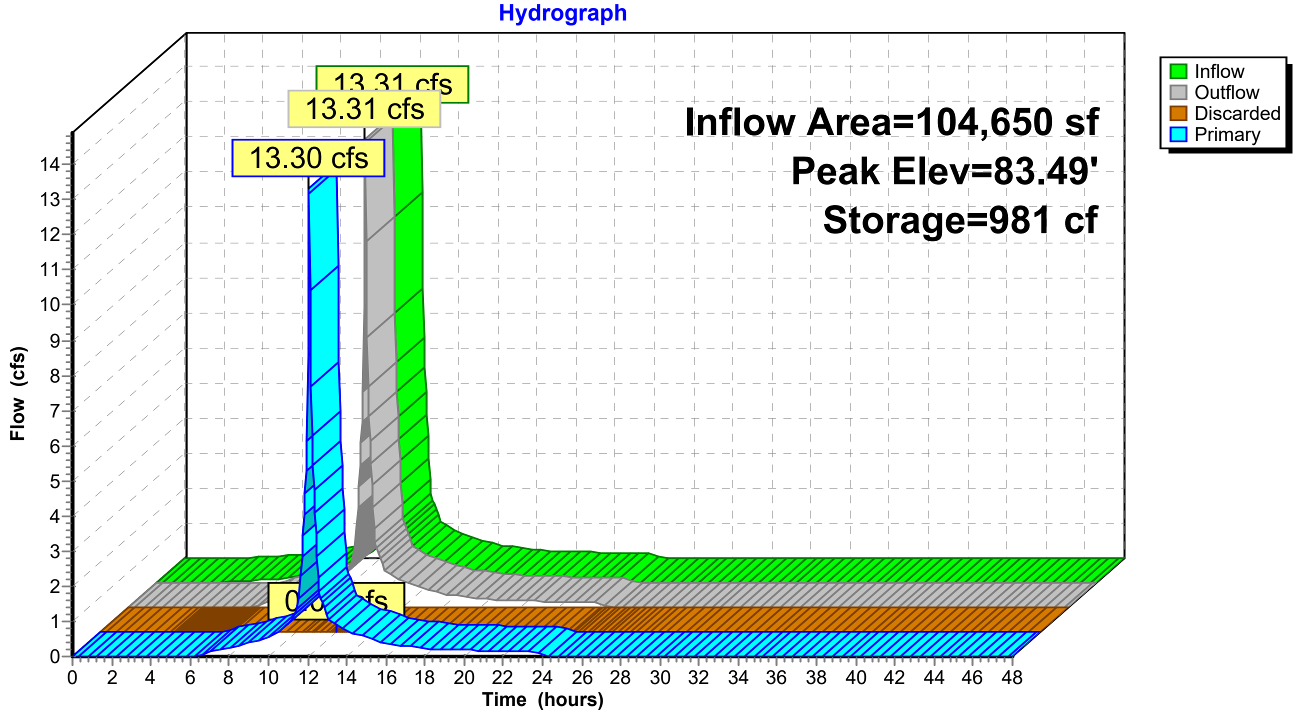
Chamber Storage + Stone Storage = 922.0 cf = 0.021 af
Overall Storage Efficiency = 52.4%
Overall System Size = 70.45' x 12.13' x 2.06'

15 Chambers
65.1 cy Field
51.6 cy Stone





Pond 4P: EX-UGIF

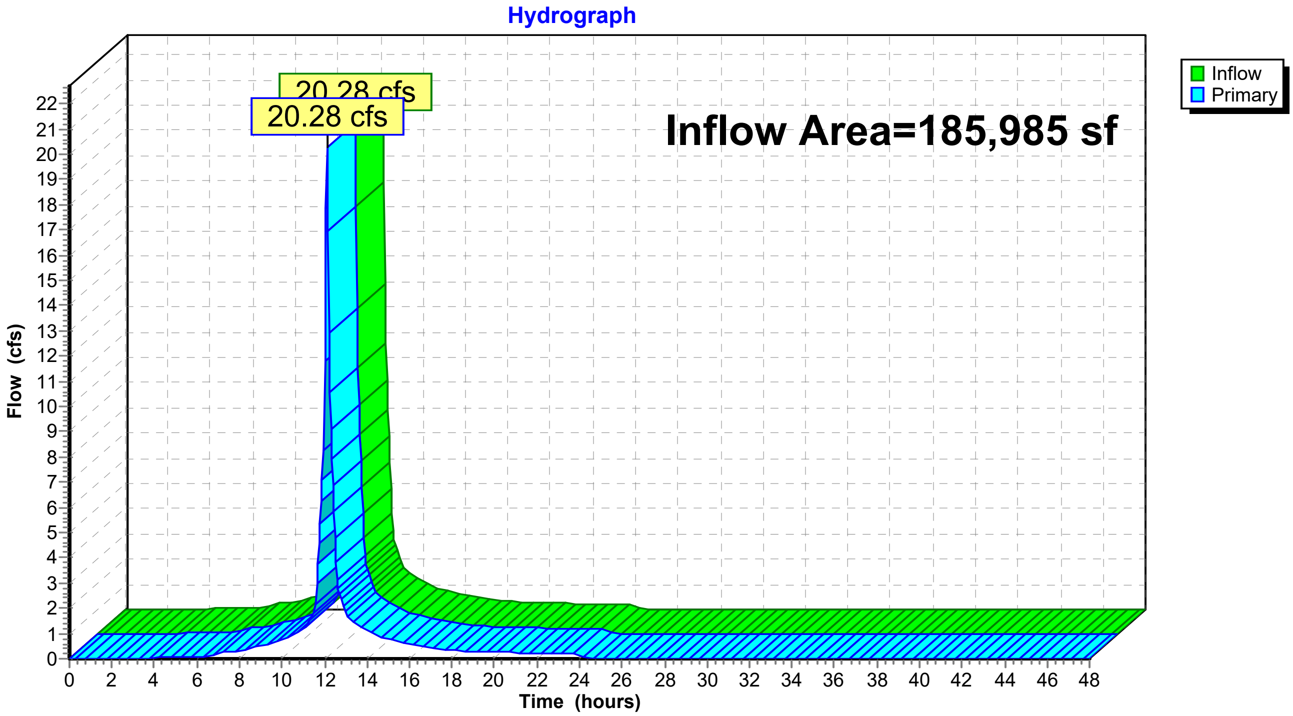


Summary for Link 1L: Lake Q

Inflow Area = 185,985 sf, 75.70% Impervious, Inflow Depth = 4.20" for 25-Year event
Inflow = 20.28 cfs @ 12.10 hrs, Volume= 65,166 cf
Primary = 20.28 cfs @ 12.10 hrs, Volume= 65,166 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs

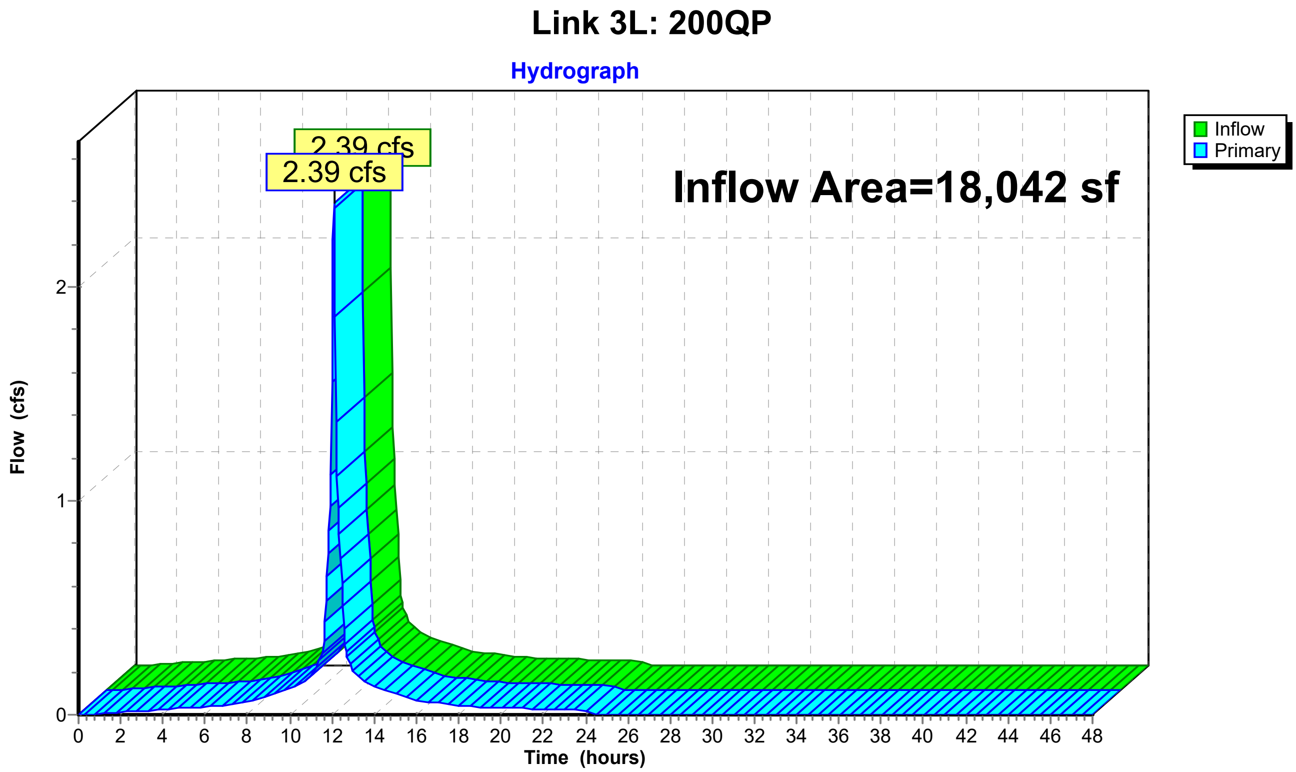
Link 1L: Lake Q



Summary for Link 3L: 200QP

Inflow Area = 18,042 sf,100.00% Impervious, Inflow Depth = 5.79" for 25-Year event
Inflow = 2.39 cfs @ 12.09 hrs, Volume= 8,708 cf
Primary = 2.39 cfs @ 12.09 hrs, Volume= 8,708 cf, Atten= 0%, Lag= 0.0 min
Routed to Link 1L : Lake Q

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs



Time span=0.00-48.00 hrs, dt=0.05 hrs, 961 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: EX-QP (to infiltration) Runoff Area=104,650 sf 85.86% Impervious Runoff Depth=7.78"
Tc=6.0 min CN=93 Runoff=19.43 cfs 67,832 cf

Subcatchment 2S: EX-shoreline Runoff Area=18,000 sf 9.14% Impervious Runoff Depth=4.16"
Tc=6.0 min UI Adjusted CN=63 Runoff=1.97 cfs 6,243 cf

Subcatchment 3S: EX-QP South (to 200QP) Runoff Area=7,828 sf 100.00% Impervious Runoff Depth=8.38"
Tc=6.0 min CN=98 Runoff=1.49 cfs 5,466 cf

Subcatchment 4S: EX-QP North (to Runoff Area=10,214 sf 100.00% Impervious Runoff Depth=8.38"
Tc=6.0 min CN=98 Runoff=1.94 cfs 7,133 cf

Subcatchment 5S: EX-QPtoPVC Runoff Area=6,447 sf 100.00% Impervious Runoff Depth=8.38"
Tc=6.0 min CN=98 Runoff=1.22 cfs 4,502 cf

Subcatchment 6S: EX-shoreline (to lake) Runoff Area=14,048 sf 0.00% Impervious Runoff Depth=3.92"
Tc=6.0 min CN=61 Runoff=1.45 cfs 4,594 cf

Subcatchment 7S: EX-QP North (to ex. Runoff Area=24,798 sf 100.00% Impervious Runoff Depth=8.38"
Tc=6.0 min CN=98 Runoff=4.71 cfs 17,317 cf

Pond 1P: Bioretention Area Peak Elev=83.47' Storage=3,399 cf Inflow=4.71 cfs 17,317 cf
Discarded=0.17 cfs 9,733 cf Primary=4.12 cfs 7,584 cf Outflow=4.29 cfs 17,317 cf

Pond 4P: EX-UGIF Peak Elev=83.63' Storage=984 cf Inflow=19.43 cfs 67,832 cf
Discarded=0.01 cfs 1,208 cf Primary=19.42 cfs 66,245 cf Outflow=19.43 cfs 67,454 cf

Link 1L: Lake Q Inflow=31.36 cfs 101,767 cf
Primary=31.36 cfs 101,767 cf

Link 3L: 200QP Inflow=3.42 cfs 12,599 cf
Primary=3.42 cfs 12,599 cf

Total Runoff Area = 185,985 sf Runoff Volume = 113,088 cf Average Runoff Depth = 7.30"
24.30% Pervious = 45,200 sf 75.70% Impervious = 140,785 sf

Summary for Subcatchment 1S: EX-QP (to infiltration)

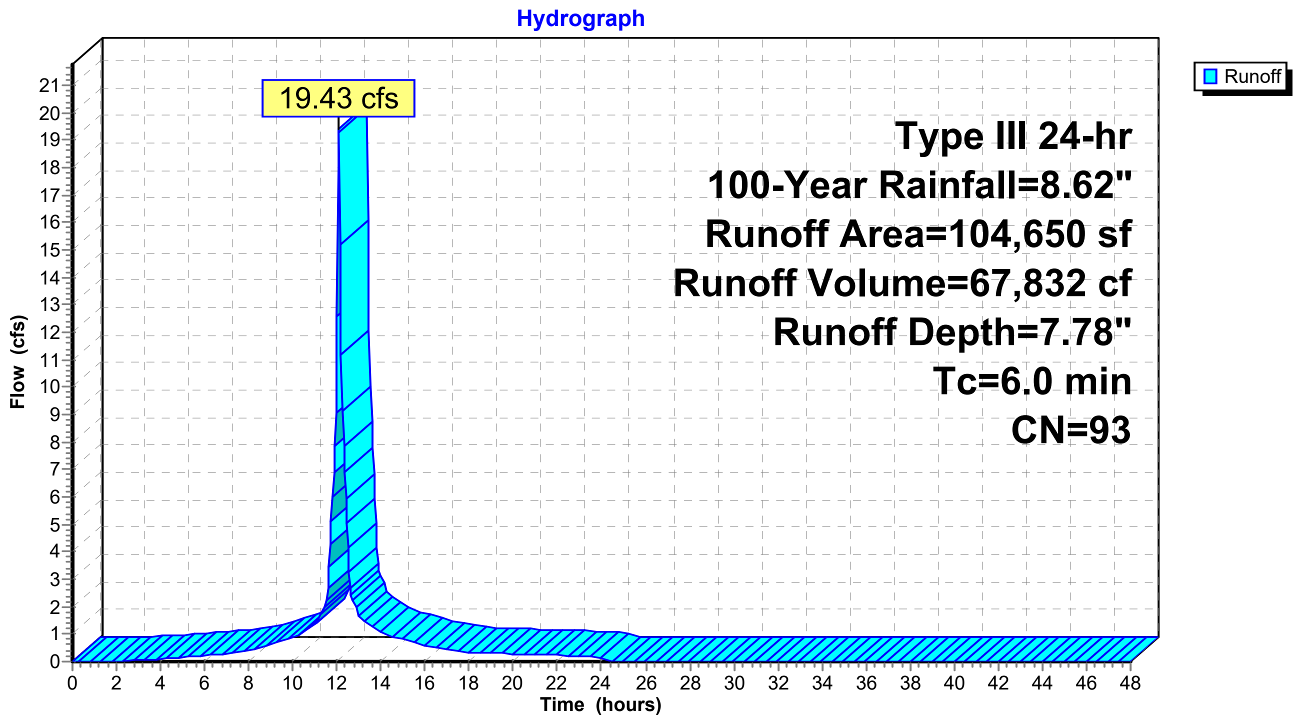
Runoff = 19.43 cfs @ 12.09 hrs, Volume= 67,832 cf, Depth= 7.78"
Routed to Pond 4P : EX-UGIF

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
71,412	98	Paved parking, HSG B
18,440	98	Roofs, HSG B
14,798	61	>75% Grass cover, Good, HSG B
104,650	93	Weighted Average
14,798		14.14% Pervious Area
89,852		85.86% Impervious Area

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

Subcatchment 1S: EX-QP (to infiltration)



Summary for Subcatchment 2S: EX-shoreline

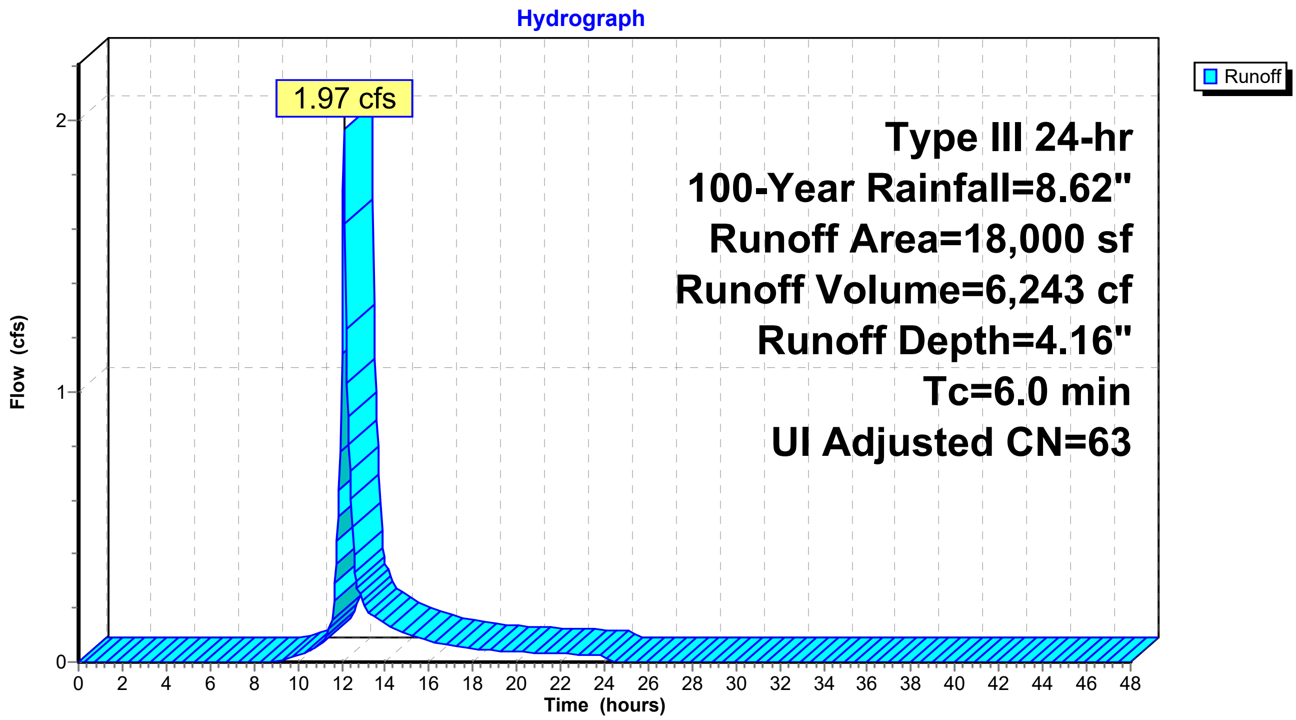
Runoff = 1.97 cfs @ 12.09 hrs, Volume= 6,243 cf, Depth= 4.16"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Adj	Description
1,646	98		Unconnected roofs, HSG B
16,354	61		>75% Grass cover, Good, HSG B
18,000	64	63	Weighted Average, UI Adjusted
16,354			90.86% Pervious Area
1,646			9.14% Impervious Area
1,646			100.00% Unconnected

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

Subcatchment 2S: EX-shoreline



Summary for Subcatchment 3S: EX-QP South (to 200QP)

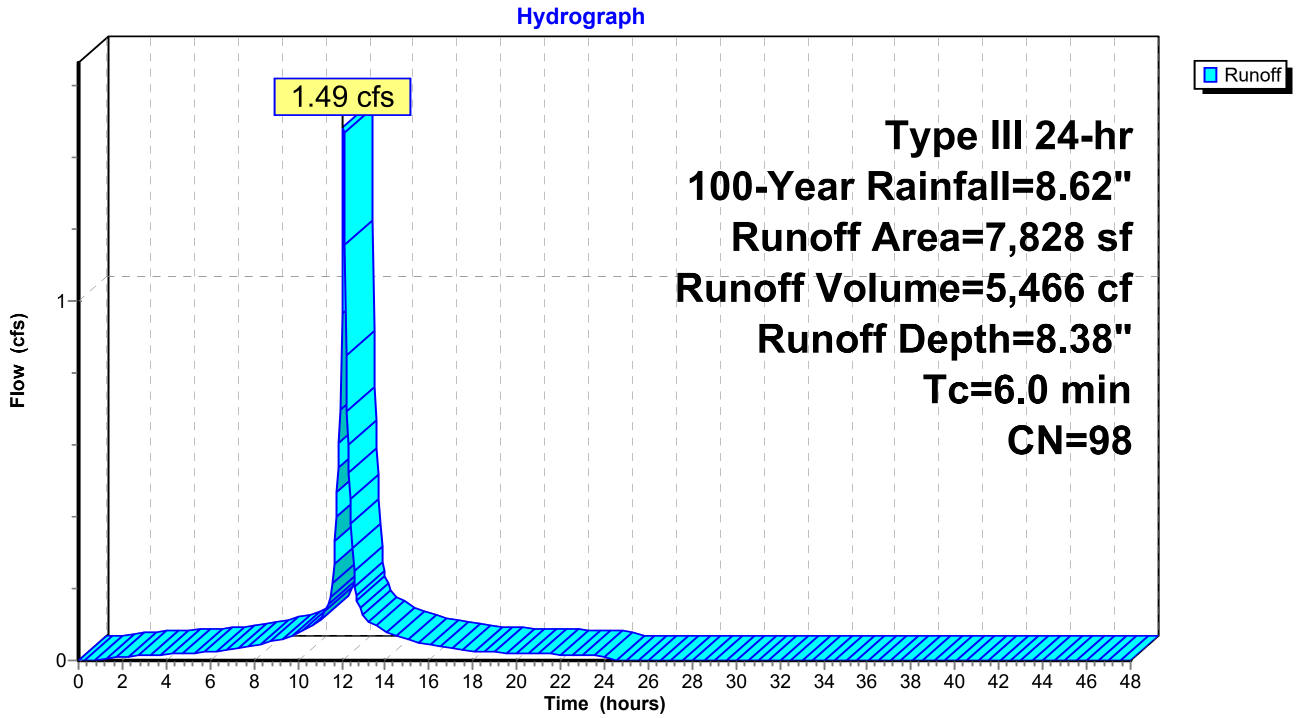
Runoff = 1.49 cfs @ 12.09 hrs, Volume= 5,466 cf, Depth= 8.38"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
7,828	98	Paved parking, HSG B
7,828		100.00% Impervious Area

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

Subcatchment 3S: EX-QP South (to 200QP)



Summary for Subcatchment 4S: EX-QP North (to 200QP)

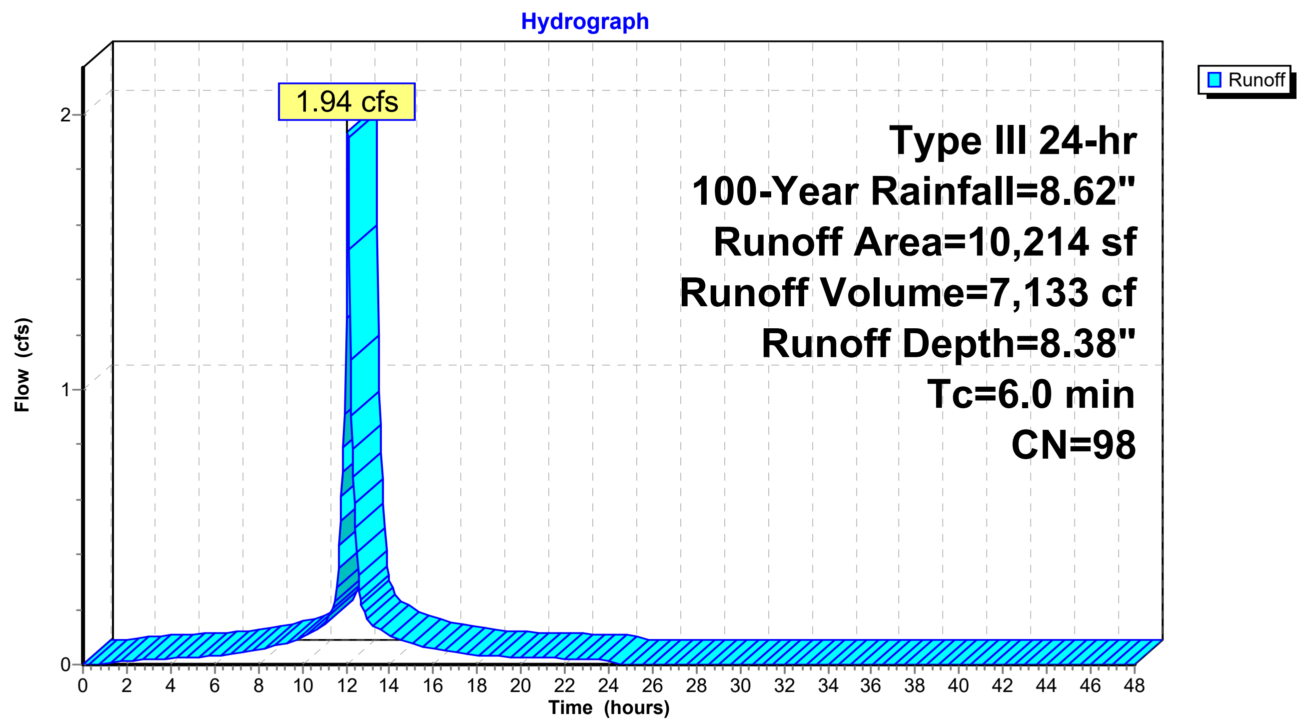
Runoff = 1.94 cfs @ 12.09 hrs, Volume= 7,133 cf, Depth= 8.38"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
10,214	98	Paved parking, HSG B
10,214		100.00% Impervious Area

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

Subcatchment 4S: EX-QP North (to 200QP)



Summary for Subcatchment 5S: EX-QPtoPVC

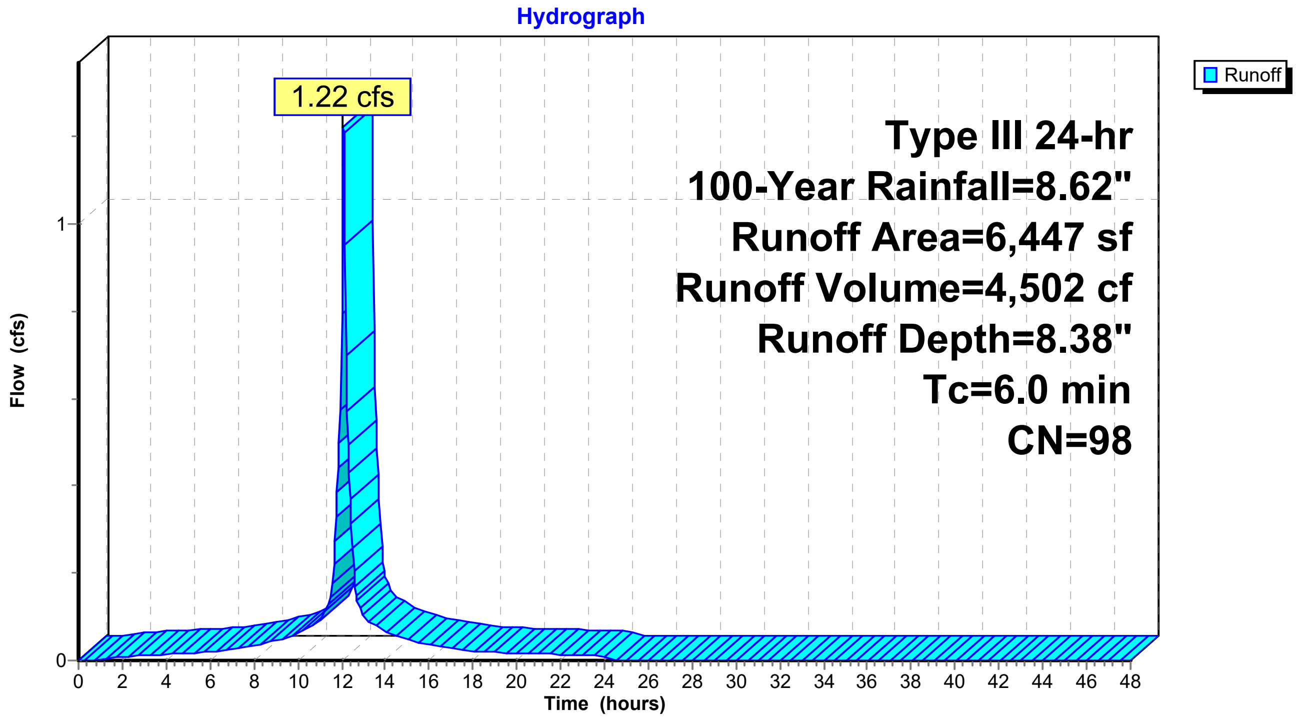
Runoff = 1.22 cfs @ 12.09 hrs, Volume= 4,502 cf, Depth= 8.38"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
6,447	98	Paved parking, HSG B
6,447		100.00% Impervious Area

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

Subcatchment 5S: EX-QPtoPVC



Summary for Subcatchment 6S: EX-shoreline (to lake)

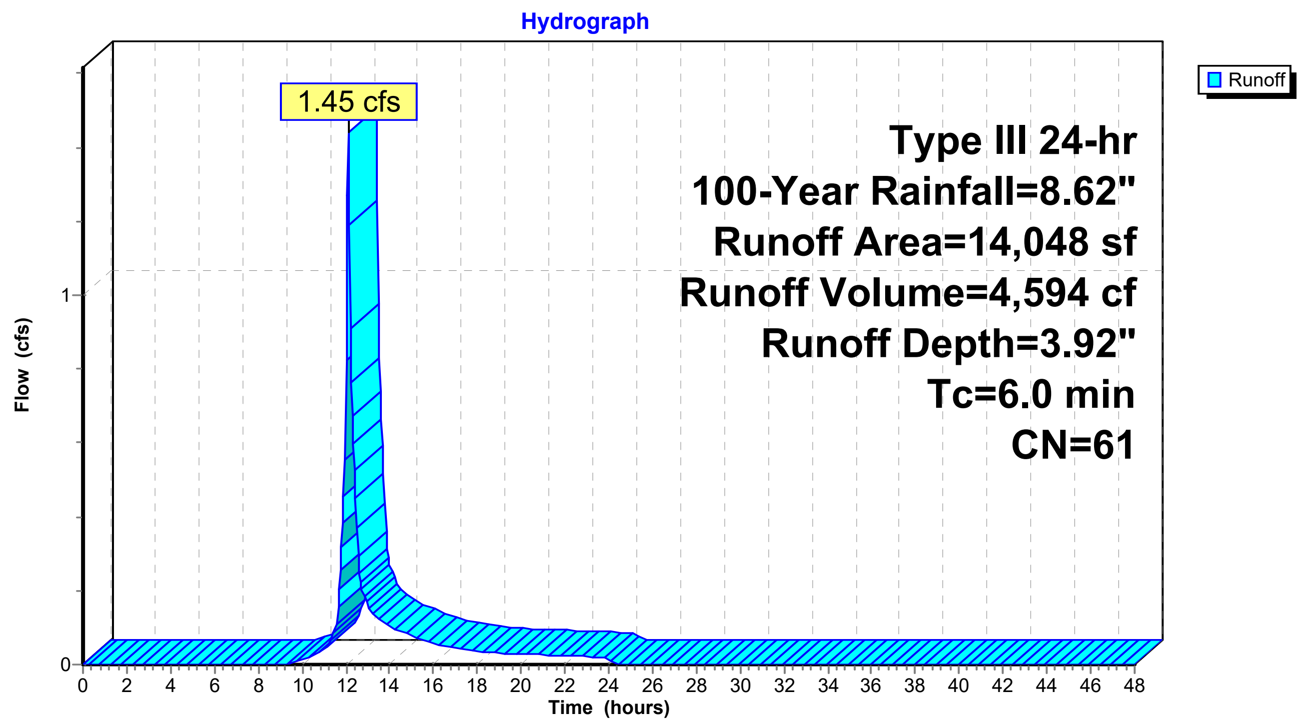
Runoff = 1.45 cfs @ 12.10 hrs, Volume= 4,594 cf, Depth= 3.92"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
14,048	61	>75% Grass cover, Good, HSG B
14,048		100.00% Pervious Area

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

Subcatchment 6S: EX-shoreline (to lake)



Summary for Subcatchment 7S: EX-QP North (to ex. bio)

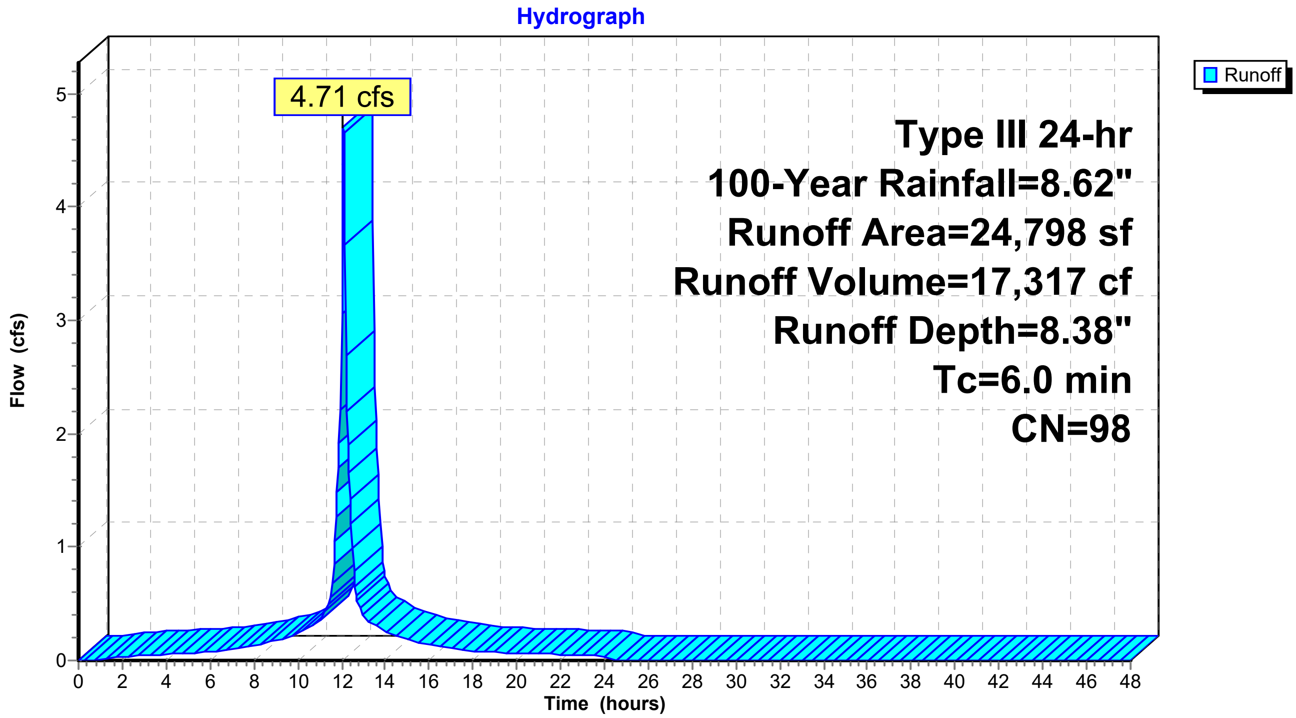
Runoff = 4.71 cfs @ 12.09 hrs, Volume= 17,317 cf, Depth= 8.38"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
24,798	98	Paved parking, HSG B
24,798		100.00% Impervious Area

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

Subcatchment 7S: EX-QP North (to ex. bio)



Summary for Pond 1P: Bioretention Area

Inflow Area = 24,798 sf,100.00% Impervious, Inflow Depth = 8.38" for 100-Year event
Inflow = 4.71 cfs @ 12.09 hrs, Volume= 17,317 cf
Outflow = 4.29 cfs @ 12.12 hrs, Volume= 17,317 cf, Atten= 9%, Lag= 2.3 min
Discarded = 0.17 cfs @ 12.12 hrs, Volume= 9,733 cf
Primary = 4.12 cfs @ 12.12 hrs, Volume= 7,584 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs
Peak Elev= 83.47' @ 12.12 hrs Surf.Area= 2,042 sf Storage= 3,399 cf

Plug-Flow detention time= 92.0 min calculated for 17,299 cf (100% of inflow)
Center-of-Mass det. time= 92.0 min (832.3 - 740.3)

Volume	Invert	Avail.Storage	Storage Description
#1	81.80'	4,840 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

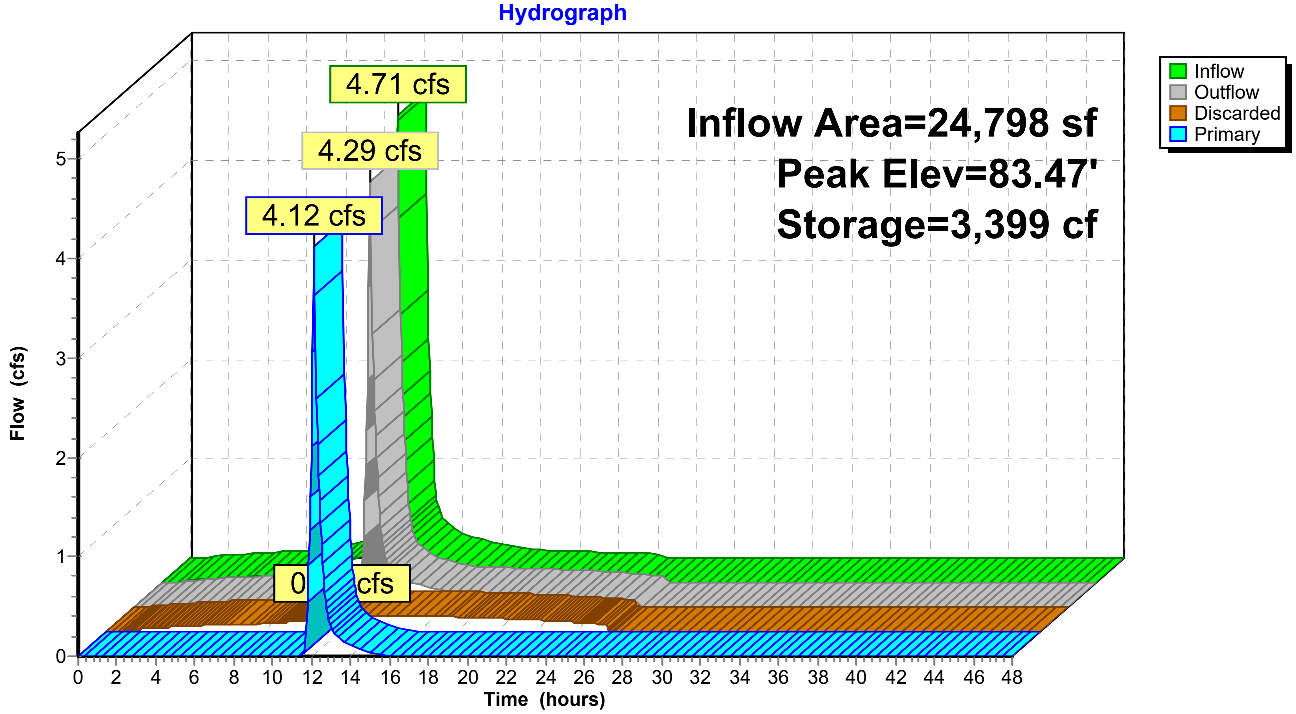
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
81.80	1,293	0	0
82.00	1,441	273	273
82.50	2,115	889	1,162
83.00	2,548	1,166	2,328
83.50	2,006	1,139	3,467
84.00	3,489	1,374	4,840

Device	Routing	Invert	Outlet Devices
#1	Discarded	81.80'	**2.400 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 75.00'
#2	Primary	83.00'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Discarded OutFlow Max=0.17 cfs @ 12.12 hrs HW=83.46' (Free Discharge)
└─**1=Exfiltration** (Controls 0.17 cfs)

Primary OutFlow Max=4.00 cfs @ 12.12 hrs HW=83.46' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 4.00 cfs @ 1.75 fps)

Pond 1P: Bioretention Area



Summary for Pond 4P: EX-UGIF

Inflow Area = 104,650 sf, 85.86% Impervious, Inflow Depth = 7.78" for 100-Year event
Inflow = 19.43 cfs @ 12.09 hrs, Volume= 67,832 cf
Outflow = 19.43 cfs @ 12.09 hrs, Volume= 67,454 cf, Atten= 0%, Lag= 0.0 min
Discarded = 0.01 cfs @ 12.09 hrs, Volume= 1,208 cf
Primary = 19.42 cfs @ 12.09 hrs, Volume= 66,245 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 83.63' @ 12.09 hrs Surf.Area= 854 sf Storage= 984 cf

Plug-Flow detention time= 20.5 min calculated for 67,454 cf (99% of inflow)
Center-of-Mass det. time= 16.8 min (780.3 - 763.5)

Volume	Invert	Avail.Storage	Storage Description
#1A	80.65'	557 cf	**12.13'W x 70.45'L x 2.06'H Field A** 1,758 cf Overall - 365 cf Embedded = 1,394 cf x 40.0% Voids
#2A	81.07'	364 cf	**CPP single-wall 12"** x 15 Inside #1 Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf Row Length Adjustment= +6.00' x 1.04 sf x 5 rows 10.13' Header x 1.04 sf x 2 = 21.1 cf Inside
#3	81.15'	101 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder** x 2 -Impervious
		1,022 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	80.80'	**1.020 in/hr Exfiltration over Wetted area above 80.80'** Conductivity to Groundwater Elevation = 79.00' Excluded Wetted area = 879 sf Phase-In= 0.01'
#2	Primary	82.50'	**999.000 in/hr Exfiltration over Wetted area above 82.50'** Conductivity to Groundwater Elevation = 75.00' Excluded Wetted area = 1,160 sf Phase-In= 0.10'
#3	Primary	83.00'	**10.0' long Sharp-Crested Rectangular Weir** 2 End Contraction(s) 0.5' Crest Height

Discarded OutFlow Max=0.01 cfs @ 12.09 hrs HW=83.62' (Free Discharge)
└─**1=Exfiltration** (Controls 0.01 cfs)

Primary OutFlow Max=18.89 cfs @ 12.09 hrs HW=83.62' (Free Discharge)
├─**2=Exfiltration** (Controls 0.90 cfs)
└─**3=Sharp-Crested Rectangular Weir** (Weir Controls 17.99 cfs @ 2.95 fps)

Pond 4P: EX-UGIF - Chamber Wizard Field A

Chamber Model = CPP single-wall 12" (Single-wall corrugated HDPE pipe)
Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
Row Length Adjustment= +6.00' x 1.04 sf x 5 rows

14.7" Wide + 12.0" Spacing = 26.7" C-C Row Spacing

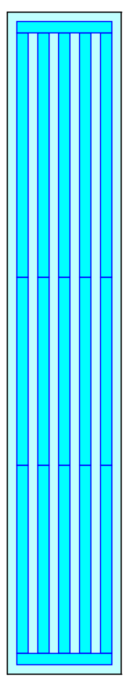
3 Chambers/Row x 20.00' Long +6.00' Row Adjustment +1.23' Header x 2 = 68.45' Row Length +12.0" End Stone x 2 = 70.45' Base Length
5 Rows x 14.7" Wide + 12.0" Spacing x 4 + 12.0" Side Stone x 2 = 12.13' Base Width
5.0" Stone Base + 14.7" Chamber Height + 5.0" Stone Cover = 2.06' Field Height

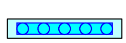
15 Chambers x 20.8 cf +6.00' Row Adjustment x 1.04 sf x 5 Rows + 10.13' Header x 1.04 sf x 2 = 364.5 cf Chamber Storage

1,758.2 cf Field - 364.5 cf Chambers = 1,393.8 cf Stone x 40.0% Voids = 557.5 cf Stone Storage

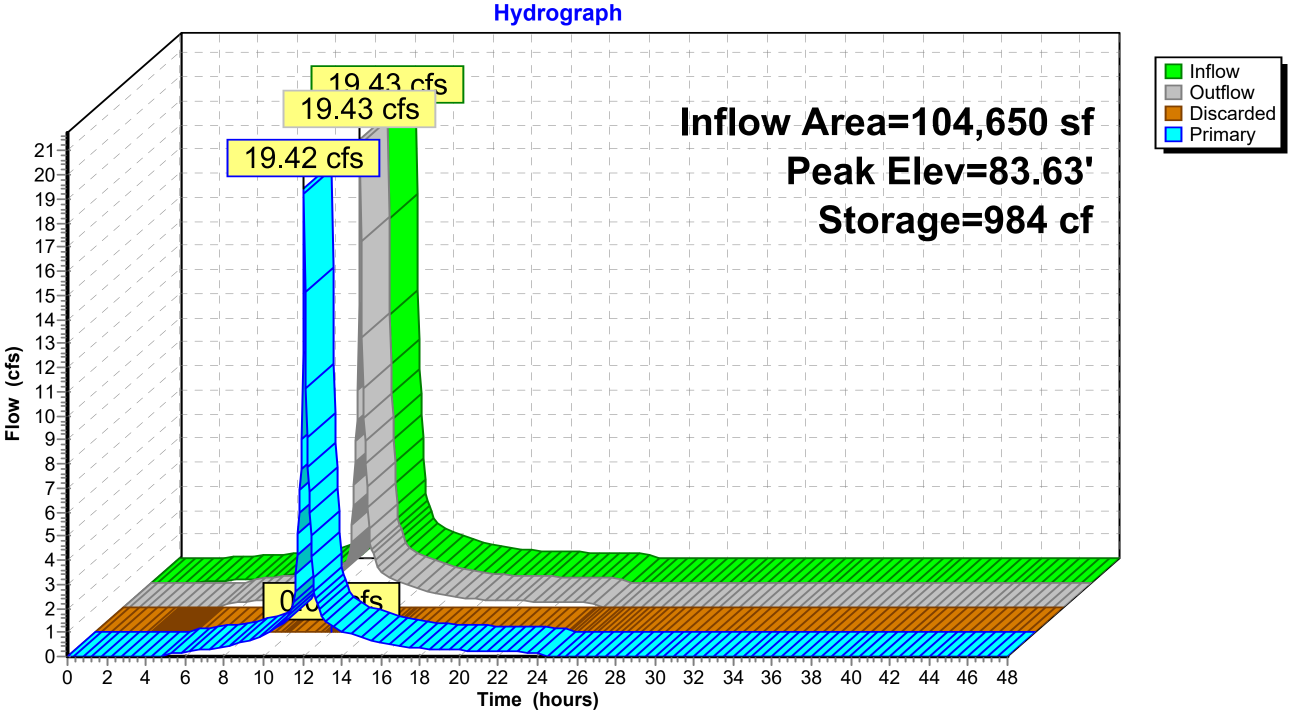
Chamber Storage + Stone Storage = 922.0 cf = 0.021 af
Overall Storage Efficiency = 52.4%
Overall System Size = 70.45' x 12.13' x 2.06'

15 Chambers
65.1 cy Field
51.6 cy Stone





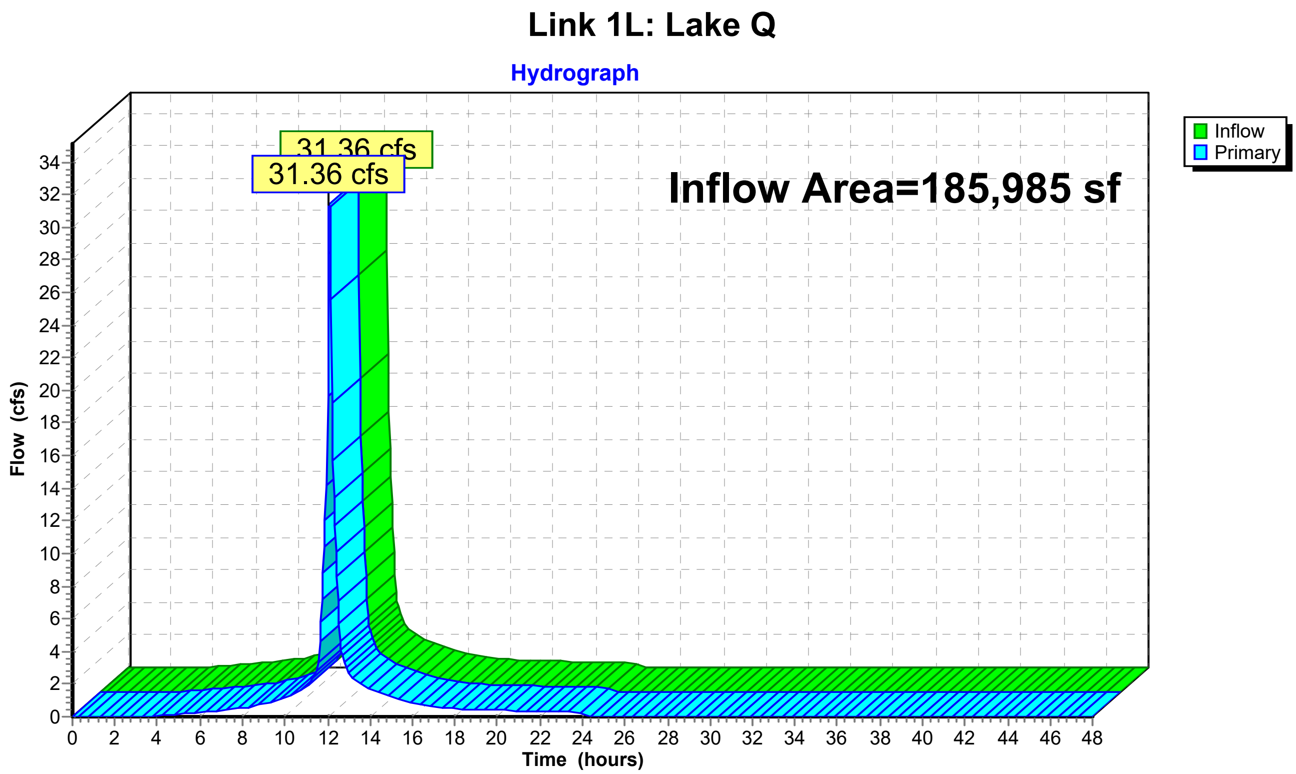
Pond 4P: EX-UGIF



Summary for Link 1L: Lake Q

Inflow Area = 185,985 sf, 75.70% Impervious, Inflow Depth = 6.57" for 100-Year event
Inflow = 31.36 cfs @ 12.09 hrs, Volume= 101,767 cf
Primary = 31.36 cfs @ 12.09 hrs, Volume= 101,767 cf, Atten= 0%, Lag= 0.0 min

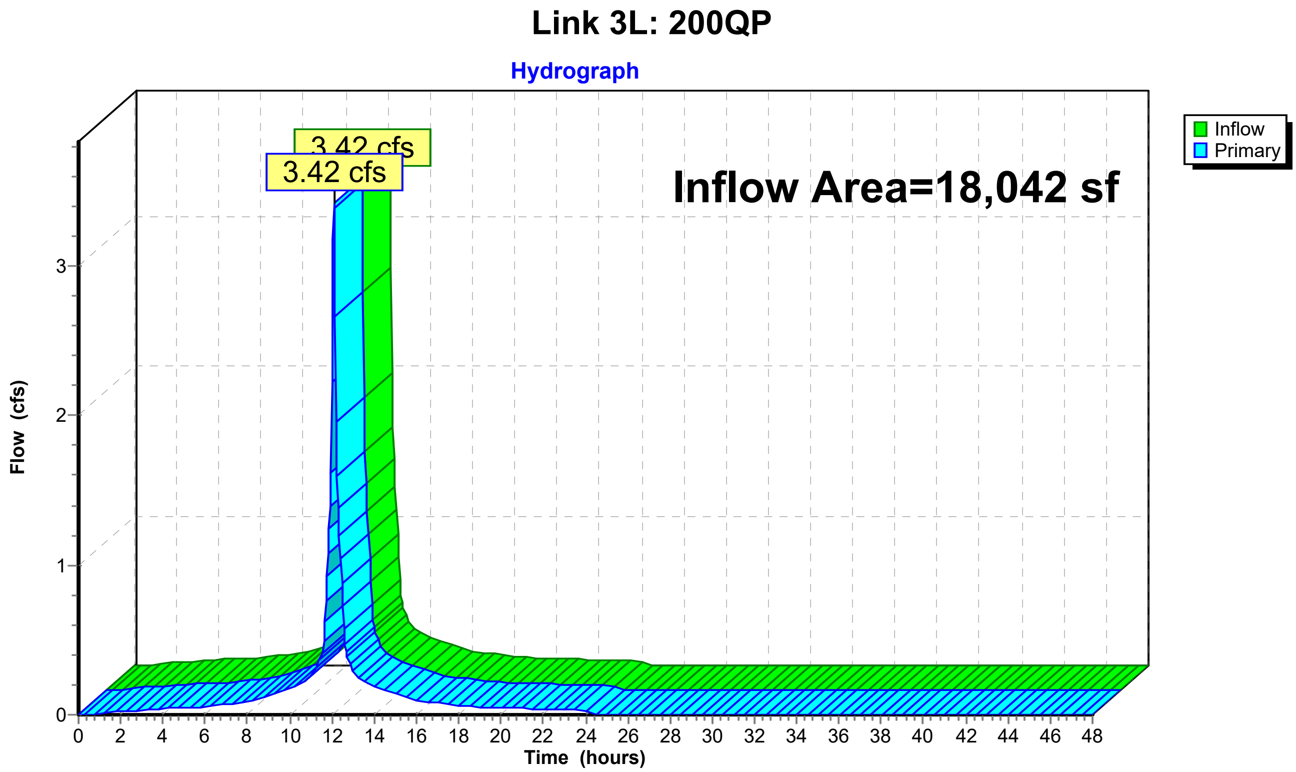
Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs



Summary for Link 3L: 200QP

Inflow Area = 18,042 sf,100.00% Impervious, Inflow Depth = 8.38" for 100-Year event
Inflow = 3.42 cfs @ 12.09 hrs, Volume= 12,599 cf
Primary = 3.42 cfs @ 12.09 hrs, Volume= 12,599 cf, Atten= 0%, Lag= 0.0 min
Routed to Link 1L : Lake Q

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.05 hrs



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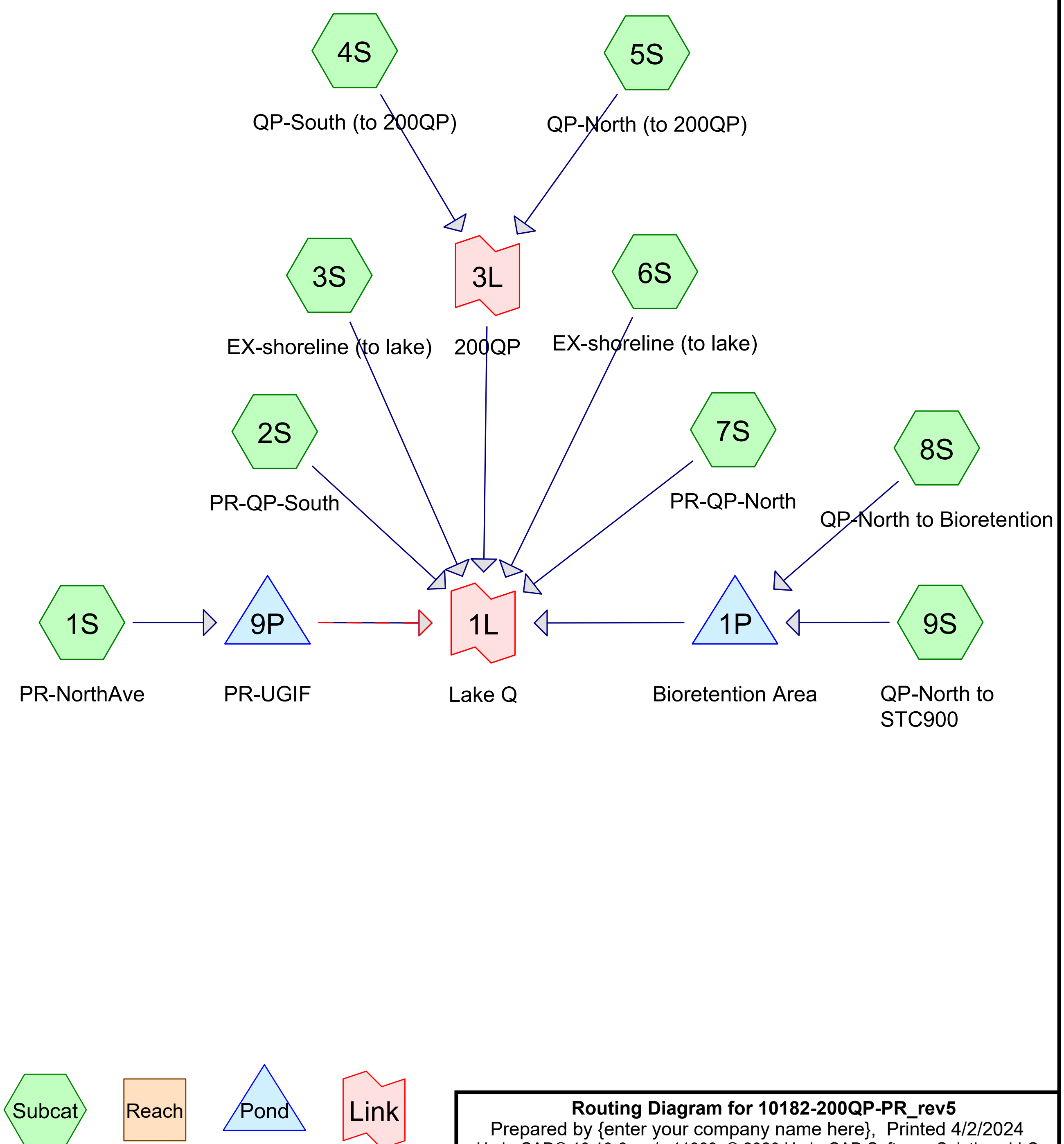
100-Year Event



Routing Diagram for 10182-200QP-PR_rev5
Prepared by {enter your company name here}, Printed 4/2/2024
HydroCAD® 10.10-6a s/n 11989 © 2020 HydroCAD Software Solutions LLC

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	Type III 24-hr		Default	24.00	1	3.16	2
2	10-Year	Type III 24-hr		Default	24.00	1	4.77	2
3	25-Year	Type III 24-hr		Default	24.00	1	6.03	2
4	100-Year	Type III 24-hr		Default	24.00	1	8.62	2

Area Listing (all nodes)

Area (sq-ft)	CN	Description (subcatchment-numbers)
46,918	61	>75% Grass cover, Good, HSG B (1S, 2S, 3S, 6S, 8S, 9S)
118,982	98	Paved parking, HSG B (1S, 2S, 4S, 5S, 7S, 8S, 9S)
18,439	98	Roofs, HSG B (1S, 2S)
1,646	98	Unconnected roofs, HSG B (3S)
185,985	**89**	**TOTAL AREA**

Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
185,985	HSG B	1S, 2S, 3S, 4S, 5S, 6S, 7S, 8S, 9S
0	HSG C	
0	HSG D	
0	Other	
185,985		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (sq-ft)	HSG-B (sq-ft)	HSG-C (sq-ft)	HSG-D (sq-ft)	Other (sq-ft)	Total (sq-ft)	Ground Cover	Sub Num
0	46,918	0	0	0	46,918	>75% Grass cover, Good	
0	118,982	0	0	0	118,982	Paved parking	
0	18,439	0	0	0	18,439	Roofs	
0	1,646	0	0	0	1,646	Unconnected roofs	
0	**185,985**	**0**	**0**	**0**	**185,985**	**TOTAL AREA**	

Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: PR-NorthAve Runoff Area=75,680 sf 81.45% Impervious Runoff Depth=2.22"
Tc=6.0 min CN=91 Runoff=4.45 cfs 14,005 cf

Subcatchment 2S: PR-QP-South Runoff Area=31,987 sf 99.70% Impervious Runoff Depth=2.93"
Tc=6.0 min CN=98 Runoff=2.25 cfs 7,804 cf

Subcatchment 3S: EX-shoreline (to lake) Runoff Area=18,044 sf 9.12% Impervious Runoff Depth=0.50"
Tc=6.0 min UI Adjusted CN=63 Runoff=0.17 cfs 754 cf

Subcatchment 4S: QP-South (to 200QP) Runoff Area=4,767 sf 100.00% Impervious Runoff Depth=2.93"
Tc=6.0 min CN=98 Runoff=0.34 cfs 1,163 cf

Subcatchment 5S: QP-North (to 200QP) Runoff Area=6,427 sf 100.00% Impervious Runoff Depth=2.93"
Tc=6.0 min CN=98 Runoff=0.45 cfs 1,568 cf

Subcatchment 6S: EX-shoreline (to lake) Runoff Area=14,077 sf 0.00% Impervious Runoff Depth=0.43"
Tc=6.0 min CN=61 Runoff=0.10 cfs 502 cf

Subcatchment 7S: PR-QP-North Runoff Area=9,060 sf 100.00% Impervious Runoff Depth=2.93"
Tc=6.0 min CN=98 Runoff=0.64 cfs 2,210 cf

Subcatchment 8S: QP-North to Runoff Area=10,224 sf 86.64% Impervious Runoff Depth=2.41"
Tc=6.0 min CN=93 Runoff=0.64 cfs 2,051 cf

Subcatchment 9S: EX-NWofQP Runoff Area=15,719 sf 94.00% Impervious Runoff Depth=2.71"
Tc=6.0 min CN=96 Runoff=1.07 cfs 3,549 cf

Pond 1P: Bioretention Area Peak Elev=83.00' Storage=2,331 cf Inflow=1.71 cfs 5,601 cf
Discarded=0.16 cfs 5,600 cf Primary=0.00 cfs 1 cf Outflow=0.16 cfs 5,601 cf

Pond 9P: PR-UGIF Peak Elev=83.79' Storage=1,249 cf Inflow=4.45 cfs 14,005 cf
Discarded=0.05 cfs 3,688 cf Primary=4.32 cfs 10,315 cf Secondary=0.00 cfs 0 cf Outflow=4.37 cfs 14,003 cf

Link 1L: Lake Q Inflow=8.22 cfs 24,316 cf
Primary=8.22 cfs 24,316 cf

Link 3L: 200QP Inflow=0.79 cfs 2,731 cf
Primary=0.79 cfs 2,731 cf

Total Runoff Area = 185,985 sf Runoff Volume = 33,607 cf Average Runoff Depth = 2.17"
25.23% Pervious = 46,918 sf 74.77% Impervious = 139,067 sf

Summary for Subcatchment 1S: PR-NorthAve

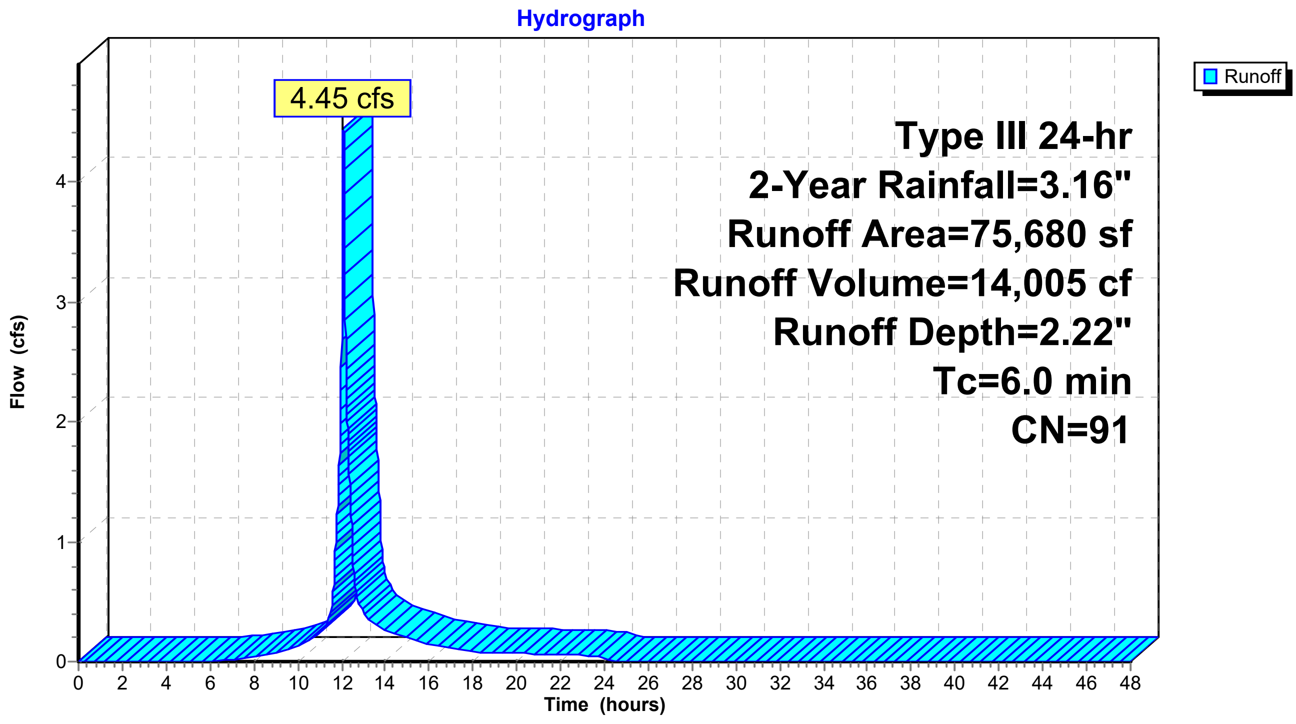
Runoff = 4.45 cfs @ 12.09 hrs, Volume= 14,005 cf, Depth= 2.22"
Routed to Pond 9P : PR-UGIF

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
44,161	98	Paved parking, HSG B
17,482	98	Roofs, HSG B
14,037	61	>75% Grass cover, Good, HSG B
75,680	91	Weighted Average
14,037		18.55% Pervious Area
61,643		81.45% Impervious Area

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

Subcatchment 1S: PR-NorthAve



Summary for Subcatchment 2S: PR-QP-South

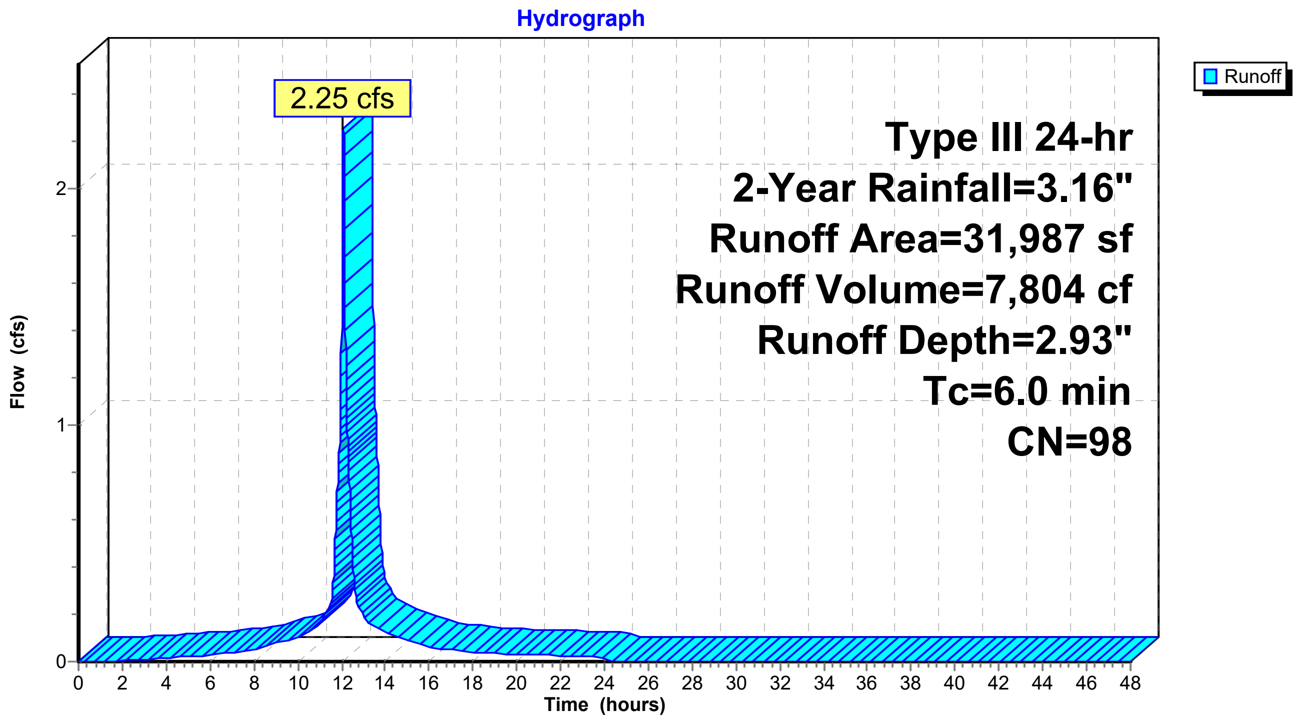
Runoff = 2.25 cfs @ 12.08 hrs, Volume= 7,804 cf, Depth= 2.93"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
30,933	98	Paved parking, HSG B
957	98	Roofs, HSG B
97	61	>75% Grass cover, Good, HSG B
31,987	98	Weighted Average
97		0.30% Pervious Area
31,890		99.70% Impervious Area

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

Subcatchment 2S: PR-QP-South



Summary for Subcatchment 3S: EX-shoreline (to lake)

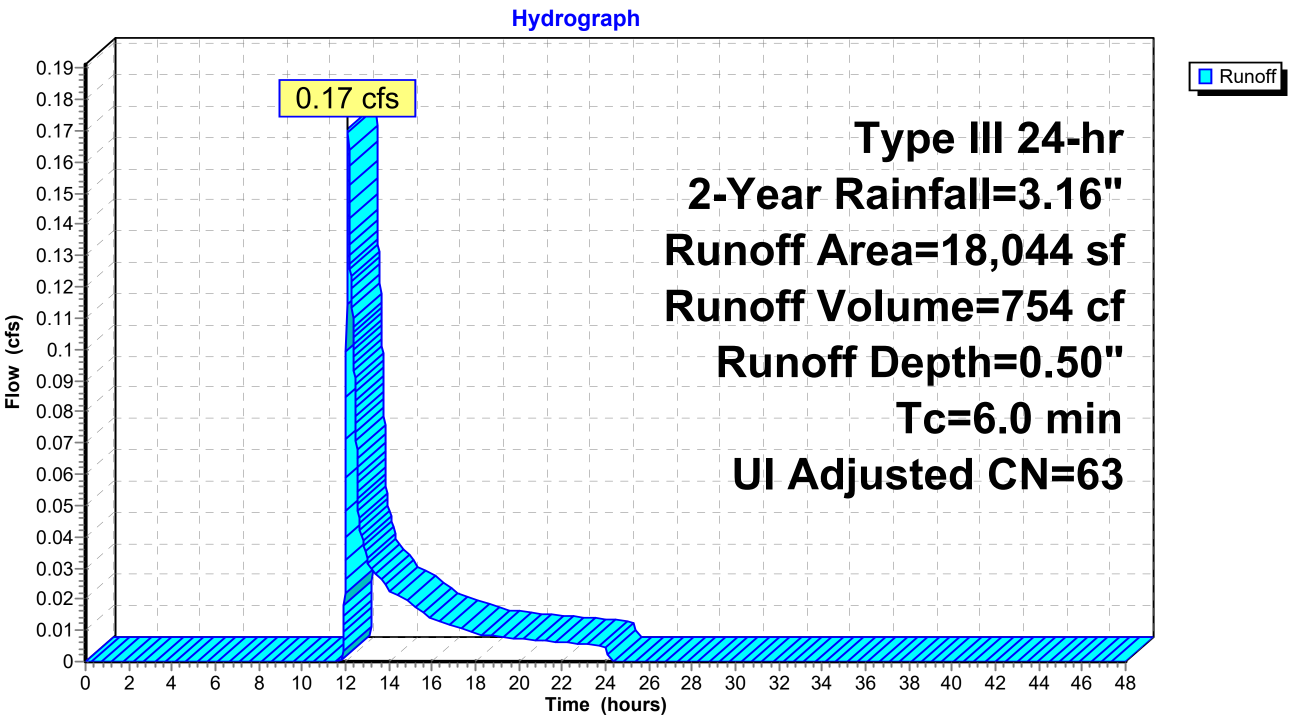
Runoff = 0.17 cfs @ 12.11 hrs, Volume= 754 cf, Depth= 0.50"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Adj	Description
16,398	61		>75% Grass cover, Good, HSG B
1,646	98		Unconnected roofs, HSG B
18,044	64	63	Weighted Average, UI Adjusted
16,398			90.88% Pervious Area
1,646			9.12% Impervious Area
1,646			100.00% Unconnected

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

Subcatchment 3S: EX-shoreline (to lake)



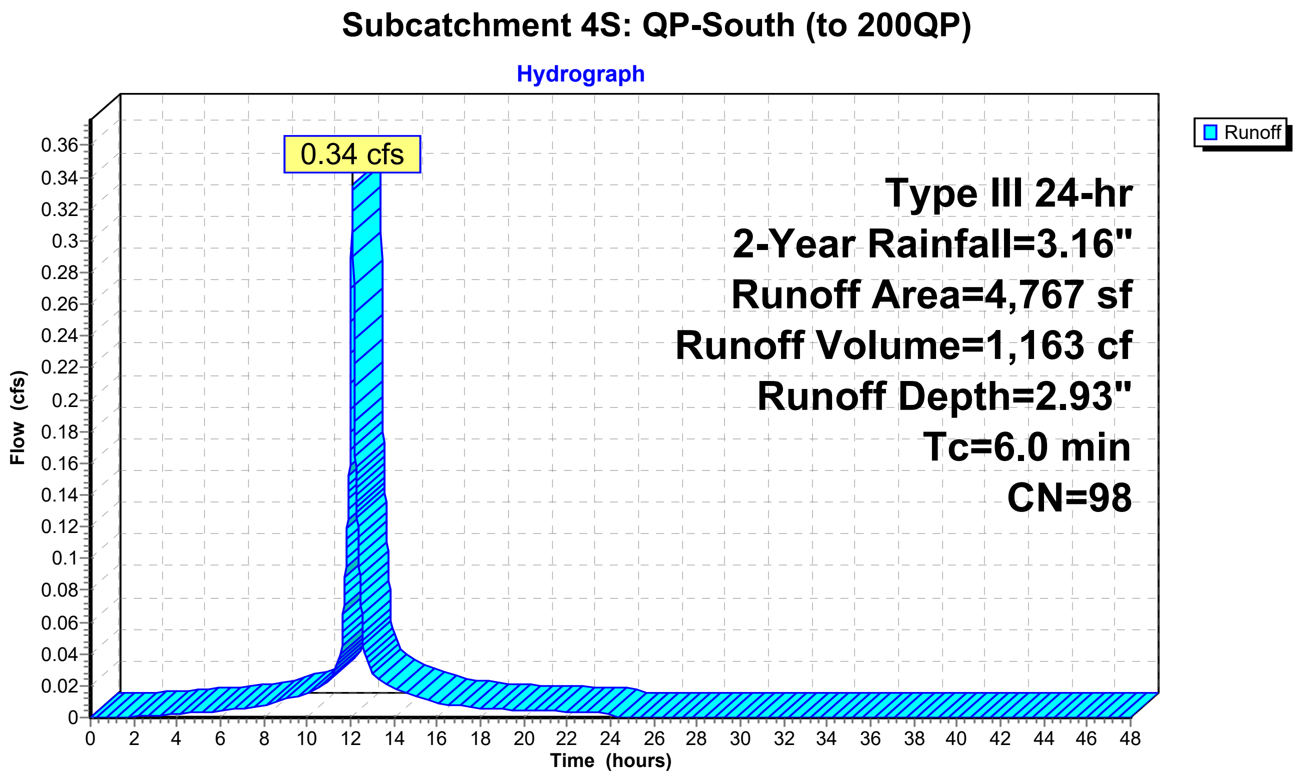
Summary for Subcatchment 4S: QP-South (to 200QP)

Runoff = 0.34 cfs @ 12.08 hrs, Volume= 1,163 cf, Depth= 2.93"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
4,767	98	Paved parking, HSG B
4,767		100.00% Impervious Area

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



Summary for Subcatchment 5S: QP-North (to 200QP)

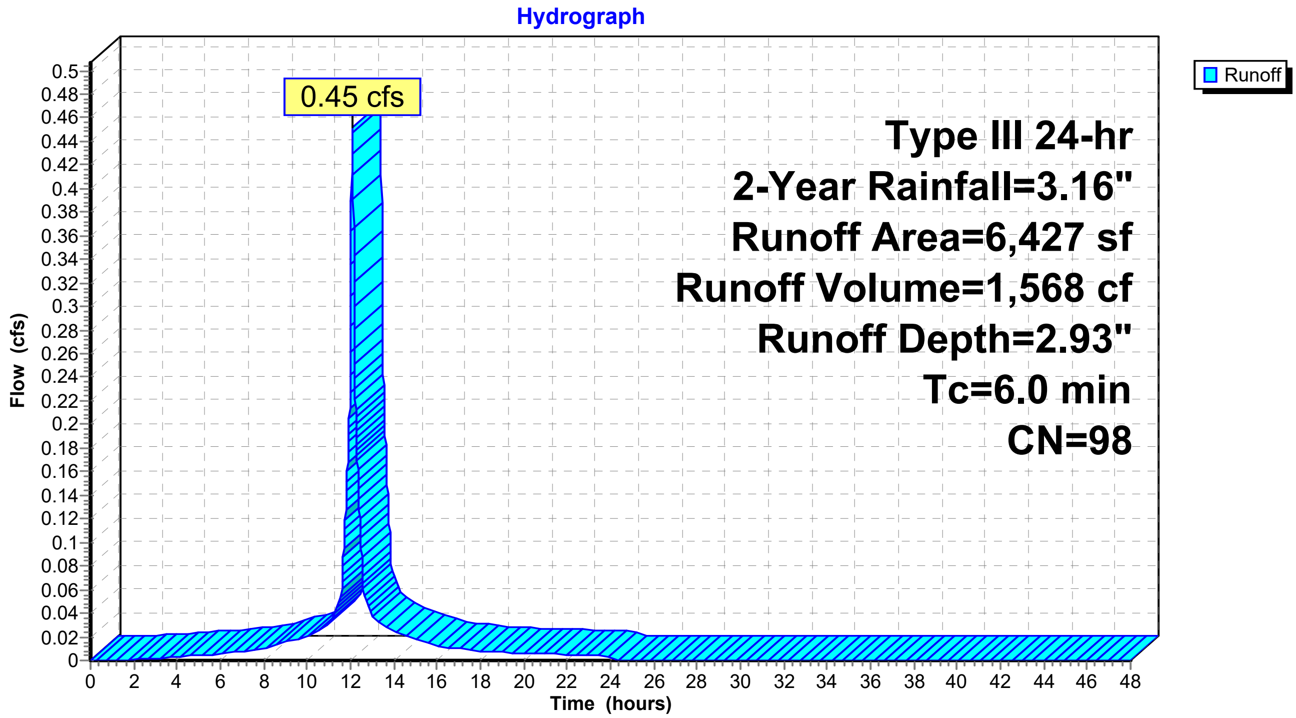
Runoff = 0.45 cfs @ 12.08 hrs, Volume= 1,568 cf, Depth= 2.93"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
6,427	98	Paved parking, HSG B
6,427		100.00% Impervious Area

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

Subcatchment 5S: QP-North (to 200QP)



Summary for Subcatchment 6S: EX-shoreline (to lake)

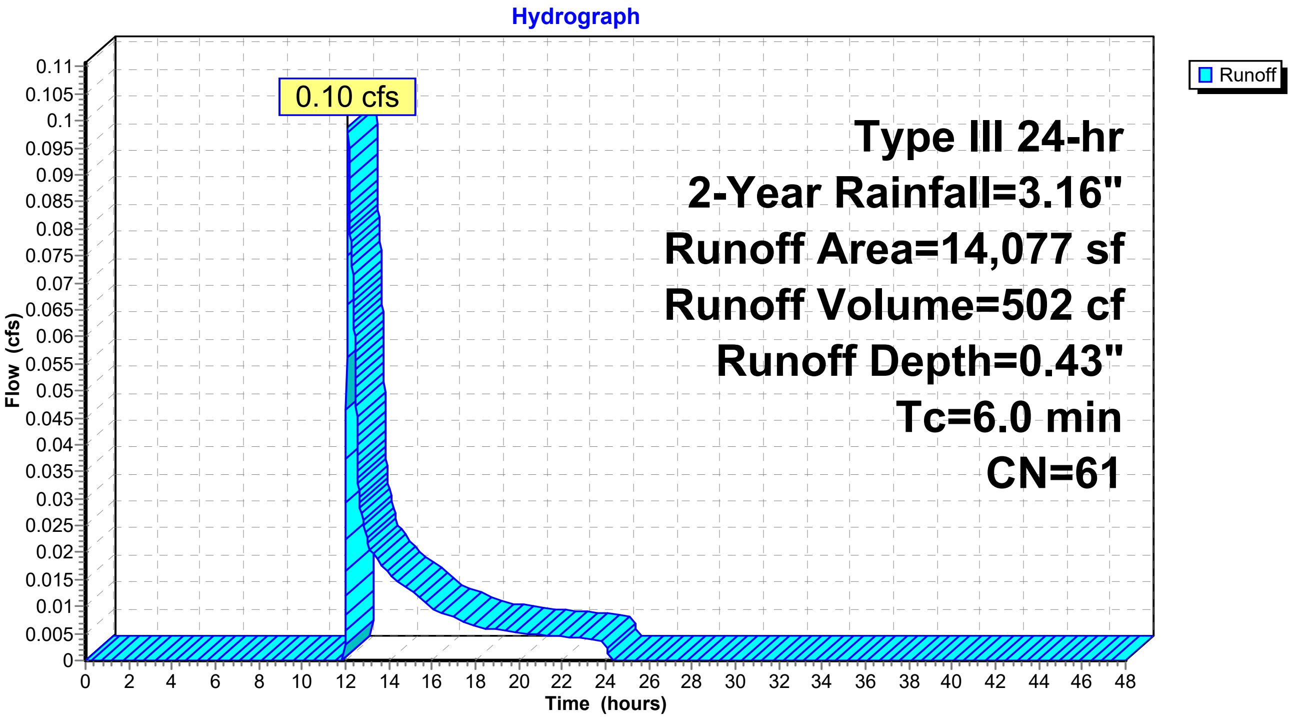
Runoff = 0.10 cfs @ 12.12 hrs, Volume= 502 cf, Depth= 0.43"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
14,077	61	>75% Grass cover, Good, HSG B
14,077		100.00% Pervious Area

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

Subcatchment 6S: EX-shoreline (to lake)



Summary for Subcatchment 7S: PR-QP-North

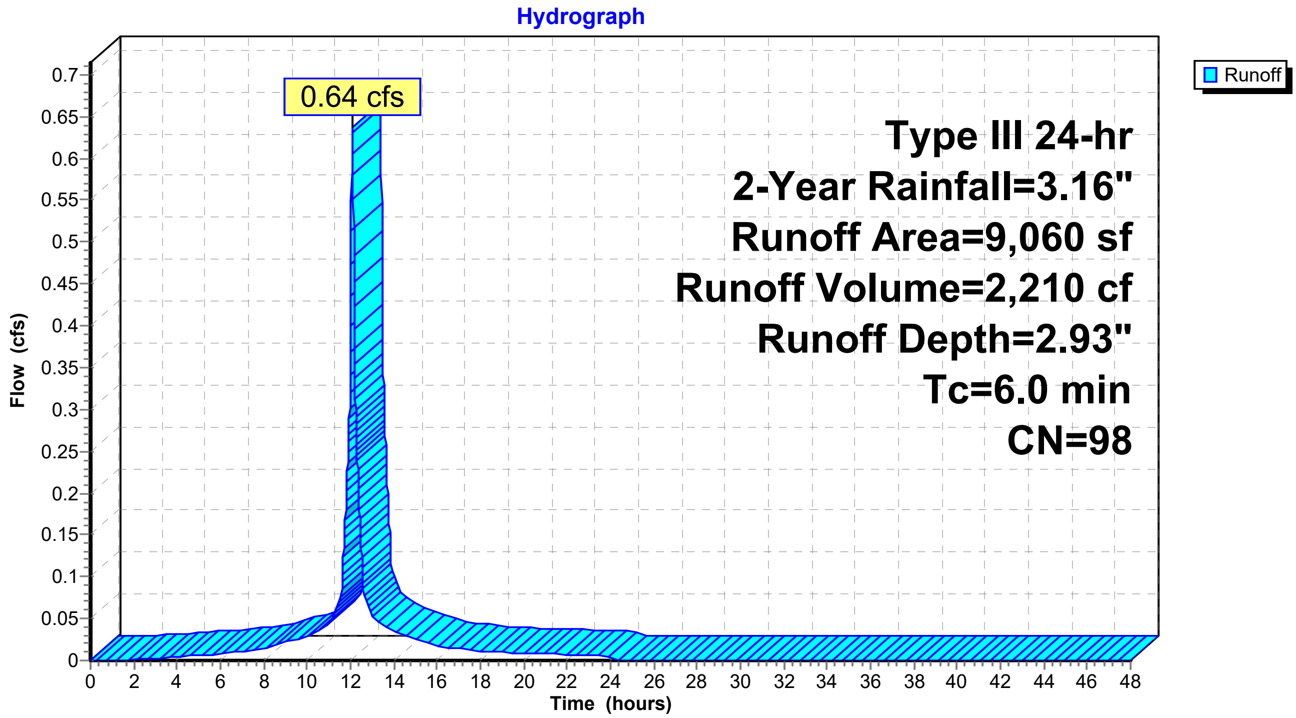
Runoff = 0.64 cfs @ 12.08 hrs, Volume= 2,210 cf, Depth= 2.93"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
9,060	98	Paved parking, HSG B
9,060		100.00% Impervious Area

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

Subcatchment 7S: PR-QP-North



Summary for Subcatchment 8S: QP-North to Bioretention

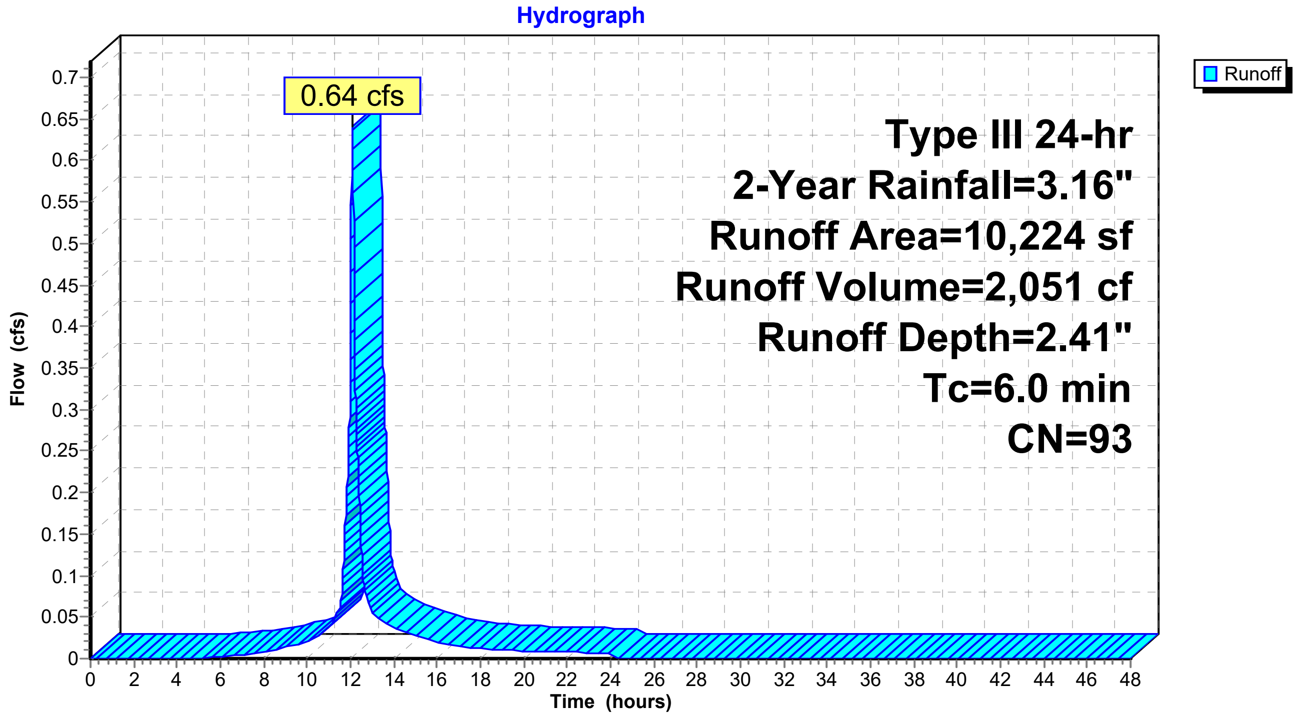
Runoff = 0.64 cfs @ 12.09 hrs, Volume= 2,051 cf, Depth= 2.41"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
8,858	98	Paved parking, HSG B
1,366	61	>75% Grass cover, Good, HSG B
10,224	93	Weighted Average
1,366		13.36% Pervious Area
8,858		86.64% Impervious Area

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

Subcatchment 8S: QP-North to Bioretention



Summary for Subcatchment 9S: EX-NWofQP

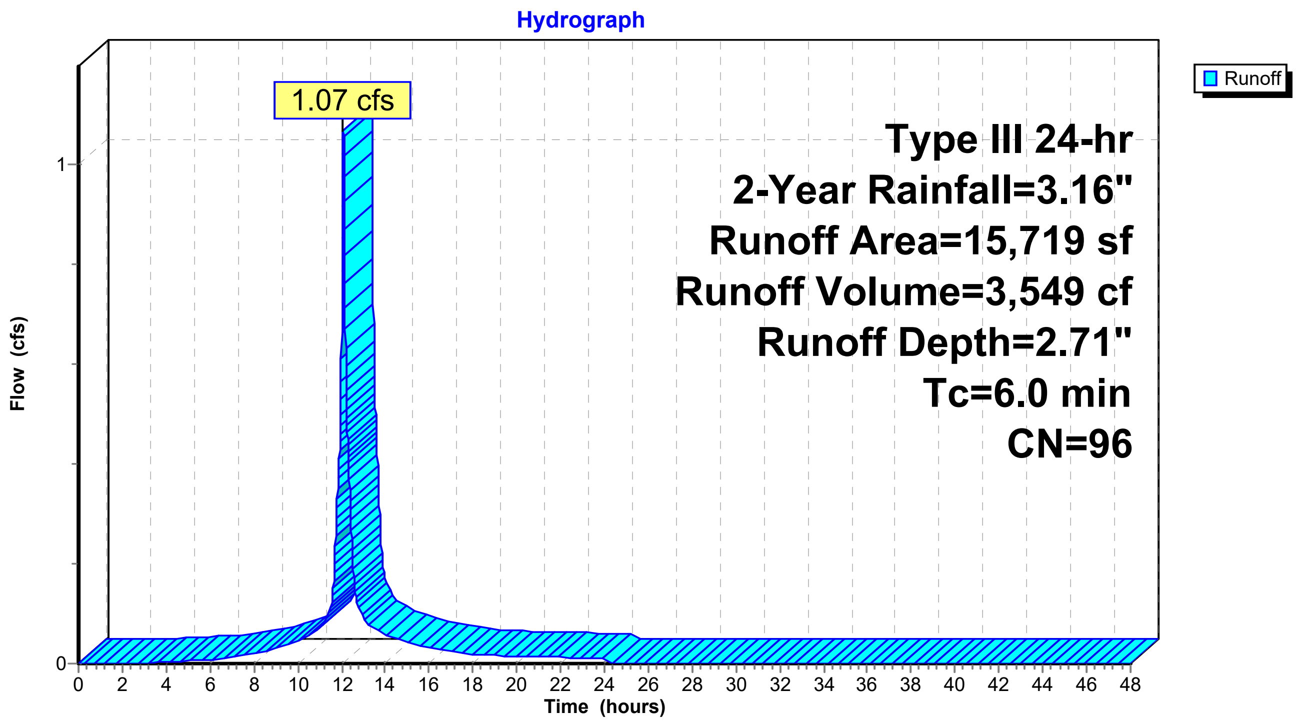
Runoff = 1.07 cfs @ 12.08 hrs, Volume= 3,549 cf, Depth= 2.71"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.16"

Area (sf)	CN	Description
14,776	98	Paved parking, HSG B
943	61	>75% Grass cover, Good, HSG B
15,719	96	Weighted Average
943		6.00% Pervious Area
14,776		94.00% Impervious Area

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

Subcatchment 9S: EX-NWofQP



Summary for Pond 1P: Bioretention Area

Inflow Area = 25,943 sf, 91.10% Impervious, Inflow Depth = 2.59" for 2-Year event
Inflow = 1.71 cfs @ 12.08 hrs, Volume= 5,601 cf
Outflow = 0.16 cfs @ 12.92 hrs, Volume= 5,601 cf, Atten= 91%, Lag= 50.3 min
Discarded = 0.16 cfs @ 13.02 hrs, Volume= 5,600 cf
Primary = 0.00 cfs @ 12.92 hrs, Volume= 1 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 83.00' @ 12.92 hrs Surf.Area= 2,547 sf Storage= 2,331 cf

Plug-Flow detention time= 137.1 min calculated for 5,599 cf (100% of inflow)
Center-of-Mass det. time= 137.1 min (918.4 - 781.3)

Volume	Invert	Avail.Storage	Storage Description
#1	81.80'	4,840 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

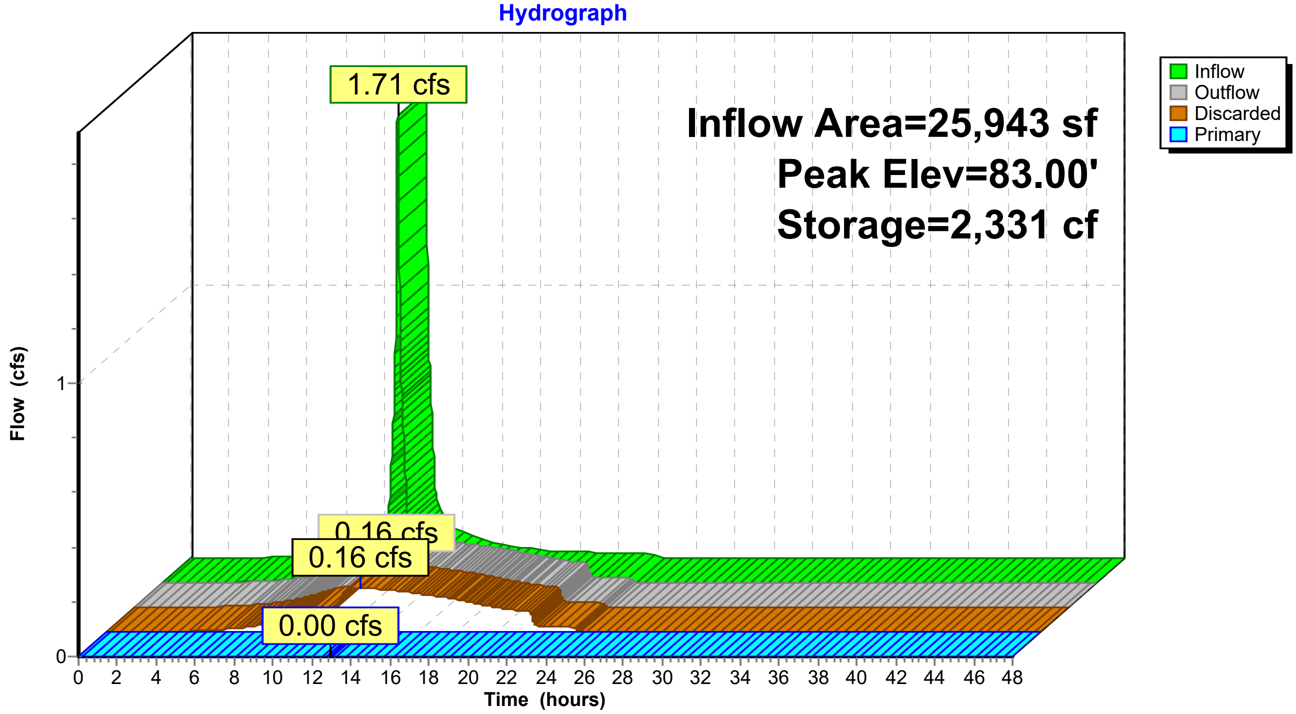
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
81.80	1,293	0	0
82.00	1,441	273	273
82.50	2,115	889	1,162
83.00	2,548	1,166	2,328
83.50	2,006	1,139	3,467
84.00	3,489	1,374	4,840

Device	Routing	Invert	Outlet Devices
#1	Discarded	81.80'	**2.400 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 75.00'
#2	Primary	83.00'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Discarded OutFlow Max=0.16 cfs @ 13.02 hrs HW=83.00' (Free Discharge)
└**1=Exfiltration** (Controls 0.16 cfs)

Primary OutFlow Max=0.00 cfs @ 12.92 hrs HW=83.00' (Free Discharge)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 0.00 cfs @ 0.08 fps)

Pond 1P: Bioretention Area



Summary for Pond 9P: PR-UGIF

Inflow Area = 75,680 sf, 81.45% Impervious, Inflow Depth = 2.22" for 2-Year event
Inflow = 4.45 cfs @ 12.09 hrs, Volume= 14,005 cf
Outflow = 4.37 cfs @ 12.10 hrs, Volume= 14,003 cf, Atten= 2%, Lag= 0.9 min
Discarded = 0.05 cfs @ 12.10 hrs, Volume= 3,688 cf
Primary = 4.32 cfs @ 12.10 hrs, Volume= 10,315 cf
Routed to Link 1L : Lake Q
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 83.79' @ 12.10 hrs Surf.Area= 1,097 sf Storage= 1,249 cf

Plug-Flow detention time= 87.7 min calculated for 14,003 cf (100% of inflow)
Center-of-Mass det. time= 87.6 min (890.6 - 802.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	80.85'	715 cf	**12.13'W x 90.45'L x 2.06'H Field A** 2,257 cf Overall - 469 cf Embedded = 1,789 cf x 40.0% Voids
#2A	81.35'	469 cf	**CPP single-wall 12"** x 20 Inside #1 Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf Row Length Adjustment= +6.00' x 1.04 sf x 5 rows 10.13' Header x 1.04 sf x 2 = 21.1 cf Inside
#3	83.50'	1,796 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc) -Impervious
#4	80.65'	50 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder**-Impervious
#5	80.85'	9 cf	**2.00'D x 3.00'H Vertical Cone/Cylinder**-Impervious
		3,040 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
83.50	0	0	0
83.72	4	0	0
84.00	1,921	270	270
84.20	5,561	748	1,018
84.30	10,000	778	1,796

Device	Routing	Invert	Outlet Devices
#1	Discarded	80.85'	**1.020 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 75.00' Phase-In= 0.01'
#2	Secondary	84.20'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#3	Primary	82.50'	**45.0 deg Sharp-Crested Vee/Trap Weir** Cv= 2.56 (C= 3.20)
#4	Primary	83.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.05 cfs @ 12.10 hrs HW=83.79' (Free Discharge)
└─**1=Exfiltration** (Controls 0.05 cfs)

Primary OutFlow Max=4.32 cfs @ 12.10 hrs HW=83.79' (Free Discharge)
├─**3=Sharp-Crested Vee/Trap Weir** (Weir Controls 1.99 cfs @ 2.90 fps)
└─**4=Orifice/Grate** (Orifice Controls 2.33 cfs @ 4.27 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=80.65' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 9P: PR-UGIF - Chamber Wizard Field A

Chamber Model = CPP single-wall 12" (Single-wall corrugated HDPE pipe)
Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
Row Length Adjustment= +6.00' x 1.04 sf x 5 rows

14.7" Wide + 12.0" Spacing = 26.7" C-C Row Spacing

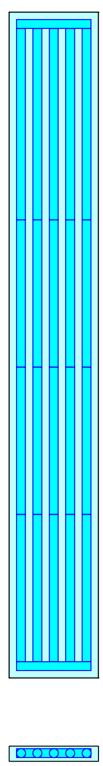
4 Chambers/Row x 20.00' Long +6.00' Row Adjustment +1.23' Header x 2 = 88.45' Row Length +12.0" End Stone x 2 = 90.45' Base Length
5 Rows x 14.7" Wide + 12.0" Spacing x 4 + 12.0" Side Stone x 2 = 12.13' Base Width
6.0" Stone Base + 14.7" Chamber Height + 4.0" Stone Cover = 2.06' Field Height

20 Chambers x 20.8 cf +6.00' Row Adjustment x 1.04 sf x 5 Rows + 10.13' Header x 1.04 sf x 2 = 468.6 cf Chamber Storage

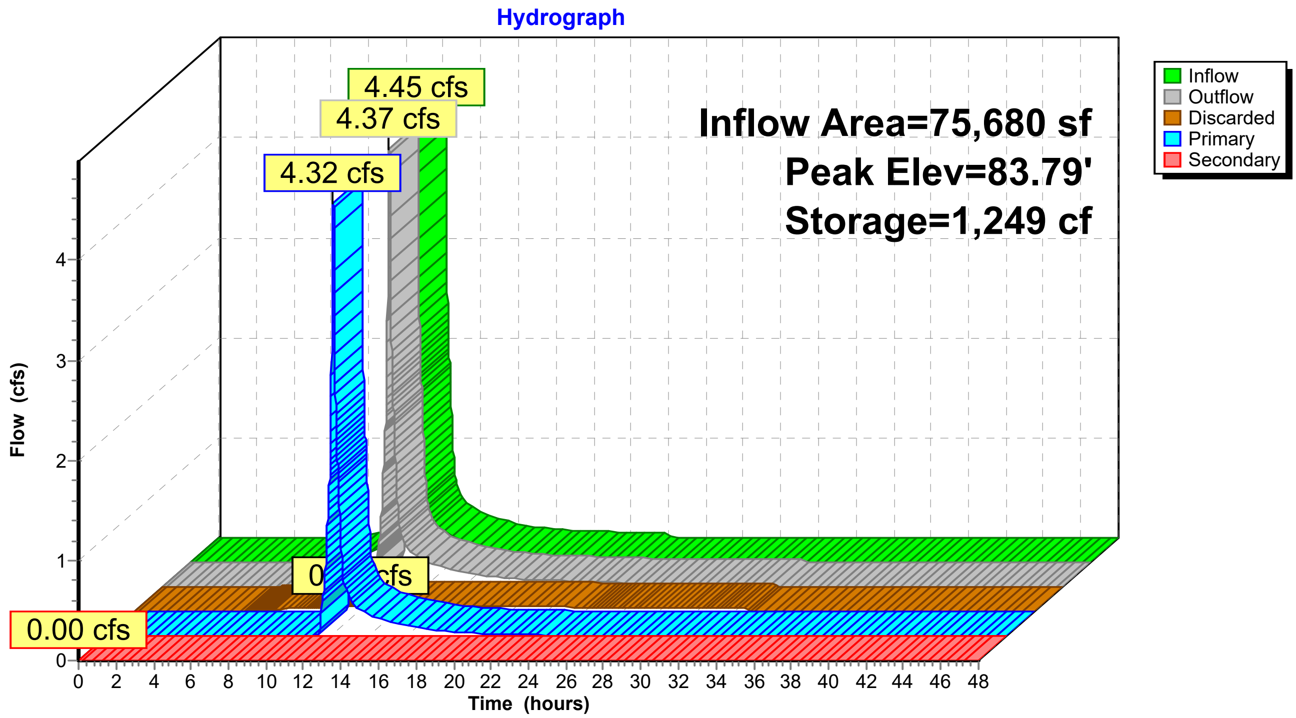
2,257.4 cf Field - 468.6 cf Chambers = 1,788.8 cf Stone x 40.0% Voids = 715.5 cf Stone Storage

Chamber Storage + Stone Storage = 1,184.1 cf = 0.027 af
Overall Storage Efficiency = 52.5%
Overall System Size = 90.45' x 12.13' x 2.06'

20 Chambers
83.6 cy Field
66.3 cy Stone



Pond 9P: PR-UGIF

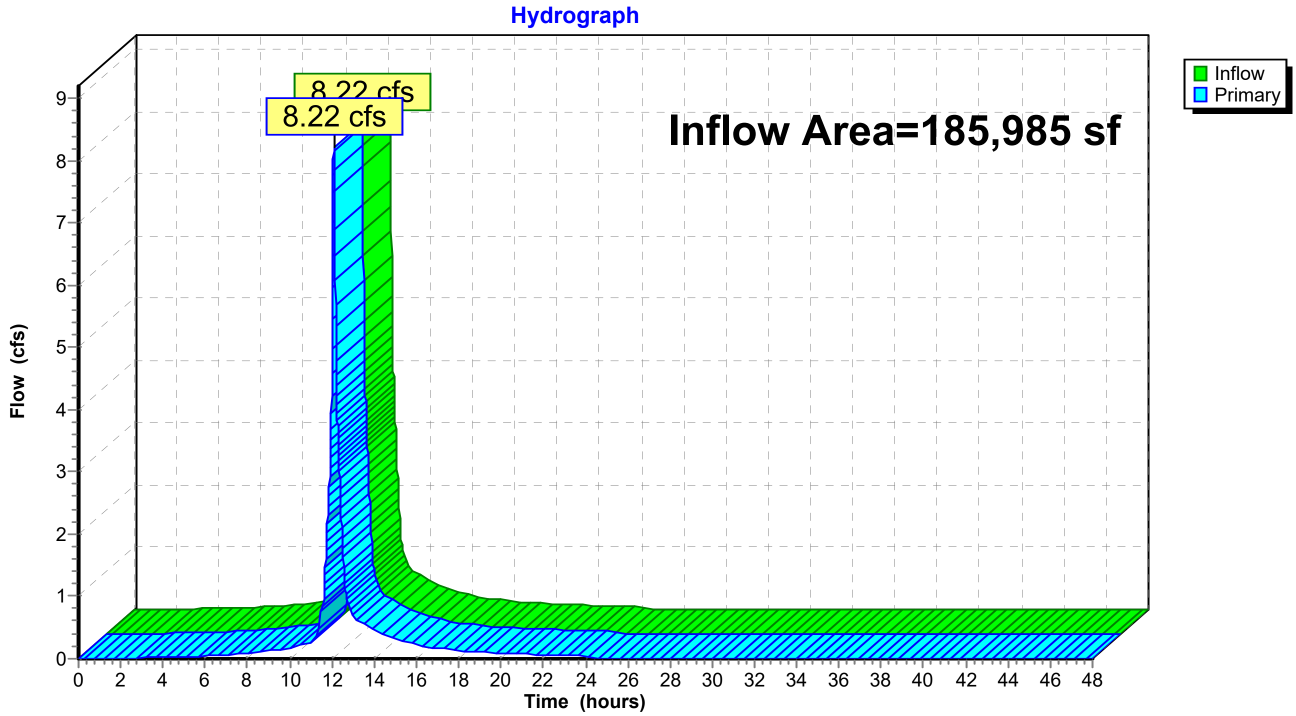


Summary for Link 1L: Lake Q

Inflow Area =	185,985 sf,	74.77% Impervious,	Inflow Depth = 1.57"	for 2-Year event
Inflow =	8.22 cfs @	12.09 hrs, Volume=	24,316 cf	
Primary =	8.22 cfs @	12.09 hrs, Volume=	24,316 cf, Atten= 0%, Lag= 0.0 min	

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

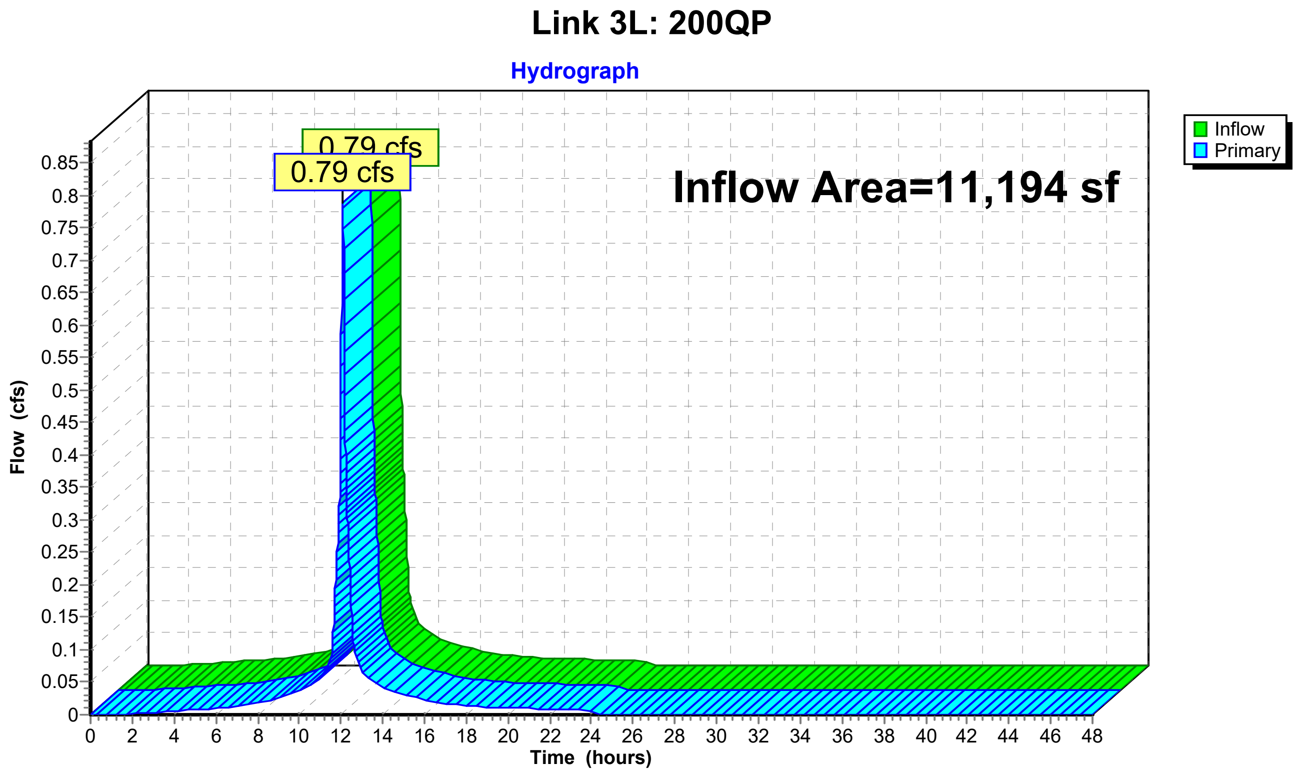
Link 1L: Lake Q



Summary for Link 3L: 200QP

Inflow Area = 11,194 sf,100.00% Impervious, Inflow Depth = 2.93" for 2-Year event
Inflow = 0.79 cfs @ 12.08 hrs, Volume= 2,731 cf
Primary = 0.79 cfs @ 12.08 hrs, Volume= 2,731 cf, Atten= 0%, Lag= 0.0 min
Routed to Link 1L : Lake Q

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs



Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: PR-NorthAve Runoff Area=75,680 sf 81.45% Impervious Runoff Depth=3.76"
Tc=6.0 min CN=91 Runoff=7.35 cfs 23,707 cf

Subcatchment 2S: PR-QP-South Runoff Area=31,987 sf 99.70% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=98 Runoff=3.42 cfs 12,085 cf

Subcatchment 3S: EX-shoreline (to lake) Runoff Area=18,044 sf 9.12% Impervious Runoff Depth=1.37"
Tc=6.0 min UI Adjusted CN=63 Runoff=0.61 cfs 2,053 cf

Subcatchment 4S: QP-South (to 200QP) Runoff Area=4,767 sf 100.00% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=98 Runoff=0.51 cfs 1,801 cf

Subcatchment 5S: QP-North (to 200QP) Runoff Area=6,427 sf 100.00% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=98 Runoff=0.69 cfs 2,428 cf

Subcatchment 6S: EX-shoreline (to lake) Runoff Area=14,077 sf 0.00% Impervious Runoff Depth=1.23"
Tc=6.0 min CN=61 Runoff=0.42 cfs 1,447 cf

Subcatchment 7S: PR-QP-North Runoff Area=9,060 sf 100.00% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=98 Runoff=0.97 cfs 3,423 cf

Subcatchment 8S: QP-North to Runoff Area=10,224 sf 86.64% Impervious Runoff Depth=3.97"
Tc=6.0 min CN=93 Runoff=1.03 cfs 3,384 cf

Subcatchment 9S: EX-NWofQP Runoff Area=15,719 sf 94.00% Impervious Runoff Depth=4.30"
Tc=6.0 min CN=96 Runoff=1.65 cfs 5,638 cf

Pond 1P: Bioretention Area Peak Elev=83.22' Storage=2,858 cf Inflow=2.68 cfs 9,022 cf
Discarded=0.16 cfs 7,011 cf Primary=1.22 cfs 2,011 cf Outflow=1.38 cfs 9,022 cf

Pond 9P: PR-UGIF Peak Elev=84.09' Storage=1,753 cf Inflow=7.35 cfs 23,707 cf
Discarded=0.05 cfs 4,051 cf Primary=6.12 cfs 19,659 cf Secondary=0.00 cfs 0 cf Outflow=6.17 cfs 23,710 cf

Link 1L: Lake Q Inflow=12.66 cfs 44,906 cf
Primary=12.66 cfs 44,906 cf

Link 3L: 200QP Inflow=1.20 cfs 4,229 cf
Primary=1.20 cfs 4,229 cf

Total Runoff Area = 185,985 sf Runoff Volume = 55,965 cf Average Runoff Depth = 3.61"
25.23% Pervious = 46,918 sf 74.77% Impervious = 139,067 sf

Summary for Subcatchment 1S: PR-NorthAve

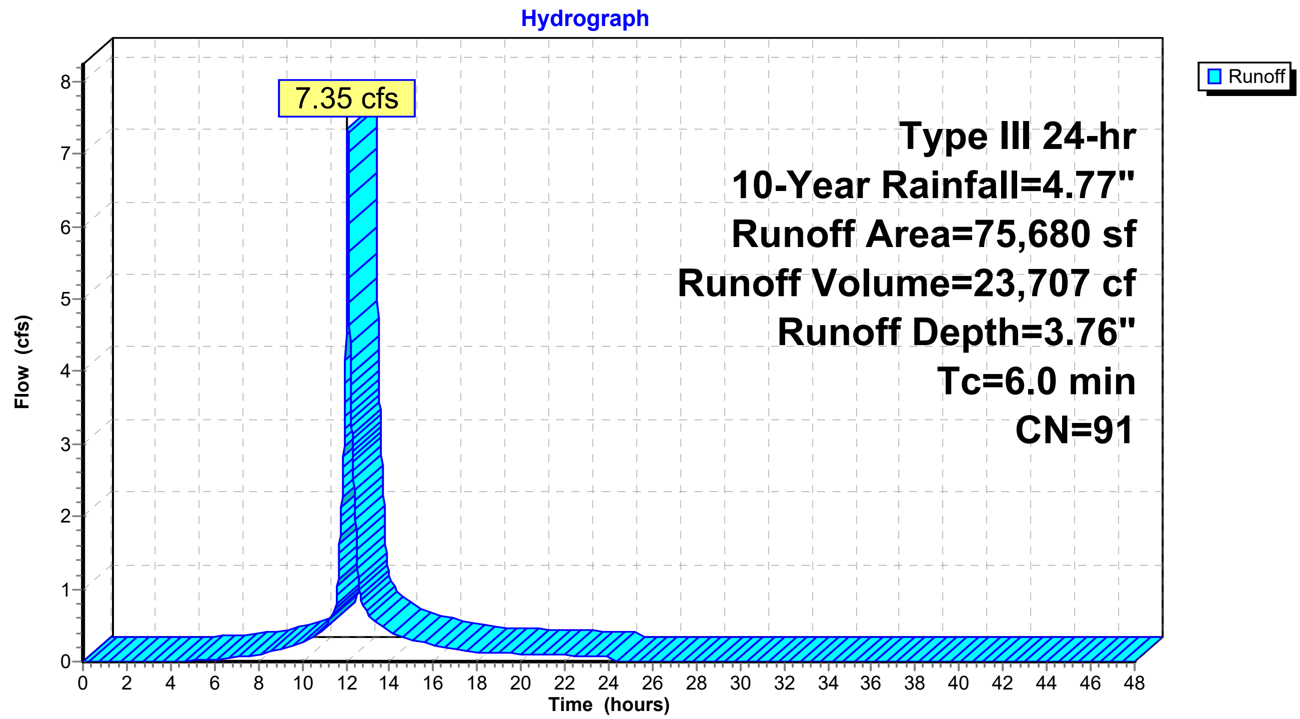
Runoff = 7.35 cfs @ 12.08 hrs, Volume= 23,707 cf, Depth= 3.76"
Routed to Pond 9P : PR-UGIF

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
44,161	98	Paved parking, HSG B
17,482	98	Roofs, HSG B
14,037	61	>75% Grass cover, Good, HSG B
75,680	91	Weighted Average
14,037		18.55% Pervious Area
61,643		81.45% Impervious Area

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

Subcatchment 1S: PR-NorthAve



Summary for Subcatchment 2S: PR-QP-South

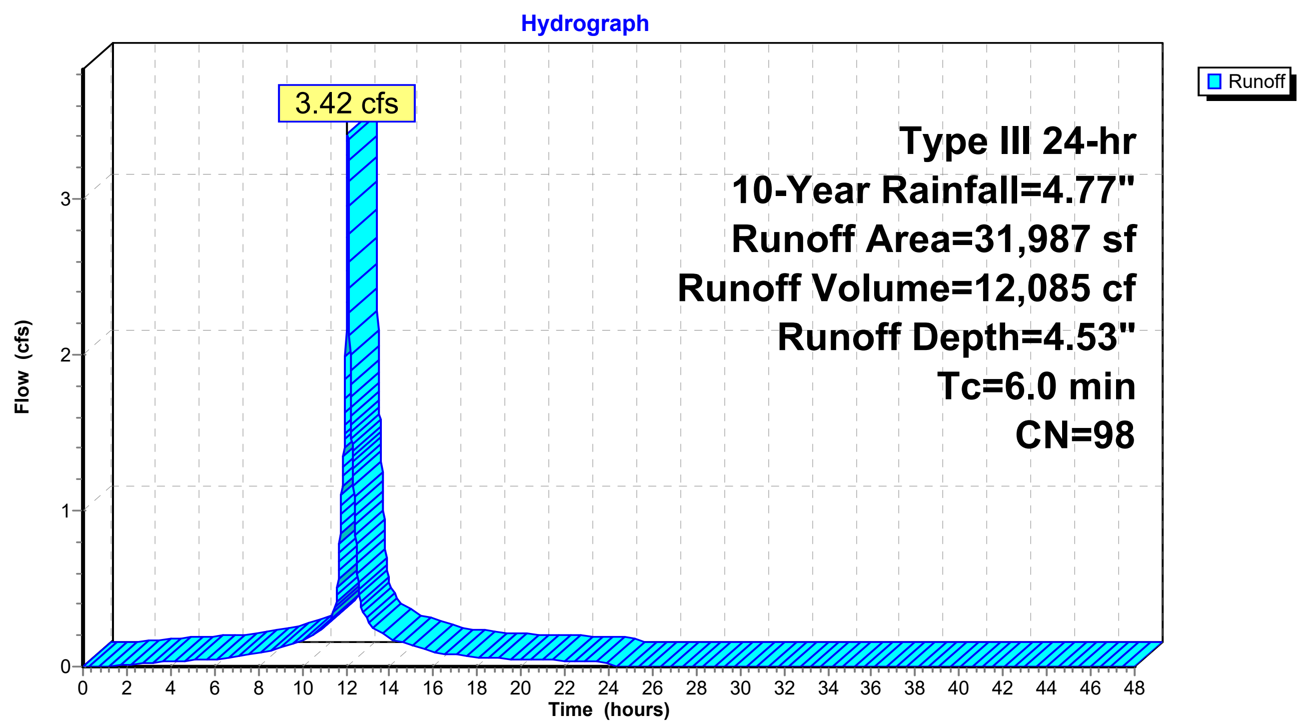
Runoff = 3.42 cfs @ 12.08 hrs, Volume= 12,085 cf, Depth= 4.53"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
30,933	98	Paved parking, HSG B
957	98	Roofs, HSG B
97	61	>75% Grass cover, Good, HSG B
31,987	98	Weighted Average
97		0.30% Pervious Area
31,890		99.70% Impervious Area

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

Subcatchment 2S: PR-QP-South



Summary for Subcatchment 3S: EX-shoreline (to lake)

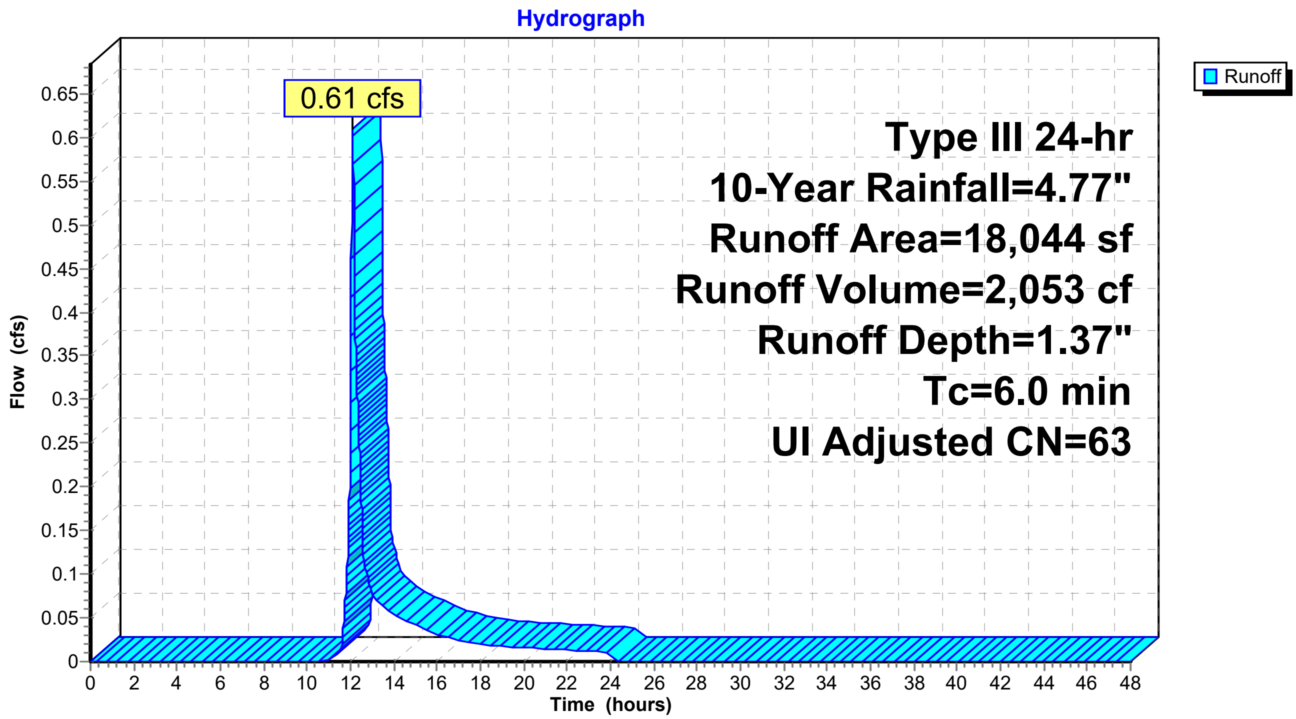
Runoff = 0.61 cfs @ 12.10 hrs, Volume= 2,053 cf, Depth= 1.37"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Adj	Description
16,398	61		>75% Grass cover, Good, HSG B
1,646	98		Unconnected roofs, HSG B
18,044	64	63	Weighted Average, UI Adjusted
16,398			90.88% Pervious Area
1,646			9.12% Impervious Area
1,646			100.00% Unconnected

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

Subcatchment 3S: EX-shoreline (to lake)



Summary for Subcatchment 4S: QP-South (to 200QP)

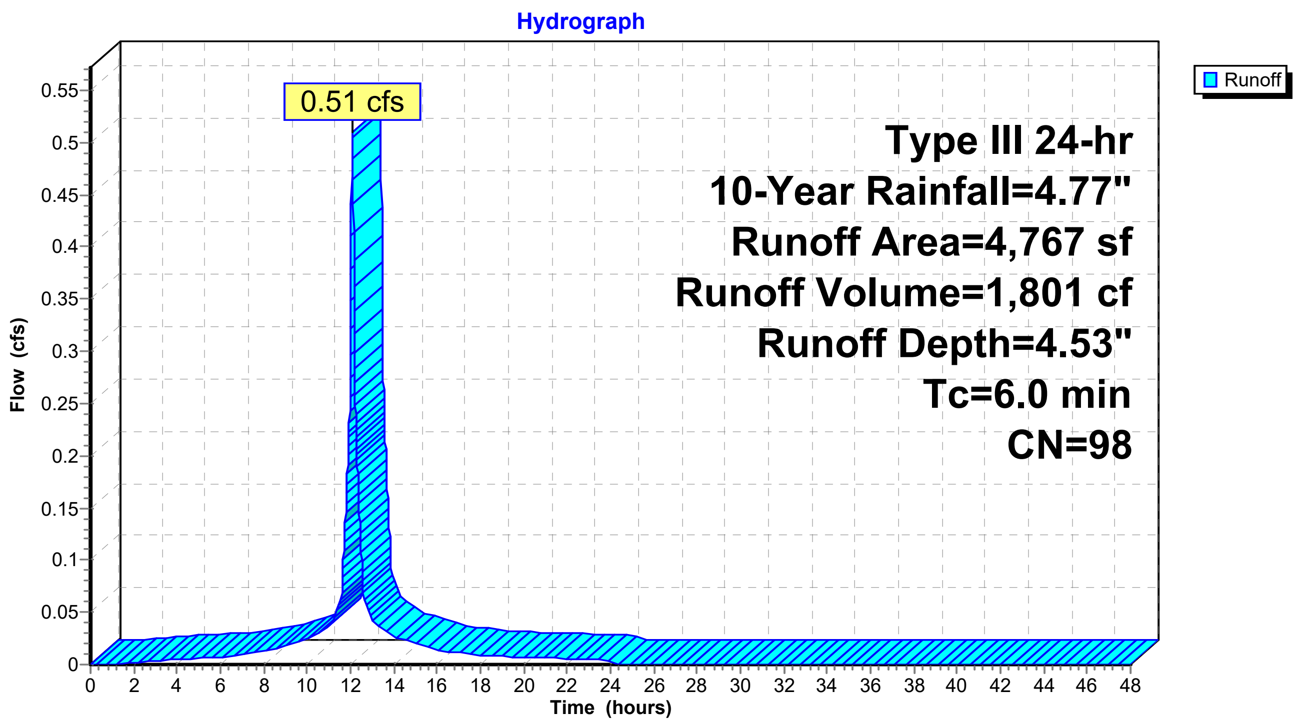
Runoff = 0.51 cfs @ 12.08 hrs, Volume= 1,801 cf, Depth= 4.53"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
4,767	98	Paved parking, HSG B
4,767		100.00% Impervious Area

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

Subcatchment 4S: QP-South (to 200QP)



Summary for Subcatchment 5S: QP-North (to 200QP)

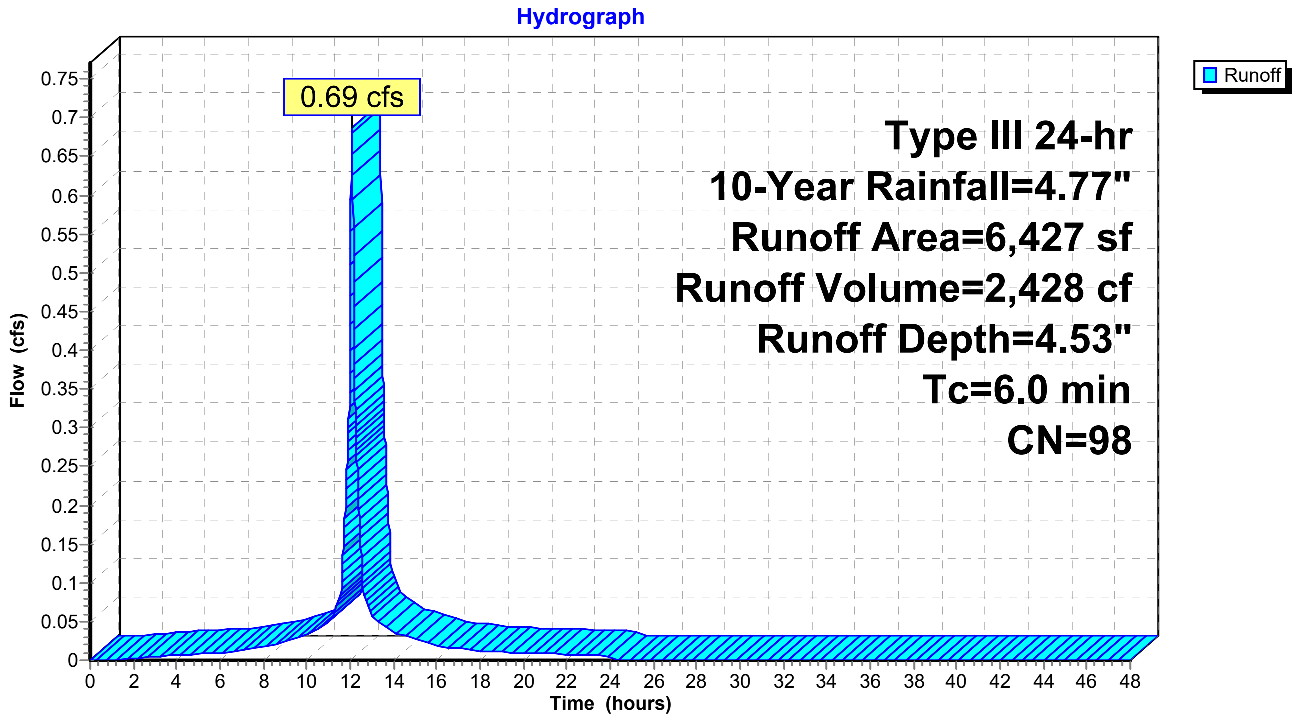
Runoff = 0.69 cfs @ 12.08 hrs, Volume= 2,428 cf, Depth= 4.53"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
6,427	98	Paved parking, HSG B
6,427		100.00% Impervious Area

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

Subcatchment 5S: QP-North (to 200QP)



Summary for Subcatchment 6S: EX-shoreline (to lake)

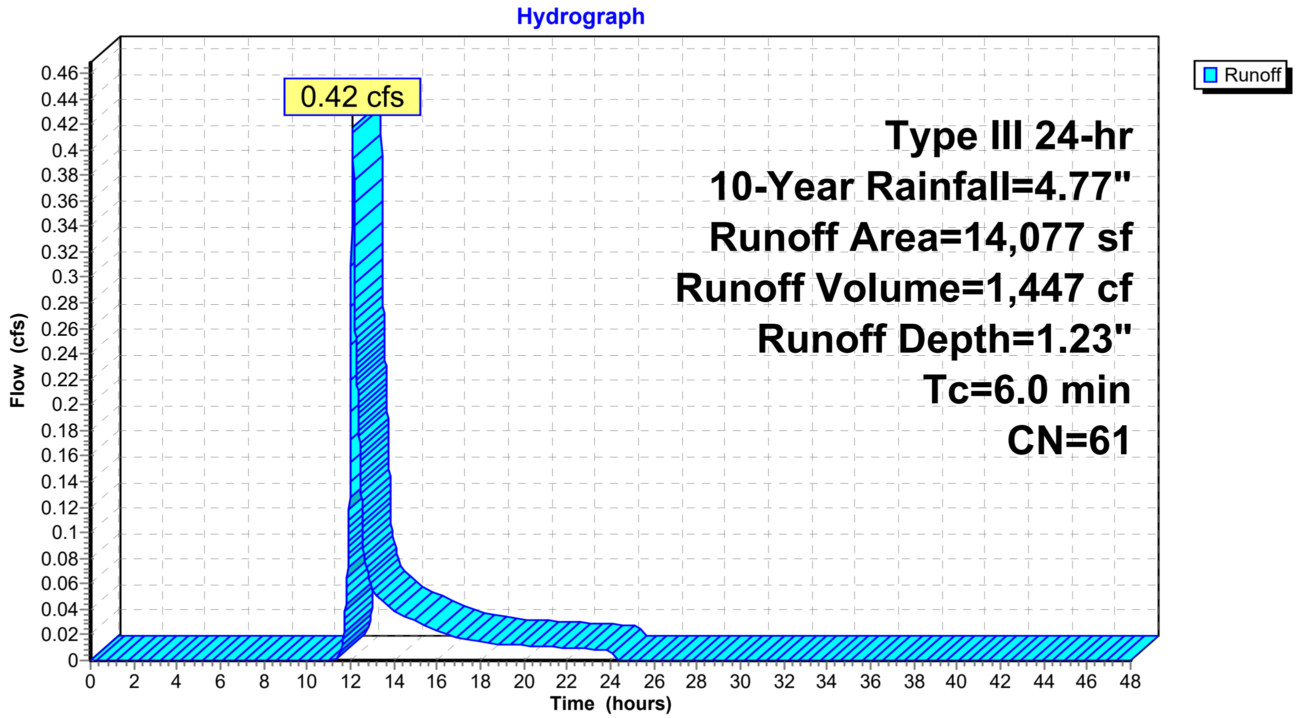
Runoff = 0.42 cfs @ 12.10 hrs, Volume= 1,447 cf, Depth= 1.23"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
14,077	61	>75% Grass cover, Good, HSG B
14,077		100.00% Pervious Area

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

Subcatchment 6S: EX-shoreline (to lake)



Summary for Subcatchment 7S: PR-QP-North

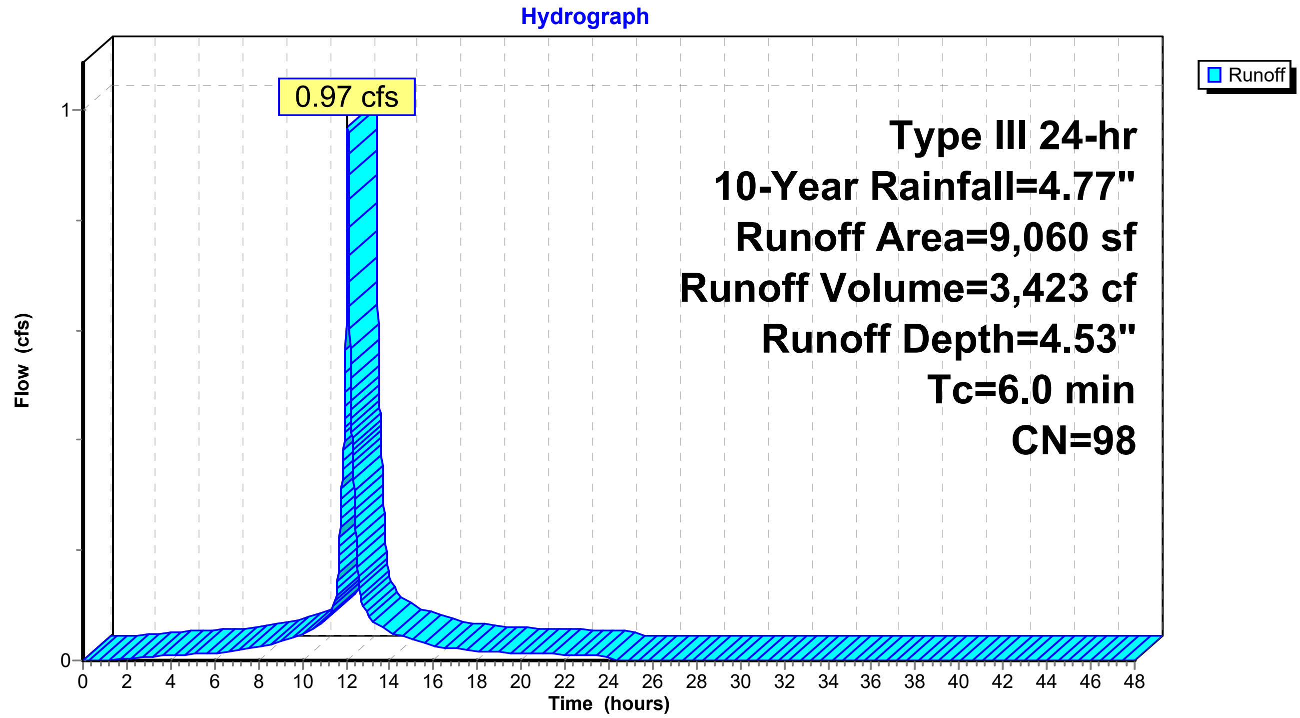
Runoff = 0.97 cfs @ 12.08 hrs, Volume= 3,423 cf, Depth= 4.53"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
9,060	98	Paved parking, HSG B
9,060		100.00% Impervious Area

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

Subcatchment 7S: PR-QP-North



Summary for Subcatchment 8S: QP-North to Bioretention

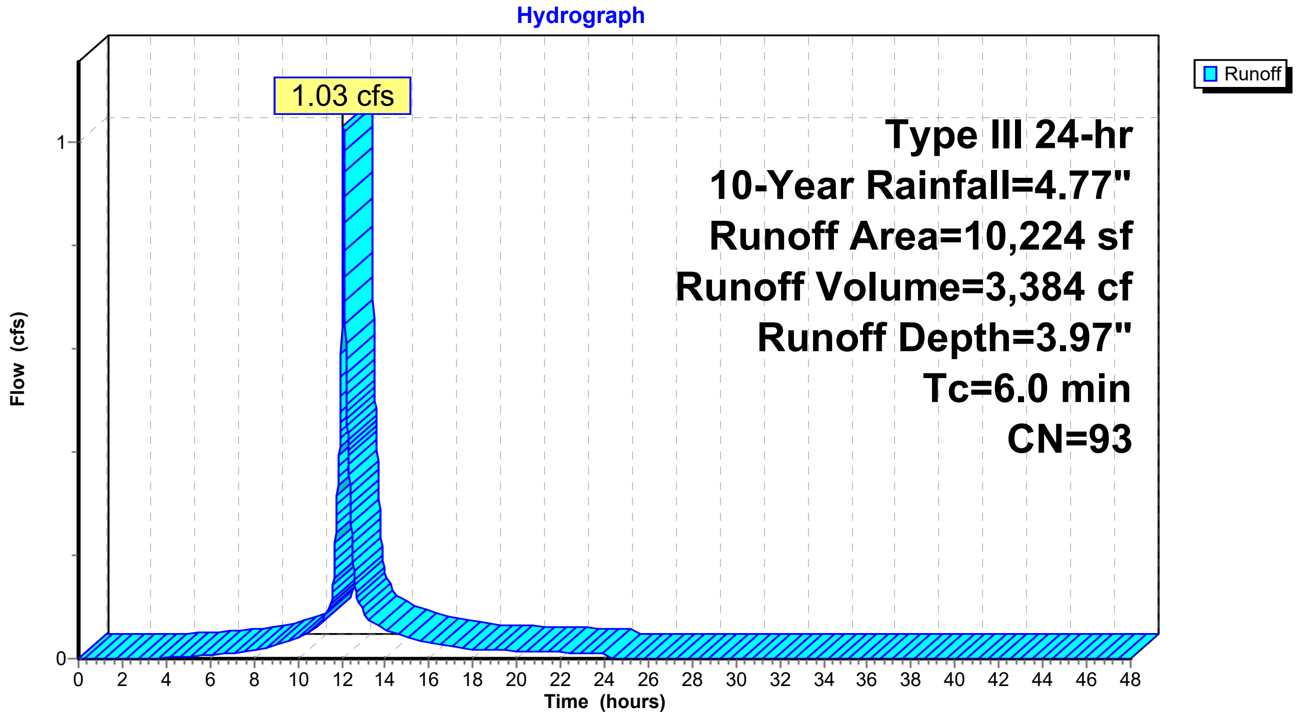
Runoff = 1.03 cfs @ 12.08 hrs, Volume= 3,384 cf, Depth= 3.97"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
8,858	98	Paved parking, HSG B
1,366	61	>75% Grass cover, Good, HSG B
10,224	93	Weighted Average
1,366		13.36% Pervious Area
8,858		86.64% Impervious Area

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

Subcatchment 8S: QP-North to Bioretention



Summary for Subcatchment 9S: EX-NWofQP

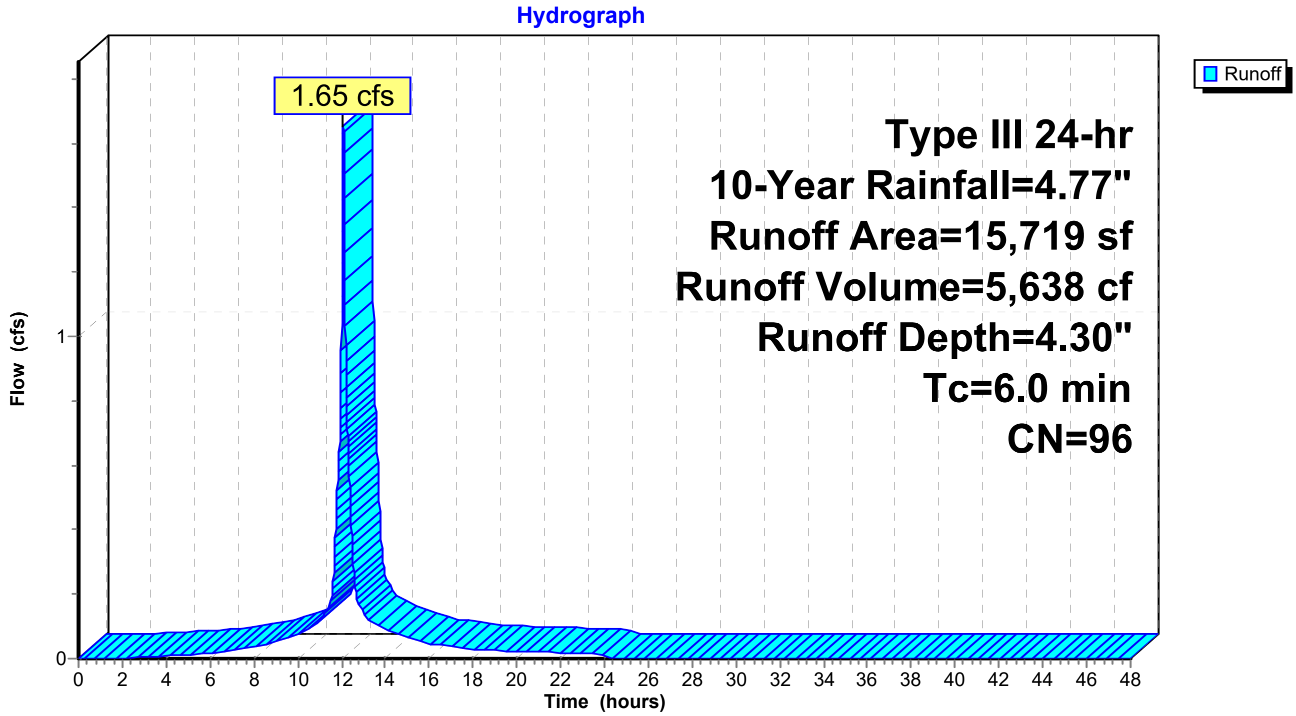
Runoff = 1.65 cfs @ 12.08 hrs, Volume= 5,638 cf, Depth= 4.30"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=4.77"

Area (sf)	CN	Description
14,776	98	Paved parking, HSG B
943	61	>75% Grass cover, Good, HSG B
15,719	96	Weighted Average
943		6.00% Pervious Area
14,776		94.00% Impervious Area

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

Subcatchment 9S: EX-NWofQP



Summary for Pond 1P: Bioretention Area

Inflow Area = 25,943 sf, 91.10% Impervious, Inflow Depth = 4.17" for 10-Year event
Inflow = 2.68 cfs @ 12.08 hrs, Volume= 9,022 cf
Outflow = 1.38 cfs @ 12.22 hrs, Volume= 9,022 cf, Atten= 48%, Lag= 8.1 min
Discarded = 0.16 cfs @ 12.22 hrs, Volume= 7,011 cf
Primary = 1.22 cfs @ 12.22 hrs, Volume= 2,011 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 83.22' @ 12.22 hrs Surf.Area= 2,312 sf Storage= 2,858 cf

Plug-Flow detention time= 116.3 min calculated for 9,020 cf (100% of inflow)
Center-of-Mass det. time= 116.3 min (885.9 - 769.6)

Volume	Invert	Avail.Storage	Storage Description
#1	81.80'	4,840 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

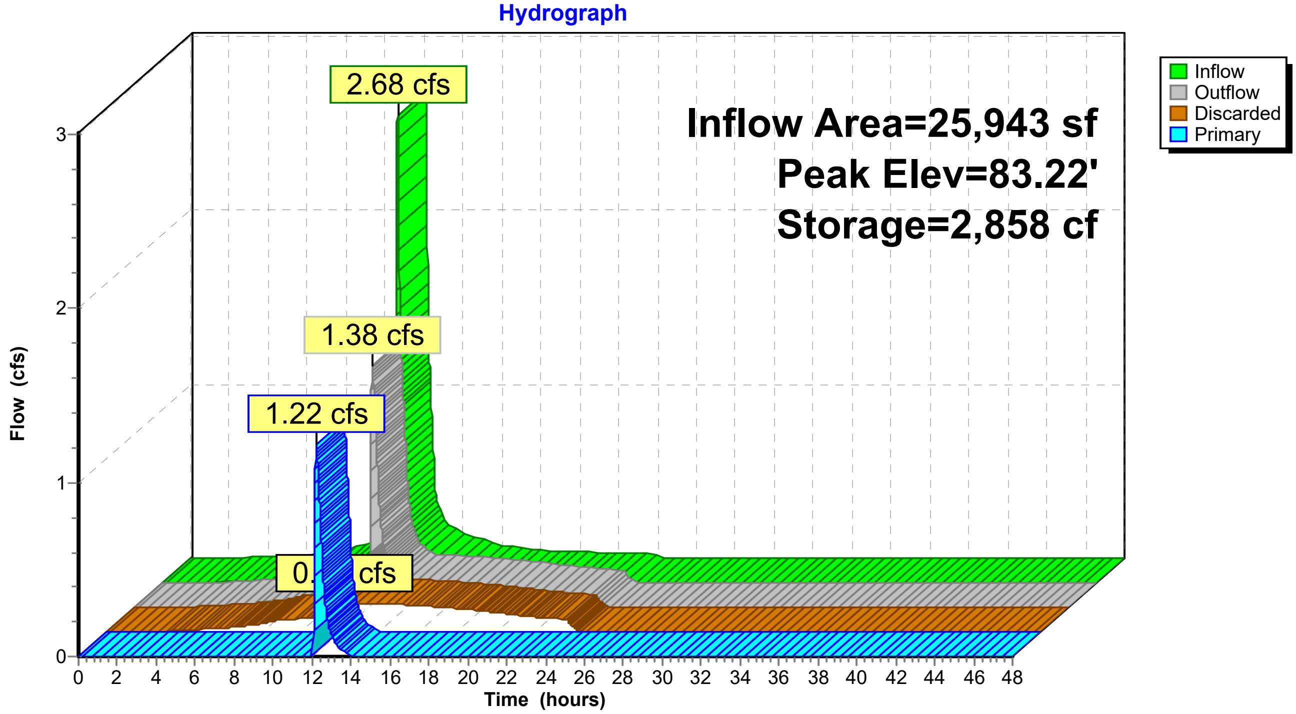
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
81.80	1,293	0	0
82.00	1,441	273	273
82.50	2,115	889	1,162
83.00	2,548	1,166	2,328
83.50	2,006	1,139	3,467
84.00	3,489	1,374	4,840

Device	Routing	Invert	Outlet Devices
#1	Discarded	81.80'	**2.400 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 75.00'
#2	Primary	83.00'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Discarded OutFlow Max=0.16 cfs @ 12.22 hrs HW=83.22' (Free Discharge)
└─**1=Exfiltration** (Controls 0.16 cfs)

Primary OutFlow Max=1.22 cfs @ 12.22 hrs HW=83.22' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 1.22 cfs @ 1.12 fps)

Pond 1P: Bioretention Area



Summary for Pond 9P: PR-UGIF

Inflow Area = 75,680 sf, 81.45% Impervious, Inflow Depth = 3.76" for 10-Year event
Inflow = 7.35 cfs @ 12.08 hrs, Volume= 23,707 cf
Outflow = 6.17 cfs @ 12.14 hrs, Volume= 23,710 cf, Atten= 16%, Lag= 3.1 min
Discarded = 0.05 cfs @ 12.14 hrs, Volume= 4,051 cf
Primary = 6.12 cfs @ 12.14 hrs, Volume= 19,659 cf
Routed to Link 1L : Lake Q
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 84.09' @ 12.14 hrs Surf.Area= 1,097 sf Storage= 1,753 cf

Plug-Flow detention time= 58.0 min calculated for 23,705 cf (100% of inflow)
Center-of-Mass det. time= 58.2 min (846.6 - 788.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	80.85'	715 cf	**12.13'W x 90.45'L x 2.06'H Field A**
			2,257 cf Overall - 469 cf Embedded = 1,789 cf x 40.0% Voids
#2A	81.35'	469 cf	**CPP single-wall 12"** x 20 Inside #1
			Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
			Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
			Row Length Adjustment= +6.00' x 1.04 sf x 5 rows
			10.13' Header x 1.04 sf x 2 = 21.1 cf Inside
#3	83.50'	1,796 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc) -Impervious
#4	80.65'	50 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder**-Impervious
#5	80.85'	9 cf	**2.00'D x 3.00'H Vertical Cone/Cylinder**-Impervious
		3,040 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
83.50	0	0	0
83.72	4	0	0
84.00	1,921	270	270
84.20	5,561	748	1,018
84.30	10,000	778	1,796

Device	Routing	Invert	Outlet Devices
#1	Discarded	80.85'	**1.020 in/hr Exfiltration over Wetted area**
			Conductivity to Groundwater Elevation = 75.00' Phase-In= 0.01'
#2	Secondary	84.20'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#3	Primary	82.50'	**45.0 deg Sharp-Crested Vee/Trap Weir** Cv= 2.56 (C= 3.20)
#4	Primary	83.00'	**10.0" Horiz. Orifice/Grate** C= 0.600
			Limited to weir flow at low heads

Discarded OutFlow Max=0.05 cfs @ 12.14 hrs HW=84.09' (Free Discharge)
└─**1=Exfiltration** (Controls 0.05 cfs)

Primary OutFlow Max=6.12 cfs @ 12.14 hrs HW=84.09' (Free Discharge)
├─**3=Sharp-Crested Vee/Trap Weir** (Weir Controls 3.38 cfs @ 3.23 fps)
└─**4=Orifice/Grate** (Orifice Controls 2.74 cfs @ 5.03 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=80.65' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Pond 9P: PR-UGIF - Chamber Wizard Field A

Chamber Model = CPP single-wall 12" (Single-wall corrugated HDPE pipe)
Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
Row Length Adjustment= +6.00' x 1.04 sf x 5 rows

14.7" Wide + 12.0" Spacing = 26.7" C-C Row Spacing

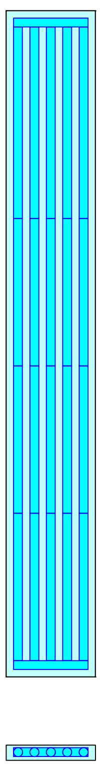
4 Chambers/Row x 20.00' Long +6.00' Row Adjustment +1.23' Header x 2 = 88.45' Row Length +12.0" End Stone x 2 = 90.45' Base Length
5 Rows x 14.7" Wide + 12.0" Spacing x 4 + 12.0" Side Stone x 2 = 12.13' Base Width
6.0" Stone Base + 14.7" Chamber Height + 4.0" Stone Cover = 2.06' Field Height

20 Chambers x 20.8 cf +6.00' Row Adjustment x 1.04 sf x 5 Rows + 10.13' Header x 1.04 sf x 2 = 468.6 cf Chamber Storage

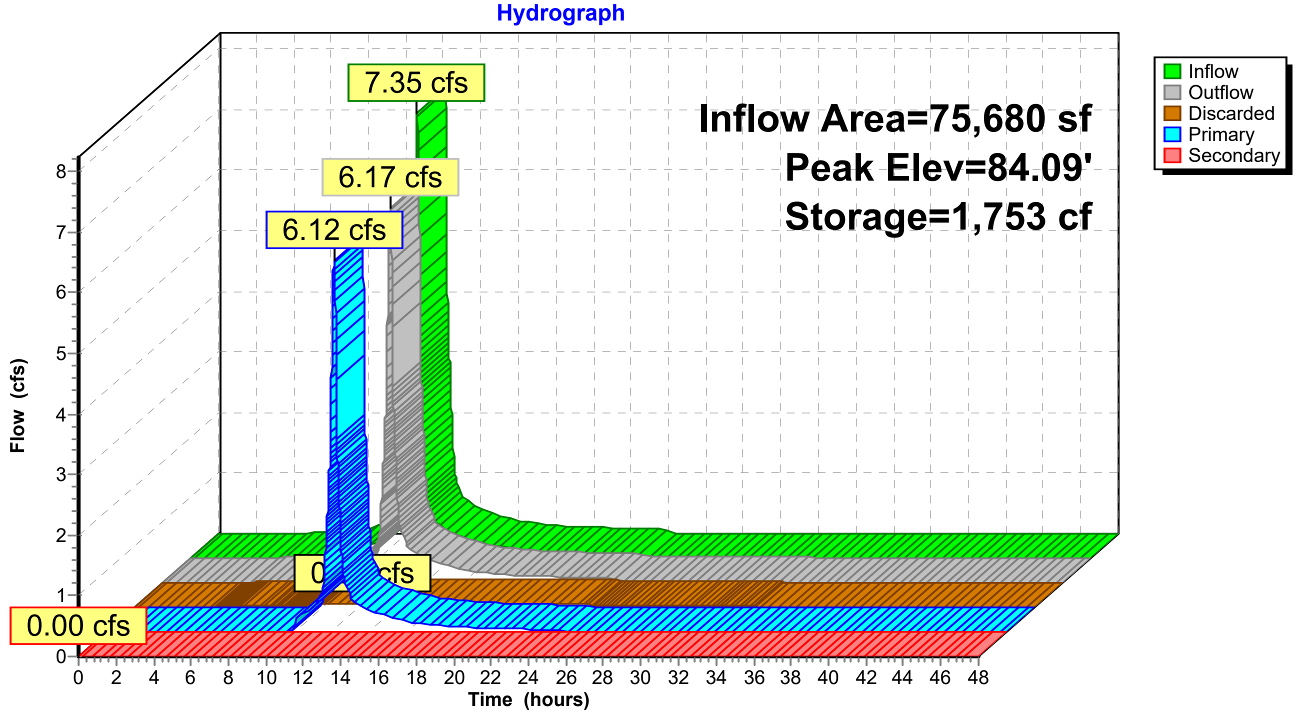
2,257.4 cf Field - 468.6 cf Chambers = 1,788.8 cf Stone x 40.0% Voids = 715.5 cf Stone Storage

Chamber Storage + Stone Storage = 1,184.1 cf = 0.027 af
Overall Storage Efficiency = 52.5%
Overall System Size = 90.45' x 12.13' x 2.06'

20 Chambers
83.6 cy Field
66.3 cy Stone



Pond 9P: PR-UGIF

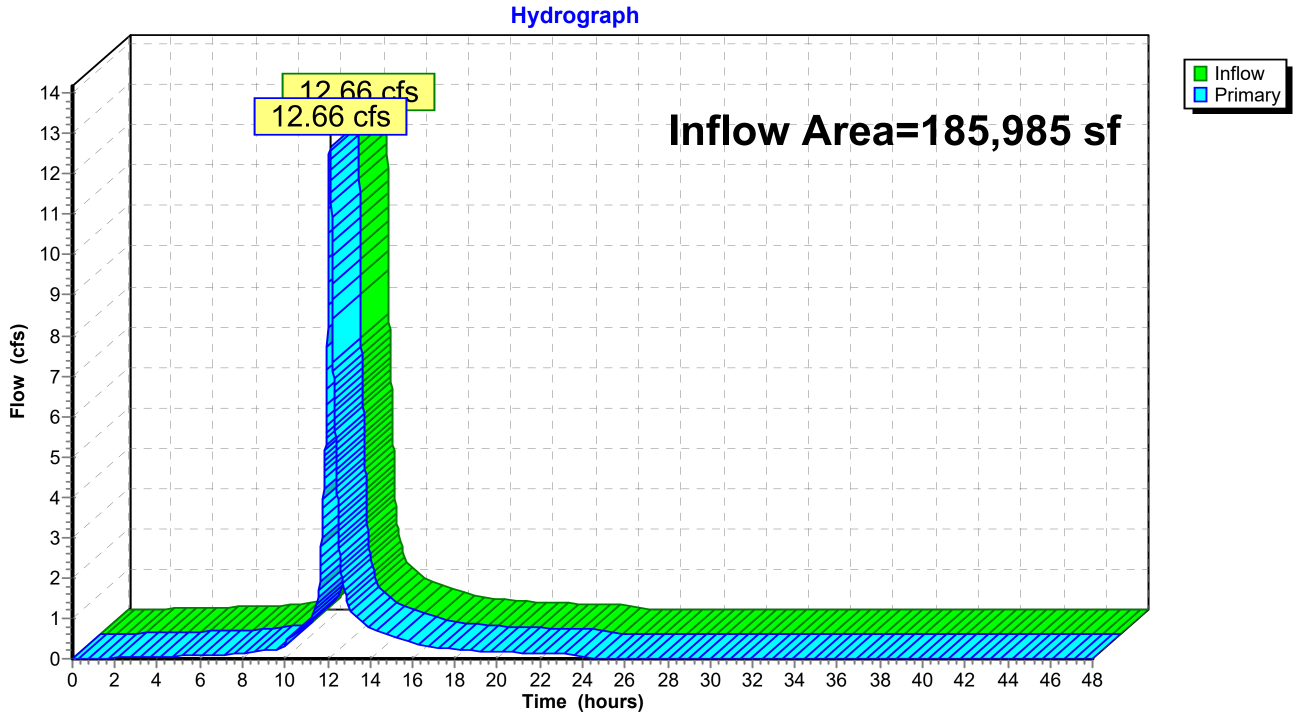


Summary for Link 1L: Lake Q

Inflow Area = 185,985 sf, 74.77% Impervious, Inflow Depth = 2.90" for 10-Year event
Inflow = 12.66 cfs @ 12.11 hrs, Volume= 44,906 cf
Primary = 12.66 cfs @ 12.11 hrs, Volume= 44,906 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

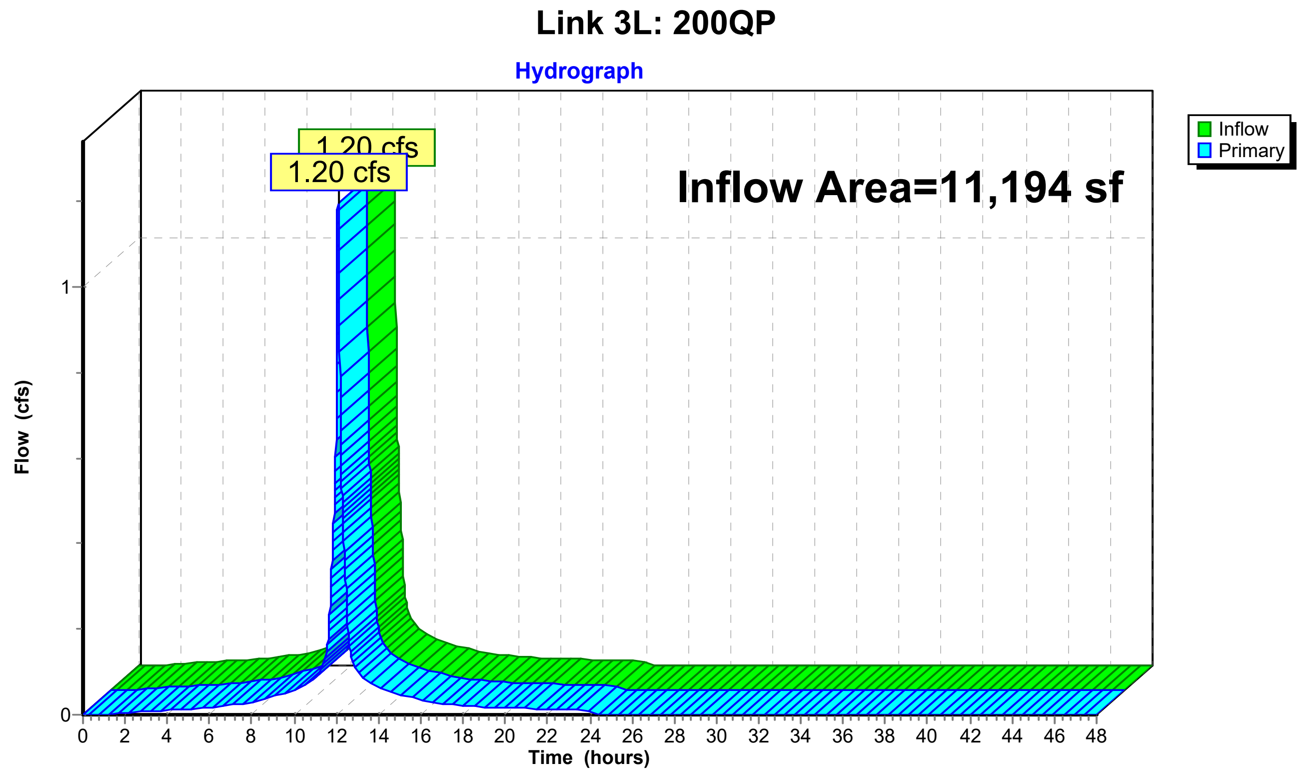
Link 1L: Lake Q



Summary for Link 3L: 200QP

Inflow Area = 11,194 sf,100.00% Impervious, Inflow Depth = 4.53" for 10-Year event
Inflow = 1.20 cfs @ 12.08 hrs, Volume= 4,229 cf
Primary = 1.20 cfs @ 12.08 hrs, Volume= 4,229 cf, Atten= 0%, Lag= 0.0 min
Routed to Link 1L : Lake Q

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs



Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: PR-NorthAve Runoff Area=75,680 sf 81.45% Impervious Runoff Depth=4.99"
Tc=6.0 min CN=91 Runoff=9.60 cfs 31,449 cf

Subcatchment 2S: PR-QP-South Runoff Area=31,987 sf 99.70% Impervious Runoff Depth=5.79"
Tc=6.0 min CN=98 Runoff=4.34 cfs 15,439 cf

Subcatchment 3S: EX-shoreline (to lake) Runoff Area=18,044 sf 9.12% Impervious Runoff Depth=2.20"
Tc=6.0 min UI Adjusted CN=63 Runoff=1.03 cfs 3,304 cf

Subcatchment 4S: QP-South (to 200QP) Runoff Area=4,767 sf 100.00% Impervious Runoff Depth=5.79"
Tc=6.0 min CN=98 Runoff=0.65 cfs 2,301 cf

Subcatchment 5S: QP-North (to 200QP) Runoff Area=6,427 sf 100.00% Impervious Runoff Depth=5.79"
Tc=6.0 min CN=98 Runoff=0.87 cfs 3,102 cf

Subcatchment 6S: EX-shoreline (to lake) Runoff Area=14,077 sf 0.00% Impervious Runoff Depth=2.03"
Tc=6.0 min CN=61 Runoff=0.73 cfs 2,376 cf

Subcatchment 7S: PR-QP-North Runoff Area=9,060 sf 100.00% Impervious Runoff Depth=5.79"
Tc=6.0 min CN=98 Runoff=1.23 cfs 4,373 cf

Subcatchment 8S: QP-North to Runoff Area=10,224 sf 86.64% Impervious Runoff Depth=5.21"
Tc=6.0 min CN=93 Runoff=1.33 cfs 4,441 cf

Subcatchment 9S: EX-NWofQP Runoff Area=15,719 sf 94.00% Impervious Runoff Depth=5.56"
Tc=6.0 min CN=96 Runoff=2.11 cfs 7,280 cf

Pond 1P: Bioretention Area Peak Elev=83.35' Storage=3,148 cf Inflow=3.44 cfs 11,720 cf
Discarded=0.17 cfs 7,911 cf Primary=2.56 cfs 3,809 cf Outflow=2.73 cfs 11,720 cf

Pond 9P: PR-UGIF Peak Elev=84.23' Storage=2,433 cf Inflow=9.60 cfs 31,449 cf
Discarded=0.05 cfs 4,246 cf Primary=7.08 cfs 27,176 cf Secondary=0.14 cfs 30 cf Outflow=7.27 cfs 31,452 cf

Link 1L: Lake Q Inflow=17.69 cfs 61,909 cf
Primary=17.69 cfs 61,909 cf

Link 3L: 200QP Inflow=1.52 cfs 5,403 cf
Primary=1.52 cfs 5,403 cf

Total Runoff Area = 185,985 sf Runoff Volume = 74,064 cf Average Runoff Depth = 4.78"
25.23% Pervious = 46,918 sf 74.77% Impervious = 139,067 sf

Summary for Subcatchment 1S: PR-NorthAve

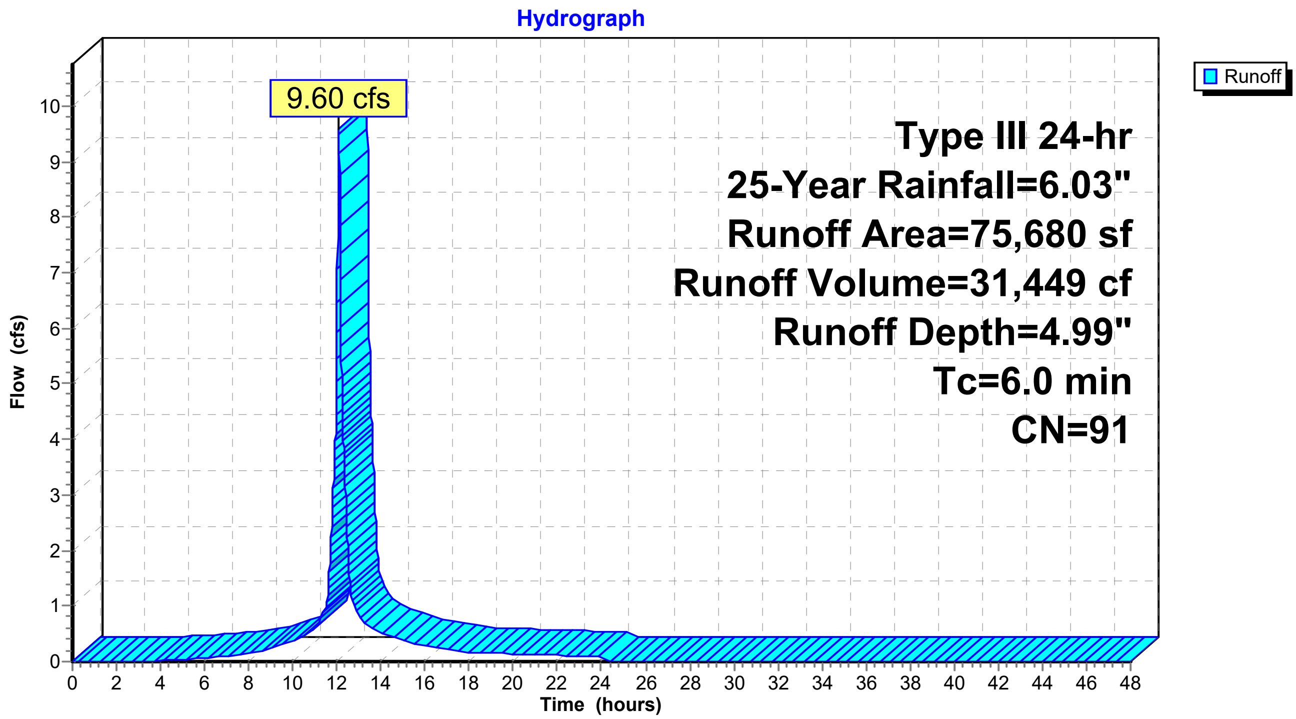
Runoff = 9.60 cfs @ 12.08 hrs, Volume= 31,449 cf, Depth= 4.99"
Routed to Pond 9P : PR-UGIF

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
44,161	98	Paved parking, HSG B
17,482	98	Roofs, HSG B
14,037	61	>75% Grass cover, Good, HSG B
75,680	91	Weighted Average
14,037		18.55% Pervious Area
61,643		81.45% Impervious Area

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

Subcatchment 1S: PR-NorthAve



Summary for Subcatchment 2S: PR-QP-South

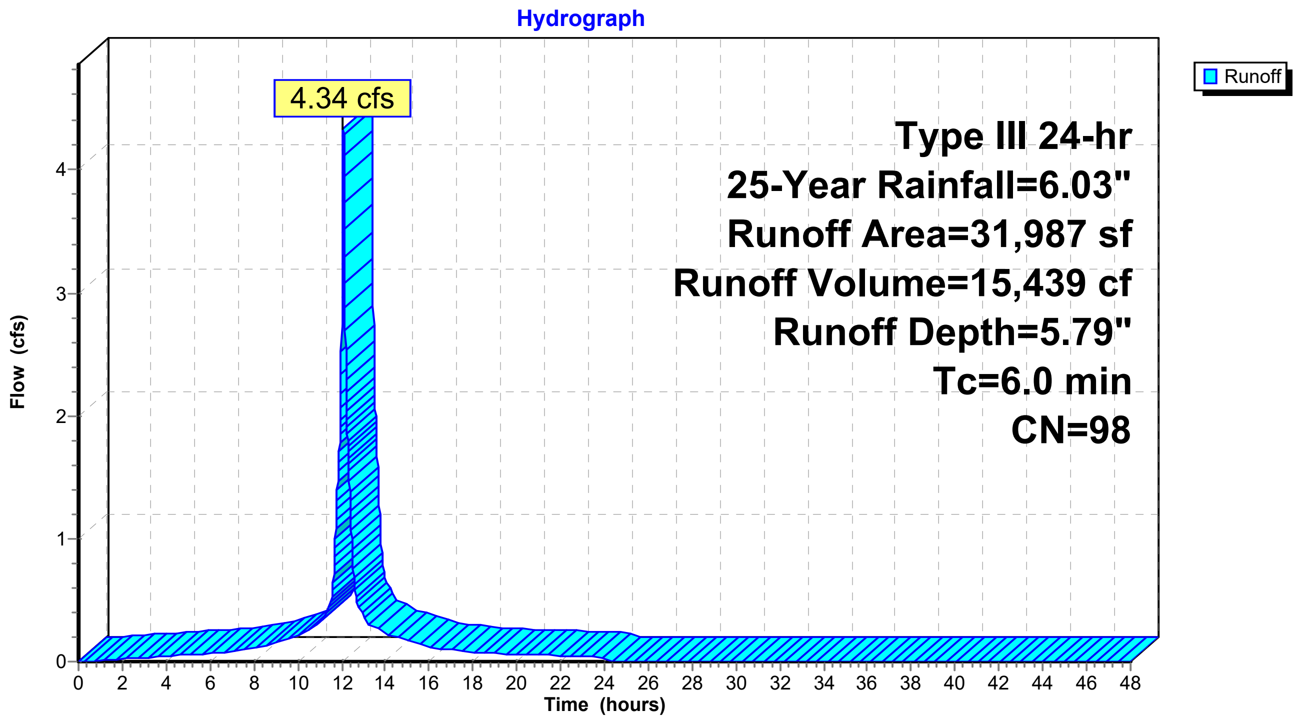
Runoff = 4.34 cfs @ 12.08 hrs, Volume= 15,439 cf, Depth= 5.79"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
30,933	98	Paved parking, HSG B
957	98	Roofs, HSG B
97	61	>75% Grass cover, Good, HSG B
31,987	98	Weighted Average
97		0.30% Pervious Area
31,890		99.70% Impervious Area

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

Subcatchment 2S: PR-QP-South



Summary for Subcatchment 3S: EX-shoreline (to lake)

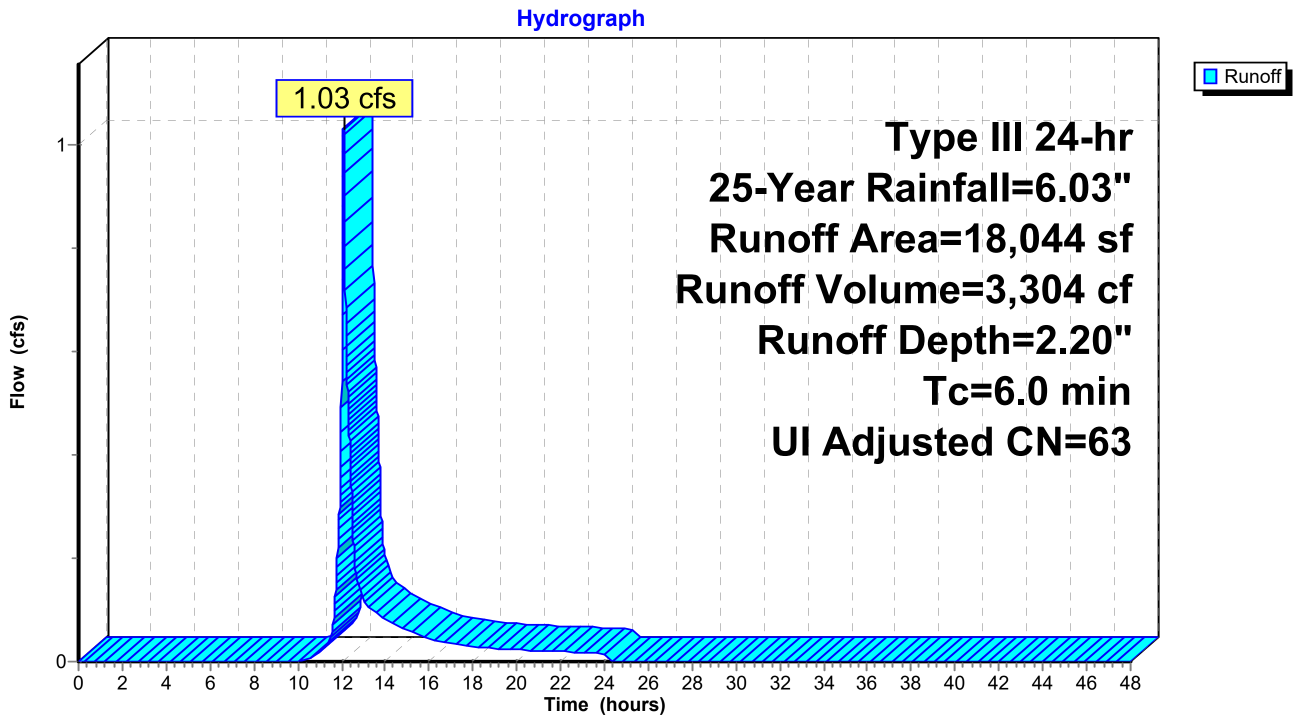
Runoff = 1.03 cfs @ 12.09 hrs, Volume= 3,304 cf, Depth= 2.20"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Adj	Description
16,398	61		>75% Grass cover, Good, HSG B
1,646	98		Unconnected roofs, HSG B
18,044	64	63	Weighted Average, UI Adjusted
16,398			90.88% Pervious Area
1,646			9.12% Impervious Area
1,646			100.00% Unconnected

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

Subcatchment 3S: EX-shoreline (to lake)



Summary for Subcatchment 4S: QP-South (to 200QP)

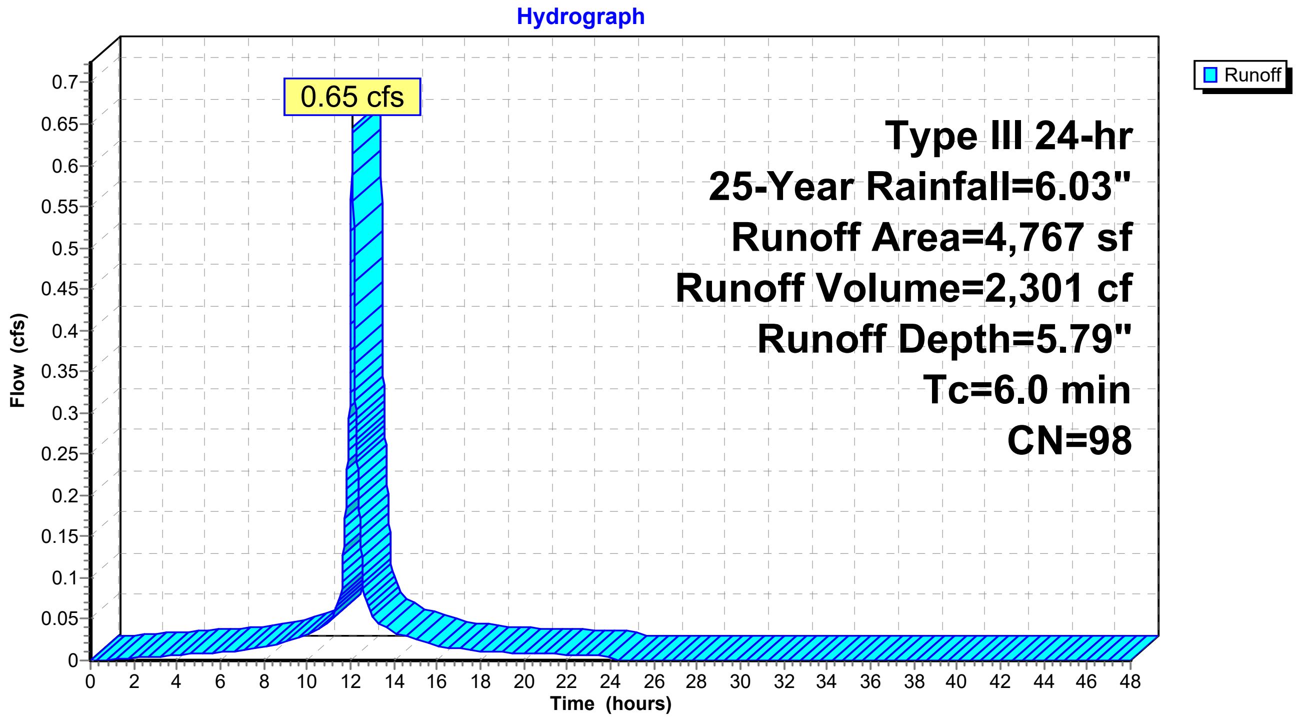
Runoff = 0.65 cfs @ 12.08 hrs, Volume= 2,301 cf, Depth= 5.79"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
4,767	98	Paved parking, HSG B
4,767		100.00% Impervious Area

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

Subcatchment 4S: QP-South (to 200QP)



Summary for Subcatchment 5S: QP-North (to 200QP)

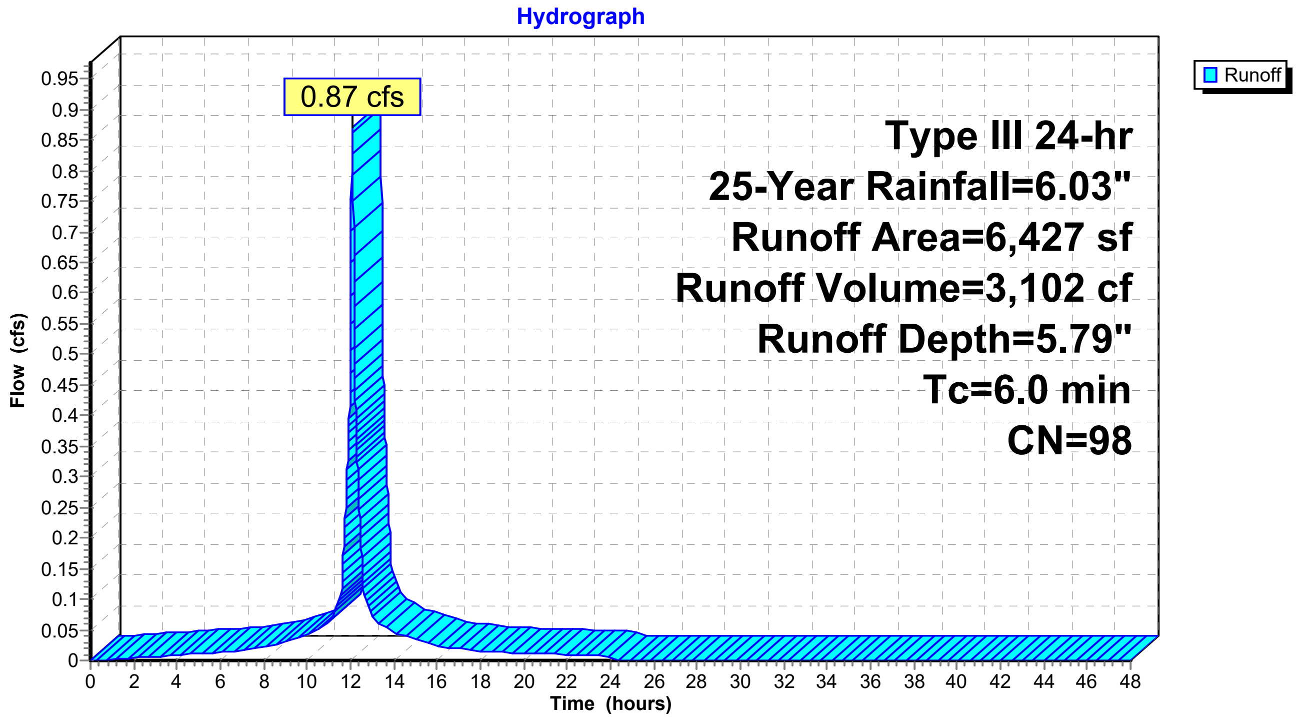
Runoff = 0.87 cfs @ 12.08 hrs, Volume= 3,102 cf, Depth= 5.79"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
6,427	98	Paved parking, HSG B
6,427		100.00% Impervious Area

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

Subcatchment 5S: QP-North (to 200QP)



Summary for Subcatchment 6S: EX-shoreline (to lake)

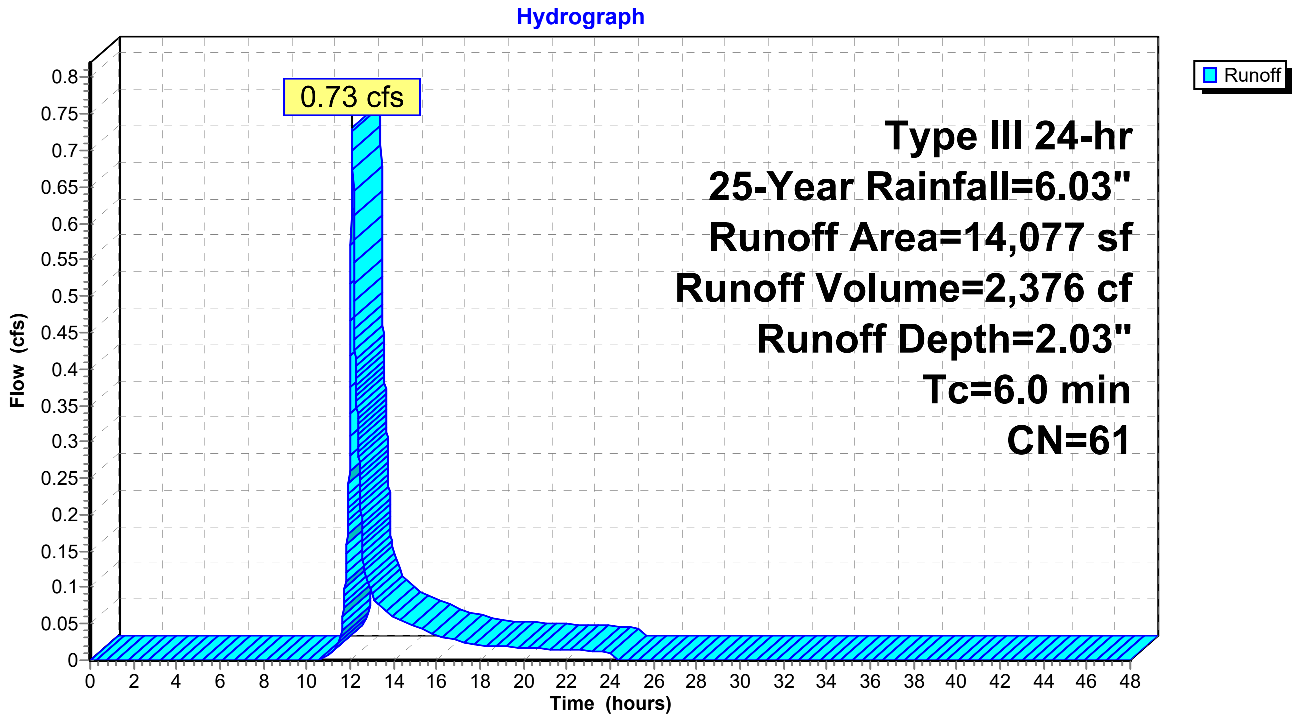
Runoff = 0.73 cfs @ 12.10 hrs, Volume= 2,376 cf, Depth= 2.03"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
14,077	61	>75% Grass cover, Good, HSG B
14,077		100.00% Pervious Area

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

Subcatchment 6S: EX-shoreline (to lake)



Summary for Subcatchment 7S: PR-QP-North

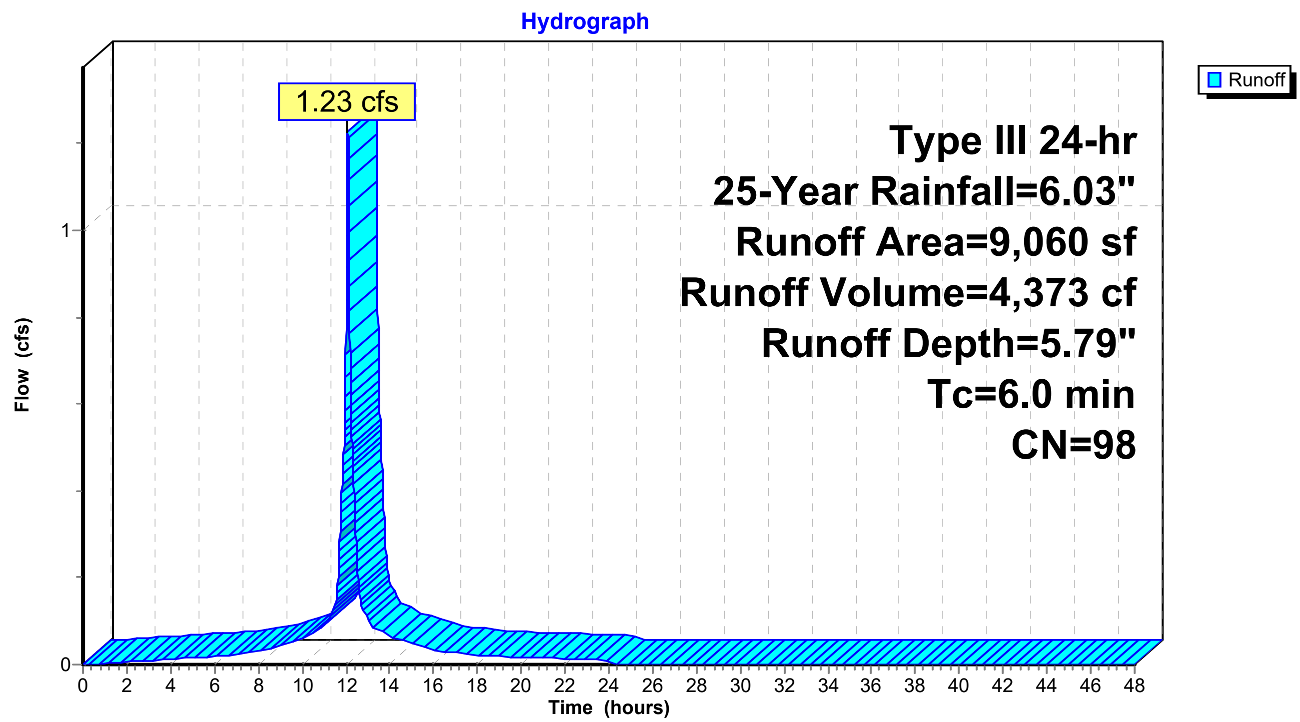
Runoff = 1.23 cfs @ 12.08 hrs, Volume= 4,373 cf, Depth= 5.79"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
9,060	98	Paved parking, HSG B
9,060		100.00% Impervious Area

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

Subcatchment 7S: PR-QP-North



Summary for Subcatchment 8S: QP-North to Bioretention

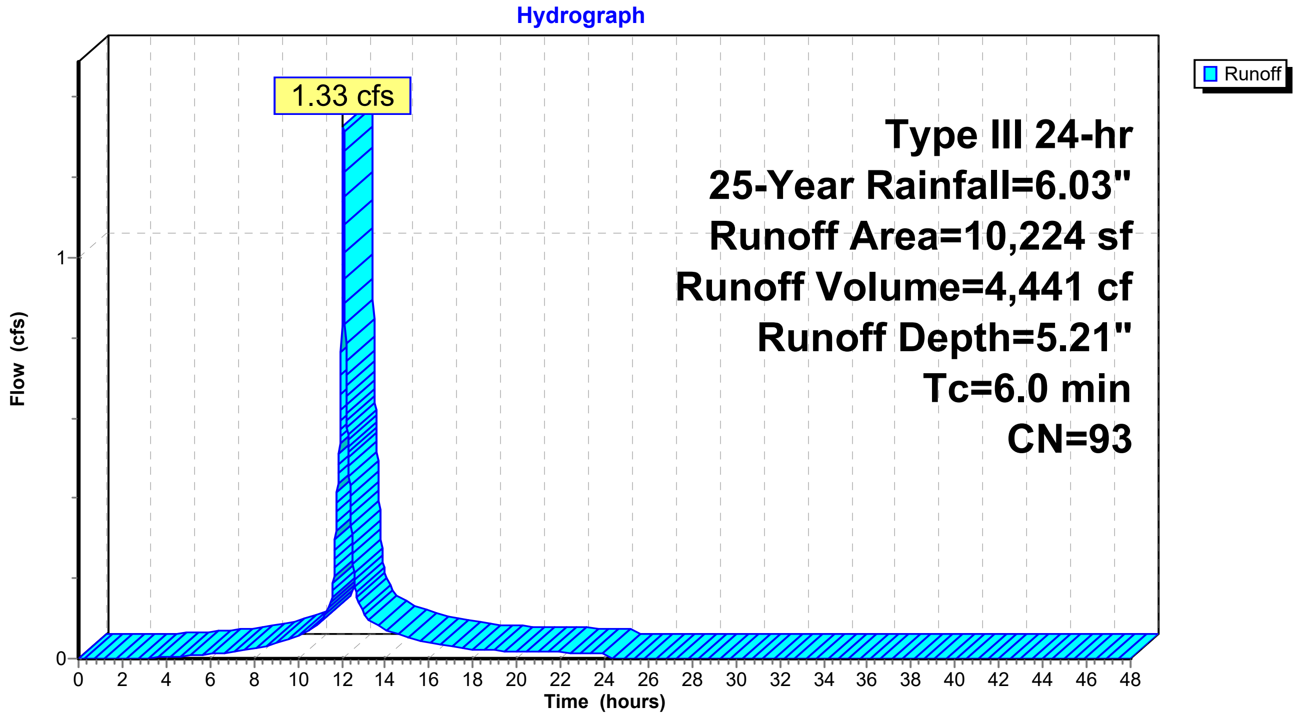
Runoff = 1.33 cfs @ 12.08 hrs, Volume= 4,441 cf, Depth= 5.21"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
8,858	98	Paved parking, HSG B
1,366	61	>75% Grass cover, Good, HSG B
10,224	93	Weighted Average
1,366		13.36% Pervious Area
8,858		86.64% Impervious Area

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

Subcatchment 8S: QP-North to Bioretention



Summary for Subcatchment 9S: EX-NWofQP

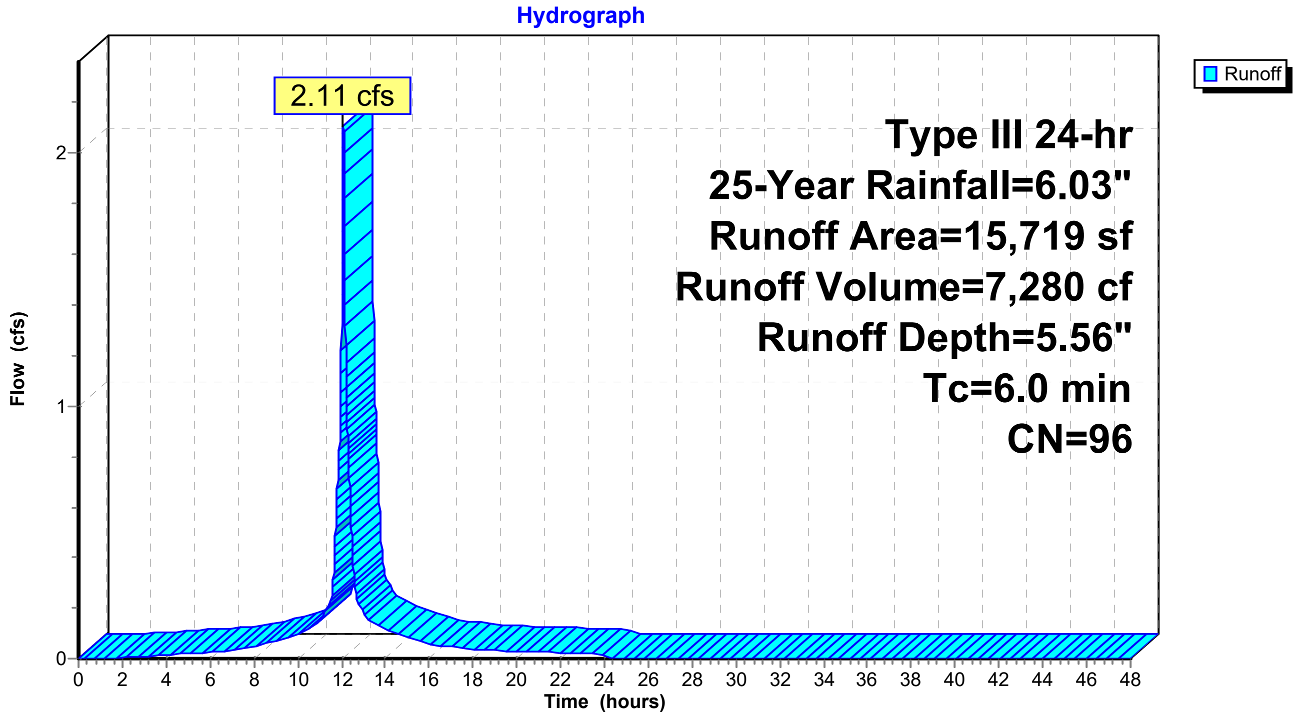
Runoff = 2.11 cfs @ 12.08 hrs, Volume= 7,280 cf, Depth= 5.56"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.03"

Area (sf)	CN	Description
14,776	98	Paved parking, HSG B
943	61	>75% Grass cover, Good, HSG B
15,719	96	Weighted Average
943		6.00% Pervious Area
14,776		94.00% Impervious Area

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

Subcatchment 9S: EX-NWofQP



Summary for Pond 1P: Bioretention Area

Inflow Area = 25,943 sf, 91.10% Impervious, Inflow Depth = 5.42" for 25-Year event
Inflow = 3.44 cfs @ 12.08 hrs, Volume= 11,720 cf
Outflow = 2.73 cfs @ 12.14 hrs, Volume= 11,720 cf, Atten= 21%, Lag= 3.6 min
Discarded = 0.17 cfs @ 12.14 hrs, Volume= 7,911 cf
Primary = 2.56 cfs @ 12.14 hrs, Volume= 3,809 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 83.35' @ 12.14 hrs Surf.Area= 2,171 sf Storage= 3,148 cf

Plug-Flow detention time= 106.0 min calculated for 11,718 cf (100% of inflow)
Center-of-Mass det. time= 106.0 min (869.7 - 763.7)

Volume	Invert	Avail.Storage	Storage Description
#1	81.80'	4,840 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

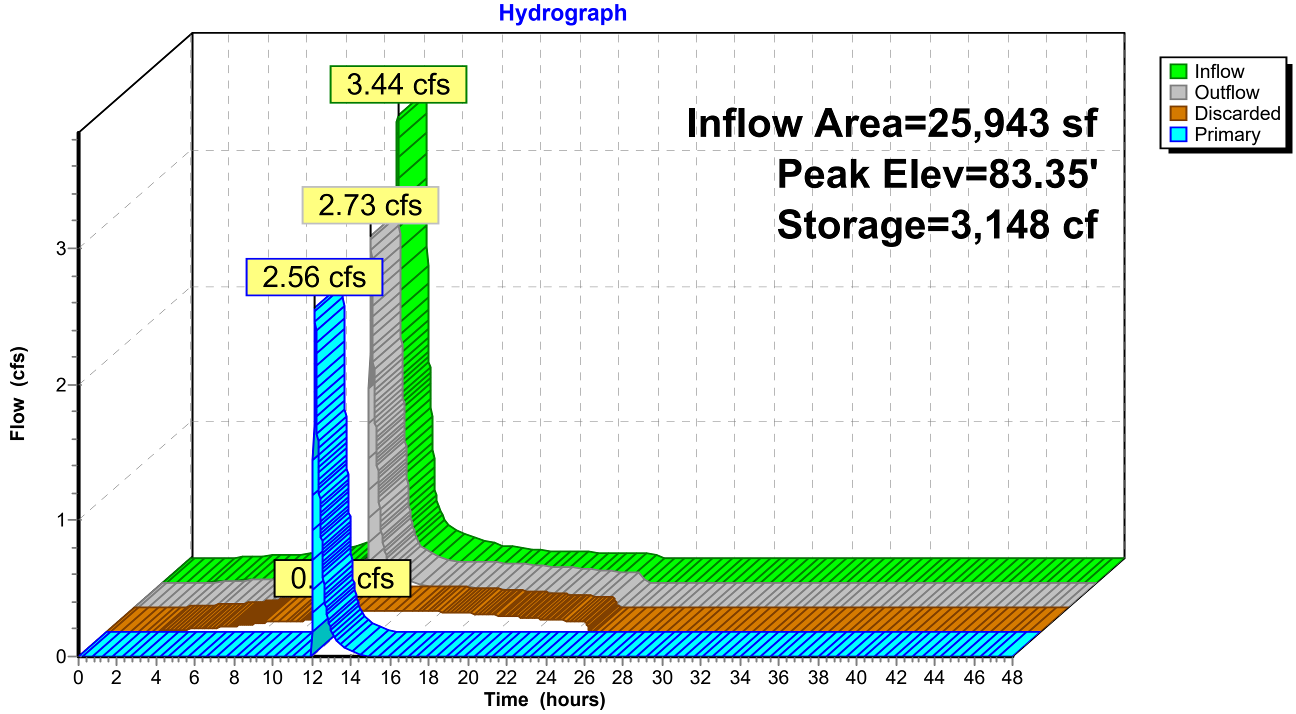
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
81.80	1,293	0	0
82.00	1,441	273	273
82.50	2,115	889	1,162
83.00	2,548	1,166	2,328
83.50	2,006	1,139	3,467
84.00	3,489	1,374	4,840

Device	Routing	Invert	Outlet Devices
#1	Discarded	81.80'	**2.400 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 75.00'
#2	Primary	83.00'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Discarded OutFlow Max=0.17 cfs @ 12.14 hrs HW=83.35' (Free Discharge)
1=Exfiltration (Controls 0.17 cfs)

Primary OutFlow Max=2.55 cfs @ 12.14 hrs HW=83.35' (Free Discharge)
2=Broad-Crested Rectangular Weir (Weir Controls 2.55 cfs @ 1.47 fps)

Pond 1P: Bioretention Area



Summary for Pond 9P: PR-UGIF

Inflow Area = 75,680 sf, 81.45% Impervious, Inflow Depth = 4.99" for 25-Year event
Inflow = 9.60 cfs @ 12.08 hrs, Volume= 31,449 cf
Outflow = 7.27 cfs @ 12.15 hrs, Volume= 31,452 cf, Atten= 24%, Lag= 4.0 min
Discarded = 0.05 cfs @ 12.15 hrs, Volume= 4,246 cf
Primary = 7.08 cfs @ 12.15 hrs, Volume= 27,176 cf
Routed to Link 1L : Lake Q
Secondary = 0.14 cfs @ 12.15 hrs, Volume= 30 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 84.23' @ 12.15 hrs Surf.Area= 1,097 sf Storage= 2,433 cf

Plug-Flow detention time= 46.8 min calculated for 31,445 cf (100% of inflow)
Center-of-Mass det. time= 46.9 min (827.8 - 780.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	80.85'	715 cf	**12.13'W x 90.45'L x 2.06'H Field A** 2,257 cf Overall - 469 cf Embedded = 1,789 cf x 40.0% Voids
#2A	81.35'	469 cf	**CPP single-wall 12"** x 20 Inside #1 Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf Row Length Adjustment= +6.00' x 1.04 sf x 5 rows 10.13' Header x 1.04 sf x 2 = 21.1 cf Inside
#3	83.50'	1,796 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc) -Impervious
#4	80.65'	50 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder**-Impervious
#5	80.85'	9 cf	**2.00'D x 3.00'H Vertical Cone/Cylinder**-Impervious
		3,040 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
83.50	0	0	0
83.72	4	0	0
84.00	1,921	270	270
84.20	5,561	748	1,018
84.30	10,000	778	1,796

Device	Routing	Invert	Outlet Devices
#1	Discarded	80.85'	**1.020 in/hr Exfiltration over Wetted area** Conductivity to Groundwater Elevation = 75.00' Phase-In= 0.01'
#2	Secondary	84.20'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#3	Primary	82.50'	**45.0 deg Sharp-Crested Vee/Trap Weir** Cv= 2.56 (C= 3.20)
#4	Primary	83.00'	**10.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.05 cfs @ 12.15 hrs HW=84.23' (Free Discharge)
└─**1=Exfiltration** (Controls 0.05 cfs)

Primary OutFlow Max=7.07 cfs @ 12.15 hrs HW=84.23' (Free Discharge)
├─**3=Sharp-Crested Vee/Trap Weir** (Weir Controls 4.16 cfs @ 3.37 fps)
└─**4=Orifice/Grate** (Orifice Controls 2.91 cfs @ 5.34 fps)

Secondary OutFlow Max=0.12 cfs @ 12.15 hrs HW=84.23' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 0.12 cfs @ 0.42 fps)

Pond 9P: PR-UGIF - Chamber Wizard Field A

Chamber Model = CPP single-wall 12" (Single-wall corrugated HDPE pipe)
Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
Row Length Adjustment= +6.00' x 1.04 sf x 5 rows

14.7" Wide + 12.0" Spacing = 26.7" C-C Row Spacing

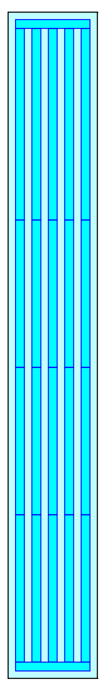
4 Chambers/Row x 20.00' Long +6.00' Row Adjustment +1.23' Header x 2 = 88.45' Row Length +12.0" End Stone x 2 = 90.45' Base Length
5 Rows x 14.7" Wide + 12.0" Spacing x 4 + 12.0" Side Stone x 2 = 12.13' Base Width
6.0" Stone Base + 14.7" Chamber Height + 4.0" Stone Cover = 2.06' Field Height

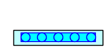
20 Chambers x 20.8 cf +6.00' Row Adjustment x 1.04 sf x 5 Rows + 10.13' Header x 1.04 sf x 2 = 468.6 cf Chamber Storage

2,257.4 cf Field - 468.6 cf Chambers = 1,788.8 cf Stone x 40.0% Voids = 715.5 cf Stone Storage

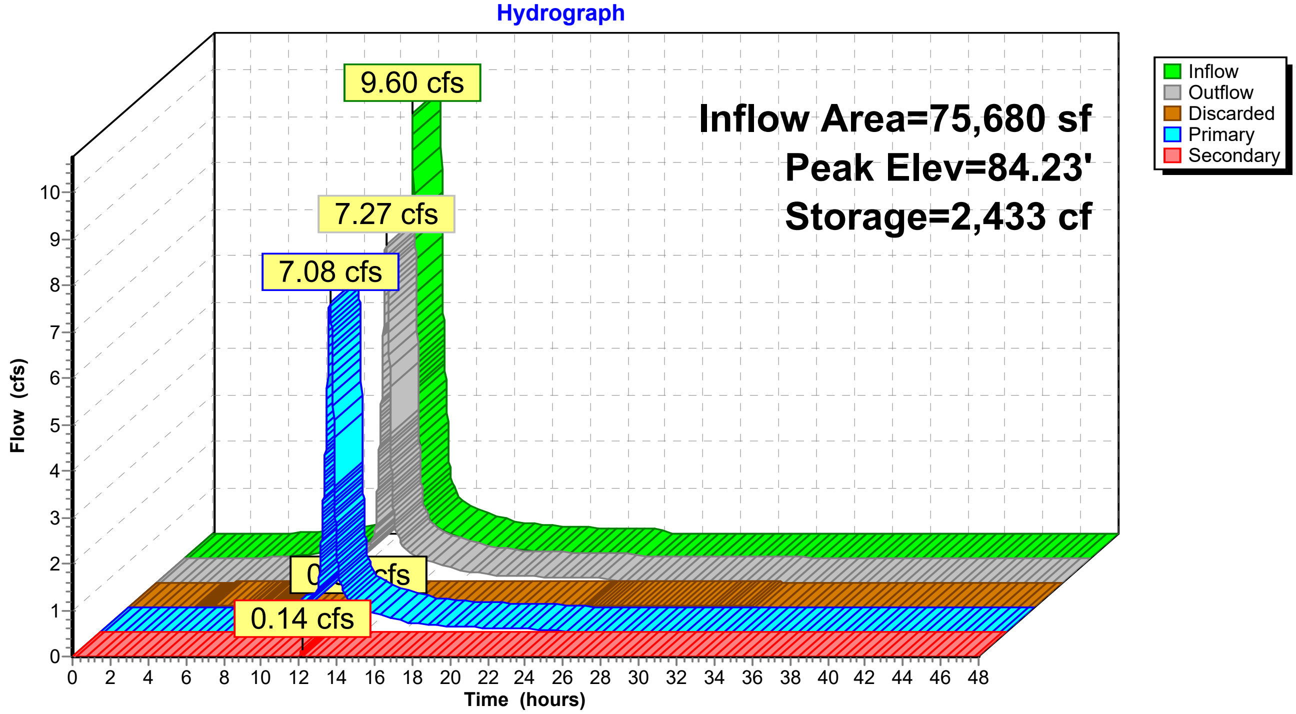
Chamber Storage + Stone Storage = 1,184.1 cf = 0.027 af
Overall Storage Efficiency = 52.5%
Overall System Size = 90.45' x 12.13' x 2.06'

20 Chambers
83.6 cy Field
66.3 cy Stone





Pond 9P: PR-UGIF

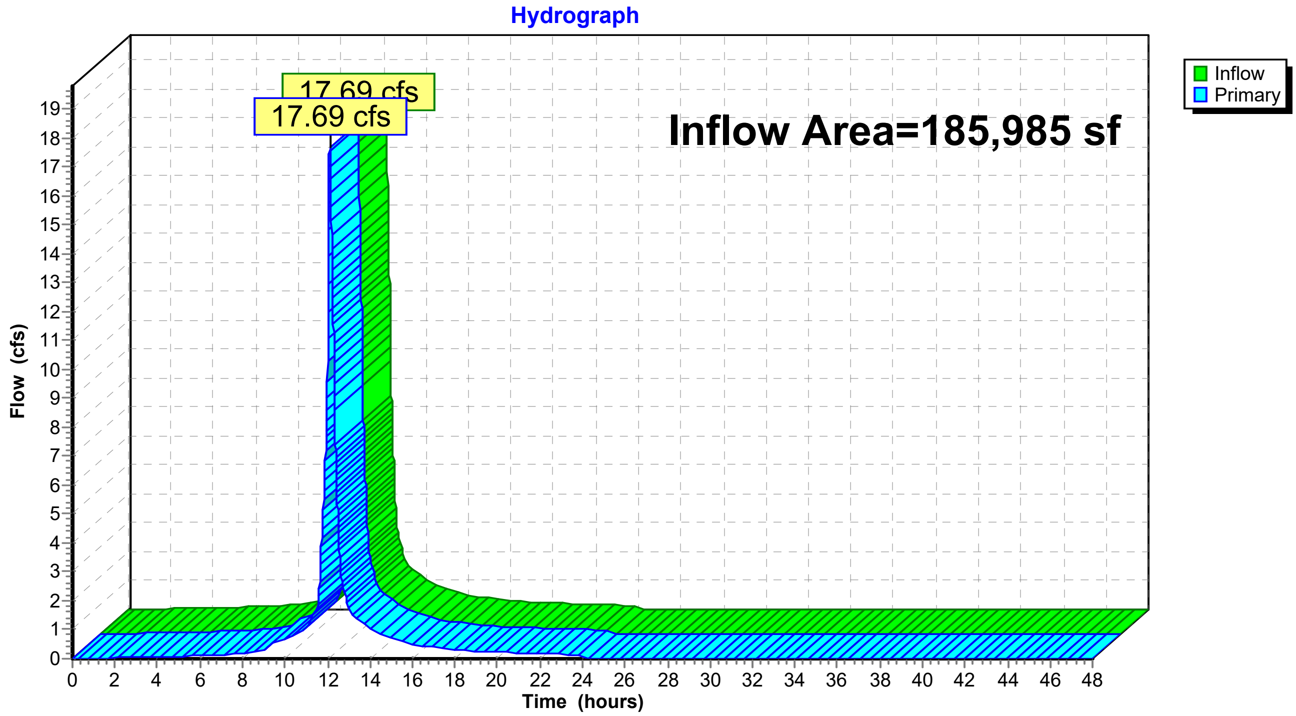


Summary for Link 1L: Lake Q

Inflow Area = 185,985 sf, 74.77% Impervious, Inflow Depth = 3.99" for 25-Year event
Inflow = 17.69 cfs @ 12.11 hrs, Volume= 61,909 cf
Primary = 17.69 cfs @ 12.11 hrs, Volume= 61,909 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

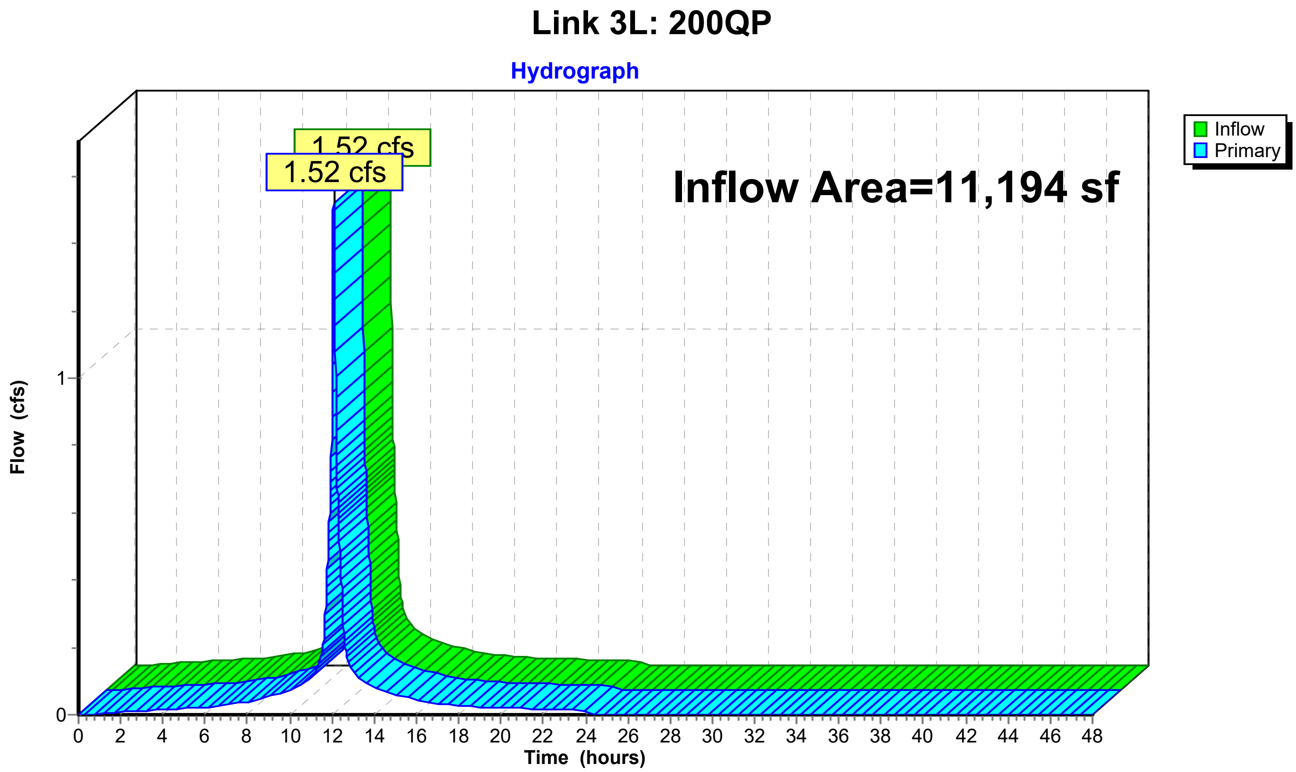
Link 1L: Lake Q



Summary for Link 3L: 200QP

Inflow Area = 11,194 sf,100.00% Impervious, Inflow Depth = 5.79" for 25-Year event
Inflow = 1.52 cfs @ 12.08 hrs, Volume= 5,403 cf
Primary = 1.52 cfs @ 12.08 hrs, Volume= 5,403 cf, Atten= 0%, Lag= 0.0 min
Routed to Link 1L : Lake Q

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs



Time span=0.00-48.00 hrs, dt=0.01 hrs, 4801 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: PR-NorthAve Runoff Area=75,680 sf 81.45% Impervious Runoff Depth=7.54"
Tc=6.0 min CN=91 Runoff=14.17 cfs 47,534 cf

Subcatchment 2S: PR-QP-South Runoff Area=31,987 sf 99.70% Impervious Runoff Depth=8.38"
Tc=6.0 min CN=98 Runoff=6.22 cfs 22,337 cf

Subcatchment 3S: EX-shoreline (to lake) Runoff Area=18,044 sf 9.12% Impervious Runoff Depth=4.16"
Tc=6.0 min UI Adjusted CN=63 Runoff=2.02 cfs 6,259 cf

Subcatchment 4S: QP-South (to 200QP) Runoff Area=4,767 sf 100.00% Impervious Runoff Depth=8.38"
Tc=6.0 min CN=98 Runoff=0.93 cfs 3,329 cf

Subcatchment 5S: QP-North (to 200QP) Runoff Area=6,427 sf 100.00% Impervious Runoff Depth=8.38"
Tc=6.0 min CN=98 Runoff=1.25 cfs 4,488 cf

Subcatchment 6S: EX-shoreline (to lake) Runoff Area=14,077 sf 0.00% Impervious Runoff Depth=3.92"
Tc=6.0 min CN=61 Runoff=1.48 cfs 4,603 cf

Subcatchment 7S: PR-QP-North Runoff Area=9,060 sf 100.00% Impervious Runoff Depth=8.38"
Tc=6.0 min CN=98 Runoff=1.76 cfs 6,327 cf

Subcatchment 8S: QP-North to Runoff Area=10,224 sf 86.64% Impervious Runoff Depth=7.78"
Tc=6.0 min CN=93 Runoff=1.94 cfs 6,627 cf

Subcatchment 9S: EX-NWofQP Runoff Area=15,719 sf 94.00% Impervious Runoff Depth=8.14"
Tc=6.0 min CN=96 Runoff=3.04 cfs 10,662 cf

Pond 1P: Bioretention Area Peak Elev=83.48' Storage=3,434 cf Inflow=4.98 cfs 17,289 cf
Discarded=0.17 cfs 9,427 cf Primary=4.38 cfs 7,862 cf Outflow=4.55 cfs 17,289 cf

Pond 9P: PR-UGIF Peak Elev=84.50' Storage=3,038 cf Inflow=14.17 cfs 47,534 cf
Discarded=0.06 cfs 4,520 cf Primary=9.24 cfs 41,463 cf Secondary=4.21 cfs 1,457 cf Outflow=13.51 cfs 47,440 cf

Link 1L: Lake Q Inflow=31.17 cfs 98,125 cf
Primary=31.17 cfs 98,125 cf

Link 3L: 200QP Inflow=2.18 cfs 7,817 cf
Primary=2.18 cfs 7,817 cf

Total Runoff Area = 185,985 sf Runoff Volume = 112,166 cf Average Runoff Depth = 7.24"
25.23% Pervious = 46,918 sf 74.77% Impervious = 139,067 sf

Summary for Subcatchment 1S: PR-NorthAve

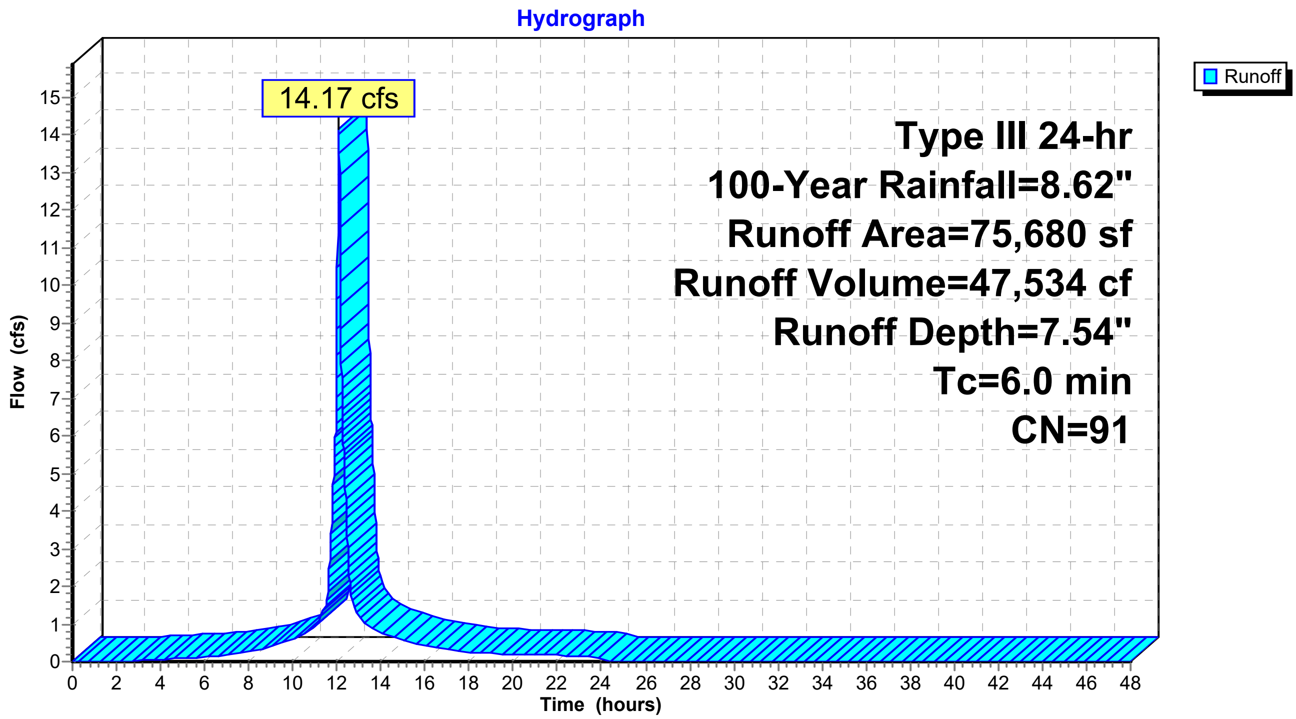
Runoff = 14.17 cfs @ 12.08 hrs, Volume= 47,534 cf, Depth= 7.54"
Routed to Pond 9P : PR-UGIF

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
44,161	98	Paved parking, HSG B
17,482	98	Roofs, HSG B
14,037	61	>75% Grass cover, Good, HSG B
75,680	91	Weighted Average
14,037		18.55% Pervious Area
61,643		81.45% Impervious Area

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

Subcatchment 1S: PR-NorthAve



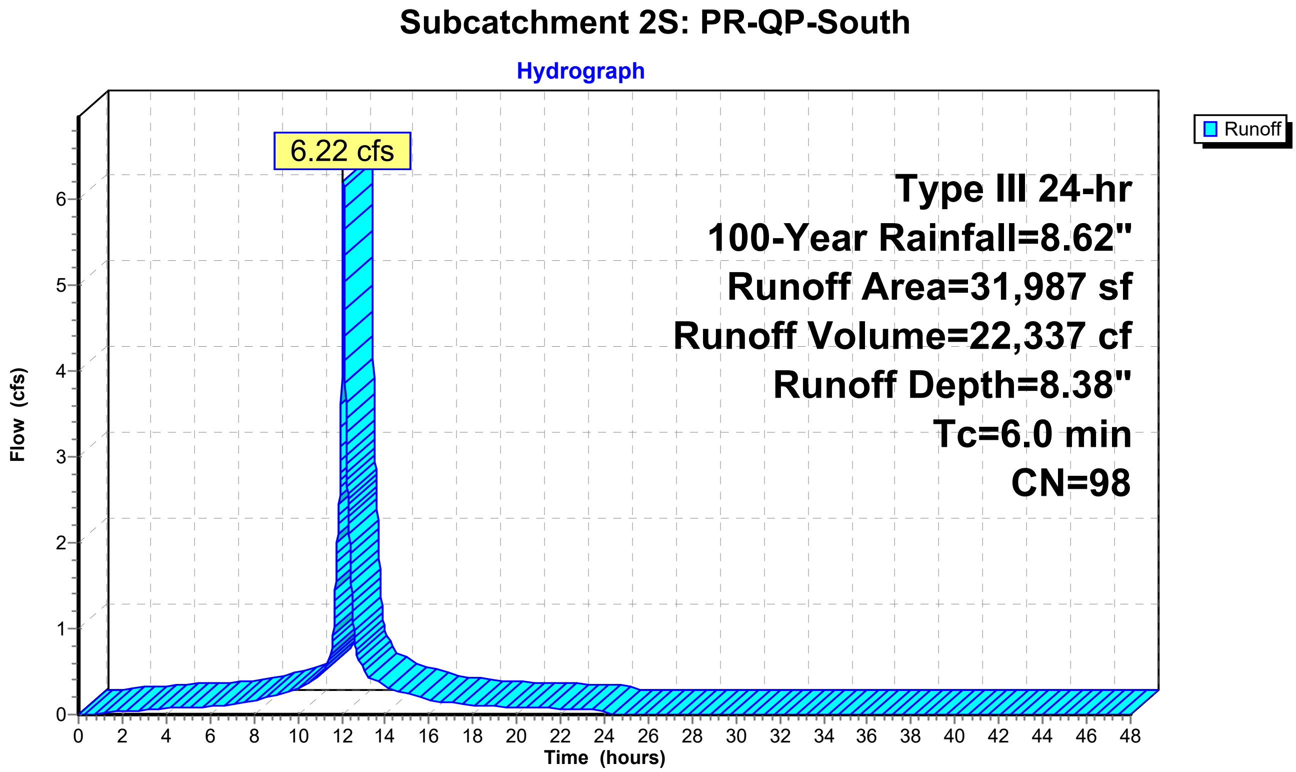
Summary for Subcatchment 2S: PR-QP-South

Runoff = 6.22 cfs @ 12.08 hrs, Volume= 22,337 cf, Depth= 8.38"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
30,933	98	Paved parking, HSG B
957	98	Roofs, HSG B
97	61	>75% Grass cover, Good, HSG B
31,987	98	Weighted Average
97		0.30% Pervious Area
31,890		99.70% Impervious Area

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



Summary for Subcatchment 3S: EX-shoreline (to lake)

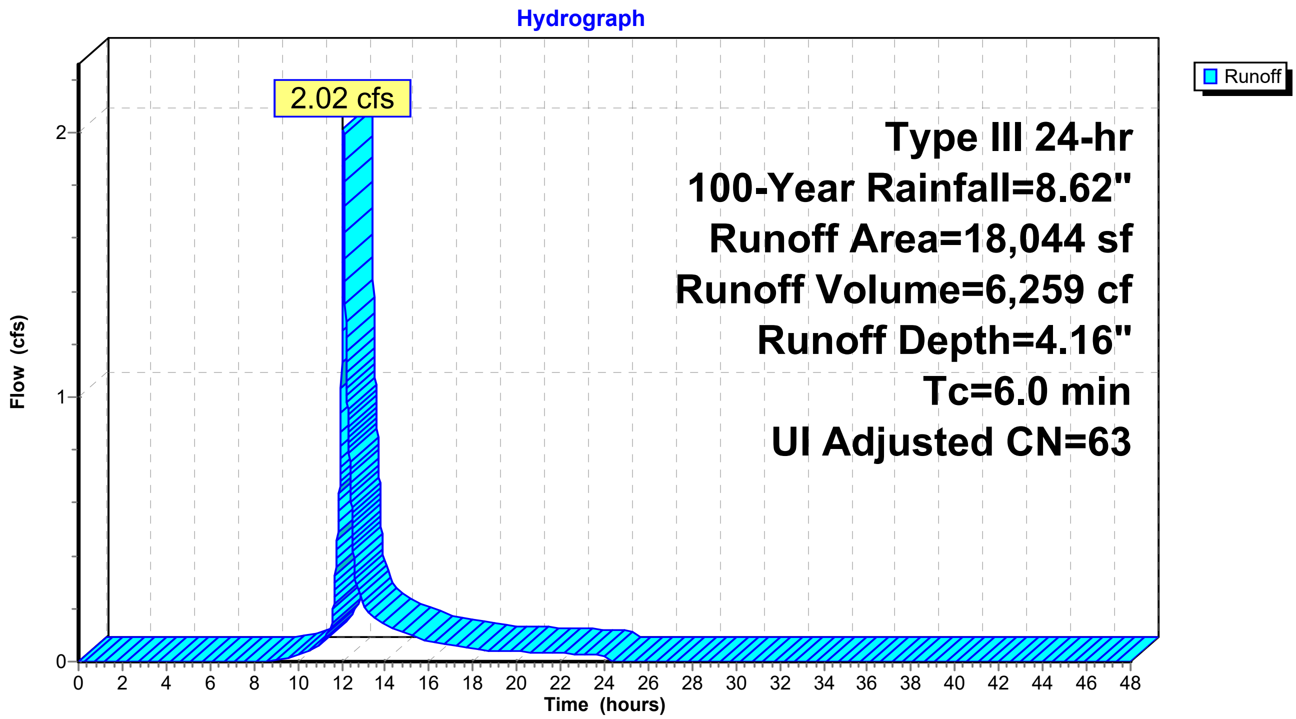
Runoff = 2.02 cfs @ 12.09 hrs, Volume= 6,259 cf, Depth= 4.16"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Adj	Description
16,398	61		>75% Grass cover, Good, HSG B
1,646	98		Unconnected roofs, HSG B
18,044	64	63	Weighted Average, UI Adjusted
16,398			90.88% Pervious Area
1,646			9.12% Impervious Area
1,646			100.00% Unconnected

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

Subcatchment 3S: EX-shoreline (to lake)



Summary for Subcatchment 4S: QP-South (to 200QP)

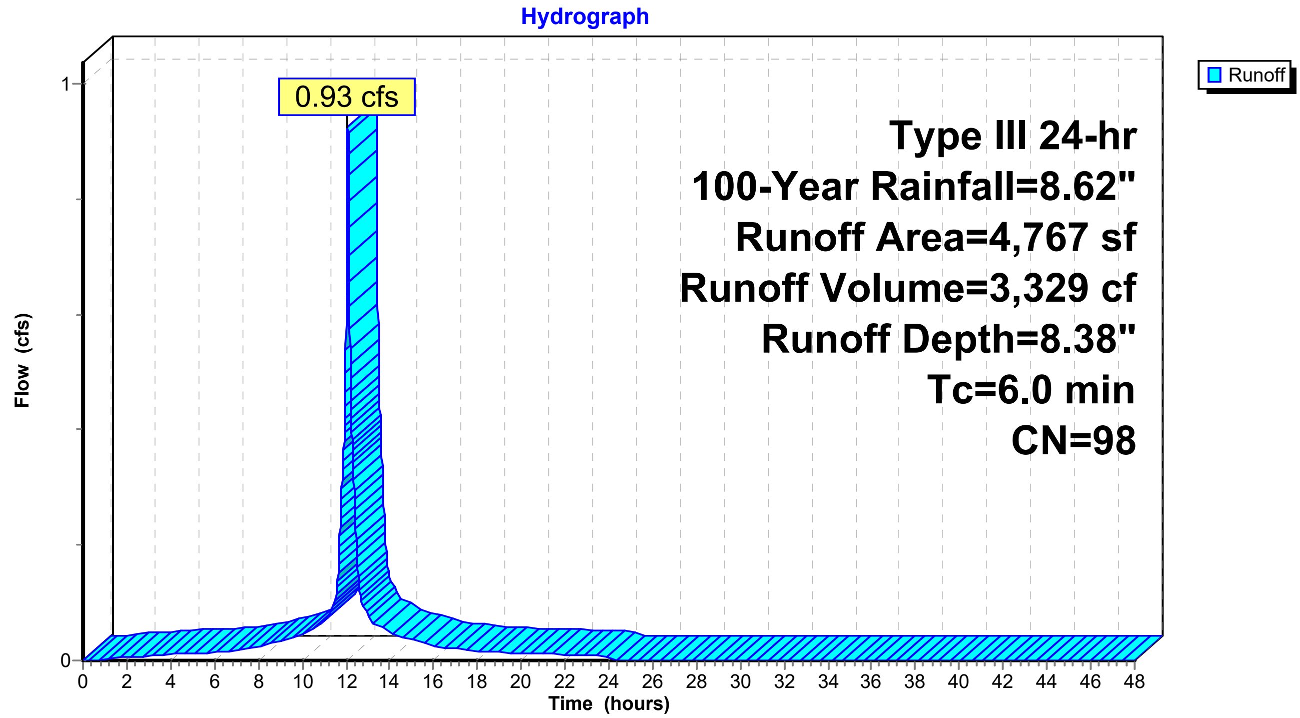
Runoff = 0.93 cfs @ 12.08 hrs, Volume= 3,329 cf, Depth= 8.38"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
4,767	98	Paved parking, HSG B
4,767		100.00% Impervious Area

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

Subcatchment 4S: QP-South (to 200QP)



Summary for Subcatchment 5S: QP-North (to 200QP)

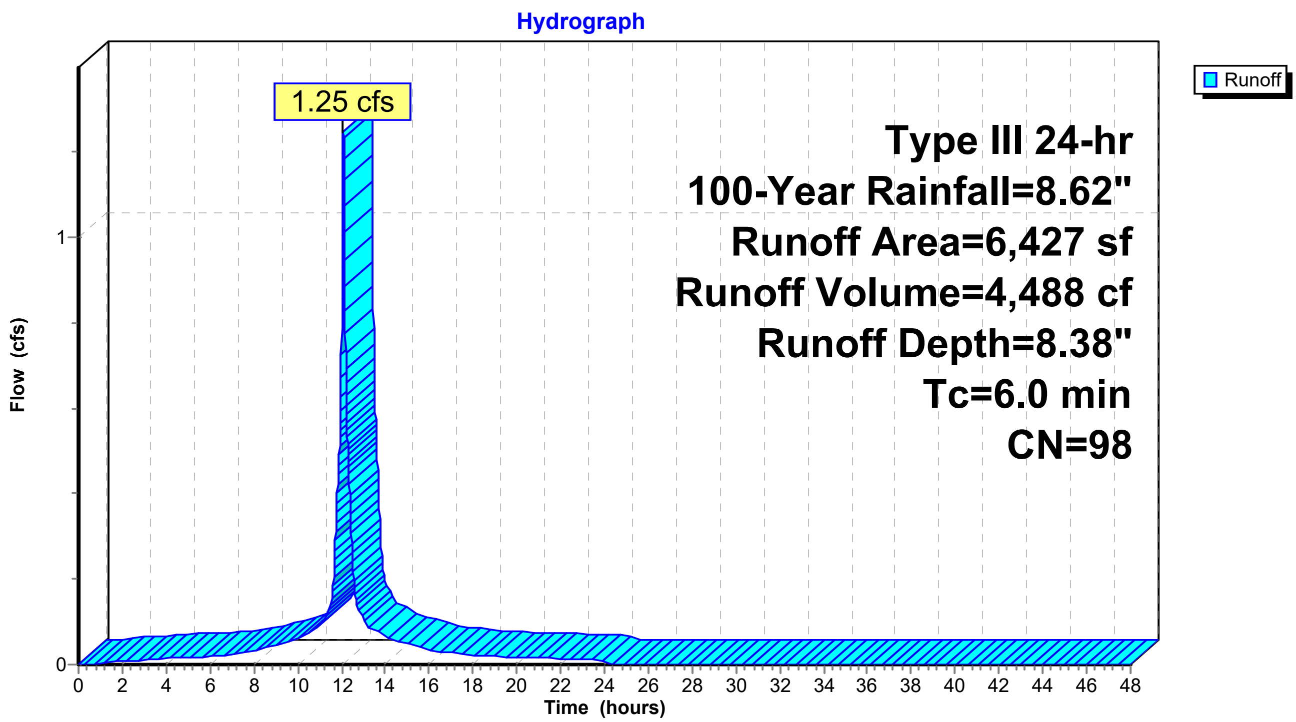
Runoff = 1.25 cfs @ 12.08 hrs, Volume= 4,488 cf, Depth= 8.38"
Routed to Link 3L : 200QP

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
6,427	98	Paved parking, HSG B
6,427		100.00% Impervious Area

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

Subcatchment 5S: QP-North (to 200QP)



Summary for Subcatchment 6S: EX-shoreline (to lake)

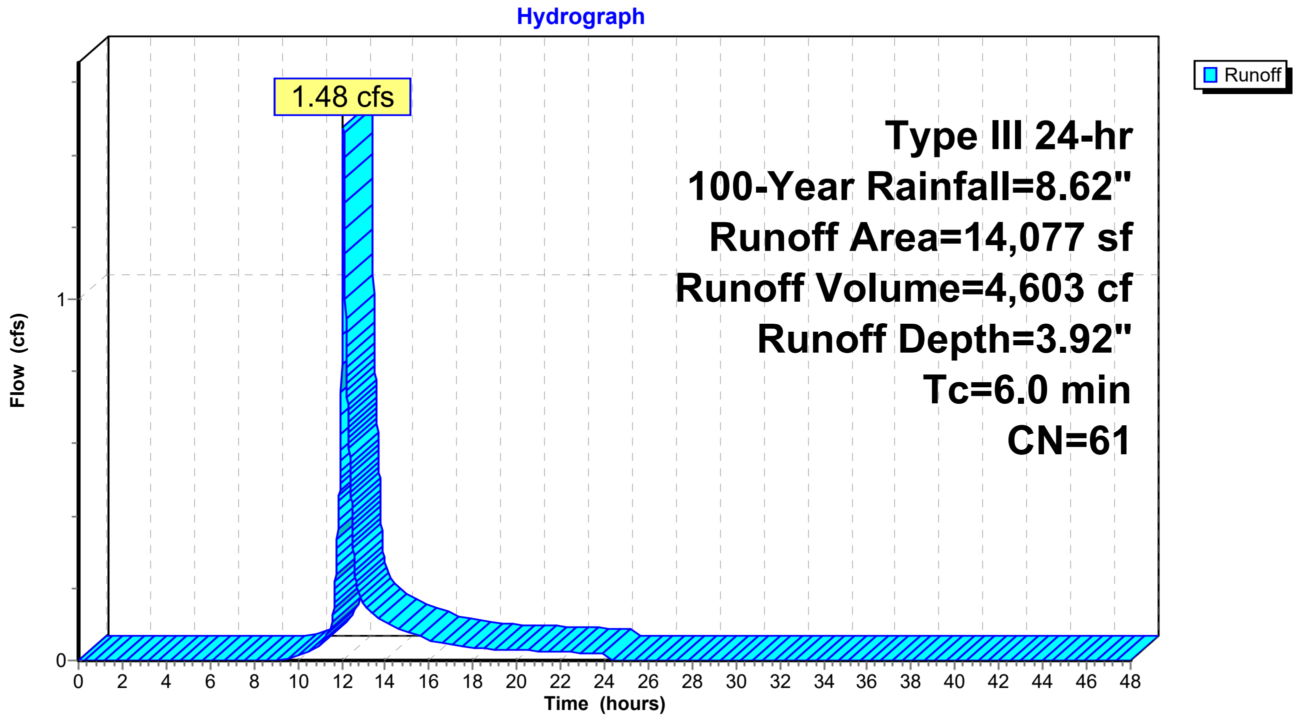
Runoff = 1.48 cfs @ 12.09 hrs, Volume= 4,603 cf, Depth= 3.92"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
14,077	61	>75% Grass cover, Good, HSG B
14,077		100.00% Pervious Area

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

Subcatchment 6S: EX-shoreline (to lake)



Summary for Subcatchment 7S: PR-QP-North

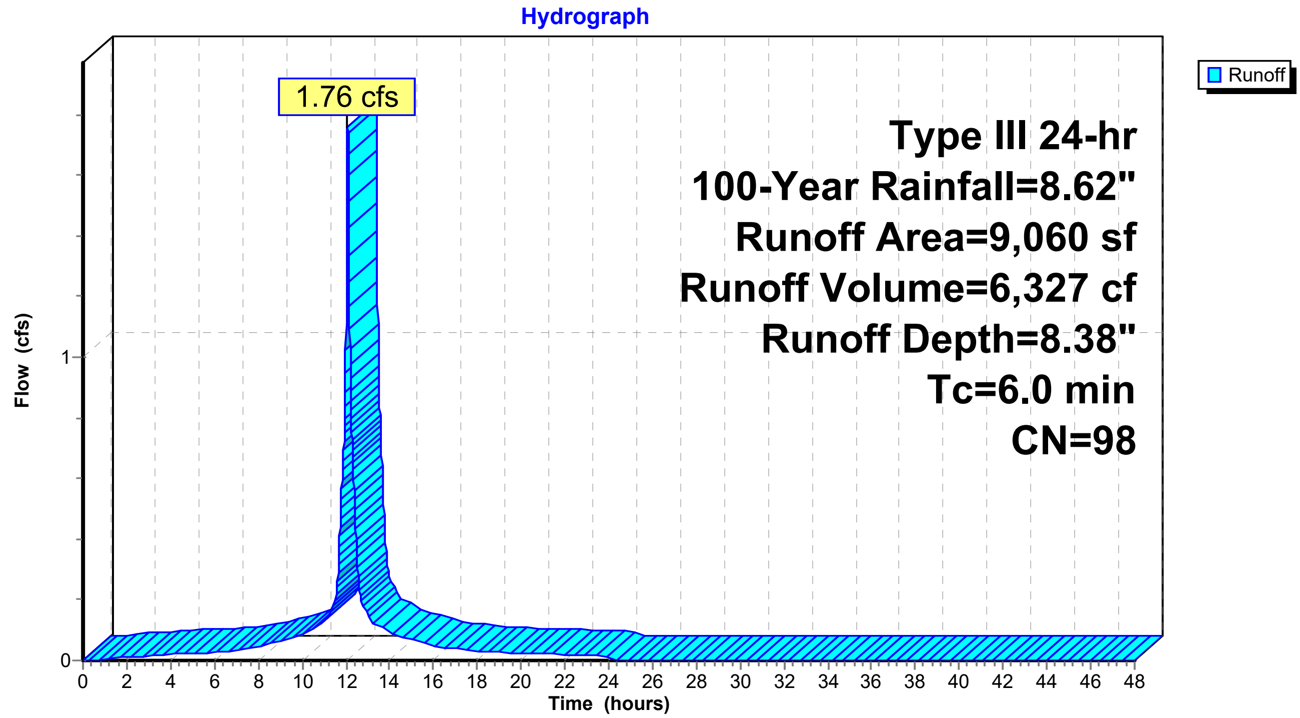
Runoff = 1.76 cfs @ 12.08 hrs, Volume= 6,327 cf, Depth= 8.38"
Routed to Link 1L : Lake Q

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
9,060	98	Paved parking, HSG B
9,060		100.00% Impervious Area

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

Subcatchment 7S: PR-QP-North



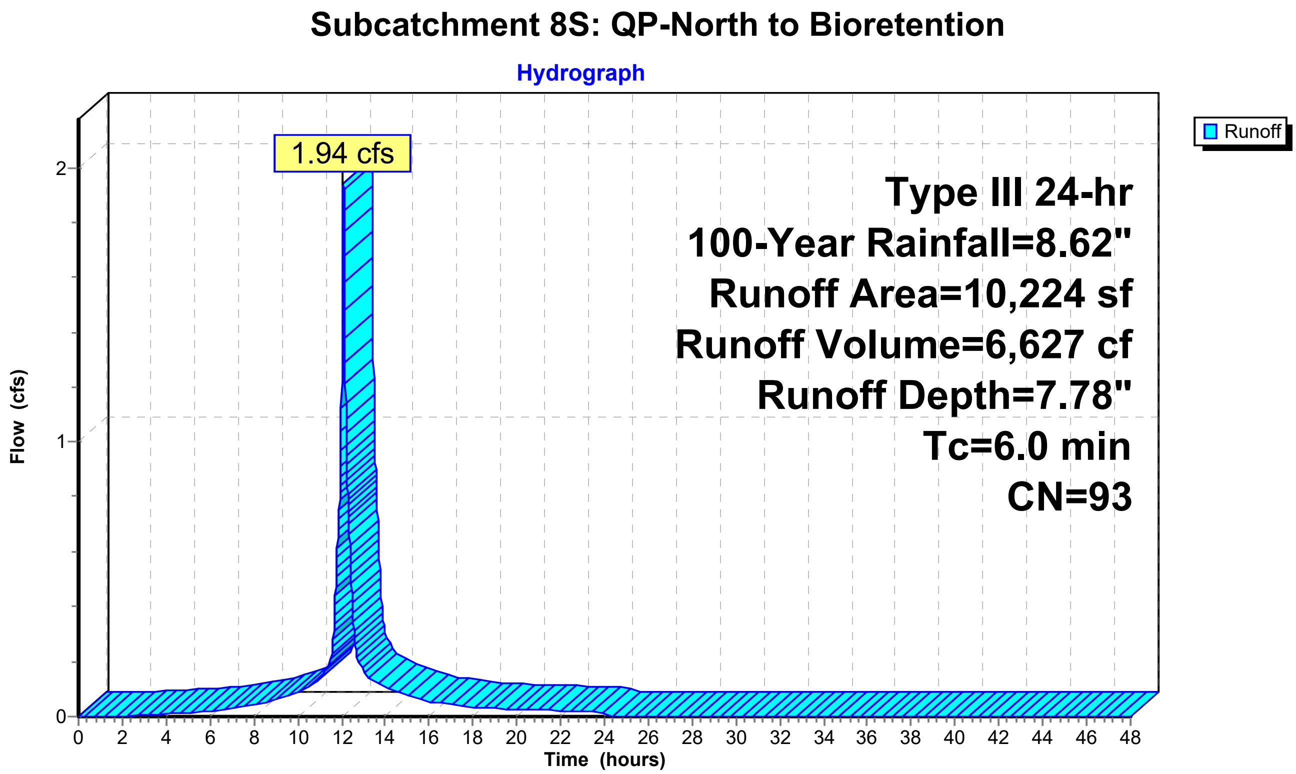
Summary for Subcatchment 8S: QP-North to Bioretention

Runoff = 1.94 cfs @ 12.08 hrs, Volume= 6,627 cf, Depth= 7.78"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
8,858	98	Paved parking, HSG B
1,366	61	>75% Grass cover, Good, HSG B
10,224	93	Weighted Average
1,366		13.36% Pervious Area
8,858		86.64% Impervious Area

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



Summary for Subcatchment 9S: EX-NWofQP

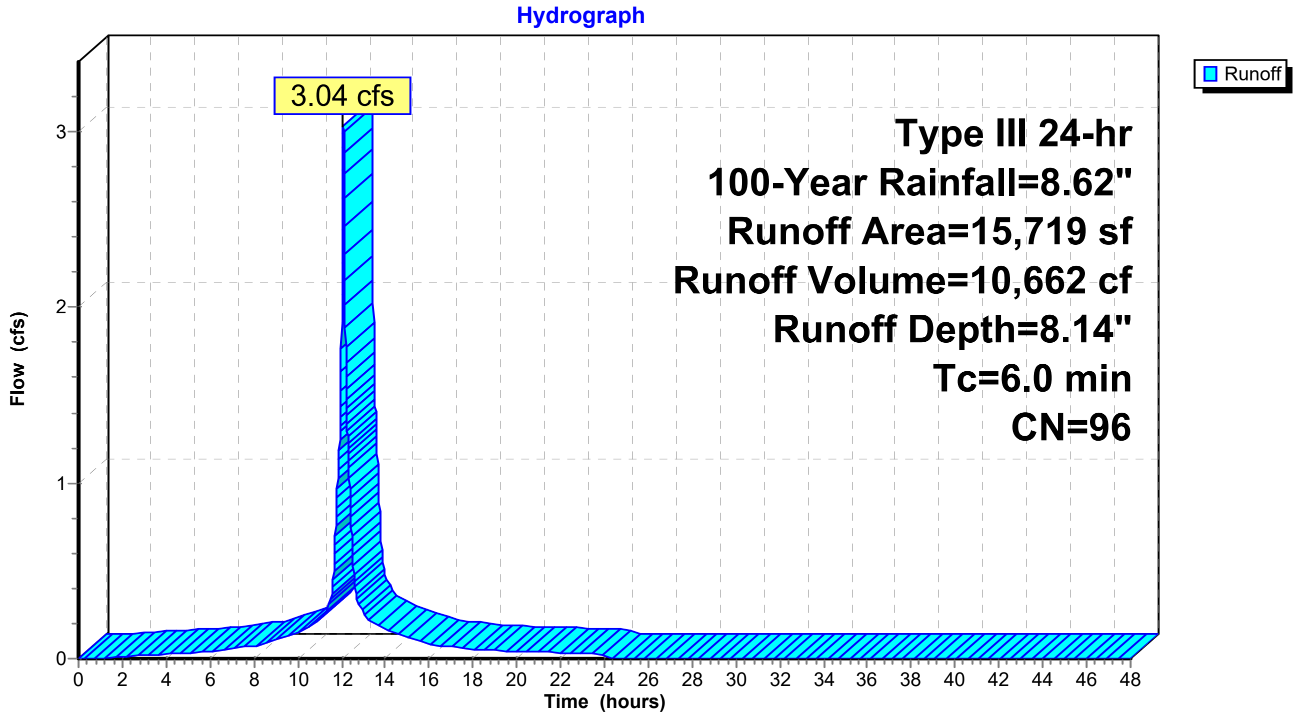
Runoff = 3.04 cfs @ 12.08 hrs, Volume= 10,662 cf, Depth= 8.14"
Routed to Pond 1P : Bioretention Area

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.62"

Area (sf)	CN	Description
14,776	98	Paved parking, HSG B
943	61	>75% Grass cover, Good, HSG B
15,719	96	Weighted Average
943		6.00% Pervious Area
14,776		94.00% Impervious Area

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

Subcatchment 9S: EX-NWofQP



Summary for Pond 1P: Bioretention Area

Inflow Area = 25,943 sf, 91.10% Impervious, Inflow Depth = 8.00" for 100-Year event
Inflow = 4.98 cfs @ 12.08 hrs, Volume= 17,289 cf
Outflow = 4.55 cfs @ 12.12 hrs, Volume= 17,289 cf, Atten= 9%, Lag= 2.1 min
Discarded = 0.17 cfs @ 12.12 hrs, Volume= 9,427 cf
Primary = 4.38 cfs @ 12.12 hrs, Volume= 7,862 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Peak Elev= 83.48' @ 12.12 hrs Surf.Area= 2,023 sf Storage= 3,434 cf

Plug-Flow detention time= 92.3 min calculated for 17,285 cf (100% of inflow)
Center-of-Mass det. time= 92.3 min (848.1 - 755.8)

Volume	Invert	Avail.Storage	Storage Description
#1	81.80'	4,840 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

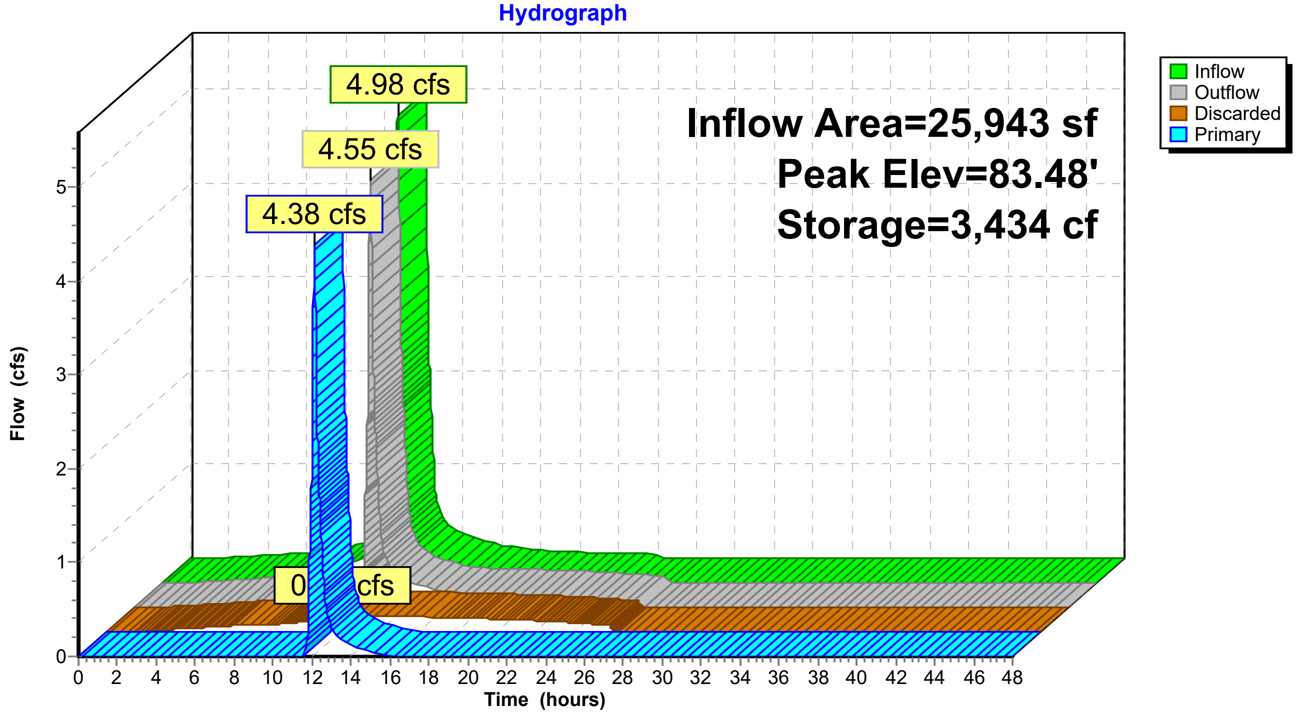
Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
81.80	1,293	0	0
82.00	1,441	273	273
82.50	2,115	889	1,162
83.00	2,548	1,166	2,328
83.50	2,006	1,139	3,467
84.00	3,489	1,374	4,840

Device	Routing	Invert	Outlet Devices
#1	Discarded	81.80'	**2.400 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 75.00'
#2	Primary	83.00'	**5.0' long x 4.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.38 2.54 2.69 2.68 2.67 2.67 2.65 2.66 2.66 2.68 2.72 2.73 2.76 2.79 2.88 3.07 3.32

Discarded OutFlow Max=0.17 cfs @ 12.12 hrs HW=83.48' (Free Discharge)
└─**1=Exfiltration** (Controls 0.17 cfs)

Primary OutFlow Max=4.38 cfs @ 12.12 hrs HW=83.48' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 4.38 cfs @ 1.81 fps)

Pond 1P: Bioretention Area



Summary for Pond 9P: PR-UGIF

Inflow Area = 75,680 sf, 81.45% Impervious, Inflow Depth = 7.54" for 100-Year event
Inflow = 14.17 cfs @ 12.08 hrs, Volume= 47,534 cf
Outflow = 13.51 cfs @ 12.10 hrs, Volume= 47,440 cf, Atten= 5%, Lag= 1.0 min
Discarded = 0.06 cfs @ 12.10 hrs, Volume= 4,520 cf
Primary = 9.24 cfs @ 12.10 hrs, Volume= 41,463 cf
Routed to Link 1L : Lake Q
Secondary = 4.21 cfs @ 12.10 hrs, Volume= 1,457 cf
Routed to Link 1L : Lake Q

Routing by Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 84.50' @ 12.10 hrs Surf.Area= 1,097 sf Storage= 3,038 cf

Plug-Flow detention time= 35.7 min calculated for 47,430 cf (100% of inflow)
Center-of-Mass det. time= 34.5 min (805.0 - 770.5)

Volume	Invert	Avail.Storage	Storage Description
#1A	80.85'	715 cf	**12.13'W x 90.45'L x 2.06'H Field A**
			2,257 cf Overall - 469 cf Embedded = 1,789 cf x 40.0% Voids
#2A	81.35'	469 cf	**CPP single-wall 12"** x 20 Inside #1
			Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
			Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
			Row Length Adjustment= +6.00' x 1.04 sf x 5 rows
			10.13' Header x 1.04 sf x 2 = 21.1 cf Inside
#3	83.50'	1,796 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc) -Impervious
#4	80.65'	50 cf	**4.00'D x 4.00'H Vertical Cone/Cylinder**-Impervious
#5	80.85'	9 cf	**2.00'D x 3.00'H Vertical Cone/Cylinder**-Impervious
		3,040 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
83.50	0	0	0
83.72	4	0	0
84.00	1,921	270	270
84.20	5,561	748	1,018
84.30	10,000	778	1,796

Device	Routing	Invert	Outlet Devices
#1	Discarded	80.85'	**1.020 in/hr Exfiltration over Wetted area**
			Conductivity to Groundwater Elevation = 75.00' Phase-In= 0.01'
#2	Secondary	84.20'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
			Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64
#3	Primary	82.50'	**45.0 deg Sharp-Crested Vee/Trap Weir** Cv= 2.56 (C= 3.20)
#4	Primary	83.00'	**10.0" Horiz. Orifice/Grate** C= 0.600
			Limited to weir flow at low heads

Discarded OutFlow Max=0.06 cfs @ 12.10 hrs HW=84.50' (Free Discharge)
└─**1=Exfiltration** (Controls 0.06 cfs)

Primary OutFlow Max=9.24 cfs @ 12.10 hrs HW=84.50' (Free Discharge)
├─**3=Sharp-Crested Vee/Trap Weir** (Weir Controls 6.02 cfs @ 3.62 fps)
└─**4=Orifice/Grate** (Orifice Controls 3.22 cfs @ 5.90 fps)

Secondary OutFlow Max=4.20 cfs @ 12.10 hrs HW=84.50' (Free Discharge)
└─**2=Broad-Crested Rectangular Weir** (Weir Controls 4.20 cfs @ 1.39 fps)

Pond 9P: PR-UGIF - Chamber Wizard Field A

Chamber Model = CPP single-wall 12" (Single-wall corrugated HDPE pipe)
Inside= 12.0"W x 12.0"H => 1.04 sf x 20.00'L = 20.8 cf
Outside= 14.7"W x 14.7"H => 1.04 sf x 20.00'L = 20.8 cf
Row Length Adjustment= +6.00' x 1.04 sf x 5 rows

14.7" Wide + 12.0" Spacing = 26.7" C-C Row Spacing

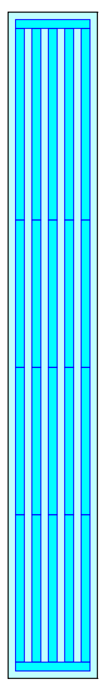
4 Chambers/Row x 20.00' Long +6.00' Row Adjustment +1.23' Header x 2 = 88.45' Row Length +12.0" End Stone x 2 = 90.45' Base Length
5 Rows x 14.7" Wide + 12.0" Spacing x 4 + 12.0" Side Stone x 2 = 12.13' Base Width
6.0" Stone Base + 14.7" Chamber Height + 4.0" Stone Cover = 2.06' Field Height

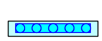
20 Chambers x 20.8 cf +6.00' Row Adjustment x 1.04 sf x 5 Rows + 10.13' Header x 1.04 sf x 2 = 468.6 cf Chamber Storage

2,257.4 cf Field - 468.6 cf Chambers = 1,788.8 cf Stone x 40.0% Voids = 715.5 cf Stone Storage

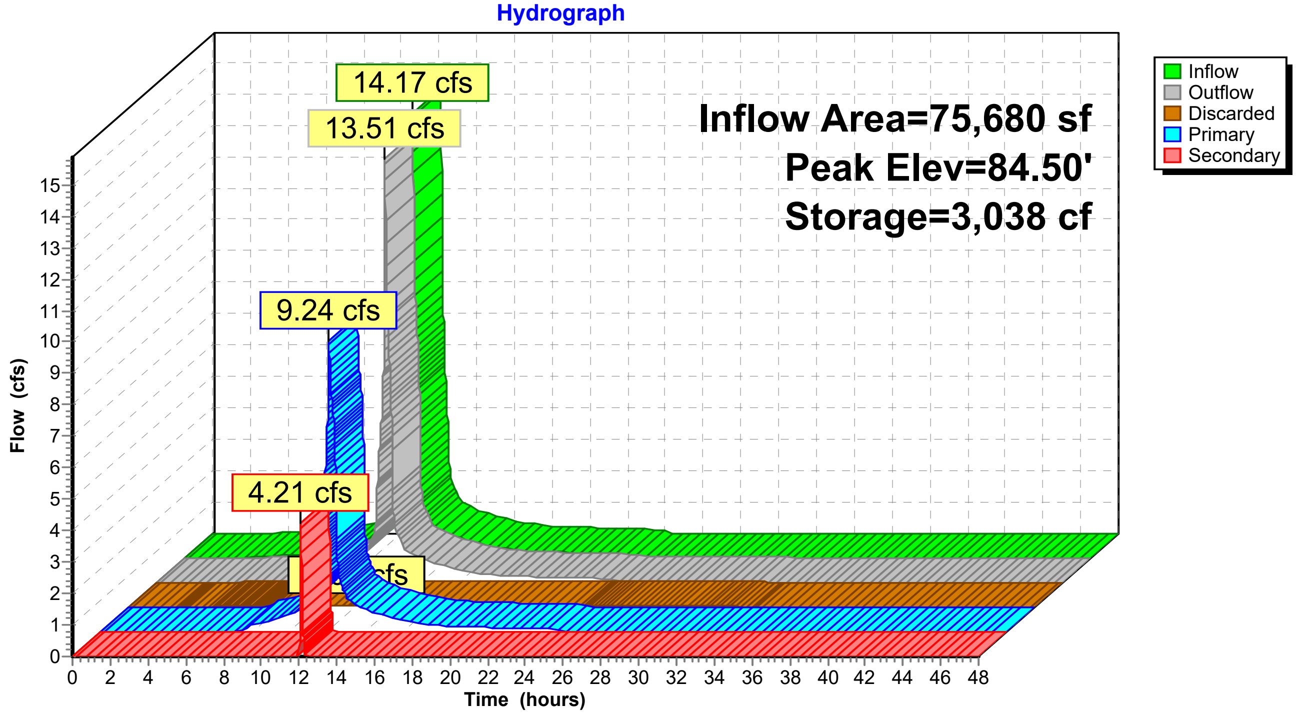
Chamber Storage + Stone Storage = 1,184.1 cf = 0.027 af
Overall Storage Efficiency = 52.5%
Overall System Size = 90.45' x 12.13' x 2.06'

20 Chambers
83.6 cy Field
66.3 cy Stone





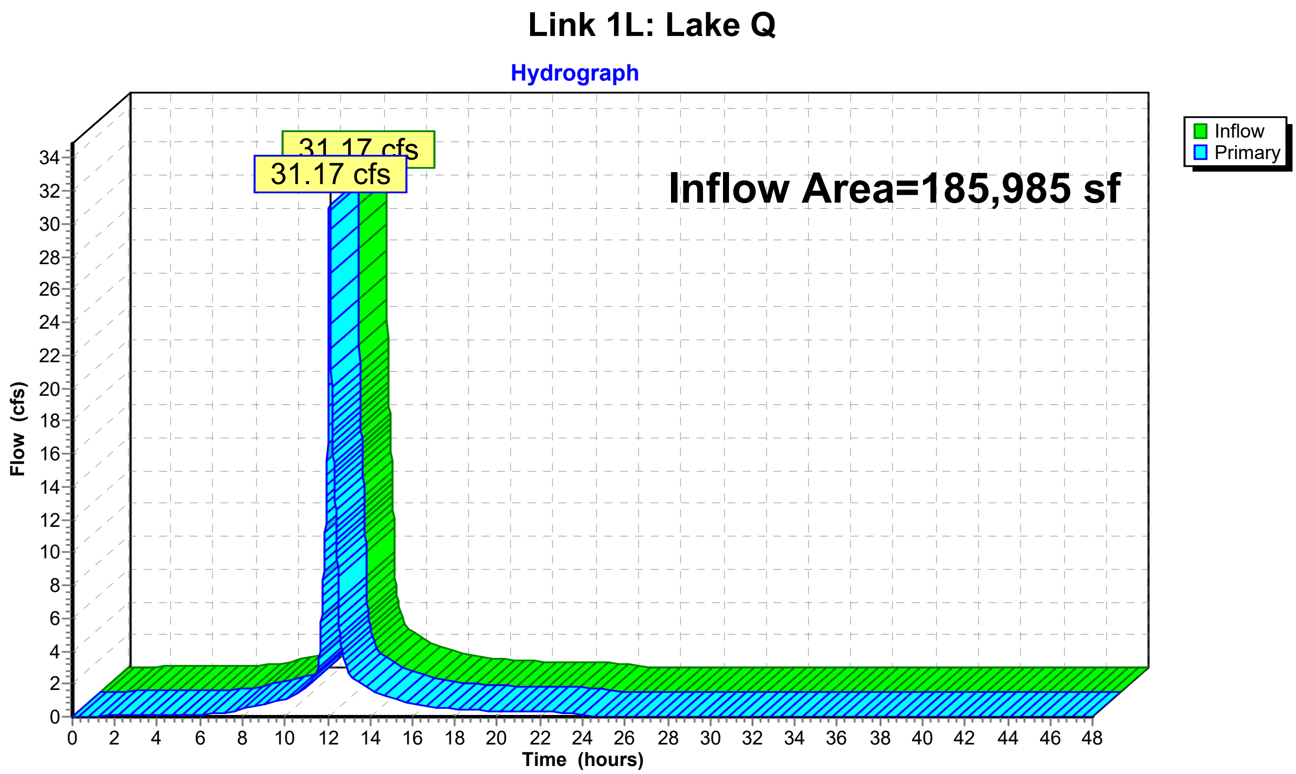
Pond 9P: PR-UGIF



Summary for Link 1L: Lake Q

Inflow Area =	185,985 sf,	74.77% Impervious,	Inflow Depth = 6.33"	for 100-Year event
Inflow =	31.17 cfs @	12.10 hrs, Volume=	98,125 cf	
Primary =	31.17 cfs @	12.10 hrs, Volume=	98,125 cf, Atten= 0%, Lag= 0.0 min	

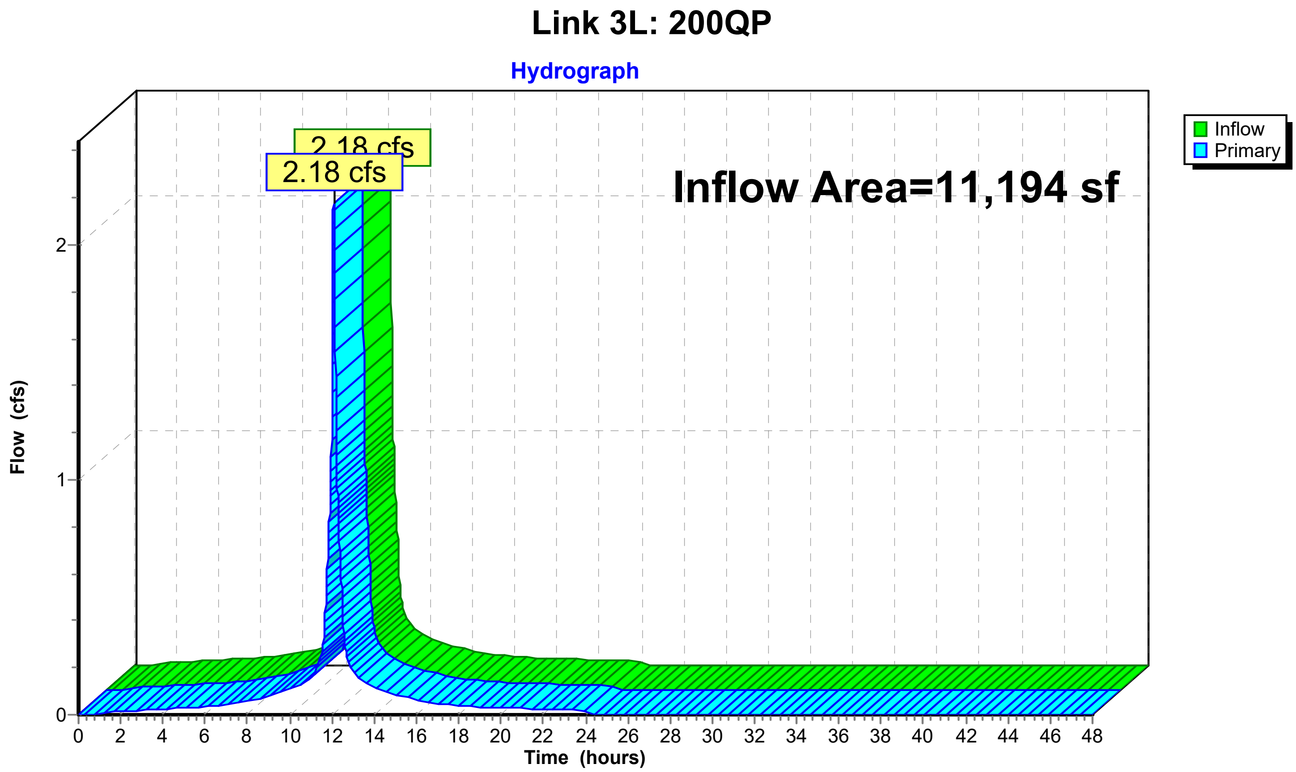
Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs



Summary for Link 3L: 200QP

Inflow Area = 11,194 sf,100.00% Impervious, Inflow Depth = 8.38" for 100-Year event
Inflow = 2.18 cfs @ 12.08 hrs, Volume= 7,817 cf
Primary = 2.18 cfs @ 12.08 hrs, Volume= 7,817 cf, Atten= 0%, Lag= 0.0 min
Routed to Link 1L : Lake Q

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs



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TOWN OF WAKEFIELD

Title	MA DEP Standard Calculations
Project	Quannapowitt Parkway Access Road Improvements
Location	Quannapowitt Parkway Wakefield, MA
Date	4-Apr-24
Revised	

By:	TWW
Checked:	WJR
Approved:	WJR

Stormwater Recharge/Water Quality Volume Table

$Rv = F*A_{imp}$

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

Rv = Required Recharge Volume (cu-ft)

F = Target Depth Factor associated with each Hydraulic Soil Group

A_{WQ} = Required Water Quality Treatment Volume (cu-ft)

D_{WQ} = Water Quality Depth 1 inch

A_{imp} - Impervious Area (pavement and rooftop area)

						Recharge Required			Water Quality Volume Required	
Subcatchment	Area (sq-ft)	Landscaped	Impervious Area (sq-ft)			F Avg. (inches)	Impervious Area (sq ft)	Rv (cu-ft)	D_{WQ} (inch)	A_{WQ}
			HSG B (F=0.35)	HSG C (F=0.25)	HSG D=(F=0.10)					
1S	69,446	12,418	57,028			0.35	57,028	1,663	1	4,752
2S	35,690	974	34,716			0.35	34,716	1,013	1	2,893
3S	18,044	16,398	1,646			0.35	1,646	48	1	137
4S*	5,890	0	5,890			0.35	5,890	172	1	491
5S*	6,427	0	6,427			0.35	6,427	187	1	536
6S	14,077	14,077	0			0.10	0	0	1	0
7S	9,060	0	9,060			0.35	9,060	264	1	755
8S	10,224	1,366	8,858			0.35	8,858	258	1	738
9S	15,719	943	14,776			0.35	14,776	431	1	1,231
Total	184,577	46,176	138,401	0	0		138,401	4,036		11,533

*Recharge calculated as part of the 200QP project NOI

TOWN OF WAKEFIELD

Title	MA DEP Standard Calculations		By:	TWW
Project	Quannapowitt Parkway Access Road Improvements		Checked:	WJR
Location	Quannapowitt Parkway Wakefield, MA		Approved:	WJR
Date	4-Apr-24			
Revised				

Stormwater Recharge Summary

	Required (cf)	Provided (cf)	
1S-ARv =	1,663	1,184	Infiltration Chambers (Below Outlet=83.00)[PR-1S]
2S-ARv =	1,013	0	Gutter Inlet/Trench Drain [PR-2S]
3S-ARv =	48	0	Overland flow on lake side of roadway [3S]
4S-ARv =*	172	0	Quannapowitt Parkway south to 200 QP [4S]
5S-ARv =*	187	0	Quannapowitt Parkway north to 200 QP [5S]
6S-ARv =	0	0	Overland flow on lake side of roadway [6S]
7S-Arv =	264	0	Gutter Inlet/Trench Drain [PR-7S]
8S&9S-ARv =	689	2,328	Ex. Bio-retention area (Below overflow berm=83.00)[PR-8S, PR-9S]
Total-Arv =	4,036	3,512	Total
Capture Area Adj.*=	6,008		

*Capture Area Adjustment	
Total impervious area	138,401
Site impervious area draining to recharge BMPs	92,979
Ratio	1.49
Adjusted ARv	6,008

Water Quality Summary

	Required (cf)	Provided (cf)	
1S-ARv =	4,752	1,184	Infiltration Chambers (Below Outlet=83.00)[PR-1S]
2S-ARv =	2,893	0	Gutter Inlet/Trench Drain [PR-2S]
3S-ARv =	137	0	Overland flow on lake side of roadway [3S]
4S-ARv =*	491	0	Quannapowitt Parkway south to 200 QP [4S]
5S-ARv =*	536	0	Quannapowitt Parkway north to 200 QP [5S]
6S-ARv =	0	0	Overland flow on lake side of roadway [6S]
7S-Arv =	755	0	Gutter Inlet/Trench Drain [PR-7S]
8S&9S-ARv =	1,969	2,328	Ex. Bio-retention area (Below overflow berm=83.00)[PR-8S, PR-9S]
Total-Arv =	11,533	3,512	Total
Capture Area Adj.*=	17,167		

*Capture Area Adjustment	
Total impervious area	138,401
Site impervious area draining to recharge BMPs	92,979
Ratio	1.49
Adjusted ARv	17,167

TOWN OF WAKEFIELD

Title	MA DEP Standard Calculations	By:	TWW
Project	Quannapowitt Parkway Access Road Improvements	Checked:	WJR
Location	Quannapowitt Parkway Wakefield, MA	Approved:	WJR
Date	4-Apr-24		
Revised			

Draindown Within 72 Hours

$Time_{drawdown}$=(Rv)(1/Design Infiltration Rate in inches per hour)(Conversion for inches to feet)(1/bottom area in sq-ft)

Infiltration Chambers (HSG B)	
Infiltration Rate (in/hr) =	1.02
Bottom Area (sq-ft) =	855
Infiltration Volume (cu-ft) =	1,184
$Time_{drawdown}$(hours) =	16.29

Existing Bio-retention Area (HSG B)	
Infiltration Rate (in/hr) =	2.4
Bottom Area (sq-ft) =	627
Infiltration Volume (cu-ft) =	2,328
$Time_{drawdown}$(hours) =	18.56

TOWN OF
WAKEFIELD

Title	MA DEP Standard Calculations
Project	Quannapowitt Parkway Access Road Improvements
Location	Quannapowitt Parkway Wakefield, MA
Date	4-Apr-24
Revised	

By:	TWW
Checked:	WJR
Approved:	WJR

Forebay Sizing/Hydrodynamic Separator Sizing

$FV = D*A_{imp}$

FV = Required Forebay Volume (cf)

D = Design Depth Factor (0.1")

A_{imp} = Contributing Impervious Area (sf)

Subcatchment	Area (sq-ft)	Landscaped	Impervious Area (sq-ft)	FV_{req}	FV_{prop}	Notes:
1S	69,446	12,418	57,028	475	N/A	Hydrodynmic Separator pretreatment
2S	35,690	974	34,716	289	N/A	Gutter inlet/trench drain
3S	18,044	16,398	1,646	14	N/A	Rooftop runoff
4S	5,890	0	5,890	49	N/A	To 200QP
5S	6,427	0	6,427	54	N/A	To 200QP
6S	14,077	14,077	0	0	N/A	No impervious
7S	9,060	0	9,060	76	N/A	Gutter inlet/trench drain
8S	10,224	1,366	8,858	74	234	Existing Bio-retention Area
9S	15,719	943	14,776	123	N/A	Hydrodynmic Separator pretreatment

WQF = qu*A*WQV

WQF = water quality flow = peak flow rate associated with first 1-inch of runoff

qu = the unit peak discharge (csm/in) (form table 4 of MassDEP guidance effective October 15, 2013)

A = impervious surface drainage area (sq. mi.)

WQV = water quality volume in watershed inches (1.0")

Subcatchment Structure	Tc (hr)	qu	A	WQV (1")	WQF
WQS-1S	0.285	593	0.002045598	1	1.2
WQS-2S	0.100	774	0.001245265	1	1.0
WQU-7S	0.100	774	0.000324983	1	0.3
WQU-9S	0.100	774	0.000530016	1	0.4

Title	Outfall Erosion Calculations
Project	Quannapowitt Parkway Roadway Improvements
Location	Quannapowitt Parkway Wakefield, MA
Date	25-Jan-24
Revised	

By:	TWW
Checked:	WJR
Approved:	WJR

Outfall Erosion Calculations - FHWA Hydraulic Engineering Circular No. 14, Third Edition - *Hydraulic Design of Energy Dissipators for Culverts and Channels*

Outfall - Underground Infiltration System

Eq. 10.4

$$D_{50} = 0.2D\left(\frac{Q}{\sqrt{g}D^{2.5}}\right)^{4/3}\left(\frac{D}{TW}\right)$$

where:

D_{50} = riprap size (ft) *
Q = design discharge (cfs)
D = culvert diameter (circular) (ft)
TW = tailwater depth (ft) **
g = accelaration due to gravity (32.2 ft/s^2)
* use FHWA riprap class
** Tailwater depth for Eq 10.4 should be limited to between 0.4D and 1.0D. If tailwater is unknown, use 0.4D

Q =	8.76	cfs
D =	1.50	ft
TW =	0.60	ft
g =	32.20	ft/s^2
D_{50} =	**0.35**	**ft**
	4	**in**
Apron	use class 1 riprap	
L	6	ft
D	14	in
W	8.5	ft

Table 10.1. Example Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
1	125	5	4D	3.5D_{50}
2	150	6	4D	3.3D_{50}
3	250	10	5D	2.4D_{50}
4	350	14	6D	2.2D_{50}
5	500	20	7D	2.0D_{50}
6	550	22	8D	2.0D_{50}

[1]D is the culvert rise.

TOWN OF WAKEFIELD

Title	Outfall Erosion Calculations
Project	Quannapowitt Parkway Roadway Improvements
Location	Quannapowitt Parkway Wakefield, MA
Date	25-Jan-24
Revised	

By:	TWW
Checked:	WJR
Approved:	WJR

Outfall - Gutter Inlet/Trench Drains

Eq D.1a
$$D_{50} = 0.023D\left(\frac{Q}{\alpha D^{2.5}}\right)\left(\frac{D}{TW}\right)^{1.2}$$

Eq D.1b
$$D_{50} = 0.014D\left(\frac{Q}{\alpha B D^{1.5}}\right)\left(\frac{D}{TW}\right)$$

where:

D_{50} = riprap size (ft) *
Q = design discharge (cfs)
D = culvert diameter (circular) or culvert rise (rectangular) (ft)
B = culvert span (rectangular) (ft)
TW = tailwater depth (ft) **
α = unit conversion constant (CU) = 1.0
* use FHWA riprap class

Q =	6.92	cfs
D =	0.75	ft
B =	2.00	ft
TW =	0.30	ft
α =	1.00	
D_{50} =	**0.14**	**ft**
	2	**in**
Apron	use class 1 riprap	
L	3	ft
D	7	in
W	8	ft

Table 10.1. Example Riprap Classes and Apron Dimensions

Class	D_{50} (mm)	D_{50} (in)	Apron Length[1]	Apron Depth
1	125	5	4D	$3.5D_{50}$
2	150	6	4D	$3.3D_{50}$
3	250	10	5D	$2.4D_{50}$
4	350	14	6D	$2.2D_{50}$
5	500	20	7D	$2.0D_{50}$
6	550	22	8D	$2.0D_{50}$

[1]D is the culvert rise.

Nutrient Calculations - Capacity and Nitrogen/Phosphorus Removal
Quanapowitt Parkway
April 4, 2024
By: TWW

Subcatchment	**1S**	**2S**	**3S**	**4S**	**5S**	**6S**	**7S**	**8S**	**9S**	**Totals**
Paved Area (sq ft)	44,161	30,933	0	4,767	6,427	0	9,060	8,858	14,776	
Roofs (sq ft)	17,482	957	1,646	0	0	0	0	0	0	
Grass (sq ft)	14,037	97	16,398	0	0	14,077	0	1,366	943	
Woods (sq ft)	0	0	0	0	0	0	0	0	0	
Total Area (sq ft)	75,680	31,987	18,044	4,767	6,427	14,077	9,060	10,224	15,719	
Impervious Area (sq ft)	61,643	31,890	1,646	4,767	6,427	0	9,060	8,858	14,776	
Total P Load	2.61	1.30	0.18	0.19	0.26	0.09	0.37	0.37	0.61	5.39
Total P Reduction	1.30	0.00	0.00	0.00	0.00	0.00	0.00	0.37	0.61	1.66
P%	50%	0%	0%	0%	0%	0%	0%	99%	99%	**31%**
Total N Load	22.23	10.99	1.73	1.64	2.21	1.00	3.12	3.15	5.16	46.07
Total N Reduction	17.65	0.00	0.00	0.00	0.00	0.00	0.00	3.15	5.16	20.79
N%	79%	0%	0%	0%	0%	0%	0%	100%	100%	**45%**

Infiltration Basin Calculations - Capacity and Nitrogen/Phosphorus Removal
Quanapowitt Parkway
January 22, 2024
By: TWW

1S Catchment Area						
Surface Type	Area (sf)	Category by Land Use	PLER (lbs/acre/yr)	P Load (lbs)	NLER (lbs/acre/yr)	N Load (lbs)
Roadways	41,592.00	COM	1.78	1.70	15.00	14.32
Woods	-	FOR	0.13	-	0.50	-
Rooftops	15,436.00	COM	1.78	0.63	15.00	5.32
Lawns	12,418.00	OPEN	0.29	0.08	3.10	0.88
Total catchment	69,446.00					
		Totals =		2.41		20.52

Proposed Underground Infiltration				
BMP Components				Design Storage (cf)
Pipe Storage				469.00
Stone Storage				715.00
				1184.00

1S Catchment Area				2nd Iteration	
Surface Type	Area (sf)	Rainfall Depth	Runoff Volume* (cf)	Rainfall Depth	Runoff Volume* (cf)
Roadways	41,592.00	0.25	866.50	0.24	831.84
Woods	-	0.03	-	0.03	-
Rooftops	15,436.00	0.25	321.58	0.24	308.72
Lawns	12,418.00	0.03	31.05	0.03	31.05
Total catchment	69,446.00				
	Catchment Runoff Volume =		1,219.13		1,171.61
		Difference =	35.13		(12.40)
	Impervious Area Treated =		1,152.96		12.64
				% Difference	4%

1S Catchment Area			
Surface Type	Area (sf)	Rainfall Depth	Runoff Volume* (cf)
Roadways	41,592.00	0.24	831.84
Woods	-	0.03	-
Rooftops	15,436.00	0.24	308.72
Lawns	12,418.00	0.03	31.05
Total catchment	69,446.00		
		Catchment Runoff Volume =	1,171.61 cf

Capacity of Underground Infiltration (inches)						
Infiltration Basin Storage (cf)	Runoff Volume	Capacity (in)	P Reduction %	P Reduction (lbs)	N Reduction %	N Reduction (lbs)
1,184.00	1,171.61	**0.24**	52%	1.26	81%	16.58

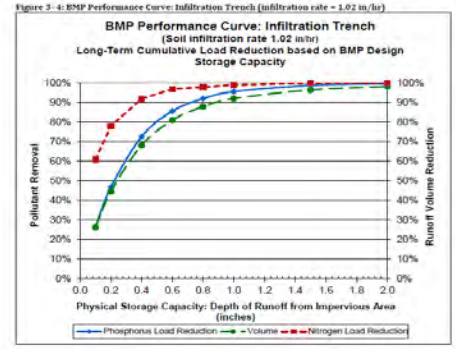
Note: Evaluation of Nitrogen and Phosphorus removal has been conducted as recommended via methology outlined in "MA Exhibit A: Proposed Permit Modifications to the EPA NPDES - MS4 Permit, December 9, 2019"

MA MS4 General Permit Appendix F Attachment 3

Table 3- 9: Infiltration Trench (IR = 1.02 in/hr) BMP Performance Table

Infiltration Trench (IR = 1.02 in/hr) BMP Performance Table: Long-Term Phosphorus & Nitrogen Load Reduction								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	26.3%	44.6%	68.2%	81.0%	88.0%	92.1%	96.5%	98.3%
Cumulative Phosphorus Load Reduction	27%	47%	73%	86%	92%	96%	99%	100%
Cumulative Nitrogen Load Reduction	61%	78%	92%	97%	98%	99%	100%	100%

Figure 3- 4: BMP Performance Curve: Infiltration Trench (infiltration rate = 1.02 in/hr)



Infiltration Basin Calculations - Capacity and Nitrogen/Phosphorus Removal
Quanapowitt Parkway
March 21, 2923
By: TWW

8S + 9S Catchment Area						
Surface Type	Area (sf)	Category by Land Use	PLER (lbs/acre/yr)	P Load (lbs)	NLER (lbs/acre/yr)	N Load (lbs)
Roadways	17,918.00	COM	1.78	0.73	15.00	6.17
Woods	-	FOR	0.13	-	0.50	-
Rooftops	-	COM	1.78	-	15.00	-
Lawns	1,366.00	OPEN	0.29	0.01	3.10	0.10
Total catchment	19,284.00					
		Totals =		0.74		6.27

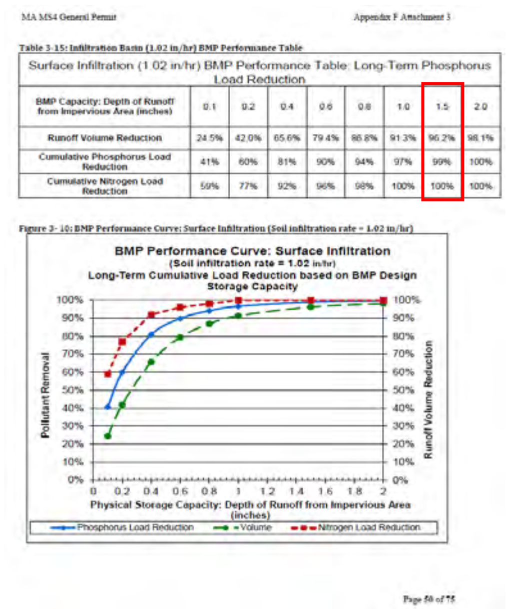
Proposed Infiltration				
BMP Components				Design Storage (cf)
Sediment Forebay				234.00
Infiltration area				2328.00
				2562.00

8S + 9S Catchment Area				2nd Iteration	
Surface Type	Area (sf)	Rainfall Depth	Runoff Volume* (cf)	Rainfall Depth	Runoff Volume* (cf)
Roadways	17,918.00	1.72	2,568.25	1.66	2,478.66
Woods	-	0.70	-	0.66	-
Rooftops	-	1.72	-	1.66	-
Lawns	1,366.00	0.70	79.68	0.66	75.13
Total catchment	19,284.00				
		Catchment Runoff Volume =	2,647.93		2,553.79
		Difference =	85.93		(8.21)
		Impervious Area Treated =	2,482.32		2,486.87
				% Difference	4%

8S + 9S Catchment Area			
Surface Type	Area (sf)	Rainfall Depth	Runoff Volume* (cf)
Roadways	17,918.00	1.66	2,478.66
Woods	-	0.66	-
Rooftops	-	1.66	-
Lawns	1,366.00	0.66	75.13
Total catchment	19,284.00		
		Catchment Runoff Volume =	2,553.79 cf

Capacity of Infiltration Basin (inches)				
Infiltration Basin Storage (cf)	Runoff Volume	Capacity (in)	P Reduction %	N Reduction %
2,562.00	2,553.79	**1.66**	99%	100%

Note: Evaluation of Nitrogen and Phosphorus removal has been conducted as recommended via methology outlined in "MA Exhibit A: Proposed Permit Modifications to the EPA NPDES - MS4 Permit, December 9, 2019"



MA MS4 General Permit — Appendix F Attachment 3

Table 3-15: Infiltration Basin (1.02 in/hr) BMP Performance Table

Surface Infiltration (1.02 in/hr) BMP Performance Table: Long-Term Phosphorus Load Reduction								
BMP Capacity: Depth of Runoff from Impervious Area (inches)	0.1	0.2	0.4	0.6	0.8	1.0	1.5	2.0
Runoff Volume Reduction	24.5%	42.0%	65.6%	79.4%	86.8%	91.3%	96.2%	98.1%
Cumulative Phosphorus Load Reduction	41%	60%	81%	90%	94%	97%	99%	100%
Cumulative Nitrogen Load Reduction	59%	77%	92%	96%	98%	100%	100%	100%

Figure 3- 10: BMP Performance Curve: Surface Infiltration (Soil infiltration rate = 1.02 in/hr)

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TOWN OF WAKEFIELD

TSS Removal Calculation Worksheet

Location: Subcatchment 1S

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Street Sweeping - 5%	**0.05**	**1.00**	**0.05**	**0.95**
Deep Sump and Hooded Catch Basin	**0.25**	**0.95**	**0.24**	**0.71**
Proprietary Treatment Practice	**0.80**	**0.71**	**0.57**	**0.14**
Subsurface Infiltration Structure	**0.80**	**0.14**	**0.11**	**0.03**
	0.00	**0.03**	**0.00**	**0.03**

Total TSS Removal = 97%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Quannapowitt Parkway
Prepared By: TWW
Date: 1/19/2024

*Equals remaining load from previous BMP (E) which enters the BMP

TOWN OF WAKEFIELD

Location: Subcatchment 2S

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Street Sweeping - 5%	**0.05**	**1.00**	**0.05**	**0.95**
Proprietary Treatment Practice	**0.80**	**0.95**	**0.76**	**0.19**
	0.00	**0.19**	**0.00**	**0.19**
	0.00	**0.19**	**0.00**	**0.19**
	0.00	**0.19**	**0.00**	**0.19**

Total TSS Removal = 81%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: **Quannapowitt Parkway**

Prepared By: **TWW**

Date: **1/19/2024**

*Equals remaining load from previous BMP (E) which enters the BMP

TOWN OF WAKEFIELD

TSS Removal Calculation Worksheet

Location: Subcatchment 7S

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Street Sweeping - 5%	0.05	1.00	0.05	0.95
Proprietary Treatment Practice	0.80	0.95	0.76	0.19
	0.00	0.19	0.00	0.19
	0.00	0.19	0.00	0.19
	0.00	0.19	0.00	0.19

Total TSS Removal = 81%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Quannapowitt Parkway

Prepared By: TWW

Date: 1/19/2024

*Equals remaining load from previous BMP (E) which enters the BMP

TOWN OF WAKEFIELD

Location: Subcatchment 8S

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Street Sweeping - 5%	0.05	1.00	0.05	0.95
Deep Sump and Hooded Catch Basin	0.25	0.95	0.24	0.71
Sediment Forebay	0.25	0.71	0.18	0.53
Bioretention Area	0.90	0.53	0.48	0.05
	0.00	0.05	0.00	0.05

Total TSS Removal = 95%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Quannapowitt Parkway
Prepared By: TWW
Date: 1/19/2024

*Equals remaining load from previous BMP (E) which enters the BMP

TOWN OF WAKEFIELD

Location: Subcatchment 9S

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Street Sweeping - 5%	**0.05**	**1.00**	**0.05**	**0.95**
Deep Sump and Hooded Catch Basin	**0.25**	**0.95**	**0.24**	**0.71**
Proprietary Treatment Practice	**0.89**	**0.71**	**0.63**	**0.08**
Sediment Forebay	**0.25**	**0.08**	**0.02**	**0.06**
Bioretention Area	**0.90**	**0.06**	**0.05**	**0.01**

Total TSS Removal = 99%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Quannapowitt Parkway

Prepared By: TWW

Date: 1/19/2024

*Equals remaining load from previous BMP (E) which enters the BMP

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www.AnokaSWCD.org
www.RainGuardian.biz

TECHNICAL MEMORANDUM

Rain Guardian Pretreatment Chambers - Functionality, Capacity, and Effectiveness

December 1, 2022

To Whom It May Concern:

OVERVIEW

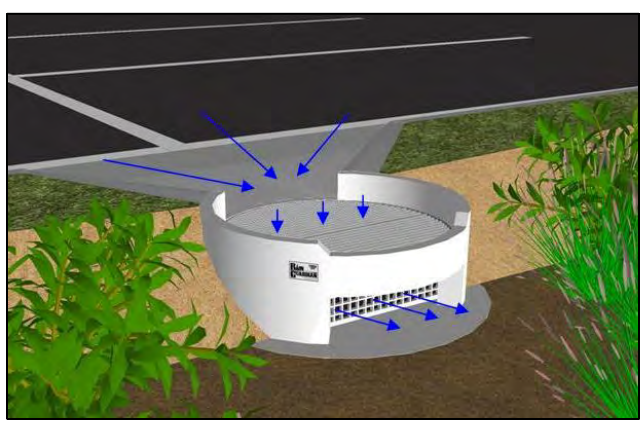
Rain Guardian pretreatment chambers were developed by Anoka Conservation District to address common inlet, pretreatment, and maintenance issues associated with stormwater BMPs. Typical inlet options for stormwater BMPs include grass filter strips and rock inlets, which are prone to erosion, require hours of maintenance, provide little or no pretreatment, and can actually cause water to bypass the practice because of their likelihood of clogging with debris. Rain Guardian pretreatment chambers provide a stable inlet to the BMP, pretreat stormwater, and simplify maintenance by capturing sediment and debris in a chamber that is quick and easy to clean.

Each Rain Guardian pretreatment chamber utilizes patented functional elements (US 8,501,016, US 8,858,804, and US 11,298,635). Therefore, each chamber operates in the same manner and has a similar flow path. The four patented functional elements and a brief description of their purpose are described below.

1. The water-impermeable sidewalls form a debris and sediment trap.
2. The filter sidewall allows the chamber to drain and dry between storm events.
3. The chamber grate captures gross solids.
4. The top debris walls capture and restrict floatables from entering or exiting the BMP.

FLOW PATH AND FUNCTIONALITY

Rain Guardian pretreatment chambers are positioned at BMP inlets. Stormwater is most commonly directed into the chamber via a curb-cut and inlet. Water passes through the top grate, which captures gross solids. Water then enters the chamber where the settling and capture of particulates occurs. The vertical filter wall positioned on the BMP side of the chamber allows the chamber to dry out between storm events. As the BMP fills, the water level rises and the top debris walls restrict floatable debris from entering or exiting the BMP. Accumulated sediment and debris are easily removed from the chamber by removing the top grate and shoveling the interior of the chamber. The vertical filter wall can be brushed or rinsed clean. Multiple outflow points exist in each chamber that allow water to exit the chamber and enter the BMP during high flows. The image to the right depicts the flow path of stormwater through the Rain Guardian Turret pretreatment chamber. The flow path through the Bunker, Fortress, and Foxhole is similar.



PONDING DEPTH, STORAGE CAPACITY, AND FLOW CAPACITY

Each Rain Guardian pretreatment chamber is designed for a specific BMP ponding depth. Bunkers are available in 9” and 12” ponding depths, the Turret is available in a 12” ponding depth, the Fortress is available in a 9” ponding depth, and the Foxhole is available in a 9” ponding depth. The ponding depths include a 1.5” drop within the inlet (gutter or apron) to each chamber.

Chamber flow capacity calculations are described in the text below and details specific to each chamber type are shown in the tables below.

Inflow is possible through one location for each chamber, the chamber inlet.

1) Chamber inlet capacity – calculated using a standard broad crested weir equation (i.e. Q=C*L*H^(3/2))

Outflow is possible through three locations for each chamber. Please note the vertical filter within the chamber was assumed to be 100% clogged because its primary function is to allow the chamber to dry out between rain events.

1) Filter overflow capacity – water can pass between the top of the filter and the bottom of the grate; calculated using the continuity equation (i.e. Q=V*A)
2) Grate overflow capacity– water can pass through the top grate beyond the vertical filter wall; calculated using an orifice equation (i.e. Q=0.0108*A*√d)
3) High volume overflow capacity– water can overtop the front debris wall onto the splash pad; calculated using a standard broad crested weir equation (i.e. Q=C*L*H^(3/2))

Rain Guardian Model	**Internal Storage Capacity (CF)**	**Inlet Flow Rate (CFS)**	**Outlet 1 - Filter Overflow Rate (CFS)**	**Outlet 2 - Grate Overflow Rate (CFS)**	**Outlet 3 – High Volume Overflow Rate (CFS)**	**Total Outlet Rate (CFS)**
Bunker	2.85	3.07	3.41	2.02	0.69	6.12
Turret	4.02	1.82	0.45	2.59	0.41	3.45
Fortress	1.36	4.12	3.92	2.46	1.47	7.85
Foxhole Inlet/Outlet Combination	1.73	2.00	1.15	2.72	0.52	4.39
Foxhole Middle Section	2.20	N/A	N/A	N/A	N/A	N/A

Values used for each structure in flow rate calculations

	INLET			**OUTLET**				
Rain Guardian Model	**C**	**L (FT)**	**H (FT)**	**C**	**L (FT)**	**H (FT)**	**FILTER OVERFLOW A (SF)**	**GRATE OVERFLOW A (SF)**
Bunker	3.087	3.438	0.438	3.087	4.021	0.146	0.528	0.580
Turret	3.087	2.190	0.417	3.087	2.406	0.146	0.128	0.745
Fortress	3.087	3.344	0.542	3.087	3.380	0.271	0.406	0.621
Foxhole Inlet/Outlet Combination	3.087	2.083	0.458	3.087	2.083	0.188	0.248	0.746

POLLUTANT REMOVAL EFFECTIVENESS

Rain Guardian Bunkers and Turrets were independently tested by the University of Minnesota St. Anthony Falls Laboratory. Removal of TSS and gross solids is included in the "*Capture of Gross Solids and Sediment by Pretreatment Practices for Bioretention*, Project Report No. 586, January 2019" and the results are summarized below.

- Bunker sediment capture –91.7% at 0.25 CFS and 75.6% at 0.5 CFS
- Bunker gross solids capture – 78.8% at 0.25 CFS and 61.4% at 0.5 CFS
- Turret sediment capture – 88.4% at 0.25 CFS and 79.1% at 0.5 CFS
- Turret gross solids capture – 86.7% at 0.25 CFS and 72.4% at 0.5 CFS

The particle size distribution of sand used in testing is summarized below in the screen captures from the report. Additional details are available in the report.

Capture of Gross Solids and Sediment by Pretreatment Practices for Bioretention
Final Report – January 2019

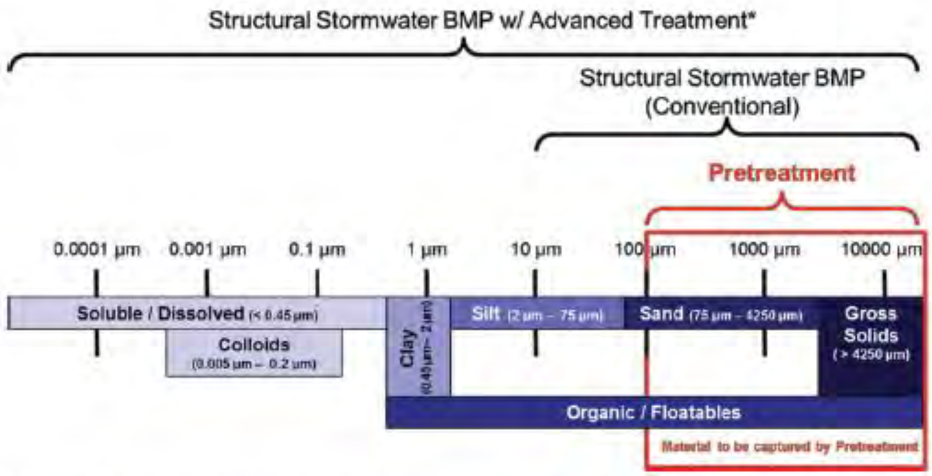


Figure 17. Pretreatment is intended to capture a portion of particles greater than 100µm (MPCA 2017b).

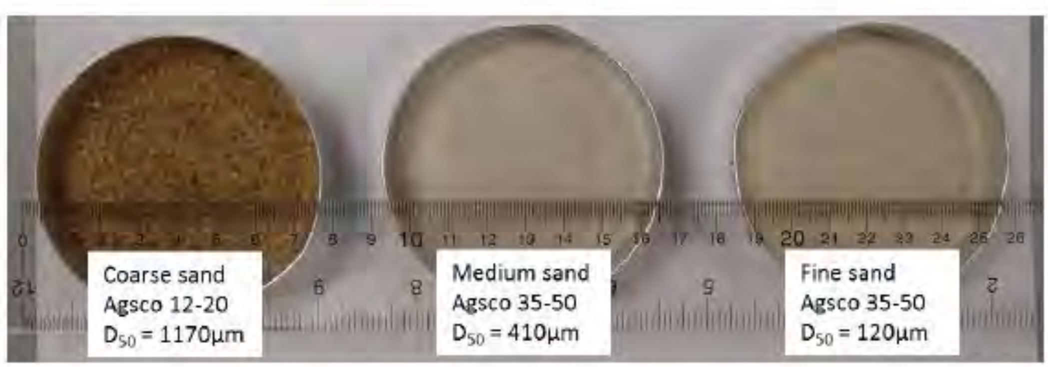


Figure 18. The three silica sands were blended in equal proportions by mass to create the sediment mix.

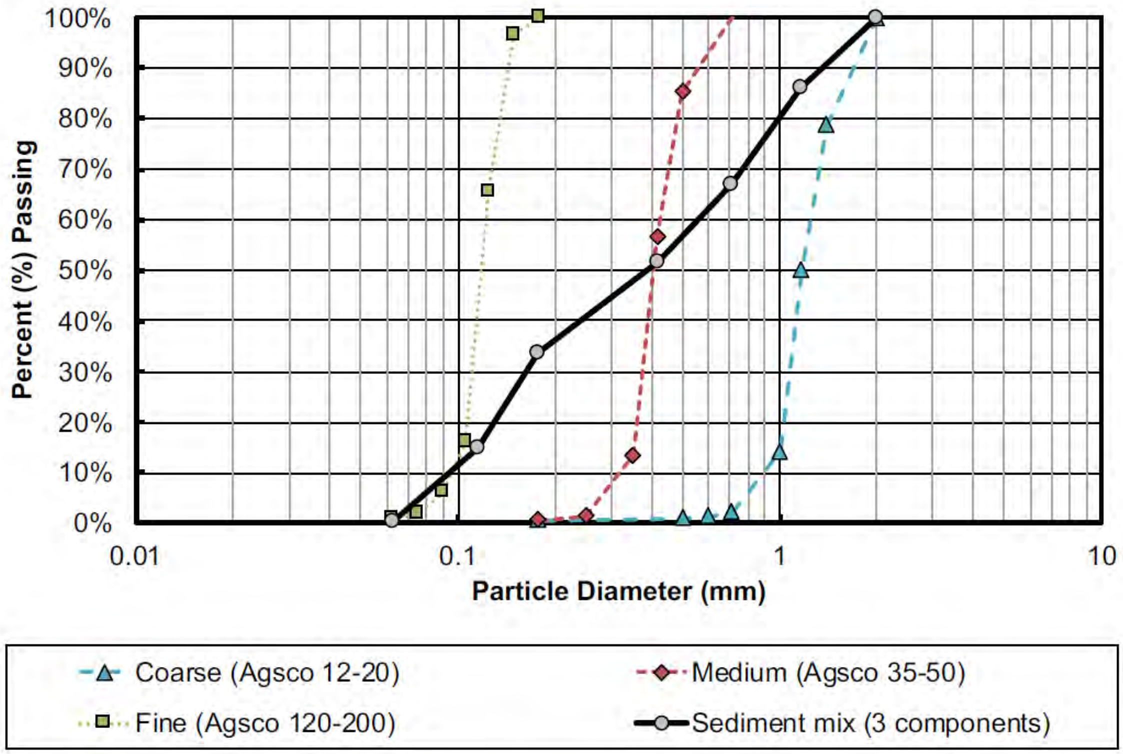
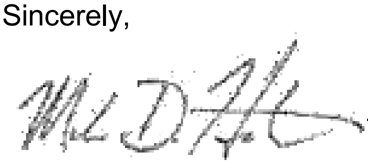


Figure 19. Particle size distribution chart of sand used in testing. Data from SAFL sieve testing.

Table 5. Sieve analysis of whole sediment mix and division of sediment classes

US Std. Sieve #	Opening size (mm)	Percent passing	Sediment Retained
10	2.00	100.0%	Foreign material
16	1.17	86.2%	Coarse
25	0.71	67.1%	Coarse
40	0.42	51.5%	Medium
80	0.18	33.5%	Medium
(140 or 120)	0.12	14.9%	Fine
Pan	--	--	Fine

Sincerely,



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TESTING SUMMARY

Field Monitoring Results
Westwood, Massachusetts

Summary: From July 1997 to November 1997 a Massachusetts firm, Environmental Sampling and Technology (EST), collected stormwater samples from a Stormceptor® Model STC 1200. Data collected from six storm events during this period indicate a very high removal rate for Total Suspended Solids (TSS). The data also indicates a high removal rate for Total Petroleum Hydrocarbons (TPH).

Average TSS Removal	Average TPH Removal
93%	**82%**

The average TSS removal rate is based on three storm events that produced significant inflow TSS levels. Significant is defined as levels that typically require treatment by regulatory permitting criteria. Only one storm event produced significant TPH levels. The TPH removal rate for this event was 82%. The TSS removal rate is higher than that predicted by the current sizing criteria

Methodology: EST, which specializes in stormwater sampling, installed two automatic stormwater samplers (ISCO Model 3700) inside the Stormceptor to collect composite samples at the inlet and outlet. The purpose of the sampling program was to determine Total Suspended Solids (TSS), Total Petroleum Hydrocarbons (TPH) and metals during a variety of storm events.

Flow was measured using a flow meter (ISCO 3230) used in conjunction with a temporary weir inserted into the 12" diameter influent pipe. The sampling program includes a composite sample consisting of twenty-eight 200ml aliquot samples collected at five-minute intervals over a four-hour period. A rain gauge mounted nearby is used to measure and record rainfall in 0.01-foot increments. Following each rain event during this five-month period, samples were collected and preserved in accordance with 40 CFR Part 136 and delivered to a certified laboratory.

Project Details: This Stormceptor was installed in October 1996 at a loading/unloading trucking area at a local manufacturing facility located in Westwood, Massachusetts. The paved area (impervious area of 0.65 acres) contributes runoff to a catch basin that is located upstream of the Stormceptor. The size of the unit was based on the sizing criteria listed in Table 5 of the Stormceptor Technical Manual.

(More information on the next page)

Event #1 (August 5, 1997)

Storm Intensity:	0.06 in/hr (1.5 mm/h)
Total Precipitation during event:	0.18 inches (4.6 mm)
Maximum Flow:	1.8 gallons per minute (0.11 L/s)
Total Flow Volume (3 hours):	122 gallons (462 L)
Composite Sample Period:	3 hours

Pollutant	Influent Composite	Effluent Composite	Pollutant Removal Rate
TSS	400 mg/l	5.3 mg/l	98%

Event #2 (August 21, 1997)

Storm Intensity:	0.08 in/hr (2.0 mm/h)
Total Precipitation during event:	0.25 inches (6.4 mm)
Maximum Flow:	2.3 gallons per minute (0.15 L/s)
Total Flow Volume (3 hours):	304 gallons (1152 L)
Composite Sample Period:	3 hours

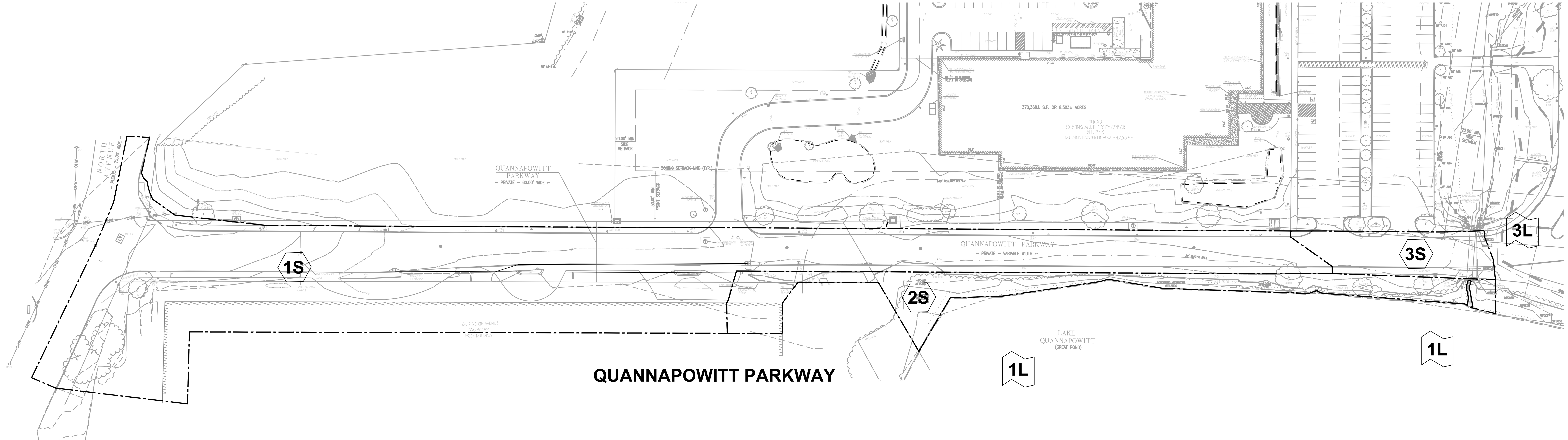
Pollutant	Influent Composite	Effluent Composite	Pollutant Removal Rate
TSS	86 mg/l	6.8 mg/l	92%
TPH	7.8 mg/l	1.4 mg/l	82%

Event #3 (September 29, 1997)

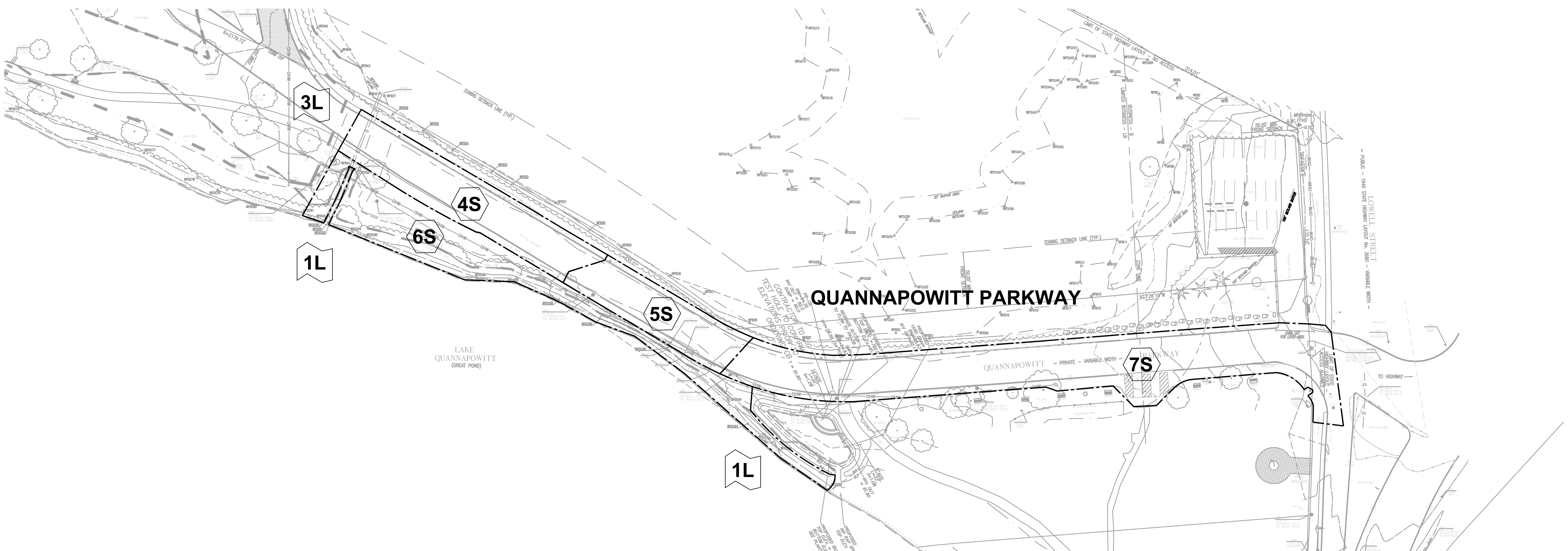
Storm Intensity:	0.03 in/hr (0.8 mm/h)
Total Precipitation during event:	0.22 inches (5.6 mm)
Maximum Flow	3.2 gallons per minute (0.2 L/s)
Total Flow Volume (7 hours)	672 gallons (2545 L)
Composite Sample Period:	7 hours

Pollutant	Influent Composite	Effluent Composite	Pollutant Removal Rate
TSS	47 mg/l	<5.0 mg/l	90%

Attachment 4: Subcatchment Maps



PLAN VIEW – SOUTH END
SCALE: 1"=50'



PLAN VIEW – NORTH END
SCALE: 1"=50'

TOWN OF WAKEFIELD

Public Works • Engineering Division • 1 Lafayette Street Wakefield, MA 01880

REVISIONS

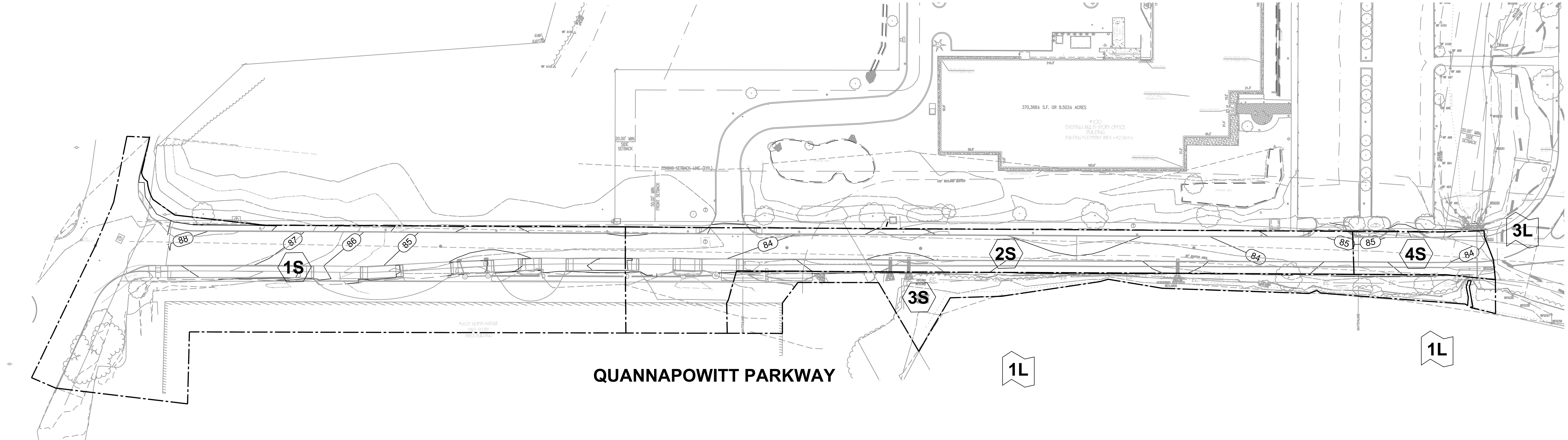
DESIGNED TWW
DRAWN TWW
CHECKED WJR
SCALE AS SHOWN

WATERSHED MAPS
EXISTING CONDITIONS
QUANNAPOWITT PARKWAY
NOVEMBER 17, 2023

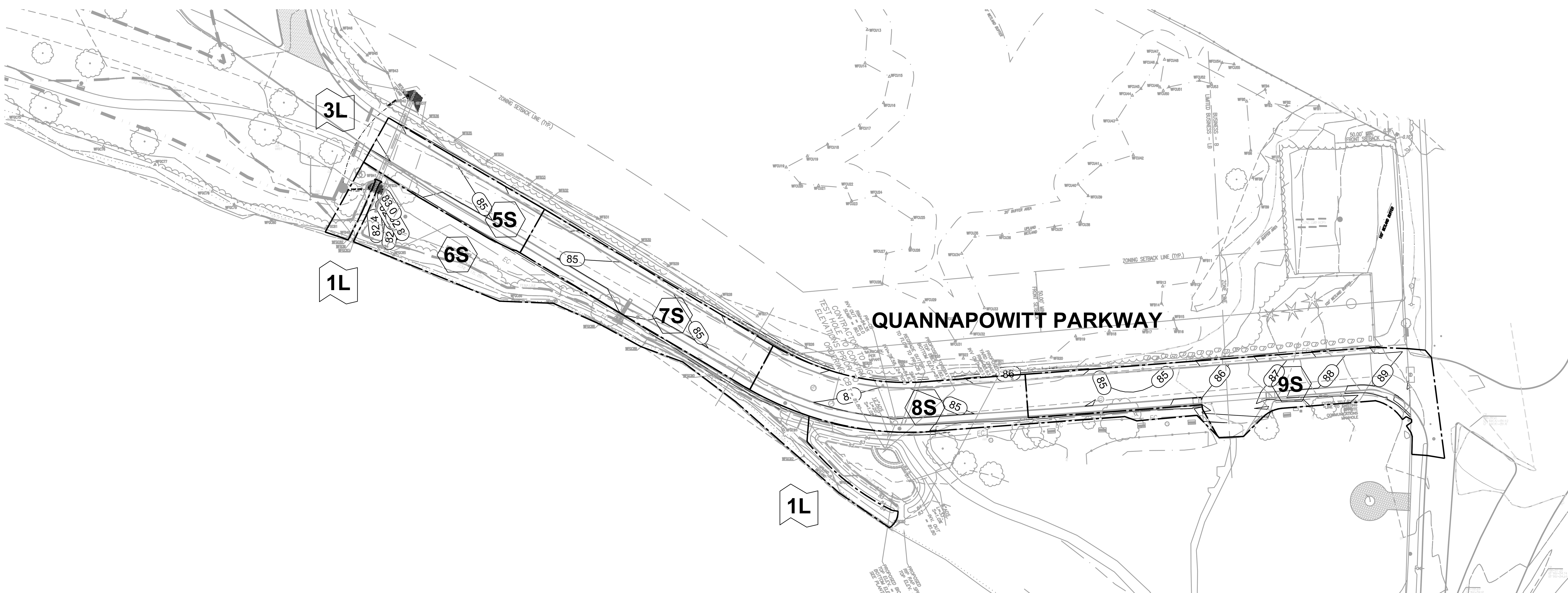
2021-99

SHEET
1 OF 2

WS-1



PLAN VIEW – SOUTH END
SCALE: 1"=50'



PLAN VIEW – NORTH END
SCALE: 1"=50'

TOWN OF WAKEFIELD

Public Works • Engineering Division • 1 Lafayette Street Wakefield, MA 01880

REVISIONS

DESIGNED	DRAWN	CHECKED	SCALE
TWW	TWW	WJR	AS SHOWN

WATERSHED MAPS
PROPOSED CONDITIONS
QUANNAPOWITT PARKWAY
NOVEMBER 17, 2023

2021-99

SHEET
2 OF 2

WS-2

Attachment 5: Operations and Maintenance Plan

SECTION 2.0 -
OPERATION & MAINTENANCE PLAN

Introduction

In accordance with the standards set forth by the Stormwater Management Policy issued by the Massachusetts Department of Environmental Protection (MassDEP), Allen & Major Associates, Inc. has prepared the following Operations & Maintenance (O&M) Plan for the existing development at 200 Quannapowitt Parkway, Wakefield, MA.

The plan is broken down into three major sections. The first section describes construction-related erosion and sedimentation controls (Demolition & Construction Maintenance Plan). The second section describes the long-term pollution prevention measures (Long Term Pollution Prevention Plan). The third section is a post-construction operation and maintenance plan designed to address the long-term maintenance needs of the stormwater management system (Long-Term Maintenance Plan – Facilities Description).

Notification Procedures for Change of Responsibility for O&M

The Stormwater Management System (SMS) for this project is owned by Cabot, Cabot & Forbes (owner). The owner shall be legally responsible for the long-term operation and maintenance of this SMS as outlined in this Operation and Maintenance Plan.

The owner shall submit an annual summary report and the completed Operation & Maintenance Schedule & Checklist to the Public Works Engineering Division and Conservation Commission (via email or print copy), highlighting inspection and maintenance activities including performances of BMPs. Should ownership of the SMS change, the owner will continue to be responsible until the succeeding owner shall notify the Commission that the succeeding owner has assumed such responsibility. Upon subsequent transfers, the responsibility shall continue to be that of transferring owner until the transferee owner notifies the Commission of its assumption of responsibility.

In the event the SMS will serve multiple lots/owners, such as the subdivision of the existing parcel or creation of lease areas, the owner(s) shall establish an association on other legally enforceable arrangements under which the association or a single party shall have legal responsibility for the operation and maintenance of the entire SMS. The legal instrument creating such responsibility shall be recorded with the Registry of Deeds and promptly following its recording, a copy thereof shall be furnished to the Commission.

Contact Information

Stormwater Management System Owner:	CCF Quannapowitt Property Company, LLC 185 Dartmouth Street Boston, MA 02116 Phone: 617-603-4000

Emergency Contact Information:

Allen & Major Associates, Inc. (Site Civil Engineer)	Phone: (781) 935-6889
Wakefield Department of Public Works	Phone: 781-246-6301
Wakefield Conservation Commission	Phone: 781-224-5015
Wakefield Fire Department (non-emergency line)	Phone: 781-246-6435
MassDEP Emergency Response	Phone: (888) 304-1133
Clean Harbors Inc (24-Hour Line)	Phone: (800) 645-8265

Demolition & Construction Maintenance Plan

1. Call Digsafe: 1-888-344-7233
2. Contact the Town of Wakefield at least three (3) days prior to start of demolition and/or construction activities.
3. Install Erosion Control measures as shown on the Plans prepared by A&M. The Town of Wakefield shall review the installation of straw bales and silt fencing prior to the start of any site demolition work. Install Construction fencing if determined to be necessary at the commencement of construction.
4. Install construction entrances, straw bales, and silt fence at the locations shown on the Erosion Control Plan prepared by A&M.
5. Site access shall be achieved only from the designated construction entrances.
6. Cut and clear trees in construction areas only (within the limit of work; see plans).
7. Stockpiles of materials subject to erosion shall be stabilized with erosion control matting or temporary seeding whenever practicable, but in no case more than 14 days after the construction activity in that portion of the site has temporarily or permanently ceased.
8. Install silt sacks and straw bales around each drain inlet prior to any demolition and or construction activities.

9. All erosion control measures shall be inspected weekly and after every rainfall event. Records of these inspections shall be kept on-site for review.
10. All erosion control measures shall be maintained, repaired, or replaced as required or at the direction of the owner's engineer or the Town of Wakefield.
11. Sediment accumulation up-gradient of the straw bales, silt fence, and stone check dams greater than 6" in depth shall be removed and disposed of in accordance with all applicable regulations.
12. If it appears that sediment is exiting the site, silt sacks shall be installed in all catch basins adjacent to the site. Sediment accumulation on all adjacent catch basin inlets shall be removed and the silt sack replaced if torn or damaged.
13. Install stone check dams on-site during construction as needed. Refer to the erosion control details. Temporary sediment basins combined with stone check damns shall be installed on-site during construction to control and collect runoff from upland areas of this site during demolition and construction activities.
14. The contractor shall comply with the Sedimentation and Erosion Control Notes as shown on the Site Development Plans and Specifications.
15. The stabilized construction entrances shall be inspected weekly and records of inspections kept. The entrances shall be maintained by adding additional clean, angular, durable stone to remove the soil from the construction vehicle's tires when exiting the site. If soil is still leaving the site via the construction vehicle tires, adjacent roadways shall be kept clean by street sweeping.
16. Dust pollution shall be controlled using on-site water trucks and/or an approved soil stabilization product.
17. During demolition and construction activities, Status Reports on compliance with this O&M Document shall be submitted weekly. The report shall document any deficiencies and corrective actions taken by the applicant.

Long-Term Pollution Prevention Plan

Standard #4 from the MassDEP Stormwater Management Handbook requires that a Long-Term Pollution Prevention Plan (LTPPP) be prepared and incorporated as part of the Operation and Maintenance Plan of the Stormwater Management System. The purpose of the LTPPP is to identify potential sources of pollution that may affect the quality of stormwater discharges, and to describe the implementation of practices to reduce the pollutants in stormwater discharges. The following items describe the source control and proper procedures of the LTPPP.

- <u>Housekeeping</u>
  The existing development has been designed to maintain a high level of water quality treatment for all stormwater discharge to the wetland areas. An Operation and Maintenance (O&M) plan has been prepared and is included in this section of the report. The owner (or its designee) is responsible for adherence to the O&M plan in a strict and complete manner.

- <u>Storing of Materials & Water Products</u>
  The trash and waste program for the site includes exterior dumpsters. There is a trash contractor used to pick up the waste material in the dumpsters. The stormwater drainage system has water quality inlets designed to capture trash and debris.

- <u>Vehicle Washing</u>
  Outdoor vehicle washing has the potential to result in high loads of nutrients, metals, and hydrocarbons during dry weather conditions, as the detergent-rich water used to wash the grime off the vehicle enters the stormwater drainage system. The existing development does not include any designated vehicle washing areas, nor is it expected that any vehicle washing will take place on-site.

- <u>Spill Prevention & Response</u>
  Sources of potential spill hazards include vehicle fluids, liquid fuels, pesticides, paints, solvents, and liquid cleaning products. The majority of the spill hazards would likely occur within the buildings and would not enter the stormwater drainage system. However, there are spill hazards from vehicle fluids or liquid fuels located outside of the buildings. These exterior spill hazards have the potential to enter the stormwater drainage system and are to be addressed as follows:

  1. Spill hazards of pesticides, paints, and solvents shall be remediated using the Manufacturers' recommended spill cleanup protocol.
  2. Vehicle fluids and liquid fuel spill shall be remediated according to the local and state regulations governing fuel spills.
  3. The owner shall have the following equipment and materials on hand to address a spill clean-up: brooms, dust pans, mops, rags, gloves, absorptive material, sand, sawdust, plastic and metal trash containers.
  4. All spills shall be cleaned up immediately after discovery.

5. Spills of toxic or hazardous material shall be reported, regardless of size, to the Massachusetts Department of Environmental Protection at (888) 304-1333.

6. Should a spill occur, the pollution prevention plan will be adjusted to include measures to prevent another spill of a similar nature. A description of the spill, along with the causes and cleanup measures will be included in the updated pollution prevention plan.

- Maintenance of Lawns, Gardens, and Other Landscaped Areas
  It should be recognized that this is a general guideline towards achieving high quality and well-groomed landscaped areas. The grounds staff/landscape contractor must recognize the shortcomings of a general maintenance plan such as this, and modify and/or augment it based on weekly, monthly, and yearly observations. In order to assure the highest quality conditions, the staff must also recognize and appreciate the need to be aware of the constantly changing conditions of the landscaping and be able to respond to them on a proactive basis. No trees shall be planted over the drain lines or recharge area, and that only shallow rooted plants and shrubs will be allowed.

  - Fertilizer
    Maintenance practices should be aimed at reducing environmental, mechanical and pest stresses to promote healthy and vigorous growth. When necessary, pest outbreaks should be treated with the most sensitive control measure available. Synthetic chemical controls should be used only as a last resort to organic and biological control methods. Fertilizer, synthetic chemical controls and pest management applications (when necessary) shall be performed only by licensed applicators in accordance with the manufacturer's label instructions when environmental conditions are conducive to controlled product application.

    Only slow-release organic fertilizers should be used in the planting and mulch areas to limit the amount of nutrients that could enter downstream resource areas. Fertilization of the planting and mulch areas will be performed within manufacturers labeling instructions and shall not exceed an NPK ration of 1:1:1 (i.e. Triple 10 fertilizer mix), considered a low nitrogen mixture. Fertilizers approved for the use under this O&M Plan are as follows:

Type:	NUFARM TRUEPOWER® (Selective Herbicide)
	BAYER ACCLAIM® (Extra Herbicide)
	DOW VISTA™ (XRT Herbicide)
	DISMISS™ (Turf Herbicide)

- Suggested Aeration Program

  In-season aeration of lawn areas is good cultural practice, and is recommended whenever feasible. It should be accomplished with a solid thin tine aeration method to reduce disruption to the use of the area. The depth of solid tine aeration is similar to core type, but should be performed when the soil is somewhat drier for a greater overall effect.

  Depending on the intensity of use, it can be expected that all landscaped lawn areas will need aeration to reduce compaction at least once per year. The first operation should occur in late May following the spring season. Methods of reducing compaction will vary based on the nature of the compaction. Compaction on newly established landscaped areas is generally limited to the top 2-3" and can be alleviated using hollow core or thin tine aeration methods.

  The spring aeration should consist of two passes at opposite directions with 1/4" hollow core tines penetrating 3-5" into the soil profile. Aeration should occur when the soil is moist but not saturated. The soil cores should be shattered in place and dragged or swept back into the turf to control thatch. If desired the cores may also be removed and the area top-dressed with sand or sandy loam. If the area drains on average too slowly, the topdressing should contain a higher percentage of sand. If it is draining on average too quickly, the top dressing should contain a higher percentage of soil and organic matter.

- Landscape Maintenance Program Practices:
  - Lawn

    1. Mow a minimum of once a week in spring, to a height of 2" to 2 1/2" high. Mowing should be frequent enough so that no more than 1/3 of grass blade is removed at each mowing. The top growth supports the roots; the shorter the grass is cute, the less the roots will grow. Short cutting also dries out the soil and encourages weeds to germinate.
    2. Mow approximately once every two weeks from July 1st to August 15th depending on lawn growth.
    3. Mow on a ten-day cycle in fall, when growth is stimulated by cooler nights and increased moisture.
    4. Do not remove grass clippings after mowing.

5. Keep mower blades sharp to prevent ragged cuts on grass leaves, which cause a brownish appearance and increase the chance for disease to enter a leaf.

- Shrubs

1. Mulch not more than 3″ depth with shredded pine or fir bark.
2. Hand prune annually, immediately after blooming, to remove 1/3 of the above-ground biomass (older stems). Stem removals are to occur within 6″ of the ground to open up shrub and maintain two-year wood (the blooming wood).
3. Hand-prune evergreen shrubs only as needed to remove dead and damaged wood and to maintain the naturalistic form of the shrub. Never mechanically shear evergreen shrubs.

- Trees

1. Provide aftercare of new tree plantings for the first three years.
2. Do not fertilize trees, it artificially stimulates them (unless tree health warrants).
3. Water once a week for the first year; twice a month for the second; once a month for the third year.
4. Prune trees on a four-year cycle.

- Invasive Species

1. Inform the Conservation Commission Agent prior to the removal of invasive species proposed either through hand work or through chemical removal.

- Storage and Use of Herbicides and Pesticides

  Prior to the use of any herbicides and pesticides, the pest management company or owner shall obtain written approval from the Wakefield Conservation Commission and comply with any additional requirements established at that time.

  Integrated Pest Management is the combination of all methods (of pest control) which may prevent, reduce, suppress, eliminate, or repel an insect population. The main requirements necessary to support any pest population are food, shelter and water, and any upset of the balance of these will assist in controlling a pest population. Scientific pest management is the knowledgeable use of all pest control methods (sanitation, mechanical, chemical) to benefit mankind's health, welfare, comfort, property and food. A Pest Management Professional (PMP) should be retained who is licensed with the Commonwealth of Massachusetts Executive Office of Energy and Environmental Affairs, Department of Agricultural Resources.

The site manager will be provided with approved bulletin before entering into or renewing an agreement to apply pesticides for the control of indoor household or structural pests, refer to 333 CMR 13.08.

Before beginning each application, the applicator must post a Department approved notice on all of the entrances to the treated room or area. The applicator must leave such notices posted after the application. The notice will be posted at conspicuous point(s) of access to the area treated. The location and number of signs will be determined by the configuration of the area to be treated based on the applicator's best judgment. It is intended to give sufficient notice so that no one comes into an area being treated unaware that the applicator is working and pesticides are being applied. However, if the contracting entity does not want the signs posted, he/she may sign a Department approved waiver indicating this.

The applicator or employer will provide to any person upon their request the following information on previously conducted applications:

1. Name and phone number of pest control company;
2. Date and time of the application;
3. Name and license number of the applicator;
4. Target pests; and
5. Name and EPA Registration Number of pesticide products applied.

- <u>Pet Waste Management</u>
  The owner's landscape crew (or designee) shall remove any obvious pet waste that has been left behind by pet owners within the development. The pet waste shall be disposed of in accordance with local and state regulations.
- <u>Operations and Management of Septic Systems</u>
  There are no proposed septic systems within the limits of the project.
- <u>Management of Deicing Chemicals and Snow</u>
  Snow will be stockpiled on site until the accumulated snow becomes a hazard to the daily operations of the site. It will be the responsibility of the snow removal contractor to properly dispose of transported snow according to MassDEP, Bureau of Resource Protection – Snow Disposal Guideline #BRPG01-01, governing the proper disposal of snow. It will be the responsibility of the snow removal contractor to follow these guidelines and all applicable laws and regulations

The owner's maintenance staff (or its designee) will be responsible for the clearing of the sidewalk and building entrances. The owner may be required to use a de-icing agent such as potassium chloride to maintain a safe walking surface. If used, the de-icing agent for the walkways and building entrances will be kept within the storage rooms located within the building. If used, de-icing agents will not be stored outside. The owner's maintenance staff will limit the application of sand.

Long-Term Maintenance Plan – Facilities Description

A maintenance log will be kept (i.e. report) summarizing inspections, maintenance, and any corrective actions taken. The log will include the date on which each inspection or maintenance task was performed, a description of the inspection findings or maintenance completed, and the name of the inspector or maintenance personnel performing the task. If a maintenance task requires the clean-out of any sediments or debris, the location where the sediment and debris was disposed after removal will be indicated. The log will be made accessible to department staff and a copy provided to the department upon request.

The following is a description of the Stormwater Management System for the project site.

<u>Stormwater Collection System – On-Site:</u>

The stormwater collection system is a series of inlets located at low points within the limits of the paved area. All of the proposed on-site catch basins incorporate a deep sump and hooded outlet. The catch basins are connected by a closed gravity pipe network routed to an isolator row within the underground detention chambers.

Roof runoff discharges directly to the underground chambers, bioretention area, or surface infiltration basin. All remaining runoff along the perimeter of the site and within the parkway, sheet flows through a sediment forebay before overflowing into the wetland areas or drainage channel.

<u>Pretreatment BMPs</u>: Regular maintenance of these BMPs is especially critical because they typically receive the highest concentration of suspended solids during the first flush of a storm event.

- Deep Sump Catch Basin:
  Precast structure equipped with grated inlet and 4' sump to allow sediment to settle out.
- Isolator Row:
  Single row of underground chambers wrapped in geotextile to filter out sediment. Equipped with overflow into remaining chambers.
- Sediment Forebay & Water Quality Swale:

Settling basin constructed at the incoming discharge points of a stormwater BMP.

Treatment BMPs:

- Exfiltrating Bioretention Area:
  Shallow depressions filled with sandy soil topped with a thick layer of mulch and planted with dense native vegetation. Equipped with overflow and underdrain.

Infiltration BMPs:

- Subsurface Structures:
  Underground chambers surrounded by stone used to store large volumes of stormwater and allow for infiltration into the groundwater.
- Infiltration Basin:
  Stormwater runoff impoundments that are constructed over permeable soils.

Other Maintenance Activity:

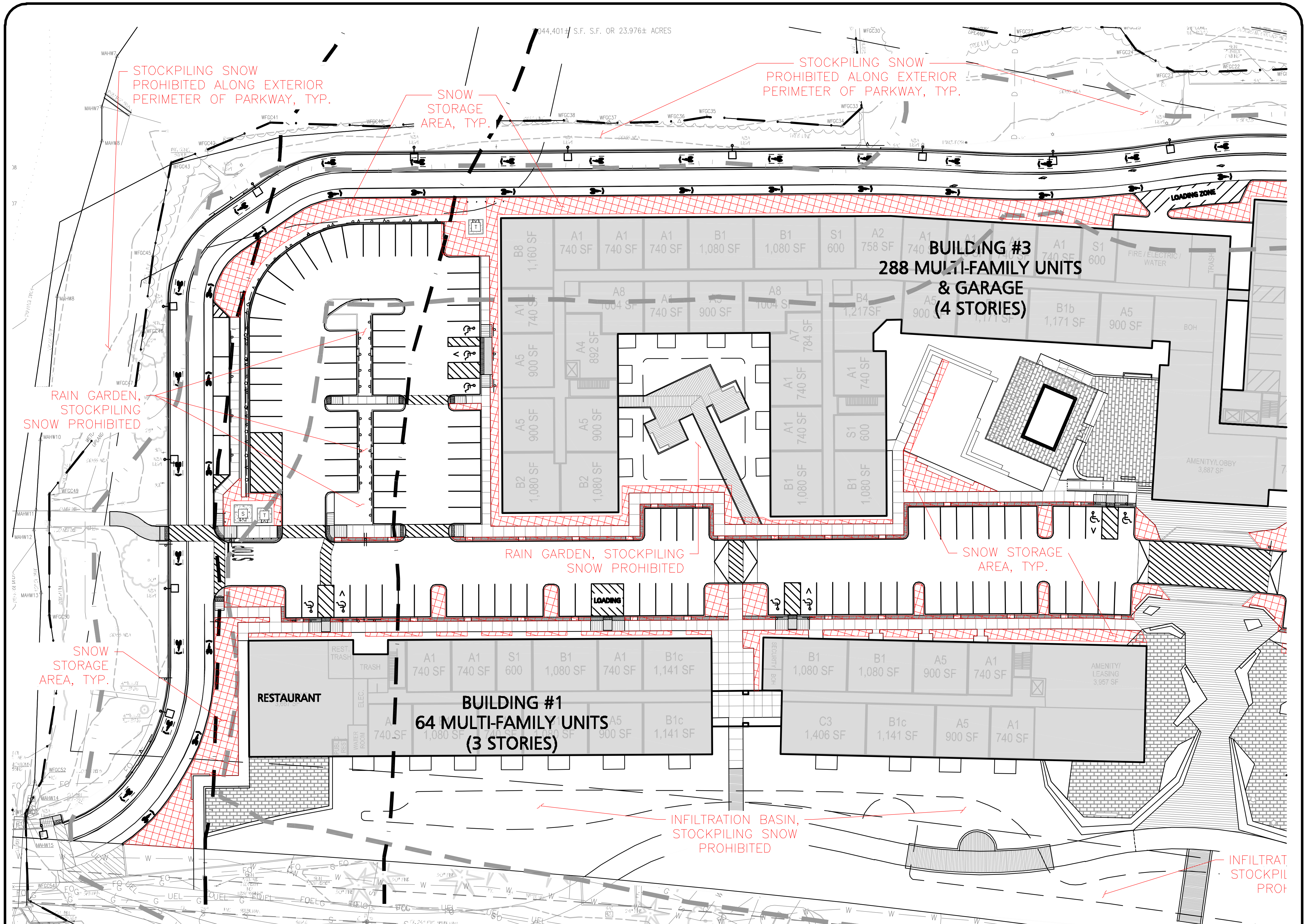
- Mosquito Control - Both above ground and underground stormwater BMPs have the potential to serve as mosquito breeding areas. Good design, proper operation and maintenance, and treatment with larvicides can minimize this potential. See the supplemental information for Mosquito Control in Stormwater Management Practices, and the Operation and Maintenance Plan Schedule for inspection schedule.
- Street Sweeping - Clear accumulations of winter sand in parking lots and along roadways at least once a year, preferably in the spring. Accumulations on pavement may be removed by pavement sweeping. Accumulations of sand along road shoulders may be removed by grading excess sand to the pavement edge and removing it manually or by a front-end loader.

Inspection and Maintenance Frequency and Corrective Measures
In accordance with MA DEP Stormwater Handbook: Volume 2, Chapter 2; the previously described BMPs will be inspected and the identified deficiencies will be corrected. Clean-out must include the removal and legal disposal of any accumulated sediments, trash, and debris. In any and all cases, operations, inspections, and maintenance activities shall utilize best practical measures to avoid and minimize impacts to wetland resource areas outside the footprint of the SMS.

Supplemental Information

- Snow Storage Exhibits
- Operation & Maintenance Plan Schedule

- Massachusetts Stormwater Handbook, Chapter 5, Miscellaneous Stormwater Topics, Mosquito Control in Stormwater Management Practices.
- MassDEP Bureau of Water Resources Snow Disposal Guidance
- Stormtech Isolator Row O&M Manual



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NOTES:

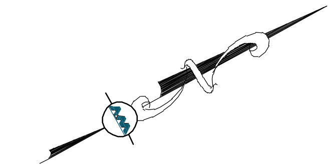
1. SNOW SHALL BE STOCKPILED ON SITE UNTIL THE ACCUMULATED SNOW BECOMES A HAZARD TO THE DAILY OPERATIONS OF THE SITE. IT WILL BE THE RESPONSIBILITY OF THE SNOW REMOVAL CONTRACTOR TO PROPERLY DISPOSE OF TRANSPORTED SNOW ACCORDING TO MASSDEP, BUREAU OF RESOURCE PROTECTION – SNOW DISPOSAL GUIDELINE #BRPG01-01, GOVERNING THE PROPER DISPOSAL OF SNOW. IT WILL BE THE RESPONSIBILITY OF THE SNOW REMOVAL CONTRACTOR TO FOLLOW THESE GUIDELINES AND ALL APPLICABLE LAWS AND REGULATIONS.

2. THE OWNER'S MAINTENANCE STAFF (OR ITS DESIGNEE) WILL BE RESPONSIBLE FOR THE CLEARING OF THE SIDEWALK AND BUILDING ENTRANCES.

GRAPHIC SCALE

60 0 30 60 120 240

(IN FEET)
1 inch = 60 ft.



APPLICANT/OWNER:
CCF QUANNAPOWITT PROPERTY COMPANY, LLC
185 DARTMOUTH STREET
BOSTON, MA 02116

PROJECT:
200-400 QUANNAPOWITT PARKWAY
WAKEFIELD, MA 01880

PROJECT NO.	1623-11	DATE:	04/08/2022
SCALE:	AS NOTED	DWG. NAME:	C-1623-11
DESIGNED BY:	ND	CHECKED BY:	TW

PREPARED BY:

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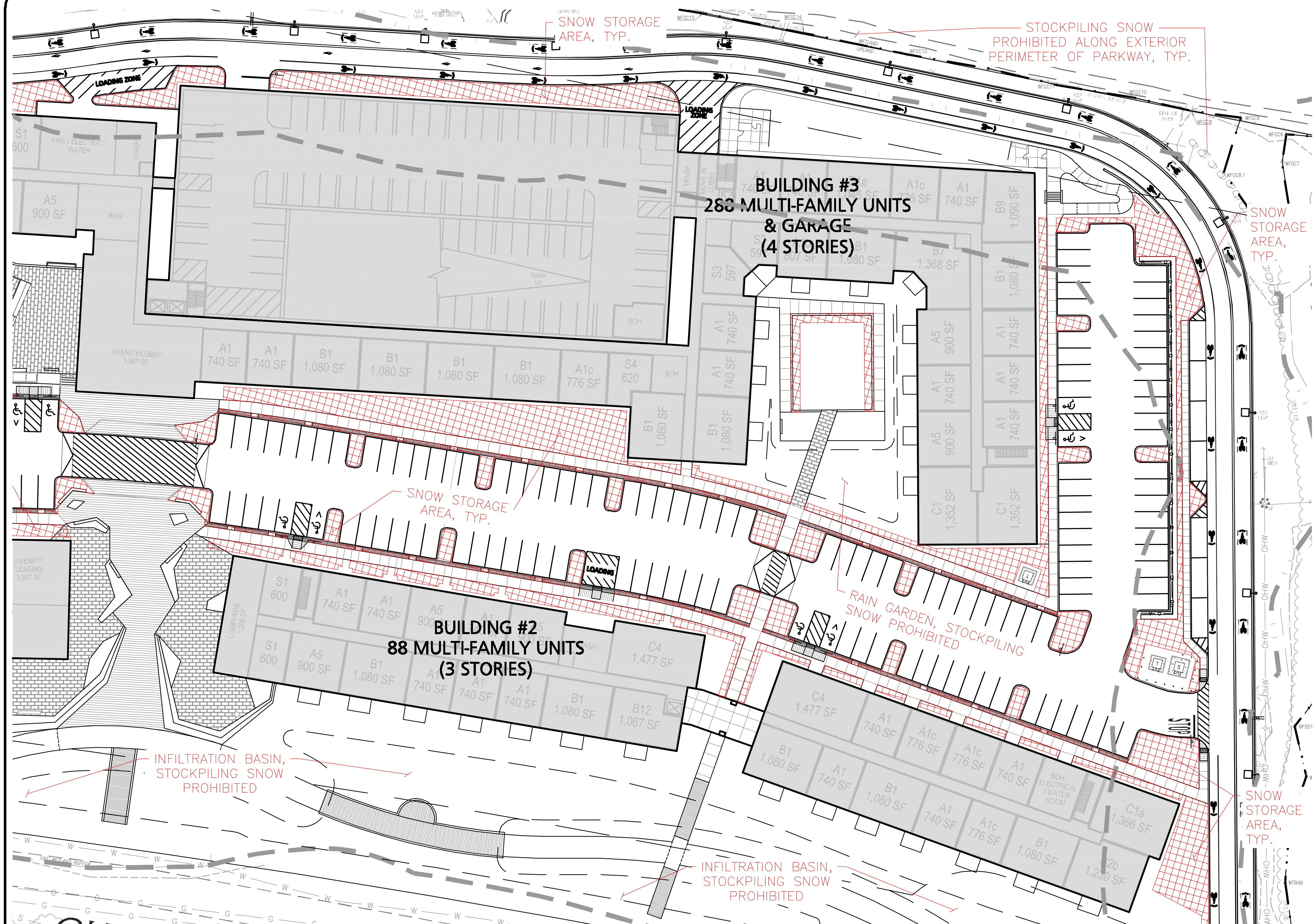

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GRAPHIC SCALE

60 0 30 60 120 240

(IN FEET)
1 inch = 60 ft.

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OPERATION AND MAINTENANCE PLAN SCHEDULE **Date:**

ALLEN & MAJOR ASSOCIATES, INC.

Project: 200 Quannapowitt Parkway
Project Address: 200 Quannapowitt Parkway Wakefield, MA

Responsible for O&M Plan: Cabot, Cabot & Forbes
Address: 185 Dartmouth Street Boston, MA

All information within table is derived from Massachussetts Stormwater Handbook: Volume 2, Chapter 2

BMP CATEGORY	BMP OR MAINTENANCE ACTIVITY	SCHEDULE/ FREQUENCY	NOTES	ESTIMATED ANNUAL MAINTENANCE COST	INSPECTION PERFORMED	
					DATE:	BY:
STRUCTURAL PRETREATMENT BMPs	DEEP SUMP CATCH BASIN	Four times per year (quarterly).	Inspect and clean catch basin units whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin.	$1,000		
	SEDIMENT FOREBAY & WATER QUALITY SWALE	Inspect monthly and clean four times per year (quarterly).	Remove accumulated sediment quarterly. Check for signs of rilling and gullying and repar as needed.	$250		
INFILTRATION BMPs	BIORETENTION AREA & RAIN GARDEN	Remove trash monthly. Remove and replace dead vegetation, prune and mulch annually.	Inspect & remove trash, Mulch, Remove dead vegetation, Replace dead vegetation, Prune, Replace entire media & all vegetation.	$3,000		
	INFILTRATION BASIN	Inspect after every major storm during first 3 months of operation and twice a year thereafter. Clean pretreatment devices twice a year and after every major storm.	Inspect to ensure proper functioning. Mow the buffer area, side slopes, and basin bottom if grassed floor; rake if stone bottom; remove trash and debris; remove grass clippings and accumulated organic matter. Inspect and clean pretreatment devices.	$1,500		
	SUBSURFACE STRUCTURES	Inspect structure inlets at least twice a year. Remove debris that may clog the system as needed.	Because subsurface structures are installed underground, they are extremely difficult to maintain. Remove any debris that might clog the system.	$500		
OTHER MAINTENANCE ACTIVITY	MISQUITO CONTROL	Inspect BMPs as needed to ensure the system's drainage time is less than the maximum 72 hour period.	Massachusetts stormwater handbook requires all stormwater practices that are designed to drain do so within 72 hours to reduce the number of mosquitos that mature to adults since the aquatic stage of a mosquito is 7-10 days.	$100		
	SNOW STORAGE	Clear and remove snow to approved storage locations as necessary to ensure systems are working properly and are protected from meltwater pollutants.	Carefully select snow disposal sites before winter. Avoid dumping removed snow over catch basins, or in detention ponds, sediment forebays, rivers, wetlands, and flood plains. It is also prohibited to dump snow in the bioretention basins or gravel swales.	$500		
	STREET SWEEPING	Clear accumulations of winter sand in parking lots and along roadways at least once a year, preferably in the spring.	Sweep, power broom or vacuum paved areas. Submit information that confirms that all street sweepings have been completed in accordance with state and local requirements	$2,000		

Chapter 5
Miscellaneous Stormwater Topics

Mosquito Control in Stormwater Management Practices

Both aboveground and underground stormwater BMPs have the potential to serve as mosquito breeding areas. Good design, proper operation and maintenance and treatment with larvicides can minimize this potential.

EPA recommends that stormwater treatment practices dewater within 3 days (72 hours) to reduce the number of mosquitoes that mature to adults, since the aquatic stage of many mosquito species is 7 to 10 days. Massachusetts has had a 72-hour dewatering rule in its Stormwater Management Standards since 1996. The 2008 technical specifications for BMPs set forth in Volume 2, Chapter 2 of the Massachusetts Stormwater Handbook also concur with this practice by requiring that all stormwater practices designed to drain do so within 72 hours.

Some stormwater practices are designed to include permanent wet pools. These practices – if maintained properly – can limit mosquito breeding by providing habitat for mosquito predators. Additional measures that can be taken to reduce mosquito populations include increasing water circulation, attracting mosquito predators by adding suitable habitat, and applying larvicides.

The Massachusetts State Reclamation and Mosquito Control Board (SRMCB), through the Massachusetts Mosquito Control Districts, can undertake further mosquito control actions specifically for the purpose of mosquito control pursuant to Massachusetts General Law Chapter 252. The Mosquito Control Board, http://www.mass.gov/agr/mosquito/, describes mosquito control methods and is in the process of developing guidance documents that describe Best Management Practices for mosquito control projects.

The SRMCB and Mosquito Control Districts are not responsible for operating and maintaining stormwater BMPs to reduce mosquito populations. The owners of property that construct the stormwater BMPs or municipalities that “accept” them through local subdivision approval are responsible for their maintenance.[1] The SRMCB is composed of officials from MassDEP, Department of Agricultural Resources, and Department of Conservation and Recreation. The nine (9) Mosquito Control Districts overseen by the SRMCB are located throughout Massachusetts, covering 176 municipalities.

Construction Period Best Management Practices for Mosquito Control

To minimize mosquito breeding during construction, it is essential that the following actions be taken to minimize the creation of standing pools by taking the following actions:

- ***Minimize Land Disturbance:*** Minimizing land disturbance reduces the likelihood of mosquito breeding by reducing silt in runoff that will cause construction period controls to clog and retain standing pools of water for more than 72 hours.
- ***Catch Basin inlets:*** Inspect and refresh filter fabric, hay bales, filter socks or stone dams on a regular basis to ensure that any stormwater ponded at the inlet drains within 8 hours after precipitation stops. Shorter periods may be necessary to avoid hydroplaning in roads

[1] MassDEP and MassHighway understand that the numerous stormwater BMPs along state highways pose a unique challenge. To address this challenge, the 2004 MassHighway Stormwater Handbook will provide additional information on appropriate operation and maintenance practices for mosquito control when the Handbook is revised to reflect the 2008 changes to the Stormwater Management Standards..

caused by water ponded at the catch basin inlet. Treat catch basin sumps with larvicides such as *Bacillus sphaericus* (*Bs*) using a licensed pesticide applicator.

- ***Check Dams:*** If temporary check dams are used during the construction period to lag peak rate of runoff or pond runoff for exfiltration, inspect and repair the check dams on a regular basis to ensure that any stormwater ponded behind the check dam drains within 72 hours.
- ***Design construction period sediment traps*** to dewater within 72 hours after precipitation. Because these traps are subject to high silt loads and tend to clog, treat them with the larvicide *Bs* after it rains from June through October, until the first frost occurs.
- ***Construction period open conveyances:*** When temporary manmade ditches are used for channelizing construction period runoff, inspect them on a regular basis to remove any accumulated sediment to restore flow capacity to the temporary ditch.
- ***Revegetating Disturbed Surfaces:*** Revegetating disturbed surfaces reduces sediment in runoff that will cause construction period controls to clog and retain standing pools of water for greater than 72 hours.
- ***Sediment fences/hay bale barriers:*** When inspections find standing pools of water beyond the 24-hour period after a storm, take action to restore barrier to its normal function.

<u>Post-Construction Stormwater Treatment Practices</u>

- Mosquito control begins with the environmentally sensitive site design. Environmentally sensitive site design that minimizes impervious surfaces reduces the amount of stormwater runoff. Disconnecting runoff using the LID Site Design credits outlined in the Massachusetts Stormwater Handbook reduces the amount of stormwater that must be conveyed to a treatment practice. Utilizing green roofs minimizes runoff from smaller storms. Storage media must be designed to dewater within 72 hours after precipitation.
- Mosquito control continues with the selection of structural stormwater BMPs that are unlikely to become breeding grounds for mosquitoes, such as:
    - ***Bioretention Areas/Rain Gardens/Sand Filter:*** These practices tend not to result in mosquito breeding. If any level spreaders, weirs or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
    - ***Infiltration Trenches:*** This practice tends not to result in mosquito breeding. If any level spreaders, weirs, or sediment forebays are used as part of the design, inspect them and correct them as necessary to prevent standing pools of water for more than 72 hours.
- Another mosquito control strategy is to select BMPs that can become habitats for mosquito predators, such as:
    - ***Constructed Stormwater Wetlands:*** Habitat features can be incorporated in constructed stormwater wetlands to attract dragonflies, amphibians, turtles, birds, bats, and other natural predators of mosquitoes.
    - ***Wet Basins:*** Wet basins can be designed to incorporate fish habitat features, such as deep pools. Introduce fish in consultation with Massachusetts Division of Fisheries and Wildlife. Vegetation within wet basins designed as fish habitat must be properly managed to ensure that vegetation does not overtake the habitat. Proper design to ensure that no low circulation or "dead" zones are created may reduce the potential for mosquito breeding. Introducing bubblers may increase water circulation in the wet basin.

Effective mosquito controls require proponents to design structural BMPs to prevent ponding and facilitate maintenance and, if necessary, the application of larvicides. Examples of such design practices include the following:

- ***Basins:*** Provide perimeter access around wet basins, extended dry detention basins and dry detention basins for both larviciding and routine maintenance. Control vegetation to ensure that access pathways stay open.
- ***BMPs without a permanent pool of water:*** All structural BMPs that do not rely on a permanent pool of water must drain and completely dewater within 72 hours after precipitation. This includes dry detention basins, extended dry detention basins, infiltration basins, and dry water quality swales. Use underdrains at extended dry detention basins to drain the small pools that form due to accumulation of silts. Wallace indicates that extended dry extended detention basins may breed more mosquitoes than wet basins. It is, therefore, imperative to design outlets from extended dry detention basins to completely dewater within the 72-hour period.
- ***Energy Dissipators and Flow Spreaders:*** Currier and Moeller, 2000 indicate that shallow recesses in energy dissipators and flow spreaders trap water where mosquitoes breed. Set the riprap in grout to reduce the shallow recesses and minimize mosquito breeding.
- ***Outlet control structures:*** Debris trapped in small orifices or on trash racks of outlet control structures such as multiple stage outlet risers may clog the orifices or the trash rack, causing a standing pool of water. Optimize the orifice size or trash rack mesh size to provide required peak rate attenuation/water quality detention/retention time while minimizing clogging.
- ***Rain Barrels and Cisterns:*** Seal lids to reduce the likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over inlets. The cistern system should be designed to ensure that all collected water is drained into it within 72 hours.
- ***Subsurface Structures, Deep Sump Catch Basins, Oil Grit Separators, and Leaching Catch Basins:*** Seal all manhole covers to reduce likelihood of mosquitoes laying eggs in standing water. Install mosquito netting over the outlet (CALTRANS 2004).

The Operation and Maintenance Plan should provide for mosquito prevention and control.

- ***Check dams:*** Inspect permanent check dams on the schedule set forth in the O&M Plan. Inspect check dams 72 hours after storms for standing water ponding behind the dam. Take corrective action if standing water is found.
- ***Cisterns:*** Apply *Bs* larvicide in the cistern if any evidence of mosquitoes is found. The Operation and Maintenance Plan shall specify how often larvicides should be applied to waters in the cistern.
- ***Water quality swales:*** Remove and properly dispose of any accumulated sediment as scheduled in the Operation and Maintenance Plan.
- ***Larvicide Treatment:*** The Operation and Maintenance Plan must include measures to minimize mosquito breeding, including larviciding.
- The party identified in the Operation and Maintenance Plan as responsible for maintenance shall see that larvicides are applied as necessary to the following stormwater treatment practices: catch basins, oil/grit separators, wet basins, wet water quality swales, dry extended detention basins, infiltration basins, and constructed stormwater wetlands. The Operation and Maintenance Plan must ensure that all larvicides are applied by a licensed pesticide applicator and in compliance with all pesticide label requirements.
- The Operation and Maintenance Plan should identify the appropriate larvicide and the time and method of application. For example, *Bacillus sphaericus (Bs*), the preferred

larvicide for stormwater BMPs, should be hand-broadcast.[2] Alternatively, Altosid, a Methopren product, may be used. Because some practices are designed to dewater between storms, such as dry extended detention and infiltration basins, the Operation and Maintenance Plan should provide that larviciding must be conducted during or immediately after wet weather, when the detention or infiltration basin has a standing pool of water, unless a product is used that can withstand extended dry periods.

REFERENCES

California Department of Transportation, 2004, BMP Retrofit Pilot Program, Final Report, Report ID CTSW – RT – 1 – 050, http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-01-050.pdf#xml=http://dap1.dot.ca.gov/cgi-bin/texis/webinator/search/pdfhi.txt?query=mosquito&db=db&pr=www&prox=page&rorder=500&rprox=500&rdfreq=500&rwfreq=500&rlead=500&sufs=0&order=r&cq=&id=4673373b7

Appendix E: Vector Monitoring and Abatement, http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/

California Department of Transportation, 2001, Final Vector Report, Caltrans BMP Retrofit Project Sites, Districts 7 and 11, http://www.dot.ca.gov/hq/env/stormwater/special/newsetup/_pdfs/new_technology/CTSW-RT-01-050/AppendixE/01_FinalVectorReport.pdf

Currier, Brian, and Moeller, 2000, Glenn, Lessons Learned: The CALTRANS Storm Water Best Management Practice Retrofit Pilot Study, prepared by the California State University Sacramento and University of California Davis for the California Department of Transportation, http://www.owp.csus.edu/research/papers/papers/PP015.pdf

Massachusetts Department of Environmental Protection, 2001, West Nile Virus, Application of Pesticides to Wetland Resource Areas and Buffer Zones and Public Water systems, Guideline No. BRPG01-02, http://www.mass.gov/dep/water/wnvpolcy.doc

O'Meara, G.F., 2003, Mosquitoes Associated With Stormwater Detention/Retention Areas, ENY627, University of Florida, Institute of Food and Agricultural Sciences Extension, http://edis.ifas.ufl.edu/mg338

Taylor, Scott M., and Currier, Brian, 1999, A Wet Pond as a Storm Water Runoff BMP – Case Study, presented at Department of Environmental Resources Engineering, Humboldt State University, Arcata, California http://www.owp.csus.edu/research/papers/papers/PP004.pdf

U.S. EPA, 2005, Stormwater Structures and Mosquitoes, EPA 833-F-05-003, http://www.epa.gov/npdes/pubs/sw_wnv.pdf

U.S. EPA, 2003, Do Stormwater Retention Ponds Contribute to Mosquito Problems, Nonpoint source News-Notes, Issue No. 71, http://notes.tetratech-ffx.com/newsnotes.nsf/0/143f7fa99c3ea25485256d0100618bc9?OpenDocument

Virginia Department of Conservation and Recreation, 2003, Vector Control, Mosquitoes and Stormwater Management, Stormwater Management Technical Bulletin No. 8, http://www.dcr.virginia.gov/soil_&_water/documents/tecbltn8.pdf

Wallace, John R., Stormwater Management and Mosquito Ecology, Stormwater Magazine, March/April 2007, http://www.gradingandexcavation.com/sw_0703_management.html

[2] *Bacillus thuringienis israelensis* or *Bti* is usually applied by helicopter to wetlands and floodplains

Roads and Stormwater BMPs

In general, the stormwater BMPs used for land development projects can also be used for new roadways and roadway improvement projects. However, for improvement of existing roads, there are often constraints that limit the choice of BMP. These constraints derive from the linear configuration of the road, the limited area within the existing right-of-way, the structural and safety requirements attendant to good roadway design, and the long-term maintainability of the roadway drainage systems. The MassHighway Handbook provides strategies for dealing with the constraints associated with providing stormwater BMPs for roadway redevelopment projects.

Roadway design can minimize impacts caused by stormwater. Reducing roadway width reduces the total and peak volume of runoff. Designing a road with country drainage (no road shoulders or curbs) disconnects roadway runoff. Disconnection of roadway runoff is eligible for the Low Impact Site Design Credit provided the drainage is disconnected in accordance with specifications outlined in Volume 3.

Like other parties, municipalities that work within wetlands jurisdictional areas and adjacent buffer zones must design and implement structural stormwater best management practices in accordance with the Stormwater Management Standards and the Stormwater Management Handbook. In addition, in municipalities and areas where state agencies operate stormwater systems, the DPWs (or other town or state agencies) must meet the “good housekeeping“ requirement of the municipality’s or agency's MS4 permit.

MassHighway has taken stormwater management one step further by working with MassDEP to develop the MassHighway Storm Water Handbook for Highways and Bridges. The purpose of the MassHighway Handbook is to provide guidance for persons involved in the design, permitting, review and implementation of state highway projects, especially those involving existing roadways where physical constraints often limit the stormwater management options available. These constraints, like those common to redevelopment sites, may make it difficult to comply precisely with the requirements of the Stormwater Management Standards and the Massachusetts Stormwater Handbook.[3] In response to these constraints, MassDEP and MHD developed specific design, permitting, review and implementation practices that meet the unique challenges of providing environmental protection for existing state roads. The information in the MassHighway Handbook may also aid in the planning and design of projects to build new highways and to add lanes to existing highways, since they may face similar difficulties in meeting the requirements of the Stormwater Management Standards.

Although it is very useful, the MassHighway Handbook does not allow MassHighway projects to proceed without individual review and approval by the issuing authority when subject to the Wetlands Protection Act Regulations, 310 CMR 10.00, or the 401 Water Quality Certification Regulations, 314 CMR 9.00. For example, MassHighway must provide a Conservation Commission with a project-specific Operation and Maintenance Plan in accordance with Standard 9 that documents how the project’s post-construction BMPs will be operated and maintained.[4]

[3] The 2004 MassHighway Handbook outlines standardized methods for dealing with these constraints as they apply to highway redevelopment projects. MassDEP and MassHighway intend to work together to provide guidance for add a lane projects when the 2004 Handbook is revised to reflect the 2008 changes to the Stormwater Management Standards.
[4] The general permit for municipal separate storm sewer systems (the MS4 Permit) requires MassHighway to develop and implement procedures for the proper operation and maintenance of stormwater BMPs. To

Some municipalities have asked if the MassHighway Handbook governs municipal road projects. The answer is no.[5] The MassHighway Handbook was developed in response to the unique problems and challenges arising out of the management of the state highway system. Like other project proponents, cities and towns planning road or other projects in areas subject to jurisdiction under the Wetlands Protection Act must design and implement LID, non-structural and structural best management practices in accordance with the Stormwater Management Standards and the Massachusetts Stormwater Handbook.

avoid duplication of effort, MassHighway may be able rely on the same procedures to fulfill the operation and maintenance requirements of Standard 9 and the MS 4 Permit.

[5] Although the MassHighway Handbook does not govern municipal road projects, cities and towns may find some of the information presented in the Handbook useful.

Commonwealth of Massachusetts
Executive Office of Energy & Environmental Affairs

Department of Environmental Protection

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Charles D. Baker
Governor

Karyn E. Polito
Lieutenant Governor

Kathleen A. Theoharides
Secretary

Martin Suuberg
Commissioner

Massachusetts Department of Environmental Protection
Bureau of Water Resources
Snow Disposal Guidance

Effective Date: December 23, 2019

Applicability: Applies to all federal, state, regional and local agencies, as well as to private businesses.

Supersedes: Bureau of Resource Protection (BRP) Snow Disposal Guideline No. BRPG97-1 issued December 12, 1997 and BRPG01-01 issued March 8, 2001; Bureau of Water Resources (BWR) snow disposal guidance issued December 21, 2015 and December 12, 2018.

Approved by: Kathleen Baskin, Assistant Commissioner, Bureau of Water Resources

PURPOSE: To provide guidelines to all government agencies and private businesses regarding snow disposal site selection, site preparation and maintenance, and emergency snow disposal options that are protective of wetlands, drinking water, and water bodies, and are acceptable to the Massachusetts Department of Environmental Protection (MassDEP), Bureau of Water Resources.

APPLICABILITY: These Guidelines are issued by MassDEP's Bureau of Water Resources on behalf of all Bureau Programs (including Drinking Water Supply, Wetlands and Waterways, Wastewater Management, and Watershed Planning and Permitting). They apply to all federal agencies, state agencies, state authorities, municipal agencies and private businesses disposing of snow in the Commonwealth of Massachusetts.

INTRODUCTION

Finding a place to dispose of collected snow poses a challenge to municipalities and businesses as they clear roads, parking lots, bridges, and sidewalks. While MassDEP is aware of the threats to public safety caused by snow, collected snow that is contaminated with road salt, sand, litter, and automotive pollutants such as oil also threatens public health and the environment.

As snow melts, road salt, sand, litter, and other pollutants are transported into surface water or through the soil where they may eventually reach the groundwater. Road salt and other pollutants can contaminate water supplies and are toxic to aquatic life at certain levels. Sand washed into waterbodies can create sand bars or fill in wetlands and ponds, impacting aquatic life, causing flooding, and affecting our use of these resources.

There are several steps that communities can take to minimize the impacts of snow disposal on public health and the environment. These steps will help communities avoid the costs of a contaminated water supply, degraded waterbodies, and flooding. Everything that occurs on the land has the potential to impact the Commonwealth's water resources. Given the authority of local government over the use of the land, municipal officials and staff have a critically important role to play in protecting our water resources.

The purpose of these guidelines is to help federal agencies, state agencies, state authorities, municipalities and businesses select, prepare, and maintain appropriate snow disposal sites before the snow begins to accumulate through the winter. Following these guidelines and obtaining the necessary approvals may also help municipalities in cases when seeking reimbursement for snow disposal costs from the Federal Emergency Management Agency is possible.

RECOMMENDED GUIDELINES

These snow disposal guidelines address: (1) site selection; (2) site preparation and maintenance; and (3) emergency snow disposal.

1. SITE SELECTION

The key to selecting effective snow disposal sites is to locate them adjacent to or on pervious surfaces in upland areas or upland locations on impervious surfaces away from water resources and drinking water wells. At these locations, the snow meltwater can filter into the soil, leaving behind sand and debris which can be removed in the spring. The following conditions should be followed:

- Within water supply Zone A and Zone II, avoid storage or disposal of snow and ice containing deicing chemicals that has been collected from streets located outside these zones. Municipalities may have a water supply protection land use control that prohibits the disposal of snow and ice containing deicing chemicals from outside the Zone A and Zone II, subject to the Massachusetts Drinking Water Regulations at 310 CMR 22.20C and 310 CMR 22.21(2).
- Avoid storage or disposal of snow or ice in Interim Wellhead Protection Areas (IWPA) of public water supply wells, and within 75 feet of a private well, where road salt may contaminate water supplies.
- Avoid dumping snow into any waterbody, including rivers, the ocean, reservoirs, ponds, or wetlands. In addition to water quality impacts and flooding, snow disposed of in open water can cause navigational hazards when it freezes into ice blocks.
- Avoid dumping snow on MassDEP-designated high and medium-yield aquifers where it may contaminate groundwater.
- Avoid dumping snow in sanitary landfills and gravel pits. Snow meltwater will create more contaminated leachate in landfills posing a greater risk to groundwater, and in gravel pits, there is little opportunity for pollutants to be filtered out of the meltwater because groundwater is close to the land surface.

- Avoid disposing of snow on top of storm drain catch basins or in stormwater drainage systems including detention basins, swales or ditches. Snow combined with sand and debris may block a stormwater drainage system, causing localized flooding. A high volume of sand, sediment, and litter released from melting snow also may be quickly transported through the system into surface water.

Recommended Site Selection Procedures

It is important that the municipal Department of Public Works or Highway Department, Conservation Commission, and Board of Health work together to select appropriate snow disposal sites. The following steps should be taken:

- Estimate how much snow disposal capacity may be needed for the season so that an adequate number of disposal sites can be selected and prepared.
- Identify sites that could potentially be used for snow disposal, such as municipal open space (e.g., parking lots or parks).
- Select sites located in upland locations that are not likely to impact sensitive environmental resources first.
- If more storage space is still needed, prioritize the sites with the least environmental impact (using the site selection criteria, and local or MassGIS maps as a guide).

Snow Disposal Mapping Assistance

MassDEP has an online mapping tool to assist in identifying possible locations to potentially dispose of snow. MassDEP encourages municipalities to use this tool to identify possible snow disposal options. The tool identifies wetland resource areas, public drinking water supplies and other sensitive locations where snow should not be disposed. The tool may be accessed through the Internet at the following web address:
https://maps.env.state.ma.us/dep/arcgis/js/templates/PSF/.

2. SITE PREPARATION AND MAINTENANCE

In addition to carefully selecting disposal sites before the winter begins, it is important to prepare and maintain these sites to maximize their effectiveness. The following maintenance measures should be undertaken for all snow disposal sites:

- A silt fence or equivalent barrier should be placed securely on the downgradient side of the snow disposal site.
- Wherever possible maintain a 50-foot vegetated buffer between the disposal site and adjacent waterbodies to filter pollutants from the meltwater.
- Clear debris from the site prior to using the site for snow disposal.
- Clear debris from the site and properly dispose of it at the end of the snow season, and no later than May 15.

3. SNOW DISPOSAL APPROVALS

Proper snow disposal may be undertaken through one of the following approval procedures:

- Routine snow disposal – Minimal, if any, administrative review is required in these cases when upland and pervious snow disposal locations or upland locations on impervious surfaces that have functioning and maintained stormwater management systems have been identified, mapped, and used for snow disposal following ordinary snowfalls. Use of upland and pervious snow disposal sites avoids wetland resource areas and allows snow meltwater to recharge groundwater and will help filter pollutants, sand, and other debris. This process will address the majority of snow removal efforts until an entity exhausts all available upland snow disposal sites. The location and mapping of snow disposal sites will help facilitate each entity's routine snow management efforts.
- Emergency Certifications – If an entity demonstrates that there is no remaining capacity at upland snow disposal locations, local conservation commissions may issue an Emergency Certification under the Massachusetts Wetlands Protection regulations to authorize snow disposal in buffer zones to wetlands, certain open water areas, and certain wetland resource areas (i.e. within flood plains). Emergency Certifications can only be issued at the request of a public agency or by order of a public agency for the protection of the health or safety of citizens, and are limited to those activities necessary to abate the emergency. See 310 CMR 10.06(1)-(4). Use the following guidelines in these emergency situations:
    - Dispose of snow in open water with adequate flow and mixing to prevent ice dams from forming.
    - Do not dispose of snow in salt marshes, vegetated wetlands, certified vernal pools, shellfish beds, mudflats, drinking water reservoirs and their tributaries, Zone IIs or IWPAs of public water supply wells, Outstanding Resource Waters, or Areas of Critical Environmental Concern.
    - Do not dispose of snow where trucks may cause shoreline damage or erosion.
    - Consult with the municipal Conservation Commission to ensure that snow disposal in open water complies with local ordinances and bylaws.

- Severe Weather Emergency Declarations – In the event of a large-scale severe weather event, MassDEP may issue a broader Emergency Declaration under the Wetlands Protection Act which allows federal agencies, state agencies, state authorities, municipalities, and businesses greater flexibility in snow disposal practices. Emergency Declarations typically authorize greater snow disposal options while protecting especially sensitive resources such as public drinking water supplies, vernal pools, land containing shellfish, FEMA designated floodways, coastal dunes, and salt marsh. In the event of severe winter storm emergencies, the snow disposal site maps created by municipalities will enable MassDEP and the Massachusetts Emergency Management Agency (MEMA) in helping communities identify appropriate snow disposal locations.

  If upland disposal sites have been exhausted, the Emergency Declaration issued by MassDEP allows for snow disposal near water bodies. In these situations, a buffer of at least 50 feet, preferably vegetated, should still be maintained between the site and the waterbody. Furthermore, it is essential that the other guidelines for preparing and maintaining snow disposal sites be followed to minimize the threat to adjacent waterbodies.

Under extraordinary conditions, when all land-based snow disposal options are exhausted, the Emergency Declaration issued by MassDEP may allow disposal of snow in certain waterbodies under certain conditions. ***A federal agency, state agency, state authority, municipality or business seeking to dispose of snow in a waterbody should take the following steps***:

- Call the emergency contact phone number [(888) 304-1133)] and notify the MEMA of the municipality's intent.
- MEMA will ask for some information about where the requested disposal will take place.
- MEMA will confirm that the disposal is consistent with MassDEP's Severe Weather Emergency Declaration and these guidelines and is therefore approved.

During declared statewide snow emergency events, MassDEP's website will also highlight the emergency contact phone number [(888) 304-1133)] for authorizations and inquiries. For further non-emergency information about this Guidance you may contact your MassDEP Regional Office Service Center:

Northeast Regional Office, Wilmington, 978-694-3246
Southeast Regional Office, Lakeville, 508-946-2714
Central Regional Office, Worcester, 508-792-7650
Western Regional Office, Springfield, 413-755-2114

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Subsurface Stormwater Management℠

Isolator™ Row O&M Manual

StormTech® Chamber System for Stormwater Management

1.0 The Isolator™ Row

1.1 INTRODUCTION

An important component of any Stormwater Pollution Prevention Plan is inspection and maintenance. The StormTech Isolator Row is a patent pending technique to inexpensively enhance Total Suspended Solids (TSS) removal and provide easy access for inspection and maintenance.

Looking down the Isolator Row from the manhole opening, woven geotextile is shown between the chamber and stone base.

1.2 THE ISOLATOR™ ROW

The Isolator Row is a row of StormTech chambers, either SC-740 or SC-310 models, that is surrounded with filter fabric and connected to a closely located manhole for easy access. The fabric-wrapped chambers provide for settling and filtration of sediment as storm water rises in the Isolator Row and ultimately passes through the filter fabric. The open bottom chambers and perforated side-walls allow storm water to flow both vertically and horizontally out of the chambers. Sediments are captured in the Isolator Row protecting the storage areas of the adjacent stone and chambers from sediment accumulation.

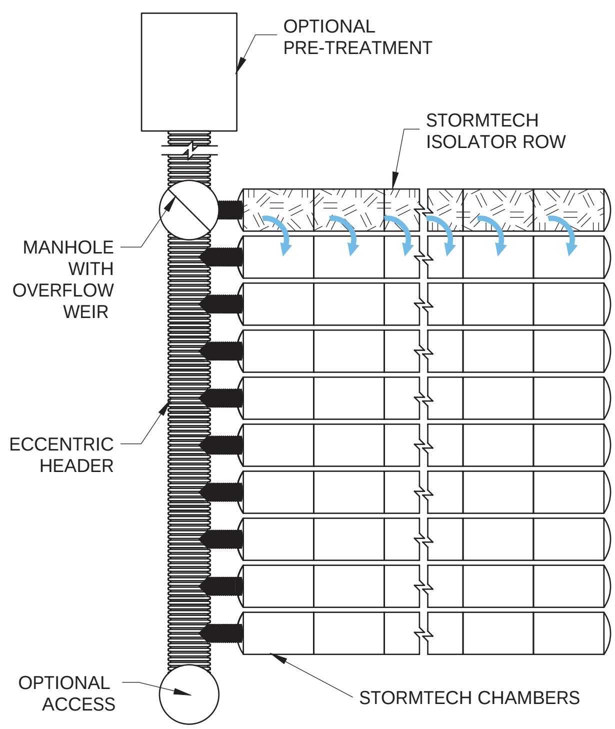
Two different fabrics are used for the Isolator Row. A woven geotextile fabric is placed between the stone and the Isolator Row chambers. The tough geotextile provides a media for storm water filtration and provides a durable surface for maintenance operations. It is also designed to prevent scour of the underlying stone and remain intact during high pressure jetting. A non-woven fabric is placed over the chambers to provide a filter media for flows passing through the perforations in the sidewall of the chamber.

The Isolator Row is typically designed to capture the "first flush" and offers the versatility to be sized on a volume basis or flow rate basis. An upstream manhole not only provides access to the Isolator Row but typically includes a high flow weir such that storm water flowrates or volumes that exceed the capacity of the Isolator Row overtop the over flow weir and discharge through a manifold to the other chambers.

The Isolator Row may also be part of a treatment train. By treating storm water prior to entry into the chamber system, the service life can be extended and pollutants such as hydrocarbons can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins, oil-water separators or can be innovative storm water treatment devices. The design of the treatment train and selection of pretreatment devices by the design engineer is often driven by regulatory requirements. Whether pretreatment is used or not, the Isolator Row is recommended by StormTech as an effective means to minimize maintenance requirements and maintenance costs.

Note: See the StormTech Design Manual for detailed information on designing inlets for a StormTech system, including the Isolator Row.

StormTech Isolator Row with Overflow Spillway
(not to scale)



2.0 Isolator Row Inspection/Maintenance

StormTech®

2.1 INSPECTION

The frequency of Inspection and Maintenance varies by location. A routine inspection schedule needs to be established for each individual location based upon site specific variables. The type of land use (i.e. industrial, commercial residential), anticipated pollutant load, percent imperviousness, climate, etc. all play a critical role in determining the actual frequency of inspection and maintenance practices.

At a minimum, StormTech recommends annual inspections. Initially, the Isolator Row should be inspected every 6 months for the first year of operation. For subsequent years, the inspection should be adjusted based upon previous observation of sediment deposition.

The Isolator Row incorporates a combination of standard manhole(s) and strategically located inspection ports (as needed). The inspection ports allow for easy access to the system from the surface, eliminating the need to perform a confined space entry for inspection purposes.

If upon visual inspection it is found that sediment has accumulated, a stadia rod should be inserted to determine the depth of sediment. When the average depth of sediment exceeds 3 inches throughout the length of the Isolator Row, clean-out should be performed.

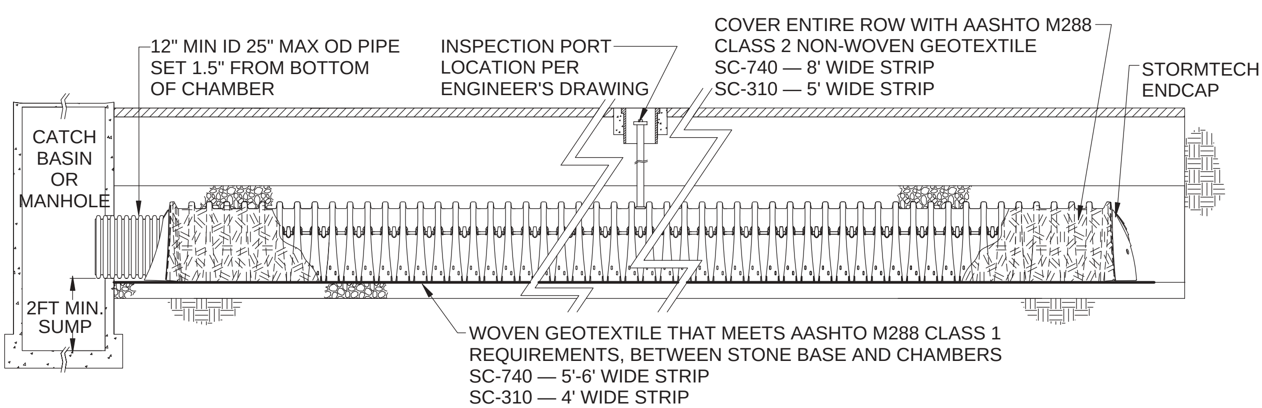
2.2 MAINTENANCE

The Isolator Row was designed to reduce the cost of periodic maintenance. By “isolating” sediments to just one row, costs are dramatically reduced by eliminating the need to clean out each row of the entire storage bed. If inspection indicates the potential need for maintenance, access is provided via a manhole(s) located on the end(s) of the row for cleanout. If entry into the manhole is required, please follow local and OSHA rules for a confined space entries.

Examples of culvert cleaning nozzles appropriate for Isolator Row maintenance. (These are not StormTech products.)

Maintenance is accomplished with the JetVac process. The JetVac process utilizes a high pressure water nozzle to propel itself down the Isolator Row while scouring and suspending sediments. As the nozzle is retrieved, the captured pollutants are flushed back into the manhole for vacuuming. Most sewer and pipe maintenance companies have vacuum/JetVac combination vehicles. Selection of an appropriate JetVac nozzle will improve maintenance efficiency. Fixed nozzles designed for culverts or large diameter pipe cleaning are preferable. Rear facing jets with an effective spread of at least 45” are best. Most JetVac reels have 400 feet of hose allowing maintenance of an Isolator Row up to 50 chambers long. **The JetVac process shall only be performed on StormTech Isolator Rows that have AASHTO class 1 woven geotextile (as specified by StormTech) over their angular base stone.**

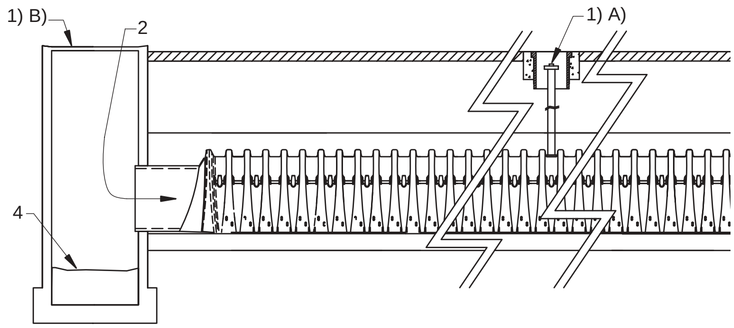
StormTech Isolator Row (not to scale)



3.0 Isolator Row Step By Step Maintenance Procedures

Step 1) Inspect Isolator Row for sediment
- A) Inspection ports (if present)
  - i. Remove lid from floor box frame
  - ii. Remove cap from inspection riser
  - iii. Using a flashlight and stadia rod, measure depth of sediment and record results on maintenance log.
  - iv. If sediment is at, or above, 3 inch depth proceed to Step 2. If not proceed to step 3.
- B) All Isolator Rows
  - i. Remove cover from manhole at upstream end of Isolator Row
  - ii. Using a flashlight, inspect down Isolator Row through outlet pipe
    1. Mirrors on poles or cameras may be used to avoid a confined space entry
    2. Follow OSHA regulations for confined space entry if entering manhole
  - iii. If sediment is at or above the lower row of sidewall holes (approximately 3 inches) proceed to Step 2. If not proceed to Step 3.

StormTech Isolator Row (not to scale)



Step 2) Clean out Isolator Row using the JetVac process
- A) A fixed culvert cleaning nozzle with rear facing nozzle spread of 45 inches or more is preferable
- B) Apply multiple passes of JetVac until backflush water is clean
- C) Vacuum manhole sump as required

Step 3) Replace all caps, lids and covers, record observations and actions

Step 4) Inspect & clean catch basins and manholes upstream of the StormTech system

Sample Maintenance Log

Date	Stadia Rod Readings: Fixed point to chamber bottom (1)	Stadia Rod Readings: Fixed point to top of sediment (2)	Sediment Depth (1) - (2)	Observations/Actions	Inspector
3/15/01	6.3 ft.	none		New installation. Fixed point is CI frame at grade	djm
9/24/01		6.2	0.1 ft.	Some grit felt	sm
6/20/03		5.8	0.5 ft.	Mucky feel, debris visible in manhole and in Isolator row, maintenance due	rv
7/7/03	6.3 ft.		0	System jetted and vacuumed	djm

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StormTech products are covered by one or more of the following patents: U.S. Patents: 5,401,459; 5,511,903; 5,716,163; 5,588,778; 5,839,844; Canadian Patents: 2,158,418 Other U.S. and Foreign Patents PendingPrinted in U.S.A.

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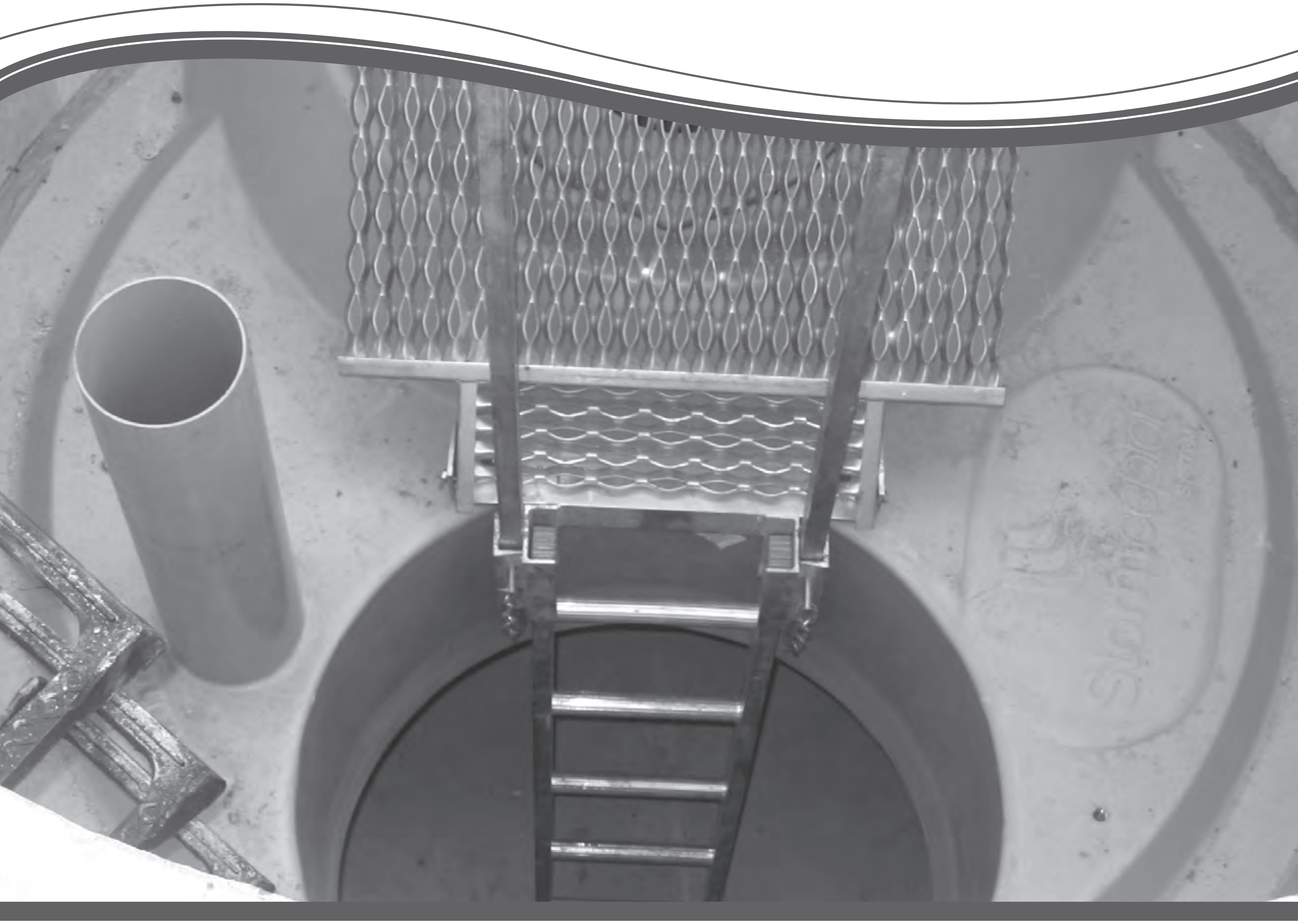
CONTECH
ENGINEERED SOLUTIONS

Stormceptor® STC
Operation and Maintenance Guide



Stormceptor® STC

Stormceptor Design Notes

- Only the STC 450i is adaptable to function with a catch basin inlet and/or inline pipes.
- Only the Stormceptor models STC 450i to STC 7200 may accommodate multiple inlet pipes.

Inlet and outlet invert elevation differences are as follows:

Inlet and Outlet Pipe Invert Elevations Differences			
Inlet Pipe Configuration	STC 450i	STC 900 to STC 7200	STC 11000 to STC 16000
Single inlet pipe	3 in. (75 mm)	1 in. (25 mm)	3 in. (75 mm)
Multiple inlet pipes	3 in. (75 mm)	3 in. (75 mm)	Only one inlet pipe.

Maximum inlet and outlet pipe diameters:

Inlet/Outlet Configuration	Inlet Unit STC 450i	In-Line Unit STC 900 to STC 7200	Series* STC 11000 to STC 16000
Straight Through	24 inch (600 mm)	42 inch (1050 mm)	60 inch (1500 mm)
Bend (90 degrees)	18 inch (450 mm)	33 inch (825 mm)	33 inch (825 mm)

- The inlet and in-line Stormceptor units can accommodate turns to a maximum of 90 degrees.
- Minimum distance from top of grade to crown is 2 feet (0.6 m)
- Submerged conditions. A unit is submerged when the standing water elevation at the proposed location of the Stormceptor unit is greater than the outlet invert elevation during zero flow conditions. In these cases, please contact your local Stormceptor representative and provide the following information:
- Top of grade elevation
- Stormceptor inlet and outlet pipe diameters and invert elevations
- Standing water elevation
- Stormceptor head loss, K = 1.3 (for submerged condition, K = 4)

Stormceptor® STC

OPERATION AND MAINTENANCE GUIDE
Table of Content

1. About Stormceptor

The Stormceptor® STC (Standard Treatment Cell) was developed by Imbrium™ Systems to address the growing need to remove and isolate pollution from the storm drain system before it enters the environment. The Stormceptor STC targets hydrocarbons and total suspended solids (TSS) in stormwater runoff. It improves water quality by removing contaminants through the gravitational settling of fine sediments and floatation of hydrocarbons while preventing the re-suspension or scour of previously captured pollutants.

The development of the Stormceptor STC revolutionized stormwater treatment, and created an entirely new category of environmental technology. Protecting thousands of waterways around the world, the Stormceptor System has set the standard for effective stormwater treatment.

1.1. Patent Information

The Stormceptor technology is protected by the following patents:

- Australia Patent No. 693,164 • 693,164 • 707,133 • 729,096 • 779401
- Austrian Patent No. 289647
- Canadian Patent No 2,009,208 •2,137,942 • 2,175,277 • 2,180,305 • 2,180,383 • 2,206,338 • 2,327,768 (Pending)
- China Patent No 1168439
- Denmark DK 711879
- German DE 69534021
- Indonesian Patent No 16688
- Japan Patent No 9-11476 (Pending)
- Korea 10-2000-0026101 (Pending)
- Malaysia Patent No PI9701737 (Pending)
- New Zealand Patent No 314646
- United States Patent No 4,985,148 • 5,498,331 • 5,725,760 • 5,753,115 • 5,849,181 • 6,068,765 • 6,371,690
- Stormceptor OSR Patent Pending • Stormceptor LCS Patent Pending

2. Stormceptor Design Overview

2.1. Design Philosophy

The patented Stormceptor System has been designed to focus on the environmental objective of providing long-term pollution control. The unique and innovative Stormceptor design allows for continuous positive treatment of runoff during all rainfall events, while ensuring that all captured pollutants are retained within the system, even during intense storm events.

An integral part of the Stormceptor design is PCSWMM for Stormceptor - sizing software developed in conjunction with Computational Hydraulics Inc. (CHI) and internationally acclaimed expert, Dr. Bill James. Using local historical rainfall data and continuous simulation modeling, this software allows a Stormceptor unit to be designed for each individual site and the corresponding water quality objectives.

By using PCSWMM for Stormceptor, the Stormceptor System can be designed to remove a wide range of particles (typically from 20 to 2,000 microns), and can also be customized to remove a specific particle size distribution (PSD). The specified PSD should accurately reflect what is in the stormwater runoff to ensure the device is achieving the desired water quality objective. Since stormwater runoff contains small particles (less than 75 microns), it is important to design a treatment system to remove smaller particles in addition to coarse particles.

2.2. Benefits

The Stormceptor System removes free oil and suspended solids from stormwater, preventing spills and non-point source pollution from entering downstream lakes and rivers. The key benefits, capabilities and applications of the Stormceptor System are as follows:

- Provides continuous positive treatment during all rainfall events
- Can be designed to remove over 80% of the annual sediment load
- Removes a wide range of particles
- Can be designed to remove a specific particle size distribution (PSD)
- Captures free oil from stormwater
- Prevents scouring or re-suspension of trapped pollutants
- Pre-treatment to reduce maintenance costs for downstream treatment measures (ponds, swales, detention basins, filters)
- Groundwater recharge protection
- Spills capture and mitigation
- Simple to design and specify
- Designed to your local watershed conditions
- Small footprint to allow for easy retrofit installations
- Easy to maintain (vacuum truck)
- Multiple inlets can connect to a single unit
- Suitable as a bend structure
- Pre-engineered for traffic loading (minimum AASHTO HS-20)
- Minimal elevation drop between inlet and outlet pipes
- Small head loss
- Additional protection provided by an 18" (457 mm) fiberglass skirt below the top of the insert, for the containment of hydrocarbons in the event of a spill.

2.3. Environmental Benefit

Freshwater resources are vital to the health and welfare of their surrounding communities. There is increasing public awareness, government regulations and corporate commitment to reducing the pollution entering our waterways. A major source of this pollution originates from stormwater runoff from urban areas. Rainfall runoff carries oils, sediment and other contaminants from roads and parking lots discharging directly into our streams, lakes and coastal waterways.

The Stormceptor System is designed to isolate contaminants from getting into the natural environment. The Stormceptor technology provides protection for the environment from spills that occur at service stations and vehicle accident sites, while also removing contaminated sediment in runoff that washes from roads and parking lots.

3. Key Operation Features

3.1. Scour Prevention

A key feature of the Stormceptor System is its patented scour prevention technology. This innovation ensures pollutants are captured and retained during all rainfall events, even extreme storms. The Stormceptor System provides continuous positive treatment for all rainfall events, including intense storms. Stormceptor slows incoming runoff, controlling and reducing velocities in the lower chamber to create a non-turbulent environment that promotes free oils and floatable debris to rise and sediment to settle.

The patented scour prevention technology, the fiberglass insert, regulates flows into the lower chamber through a combination of a weir and orifice while diverting high energy flows away through the upper chamber to prevent scouring. Laboratory testing demonstrated no scouring when tested up to 125% of the unit's operating rate, with the unit loaded to 100% sediment capacity (NJDEP, 2005). Second, the depth of the lower chamber ensures the sediment storage zone is adequately separated from the path of flow in the lower chamber to prevent scouring.

3.2. Operational Hydraulic Loading Rate

Designers and regulators need to evaluate the treatment capacity and performance of manufactured stormwater treatment systems. A commonly used parameter is the "operational hydraulic loading rate" which originated as a design methodology for wastewater treatment devices.

Operational hydraulic loading rate may be calculated by dividing the flow rate into a device by its settling area. This represents the critical settling velocity that is the prime determinant to quantify the influent particle size and density captured by the device. PCSWMM for Stormceptor uses a similar parameter that is calculated by dividing the hydraulic detention time in the device by the fall distance of the sediment.

$$v_{SC} = \frac{H}{6_H} = \frac{Q}{A_S}$$

Where:

v_{SC} = critical settling velocity, ft/s (m/s)

H = tank depth, ft (m)

$Ø_H$ = hydraulic detention time, ft/s (m/s)

Q = volumetric flow rate, ft3/s (m3/s)

A_S = surface area, ft^2 (m^2)

(Tchobanoglous, G. and Schroeder, E.D. 1987. Water Quality. Addison Wesley.)

Unlike designing typical wastewater devices, stormwater systems are designed for highly variable flow rates including intense peak flows. PCSWMM for Stormceptor incorporates all of the flows into its calculations, ensuring that the operational hydraulic loading rate is considered not only for one flow rate, but for all flows including extreme events.

3.3. Double Wall Containment

The Stormceptor System was conceived as a pollution identifier to assist with identifying illicit discharges. The fiberglass insert has a continuous skirt that lines the concrete barrel wall for a depth of 18 inches (457 mm) that provides double wall containment for hydrocarbons storage. This protective barrier ensures that toxic floatables do not migrate through the concrete wall into the surrounding soils.

4. Stormceptor Product Line

4.1. Stormceptor Models

A summary of Stormceptor models and capacities are listed in Table 1.

Table 1. Stormceptor Models

Stormceptor Model	Total Storage Volume U.S. Gal (L)	Hydrocarbon Storage Capacity U.S. Gal (L)	Maximum Sediment Capacity ft^3 (L)
STC 450i	470 (1,780)	86 (330)	46 (1,302)
STC 900	952 (3,600)	251 (950)	89 (2,520)
STC 1200	1,234 (4,670)	251 (950)	127 (3,596)
STC 1800	1,833 (6,940)	251 (950)	207 (5,861)
STC 2400	2,462 (9,320)	840 (3,180)	205 (5,805)
STC 3600	3,715 (1,406)	840 (3,180)	373 (10,562)
STC 4800	5,059 (1,950)	909 (3,440)	543 (15,376)
STC 6000	6,136 (23,230)	909 (3,440)	687 (19,453)
STC 7200	7,420 (28,090)	1,059 (4,010)	839 (23,757)
STC 11000	11,194 (42,370)	2,797 (10, 590)	1,086 (30,752)
STC 13000	13,348 (50,530)	2,797 (10, 590)	1,374 (38,907)
STC 16000	15,918 (60,260)	3,055 (11, 560)	1,677 (47,487)

NOTE: Storage volumes may vary slightly from region to region. For detailed information, contact your local Stormceptor representative.

4.2. Inline Stormceptor

The Inline Stormceptor, Figure 1, is the standard design for most stormwater treatment applications. The patented Stormceptor design allows the Inline unit to maintain continuous positive treatment of total suspended solids (TSS) year-round, regardless of flow rate. The Inline Stormceptor is composed of a precast concrete tank with a fiberglass insert situated at the invert of the storm sewer pipe, creating an upper chamber above the insert and a lower chamber below the insert.

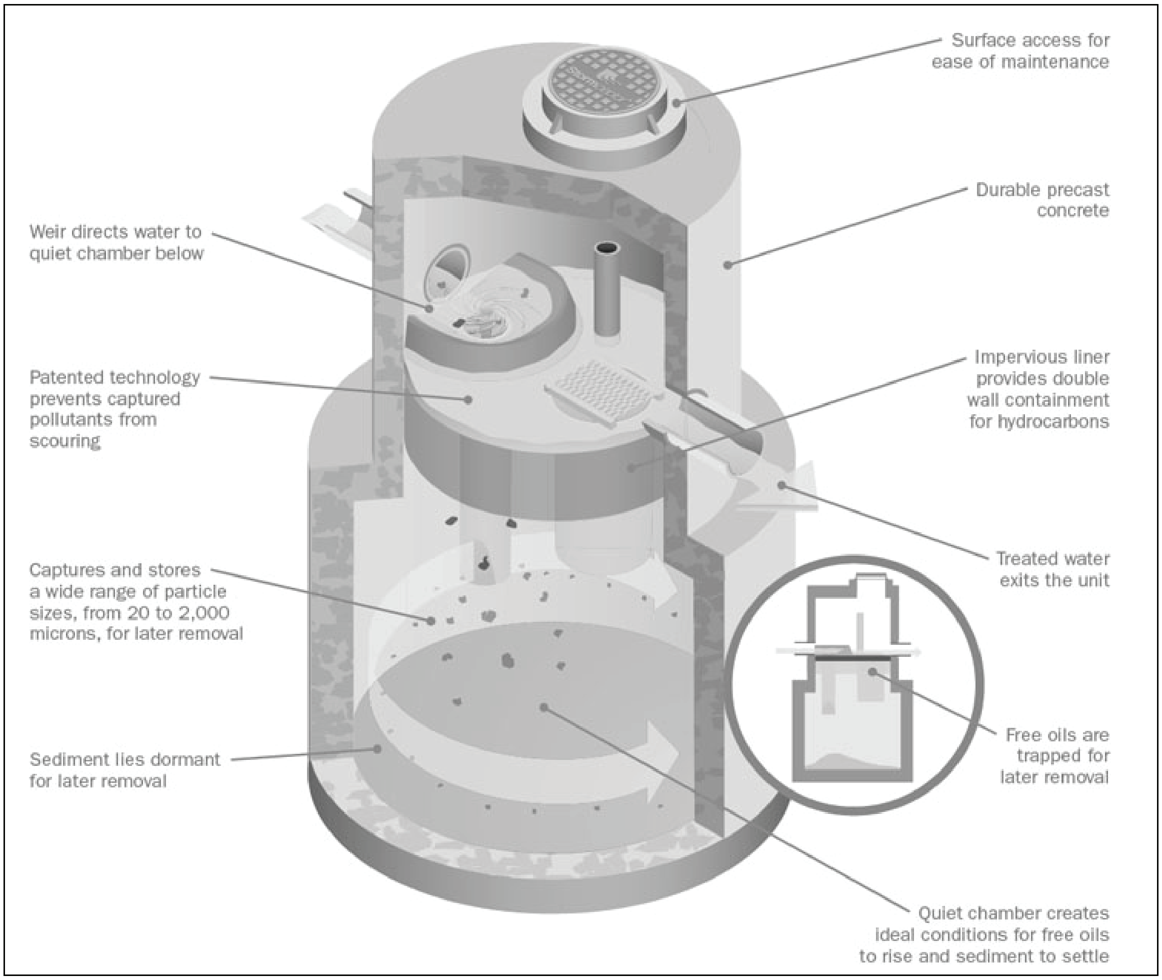


Figure 1. Inline Stormceptor

Operation

As water flows into the Stormceptor unit, it is slowed and directed to the lower chamber by a weir and drop tee. The stormwater enters the lower chamber, a non-turbulent environment, allowing free oils to rise and sediment to settle. The oil is captured underneath the fiberglass insert and shielded from exposure to the concrete walls by a fiberglass skirt. After the pollutants separate, treated water continues up a riser pipe, and exits the lower chamber on the downstream side of the weir before leaving the unit. During high flow events, the Stormceptor System's patented scour prevention technology ensures continuous pollutant removal and prevents re-suspension of previously captured pollutants.

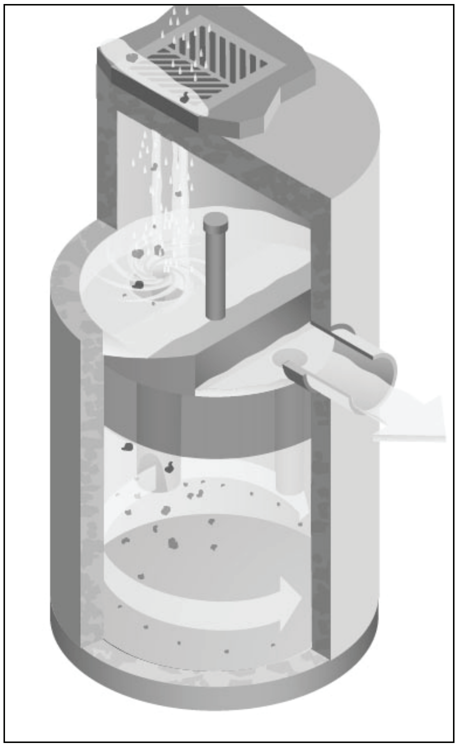


Figure 2. Inlet Stormceptor

4.3. Inlet Stormceptor

The Inlet Stormceptor System, Figure 2, was designed to provide protection for parking lots, loading bays, gas stations and other spill-prone areas. The Inlet Stormceptor is designed to remove sediment from stormwater introduced through a grated inlet, a storm sewer pipe, or both.

The Inlet Stormceptor design operates in the same manner as the Inline unit, providing continuous positive treatment, and ensuring that captured material is not re-suspended.

4.4. Series Stormceptor

Designed to treat larger drainage areas, the Series Stormceptor System, Figure 3, consists of two adjacent Stormceptor models that function in parallel. This design eliminates the need for additional structures and piping to reduce installation costs.

Figure 3. Series System

The Series Stormceptor design operates in the same manner as the Inline unit, providing continuous positive treatment, and ensuring that captured material is not re-suspended.

5. Sizing the Stormceptor System

The Stormceptor System is a versatile product that can be used for many different aspects of water quality improvement. While addressing these needs, there are conditions that the designer needs to be aware of in order to size the Stormceptor model to meet the demands of each individual site in an efficient and cost-effective manner.

PCSWMM for Stormceptor is the support tool used for identifying the appropriate Stormceptor model. In order to size a unit, it is recommended the user follow the seven design steps in the program. The steps are as follows:

STEP 1 – Project Details

The first step prior to sizing the Stormceptor System is to clearly identify the water quality objective for the development. It is recommended that a level of annual sediment (TSS) removal be identified and defined by a particle size distribution.

STEP 2 – Site Details

Identify the site development by the drainage area and the level of imperviousness. It is recommended that imperviousness be calculated based on the actual area of imperviousness based on paved surfaces, sidewalks and rooftops.

STEP 3 – Upstream Attenuation

The Stormceptor System is designed as a water quality device and is sometimes used in conjunction with onsite water quantity control devices such as ponds or underground detention systems. When possible, a greater benefit is typically achieved when installing a Stormceptor unit upstream of a detention facility. By placing the Stormceptor unit upstream of a detention structure, a benefit of less maintenance of the detention facility is realized.

STEP 4 – Particle Size Distribution

It is critical that the PSD be defined as part of the water quality objective. PSD is critical for the design of treatment system for a unit process of gravity settling and governs the size of a treatment system. A range of particle sizes has been provided and it is recommended that clays and silt-sized particles be considered in addition to sand and gravel-sized particles. Options and sample PSDs are provided in PCSWMM for Stormceptor. The default particle size distribution is the Fine Distribution, Table 2, option.

Table 2. Fine Distribution

Particle Size	Distribution	Specific Gravity
20	20%	1.3
60	20%	1.8
150	20%	2.2
400	20%	2.65
2000	20%	2.65

If the objective is the long-term removal of 80% of the total suspended solids on a given site, the PSD should be representative of the expected sediment on the site. For example, a system designed to remove 80% of coarse particles (greater than 75 microns) would provide relatively poor removal efficiency of finer particles that may be naturally prevalent in runoff from the site.

Since the small particle fraction contributes a disproportionately large amount of the total available particle surface area for pollutant adsorption, a system designed primarily for coarse particle capture will compromise water quality objectives.

STEP 5 – Rainfall Records

Local historical rainfall has been acquired from the U.S. National Oceanic and Atmospheric Administration, Environment Canada and regulatory agencies across North America. The rainfall data provided with PCSMM for Stormceptor provides an accurate estimation of small storm hydrology by modeling actual historical storm events including duration, intensities and peaks.

STEP 6 – Summary

At this point, the program may be executed to predict the level of TSS removal from the site. Once the simulation has completed, a table shall be generated identifying the TSS removal of each Stormceptor unit.

STEP 7 – Sizing Summary

Performance estimates of all Stormceptor units for the given site parameters will be displayed in a tabular format. The unit that meets the water quality objective, identified in Step 1, will be highlighted.

5.1. PCSWMM for Stormceptor

The Stormceptor System has been developed in conjunction with PCSWMM for Stormceptor as a technological solution to achieve water quality goals. Together, these two innovations model, simulate, predict and calculate the water quality objectives desired by a design engineer for TSS removal.

PCSWMM for Stormceptor is a proprietary sizing program which uses site specific inputs to a computer model to simulate sediment accumulation, hydrology and long-term total suspended solids removal. The model has been calibrated to field monitoring results from Stormceptor units that have been monitored in North America. The sizing methodology can be described by three processes:

1. Determination of real time hydrology
2. Buildup and wash off of TSS from impervious land areas
3. TSS transport through the Stormceptor (settling and discharge). The use of a calibrated model is the preferred method for sizing stormwater quality structures for the following reasons:
    » The hydrology of the local area is properly and accurately incorporated in the sizing (distribution of flows, flow rate ranges and peaks, back-to-back storms, inter-event times)
    » The distribution of TSS with the hydrology is properly and accurately considered in the sizing
    » Particle size distribution is properly considered in the sizing
    » The sizing can be optimized for TSS removal
    » The cost benefit of alternate TSS removal criteria can be easily assessed
    » The program assesses the performance of all Stormceptor models. Sizing may be selected based on a specific water quality outcome or based on the Maximum Extent Practicable

For more information regarding PCSWMM for Stormceptor, contact your local Stormceptor representative, or visit www.imbriumsystems.com to download a free copy of the program.

5.2. Sediment Loading Characteristics

The way in which sediment is transferred to stormwater can have a considerable effect on which type of system is implemented. On typical impervious surfaces (e.g. parking lots) sediment will build over time and wash off with the next rainfall. When rainfall patterns are examined, a short intense storm will have a higher concentration of sediment than a long slow drizzle. Together with rainfall data representing the site's typical rainfall patterns, sediment loading characteristics play a part in the correct sizing of a stormwater quality device.

Typical Sites

For standard site design of the Stormceptor System, PCSWMM for Stormceptor is utilized to accurately assess the unit's performance. As an integral part of the product's design, the program can be used to meet local requirements for total suspended solid removal. Typical installations of manufactured stormwater treatment devices would occur on areas such as paved parking lots or paved roads. These are considered "stable" surfaces which have non – erodible surfaces.

Unstable Sites

While standard sites consist of stable concrete or asphalt surfaces, sites such as gravel parking lots, or maintenance yards with stockpiles of sediment would be classified as "unstable". These types of sites do not exhibit first flush characteristics, are highly erodible and exhibit atypical sediment loading characteristics and must therefore be sized more carefully. Contact your local Stormceptor representative for assistance in selecting a proper unit sized for such unstable sites.

6. Spill Controls

When considering the removal of total petroleum hydrocarbons (TPH) from a storm sewer system there are two functions of the system: oil removal, and spill capture.

'Oil Removal' describes the capture of the minute volumes of free oil mobilized from impervious surfaces. In this instance relatively low concentrations, volumes and flow rates are considered. While the Stormceptor unit will still provide an appreciable oil removal function during higher flow events and/or with higher TPH concentrations, desired effluent limits may be exceeded under these conditions.

‘Spill Capture’ describes a manner of TPH removal more appropriate to recovery of a relatively high volume of a single phase deleterious liquid that is introduced to the storm sewer system over a relatively short duration. The two design criteria involved when considering this manner of introduction are overall volume and the specific gravity of the material. A standard Stormceptor unit will be able to capture and retain a maximum spill volume and a minimum specific gravity.

For spill characteristics that fall outside these limits, unit modifications are required. Contact your local Stormceptor Representative for more information.

One of the key features of the Stormceptor technology is its ability to capture and retain spills. While the standard Stormceptor System provides excellent protection for spill control, there are additional options to enhance spill protection if desired.

6.1. Oil Level Alarm

The oil level alarm is an electronic monitoring system designed to trigger a visual and audible alarm when a pre-set level of oil is reached within the lower chamber. As a standard, the oil

level alarm is designed to trigger at approximately 85% of the unit’s available depth level for oil capture. The feature acts as a safeguard against spills caused by exceeding the oil storage capacity of the separator and eliminates the need for manual oil level inspection.

The oil level alarm installed on the Stormceptor insert is illustrated in Figure 4.

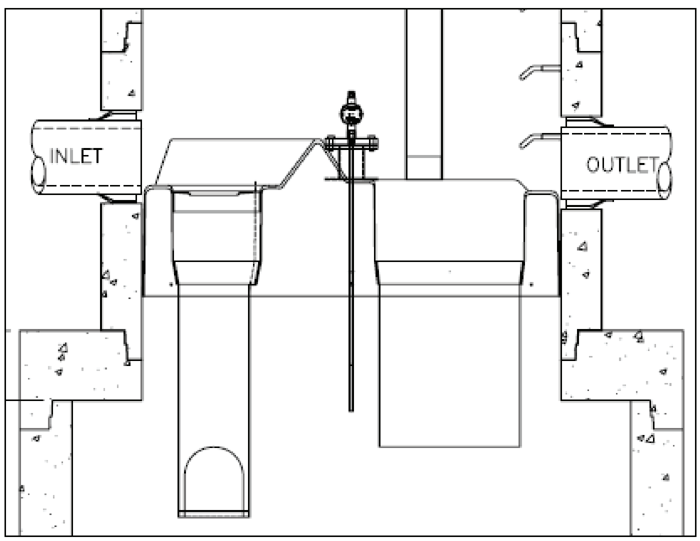


Figure 4. Oil level alarm

6.2. Increased Volume Storage Capacity

The Stormceptor unit may be modified to store a greater spill volume than is typically available. Under such a scenario, instead of installing a larger than required unit, modifications can be made to the recommended Stormceptor model to accommodate larger volumes. Contact your local Stormceptor representative for additional information and assistance for modifications.

7. Stormceptor Options

The Stormceptor System allows flexibility to incorporate to existing and new storm drainage infrastructure. The following section identifies considerations that should be reviewed when installing the system into a drainage network. For conditions that fall outside of the recommendations in this section, please contact your local Stormceptor representative for further guidance.

7.1. Installation Depth Minimum Cover

The minimum distance from the top of grade to the crown of the inlet pipe is 24 inches (600 mm). For situations that have a lower minimum distance, contact your local Stormceptor representative.

7.2. Maximum Inlet and Outlet Pipe Diameters

Maximum inlet and outlet pipe diameters are illustrated in Figure 5. Contact your local Stormceptor representative for larger pipe diameters

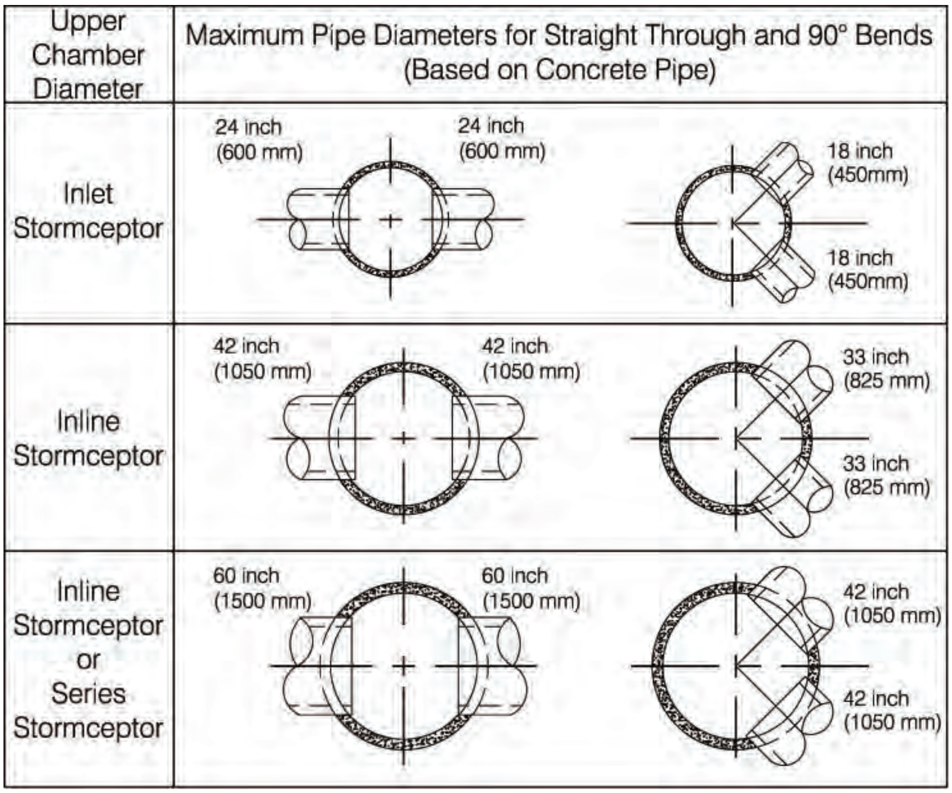


Figure 5. Maximum pipe diameters for straight through and bend applications

*The bend should only be incorporated into the second structure (downstream structure) of the Series Stormceptor System

7.3. Bends

The Stormceptor System can be used to change horizontal alignment in the storm drain network up to a maximum of 90 degrees. Figure 6 illustrates the typical bend situations of the Stormceptor System. Bends should only be applied to the second structure (downstream structure) of the Series Stormceptor System.

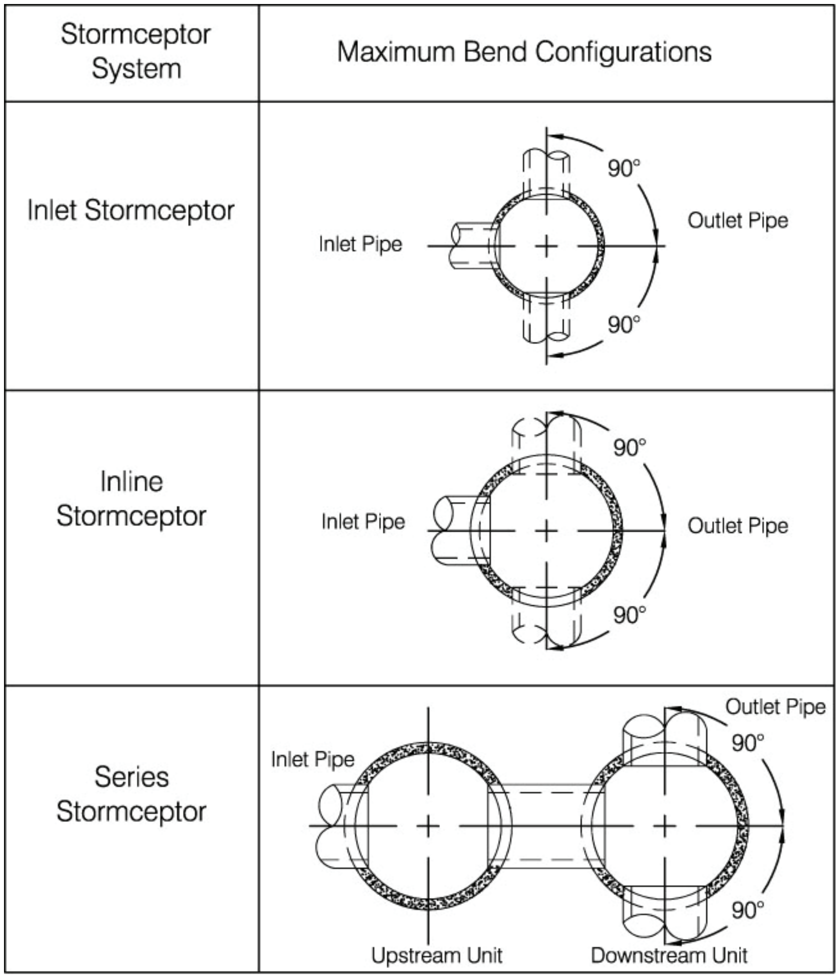


Figure 6. Maximum bend angles

7.4. Multiple Inlet Pipes

The Inlet and Inline Stormceptor System can accommodate two or more inlet pipes. The maximum number of inlet pipes that can be accommodated into a Stormceptor unit is a function of the number, alignment and diameter of the pipes and its effects on the structural integrity of the precast concrete. When multiple inlet pipes are used for new developments, each inlet pipe shall have an invert elevation 3 inches (75 mm) higher than the outlet pipe invert elevation.

7.5. Inlet/Outlet Pipe Invert Elevations

Recommended inlet and outlet pipe invert differences are listed in Table 3.

Table 3. Recommended Drops Between Inlet and Outlet Pipe Inverts

Number of Inlet Pipes	Inlet System	In-Line System	Series System
1	3 inches (75 mm)	1 inch (25 mm)	3 inches (75 mm)
>1	3 inches (75 mm)	3 inches (75 mm)	Not Applicable

7.6. Shallow Stormceptor

In cases where there may be restrictions to the depth of burial of storm sewer systems. In this situation, for selected Stormceptor models, the lower chamber components may be increased in diameter to reduce the overall depth of excavation required.

7.7. Customized Live Load

The Stormceptor system is typically designed for local highway truck loading (AASHTO HS- 20). When the project requires live loads greater than HS-20, the Stormceptor System may be customized structurally for a pre-specified live load. Contact your local Stormceptor representative for customized loading conditions.

7.8. Pre-treatment

The Stormceptor System may be sized to remove sediment and for spills control in conjunction with other stormwater BMPs to meet the water quality objective. For pretreatment applications, the Stormceptor System should be the first unit in a treatment train. The benefits of pre-treatment include the extension of the operational life (extension of maintenance frequency) of large stormwater management facilities, prevention of spills and lower total life- cycle maintenance cost.

7.9. Head loss

The head loss through the Stormceptor System is similar to a 60 degree bend at a manhole. The K value for calculating minor losses is approximately 1.3 (minor loss = k*1.3v2/2g).

However, when a Submerged modification is applied to a Stormceptor unit, the corresponding K value is 4.

7.10. Submerged

The Submerged modification, Figure 7, allows the Stormceptor System to operate in submerged or partially submerged storm sewers. This configuration can be installed on all models of the Stormceptor System by modifying the fiberglass insert. A customized weir height and a secondary drop tee are added.

Submerged instances are defined as standing water in the storm drain system during zero flow conditions. In these instances, the following information is necessary for the proper design and application of submerged modifications:

- Stormceptor top of grade elevation
- Stormceptor outlet pipe invert elevation
- Standing water elevation

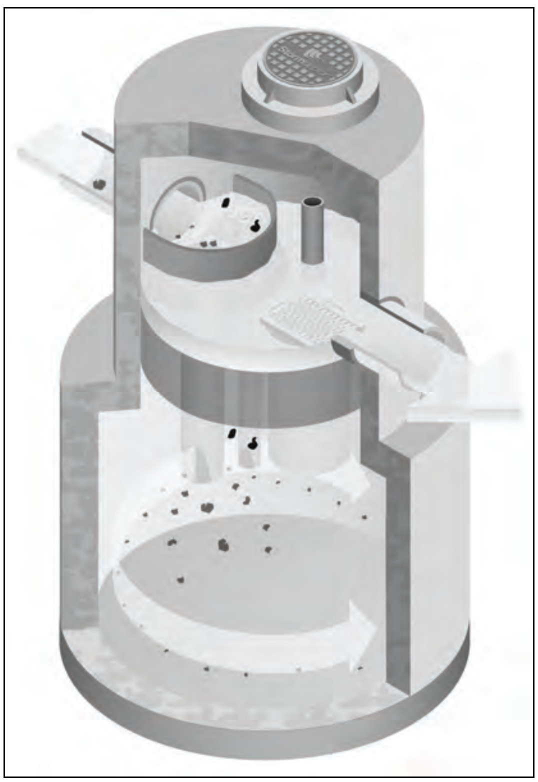


Figure 7. Submerged Stormceptor

8. Comparing Technologies

Designers have many choices available to achieve water quality goals in the treatment of stormwater runoff. Since many alternatives are available for use in stormwater quality treatment it is important to consider how to make an appropriate comparison between "approved alternatives". The following is a guide to assist with the accurate comparison of differing technologies and performance claims.

8.1. Particle Size Distribution (PSD)

The most sensitive parameter to the design of a stormwater quality device is the selection of the design particle size. While it is recommended that the actual particle size distribution (PSD) for sites be measured prior to sizing, alternative values for particle size should be selected to represent what is likely to occur naturally on the site. A reasonable estimate of a particle size distribution likely to be found on parking lots or other impervious surfaces should consist of a wide range of particles such as 20 microns to 2,000 microns (Ontario MOE, 1994).

There is no absolute right particle size distribution or specific gravity and the user is cautioned to review the site location, characteristics, material handling practices and regulatory requirements when selecting a particle size distribution. When comparing technologies, designs using different PSDs will result in incomparable TSS removal efficiencies. The PSD of the TSS removed needs to be standard between two products to allow for an accurate comparison.

8.2. Scour Prevention

In order to accurately predict the performance of a manufactured treatment device, there must be confidence that it will perform under all conditions. Since rainfall patterns cannot be predicted, stormwater quality devices placed in storm sewer systems must be able to withstand extreme events, and ensure that all pollutants previously captured are retained in the system.

In order to have confidence in a system's performance under extreme conditions, independent validation of scour prevention is essential when examining different technologies. Lack of independent verification of scour prevention should make a designer wary of accepting any product's performance claims.

8.3. Hydraulics

Full scale laboratory testing has been used to confirm the hydraulics of the Stormceptor System. Results of lab testing have been used to physically design the Stormceptor System and the sewer pipes entering and leaving the unit. Key benefits of Stormceptor are:

- Low head loss (typical k value of 1.3)
- Minimal inlet/outlet invert elevation drop across the structure
- Use as a bend structure
- Accommodates multiple inlets

The adaptability of the treatment device to the storm sewer design infrastructure can affect the overall performance and cost of the site.

8.4. Hydrology

Stormwater quality treatment technologies need to perform under varying climatic conditions. These can vary from long low intensity rainfall to short duration, high intensity storms. Since a treatment device is expected to perform under all these conditions, it makes sense that any system's design should accommodate those conditions as well.

Long-term continuous simulation evaluates the performance of a technology under the varying conditions expected in the climate of the subject site. Single, peak event design does not provide this information and is not equivalent to long-term simulation. Designers should request long-term simulation performance to ensure the technology can meet the long-term water quality objective.

9. Testing

The Stormceptor System has been the most widely monitored stormwater treatment technology in the world. Performance verification and monitoring programs are completed to the strictest standards and integrity. Since its introduction in 1990, numerous independent field tests and studies detailing the effectiveness of the Stormceptor System have been completed.

- Coventry University, UK – 97% removal of oil, 83% removal of sand and 73% removal of peat
- National Water Research Institute, Canada, - scaled testing for the development of the Stormceptor System identifying both TSS removal and scour prevention.
- New Jersey TARP Program – full scale testing of an STC 900 demonstrating 75% TSS removal of particles from 1 to 1000 microns. Scour testing completed demonstrated that the system does not scour. The New Jersey Department of Environmental Protection was followed.
- City of Indianapolis – full scale testing of an STC 900 demonstrating over 80% TSS removal of particles from 50 microns to 300 microns at 130% of the unit's operating rate. Scour testing completed demonstrated that the system does not scour.
- Westwood Massachusetts (1997), demonstrated >80% TSS removal
- Como Park (1997), demonstrated 76% TSS removal
- Ontario MOE SWAMP Program – 57% removal of 1 to 25 micron particles
- Laval Quebec – 50% removal of 1 to 25 micron particles

10. Installation

The installation of the concrete Stormceptor should conform in general to state highway, or local specifications for the installation of manholes. Selected sections of a general specification that are applicable are summarized in the following sections.

10.1. Excavation

Excavation for the installation of the Stormceptor should conform to state highway, or local specifications. Topsoil removed during the excavation for the Stormceptor should be stockpiled in designated areas and should not be mixed with subsoil or other materials.

Topsoil stockpiles and the general site preparation for the installation of the Stormceptor should conform to state highway or local specifications.

The Stormceptor should not be installed on frozen ground. Excavation should extend a minimum of 12 inches (300 mm) from the precast concrete surfaces plus an allowance for shoring and bracing where required. If the bottom of the excavation provides an unsuitable foundation additional excavation may be required.

In areas with a high water table, continuous dewatering may be required to ensure that the excavation is stable and free of water.

10.2. Backfilling

Backfill material should conform to state highway or local specifications. Backfill material should be placed in uniform layers not exceeding 12 inches (300mm) in depth and compacted to state highway or local specifications.

11. Stormceptor Construction Sequence

The concrete Stormceptor is installed in sections in the following sequence:

1. Aggregate base
2. Base slab
3. Lower chamber sections
4. Upper chamber section with fiberglass insert
5. Connect inlet and outlet pipes
6. Assembly of fiberglass insert components (drop tee, riser pipe, oil cleanout port and orifice plate
7. Remainder of upper chamber
8. Frame and access cover

The precast base should be placed level at the specified grade. The entire base should be in contact with the underlying compacted granular material. Subsequent sections, complete with joint seals, should be installed in accordance with the precast concrete manufacturer's recommendations.

Adjustment of the Stormceptor can be performed by lifting the upper sections free of the excavated area, re-leveling the base and re-installing the sections. Damaged sections and gaskets should be repaired or replaced as necessary. Once the Stormceptor has been constructed, any lift holes must be plugged with mortar.

12. Maintenance

12.1. Health and Safety

The Stormceptor System has been designed considering safety first. It is recommended that confined space entry protocols be followed if entry to the unit is required. In addition, the fiberglass insert has the following health and safety features:

- Designed to withstand the weight of personnel
- A safety grate is located over the 24 inch (600 mm) riser pipe opening
- Ladder rungs can be provided for entry into the unit, if required

12.2. Maintenance Procedures

Maintenance of the Stormceptor system is performed using vacuum trucks. No entry into the unit is required for maintenance (in most cases). The vacuum service industry is a well- established sector of the service industry that cleans underground tanks, sewers and catch basins. Costs to clean a Stormceptor will vary based on the size of unit and transportation distances.

The need for maintenance can be determined easily by inspecting the unit from the surface. The depth of oil in the unit can be determined by inserting a dipstick in the oil inspection/cleanout port.

Similarly, the depth of sediment can be measured from the surface without entry into the Stormceptor via a dipstick tube equipped with a ball valve. This tube would be inserted through the riser pipe. Maintenance should be performed once the sediment depth exceeds the guideline values provided in the Table 4.

Table 4. Sediment Depths Indicating Required Servicing*

Particle Size	Specific Gravity
Model	Sediment Depth inches (mm)
450i	8 (200)
900	8 (200)
1200	10 (250)
1800	15 (381)
2400	12 (300)
3600	17 (430)
4800	15 (380)
6000	18 (460)
7200	15 (381)
11000	17 (380)
13000	20 (500)
16000	17 (380)
* based on 15% of the Stormceptor unit's total storage	

Although annual servicing is recommended, the frequency of maintenance may need to be increased or reduced based on local conditions (i.e. if the unit is filling up with sediment more quickly than projected, maintenance may be required semi-annually; conversely once the site has stabilized maintenance may only be required every two or three years).

Oil is removed through the oil inspection/cleanout port and sediment is removed through the riser pipe. Alternatively oil could be removed from the 24 inches (600 mm) opening if water is removed from the lower chamber to lower the oil level below the drop pipes.

The following procedures should be taken when cleaning out Stormceptor:

1. Check for oil through the oil cleanout port
2. Remove any oil separately using a small portable pump
3. Decant the water from the unit to the sanitary sewer, if permitted by the local regulating authority, or into a separate containment tank
4. Remove the sludge from the bottom of the unit using the vacuum truck
5. Re-fill Stormceptor with water where required by the local jurisdiction

12.3. Submerged Stormceptor

Careful attention should be paid to maintenance of the Submerged Stormceptor System. In cases where the storm drain system is submerged, there is a requirement to plug both the inlet and outlet pipes to economically clean out the unit.

12.4. Hydrocarbon Spills

The Stormceptor is often installed in areas where the potential for spills is great. The Stormceptor System should be cleaned immediately after a spill occurs by a licensed liquid waste hauler.

12.5. Disposal

Requirements for the disposal of material from the Stormceptor System are similar to that of any other stormwater Best Management Practice (BMP) where permitted. Disposal options for the sediment may range from disposal in a sanitary trunk sewer upstream of a sewage treatment plant, to disposal in a sanitary landfill site. Petroleum waste products collected in the Stormceptor (free oil/chemical/fuel spills) should be removed by a licensed waste management company.

12.6. Oil Sheens

With a steady influx of water with high concentrations of oil, a sheen may be noticeable at the Stormceptor outlet. This may occur because a rainbow or sheen can be seen at very small oil concentrations (<10 mg/L). Stormceptor will remove over 98% of all free oil spills from storm sewer systems for dry weather or frequently occurring runoff events.

The appearance of a sheen at the outlet with high influent oil concentrations does not mean the unit is not working to this level of removal. In addition, if the influent oil is emulsified the Stormceptor will not be able to remove it. The Stormceptor is designed for free oil removal and not emulsified conditions.

SUPPORT

Drawings and specifications are available at www.ContechES.com.
Site-specific design support is available from our engineers.

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Maintenance Guide

Rain Guardian pretreatment chambers simplify bioretention maintenance by collecting sand, leaves, grass clippings, and other debris in an easy to clean, confined location. Regularly maintaining the Rain Guardian sustains its functionality by maximizing storage and filtration capacities. Maintenance frequency is variable and depends on many factors such as rainfall frequency, drainage area size and land use type, and season of the year. The general cleaning process is similar for all Rain Guardian models (i.e. Bunker, Foxhole, and Turret).

Following rain events, inspect the pretreatment chamber for debris on the top grate, within the chamber, and on the vertical, drop-in filter wall. The maintenance steps described below should be completed if areas of the top grate are clogged, the chamber is >75% full, or the vertical filter wall is clogged. Maintenance should be completed when stormwater has completely drained from the bioretention practice. The filter wall allows the chamber to dry between rain events, which further simplifies maintenance by ensuring removed debris is largely dry. Ensure all debris collected during cleaning of the chamber is completely removed from the site and properly disposed of according to local environmental rules. Once cleaning is complete, reinstall the filter wall with filter fabric facing the inside of the chamber and replace the top grate. For the Foxhole, reinstall the top lid, including optional lid anchor screws if equipped.

Clear Debris from Top Grate

- Foxhole only—remove top lid, including optional lid anchor screws if equipped
- Leaf litter and garbage commonly accumulate on the top grate
- Simply remove and dispose of debris by hand or with a shovel prior to removing top grate

Remove Debris from Inside Chamber

- Remove top grate and place on paved inlet to avoid damage to nearby plants
- Remove and dispose of accumulated debris within chamber using a shovel

Clean Filter Wall

- Remove drop-in filter by lifting vertically
- Clean filter wall with a stiff bristled broom or rinse clean with pressurized water

www.RainGuardian.biz

ANOKA CONSERVATION DISTRICT
1318 McKay Dr. NE, Suite 300
Ham Lake, MN 55304
(763) 434-2030 (M-F 8:00-4:30)

Attachment 6: Notice of Intent Plans

Attachment 7: Compensatory Flood Storage Calculation

Compensatory Flood Storage Calculation

Floodplain Impact and Mitigation Summary			
Elevation (FT)	Floodplain Impact (CY)	Floodplain Mitigation (CY)	Floodplain Net (CY)
82.4-83	5.4	6.0	0.6
82-82.4	0	0	0
Totals	**5.4**	**6.0**	**0.6**

The floodplain storage calculation shows an overall increase in floodplain storage of 0.6 CY.

Attachment 8: Soil Report

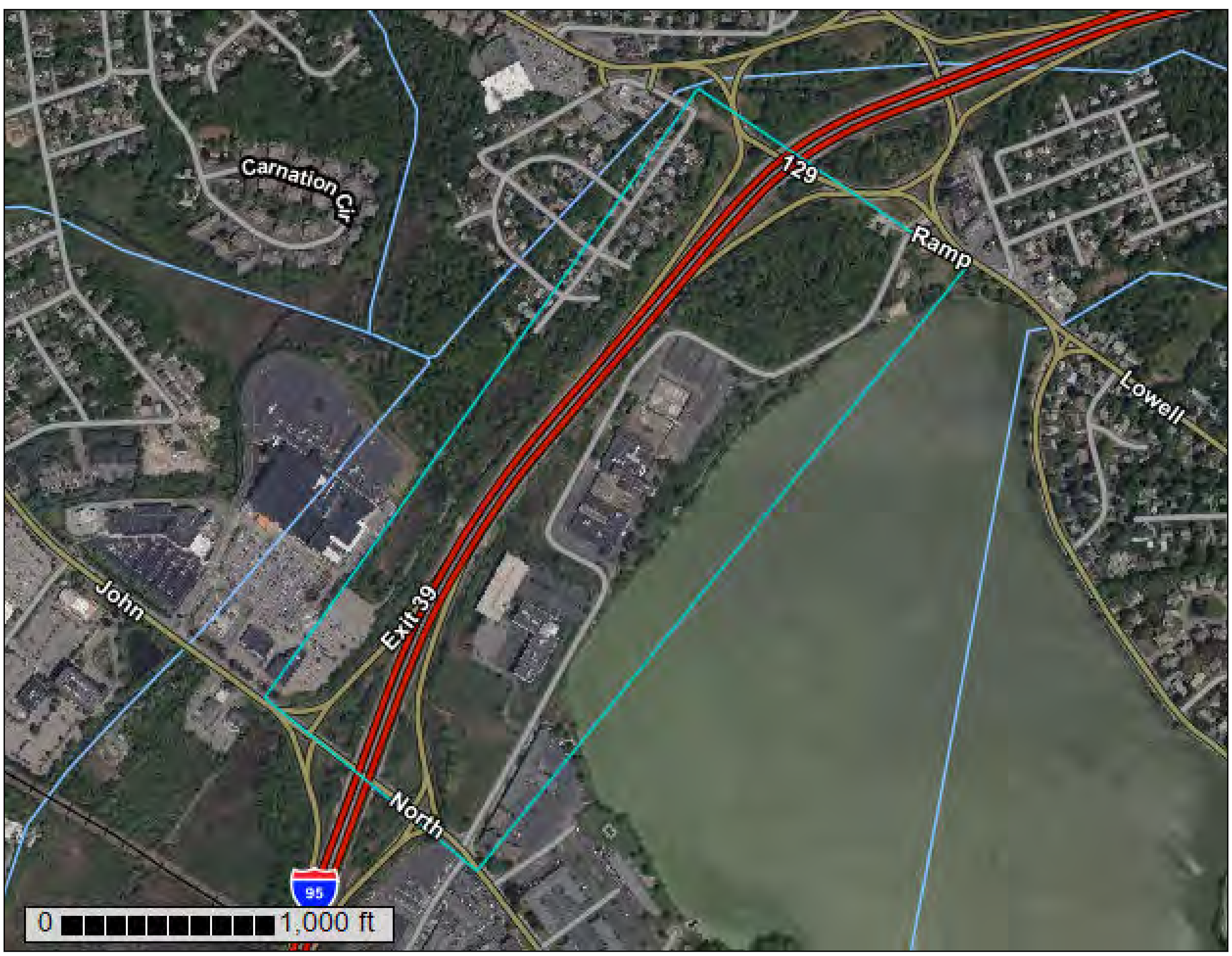
United States Department of Agriculture

Natural Resources Conservation Service

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

Custom Soil Resource Report for Middlesex County, Massachusetts

Quannapowitt Parkway



March 1, 2023

Preface

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

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

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

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

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

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

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Contents

How Soil Surveys Are Made

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

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

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

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

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

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

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

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

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

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

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

Soil Map

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

Soil Map


71° 5' 32" W
71° 4' 39" W
42° 31' 39" N
42° 30' 47" N
328200
328400
328600
328800
329000
329200
4710400
4710200
4710000
4709800
4709600
4709400
4709200
4709000
Bay
Torre St
129
Ramp
626B
51A
52A
656
1
603
Exit 39
North
95
Soil Map may not be valid at this scale.
N
Map Scale: 1:7,770 if printed on A portrait (8.5" x 11") sheet.
Meters
0
100
200
400
600
Feet
0
350
700
1400
2100
Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 19N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

Soil Survey Area: Middlesex County, Massachusetts
Survey Area Data: Version 22, Sep 9, 2022

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

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

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

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
1	Water	14.6	12.7%
51A	Swansea muck, 0 to 1 percent slopes	7.5	6.6%
52A	Freetown muck, 0 to 1 percent slopes	8.3	7.2%
603	Urban land, wet substratum	1.6	1.4%
626B	Merrimac-Urban land complex, 0 to 8 percent slopes	4.9	4.3%
656	Udorthents-Urban land complex	77.9	67.9%
Totals for Area of Interest		**114.7**	**100.0%**

Map Unit Descriptions

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

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

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

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

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

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

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

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

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

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

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

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

Middlesex County, Massachusetts

1—Water

Map Unit Setting

National map unit symbol: 996p
Frost-free period: 110 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

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

Description of Water

Setting

Landform position (two-dimensional): Toeslope
Landform position (three-dimensional): Dip
Down-slope shape: Linear
Across-slope shape: Linear

51A—Swansea muck, 0 to 1 percent slopes

Map Unit Setting

National map unit symbol: 2trl2
Elevation: 0 to 1,140 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Swansea and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Swansea

Setting

Landform: Bogs, swamps
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Highly decomposed organic material over loose sandy and gravelly glaciofluvial deposits

Typical profile

Oa1 - 0 to 24 inches: muck
Oa2 - 24 to 34 inches: muck
Cg - 34 to 79 inches: coarse sand

Properties and qualities

Slope: 0 to 1 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water supply, 0 to 60 inches: Very high (about 16.5 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8w
Hydrologic Soil Group: B/D
Ecological site: F144AY043MA - Acidic Organic Wetlands
Hydric soil rating: Yes

Minor Components

Freetown

Percent of map unit: 10 percent
Landform: Bogs, swamps
Landform position (three-dimensional): Dip
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Scarboro

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

Whitman

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

52A—Freetown muck, 0 to 1 percent slopes

Map Unit Setting

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

Map Unit Composition

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

Description of Freetown

Setting

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

Typical profile

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

Properties and qualities

Slope: 0 to 1 percent
Surface area covered with cobbles, stones or boulders: 0.0 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Very poorly drained
Runoff class: Negligible
Capacity of the most limiting layer to transmit water (Ksat): Moderately low to high (0.14 to 14.17 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: Rare
Frequency of ponding: Frequent
Available water supply, 0 to 60 inches: Very high (about 19.2 inches)

Interpretive groups

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

Minor Components

Whitman

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

Scarboro

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

Swansea

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

603—Urban land, wet substratum

Map Unit Setting

National map unit symbol: 9951
Mean annual precipitation: 32 to 50 inches
Mean annual air temperature: 45 to 50 degrees F
Frost-free period: 110 to 200 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Excavated and filled land over alluvium and/or marine deposits

Minor Components

Udorthents, loamy

Percent of map unit: 10 percent
Hydric soil rating: No

Rock outcrop

Percent of map unit: 5 percent
Landform: Ledges
Landform position (two-dimensional): Summit
Landform position (three-dimensional): Head slope
Down-slope shape: Concave
Across-slope shape: Concave

626B—Merrimac-Urban land complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2tyr9
Elevation: 0 to 820 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 250 days
Farmland classification: Not prime farmland

Map Unit Composition

Merrimac and similar soils: 45 percent
Urban land: 40 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Merrimac

Setting

Landform: Outwash plains, outwash terraces, moraines, eskers, kames
Landform position (two-dimensional): Summit, shoulder, backslope, footslope
Landform position (three-dimensional): Crest, side slope, riser, tread
Down-slope shape: Convex
Across-slope shape: Convex
Parent material: Loamy glaciofluvial deposits derived from granite, schist, and gneiss over sandy and gravelly glaciofluvial deposits derived from granite, schist, and gneiss

Typical profile

Ap - 0 to 10 inches: fine sandy loam
Bw1 - 10 to 22 inches: fine sandy loam
Bw2 - 22 to 26 inches: stratified gravel to gravelly loamy sand
2C - 26 to 65 inches: stratified gravel to very gravelly sand

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: More than 80 inches
Drainage class: Somewhat excessively drained
Runoff class: Very low
Capacity of the most limiting layer to transmit water (Ksat): Moderately high to very high (1.42 to 99.90 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Calcium carbonate, maximum content: 2 percent
Maximum salinity: Nonsaline (0.0 to 1.4 mmhos/cm)
Sodium adsorption ratio, maximum: 1.0
Available water supply, 0 to 60 inches: Low (about 4.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: A
Ecological site: F144AY022MA - Dry Outwash
Hydric soil rating: No

Description of Urban Land

Typical profile

M - 0 to 10 inches: cemented material

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 0 inches to manufactured layer
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low (0.00 to 0.00 in/hr)
Available water supply, 0 to 60 inches: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8
Hydrologic Soil Group: D
Hydric soil rating: Unranked

Minor Components

Windsor

Percent of map unit: 5 percent
Landform: Outwash terraces, dunes, outwash plains, deltas
Landform position (three-dimensional): Tread, riser
Down-slope shape: Linear, convex
Across-slope shape: Linear, convex
Hydric soil rating: No

Sudbury

Percent of map unit: 5 percent
Landform: Deltas, terraces, outwash plains
Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Tread, dip
Down-slope shape: Concave

Across-slope shape: Linear
Hydric soil rating: No

Hinckley

Percent of map unit: 5 percent
Landform: Deltas, kames, eskers, outwash plains
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Head slope, nose slope, crest, side slope, rise
Down-slope shape: Convex
Across-slope shape: Convex, linear
Hydric soil rating: No

656—Udorthents-Urban land complex

Map Unit Setting

National map unit symbol: 995k
Elevation: 0 to 3,000 feet
Mean annual precipitation: 32 to 54 inches
Mean annual air temperature: 43 to 54 degrees F
Frost-free period: 110 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Udorthents and similar soils: 45 percent
Urban land: 35 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Udorthents

Setting

Parent material: Loamy alluvium and/or sandy glaciofluvial deposits and/or loamy glaciolacustrine deposits and/or loamy marine deposits and/or loamy basal till and/or loamy lodgment till

Properties and qualities

Slope: 0 to 15 percent
Depth to restrictive feature: More than 80 inches
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None

Description of Urban Land

Setting

Landform position (two-dimensional): Footslope
Landform position (three-dimensional): Base slope
Down-slope shape: Linear
Across-slope shape: Linear

Parent material: Excavated and filled land

Minor Components

Canton

Percent of map unit: 10 percent
Landform: Hills
Landform position (two-dimensional): Backslope, toeslope
Landform position (three-dimensional): Side slope, base slope
Down-slope shape: Linear
Across-slope shape: Convex
Hydric soil rating: No

Merrimac

Percent of map unit: 5 percent
Landform: Terraces, plains
Landform position (two-dimensional): Shoulder
Landform position (three-dimensional): Tread, rise
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Paxton

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Summit, backslope
Landform position (three-dimensional): Head slope, side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

References

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

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

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deep-water habitats of the United States. U.S. Fish and Wildlife Service FWS/OBS-79/31.

Federal Register. July 13, 1994. Changes in hydric soils of the United States.

Federal Register. September 18, 2002. Hydric soils of the United States.

Hurt, G.W., and L.M. Vasilas, editors. Version 6.0, 2006. Field indicators of hydric soils in the United States.

National Research Council. 1995. Wetlands: Characteristics and boundaries.

Soil Survey Division Staff. 1993. Soil survey manual. Soil Conservation Service. U.S. Department of Agriculture Handbook 18. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_054262

Soil Survey Staff. 1999. Soil taxonomy: A basic system of soil classification for making and interpreting soil surveys. 2nd edition. Natural Resources Conservation Service, U.S. Department of Agriculture Handbook 436. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053577

Soil Survey Staff. 2010. Keys to soil taxonomy. 11th edition. U.S. Department of Agriculture, Natural Resources Conservation Service. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053580

Tiner, R.W., Jr. 1985. Wetlands of Delaware. U.S. Fish and Wildlife Service and Delaware Department of Natural Resources and Environmental Control, Wetlands Section.

United States Army Corps of Engineers, Environmental Laboratory. 1987. Corps of Engineers wetlands delineation manual. Waterways Experiment Station Technical Report Y-87-1.

United States Department of Agriculture, Natural Resources Conservation Service. National forestry manual. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/home/?cid=nrcs142p2_053374

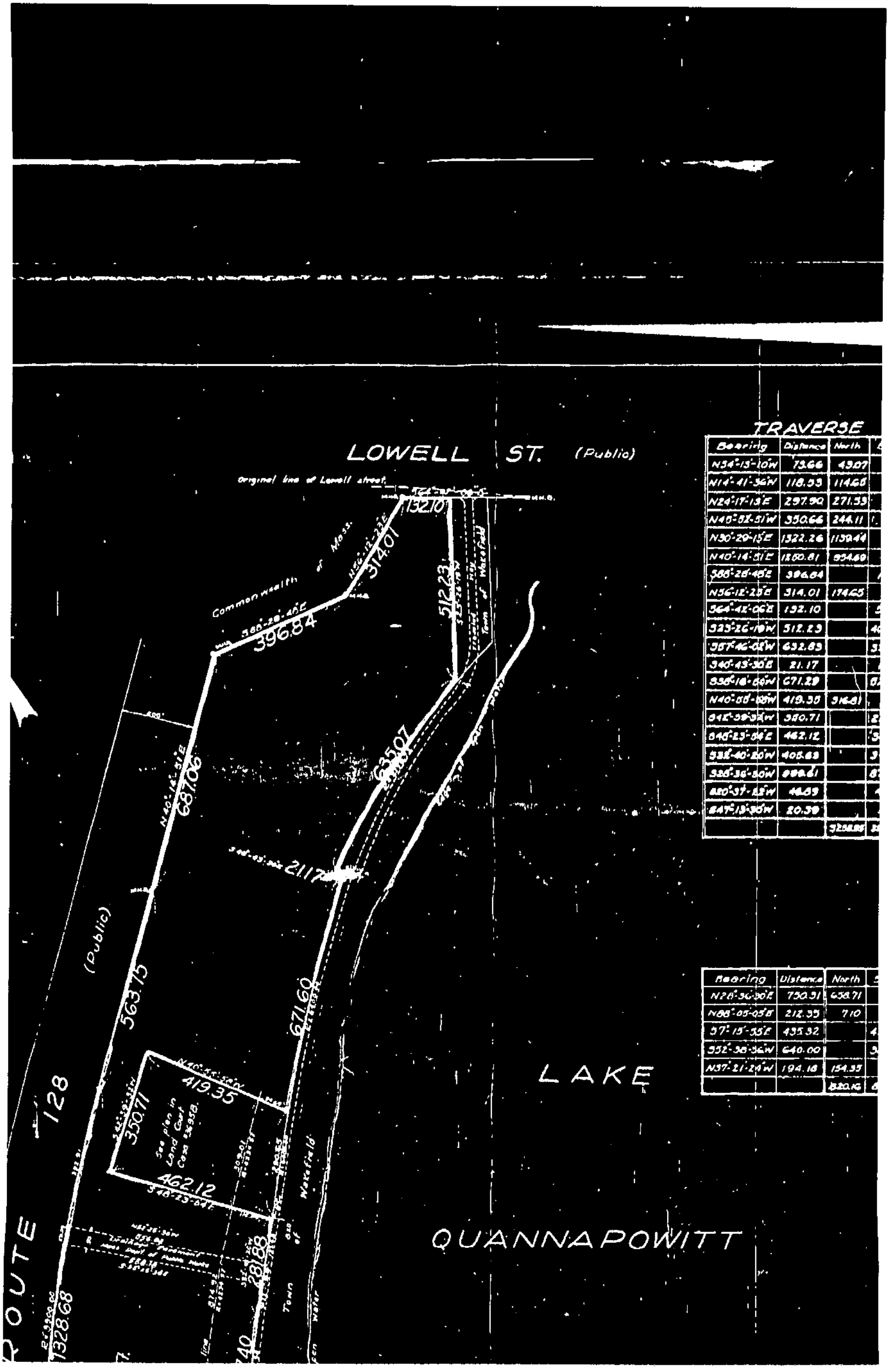
United States Department of Agriculture, Natural Resources Conservation Service. National range and pasture handbook. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/landuse/rangepasture/?cid=stelprdb1043084

United States Department of Agriculture, Natural Resources Conservation Service. National soil survey handbook, title 430-VI. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/scientists/?cid=nrcs142p2_054242

United States Department of Agriculture, Natural Resources Conservation Service. 2006. Land resource regions and major land resource areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296. http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/soils/?cid=nrcs142p2_053624

United States Department of Agriculture, Soil Conservation Service. 1961. Land capability classification. U.S. Department of Agriculture Handbook 210. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_052290.pdf

Attachment 9: Supplemental Information



TRAVERSE

Bearing	Distance	North
N34°-15'-10"W	73.66	43.07
N14°-41'-36"W	118.53	114.68
N24°-17'-13"E	297.90	271.53
N40°-52'-51"W	350.66	244.11
N30°-29'-15"E	1322.26	1139.44
N40°-14'-51"E	1260.81	854.69
S88°-26'-45"E	396.84	
N56°-12'-25"E	314.01	174.65
S64°-42'-06"E	132.10	
S23°-26'-19"W	512.23	
S37°-46'-02"W	632.83	
S40°-43'-30"E	21.17	
S36°-16'-06"W	671.29	
N40°-58'-58"W	419.30	316.81
S42°-39'-32"W	350.71	
S46°-23'-04"E	462.12	
S32°-40'-20"W	405.63	
S36°-36'-50"W	999.61	
S20°-37'-12"W	46.69	
S47°-13'-36"W	20.39	
		3258.85

Bearing	Distance	North
N28°-36'-30"E	750.31	658.71
N88°-05'-05"E	212.35	7.10
S7°-15'-55"E	435.32	
S52°-36'-36"W	640.00	
N37°-21'-24"W	194.16	154.35
		820.16

CPB:LOE 7-1-55 (6)

BK 8519 PG 453

296371

JUL 15 1955 440 REC 3 H 16 M P M

THIS INDENTURE made the 13th day of July 1955, between the Town of Wakefield, a municipal corporation duly chartered in the Commonwealth of Massachusetts and acting through its duly elected Board of Selectmen (hereinafter called the "Lessor", which expression shall include its successors where the context so admits) of the one part, and American Mutual Liability Insurance Company, a Massachusetts corporation having a usual place of business in Boston in said Commonwealth (hereinafter called the "Lessee", which expression shall include its successors and assigns where the context so admits) of the other part.

WITNESSETH that in consideration of the rent and covenants herein reserved and contained on the part of the Lessee to be paid, performed and observed, and for other valuable consideration paid, the Lessor does hereby demise and lease unto the Lessee a parcel of land lying within the "general locus" in said Wakefield bounded Southeasterly by Lake Quannapowitt, Southwesterly by North Avenue, Northwesterly and Northerly by land of the Commonwealth of Massachusetts taken for the location of Route 128, and North-

The within lease affects land described in Certificate of Title No. 70631
[illegible]

Whitman and Howard, dated May 1955, hereinafter referred to; and

NORTHEASTERLY by the line of Harvest Road (sometimes called Gravel Road) extended to Lake Quannapowitt.

Being the premises lying within the area marked in red ink and bounded by the points marked "A", "B", "C", and "D", as shown on a blueprint of "Plan of Land in Wakefield, Mass., May 1955, Whitman and Howard, Civil Engineers", hereto attached and incorporated herein by reference.

The Lessor does further grant unto the Lessee during the term hereof an easement over all the other land of the Lessor lying within the "general locus" above described; provided, however, that as to the land lying further Northeasterly than the line of said Harvest Road extended to Lake Quannapowitt, such easement shall be confined to the travelled way crossing land of the Lessor, known as Quannapowitt Parkway. Such easement shall be for the following purposes and uses: (a) For travel by foot or vehicle and for all other purposes for which roads are customarily used in the Town of Wakefield; (b) for the installation, maintenance, repair, and renewal of wires, drains, culverts, conduits, pipes, and other vehicles for the transmission and transportation of electricity, gas, water, telephone service, sewage, surface and subsurface drainage, and other utilities and materials either above or below or on the ground, including the right to enter upon and make use of the land in any way necessary or convenient in connection therewith; and (c) for the installation, maintenance, and repair of roads, walks, trees, shrubs and flower gardens.

To have and to hold the premises hereby demised unto the Lessee for the term of ninety-nine (99) years beginning with the date hereof and yielding and paying therefor the rent of One Dollar ($1.00) for said entire term.

3-5

172962

And the Lessee covenants with the Lessor that the Lessee during said term shall make no use of the demised premises which shall create a nuisance or be unlawful, and will occupy the same as grounds for the home office building of one or more insurance companies.

The Lessor reserves the right to enter upon said premises for the purpose of installing, maintaining, repairing, and renewing pipes and other vehicles for the transmission of water and sewage.

IN WITNESS WHEREOF the said parties have hereunto set their hands and respective corporate seals the day, month and year first above written.

TOWN OF WAKEFIELD

By Harry H. Denning

Calvin S. Simpson

Thomas W. Akerson

Francis J. Colani

Matthew P. Curran

ATTEST: Charles F. Young

Town Clerk

AMERICAN MUTUAL LIABILITY INSURANCE COMPANY

ATTEST: [illegible] Secretary

Leslie P. Henry S. Vice Pres.

thereunto duly authorized

COMMONWEALTH OF MASSACHUSETTS

Middlesex, SS. July 14, 1955

Then personally appeared the above-named Harry H. Denning, Selectman of the Town of Wakefield, and acknowledged the foregoing instrument to be the free act and deed of said Town, before me.

William J. [illegible]

Notary Public

My commission expires January 29, 1960

4-5

[illegible]sed by Cox

[illegible]ked by Martin

296371

RECEIVED AND ENTERED
MIDDLESEX COUNTY
REGISTRY OF DEEDS
SOUTHERN DISTRICT
ATTEST:
William C. Bailey
REGISTER

DOCUMENT NO. 296371

BOTH WAYS

INDENTURE

Between

Town of Wakefield

and

American Mutual Liability
Insurance Company

Middlesex Registry

JUL 15 1955

RECEIVED FOR REGISTRATION
3 O'CLOCK 10 M P M
NOTED ON CERTIFICATE NO. 70637
IN REGISTRATION BOOK 472 PAGE 797

2.00

Hill, Barlow, Goodale & Wiswall
53 State St., Boston 9

5-5

9135.

DEC 26-57 PM 12:54 0810 ...60

32687

THIS INDENTURE made this Tenth day of September, 1957, between the Town of Wakefield, a municipal corporation duly chartered in the Commonwealth of Massachusetts and acting through its duly elected Board of Selectmen (hereinafter called the "Lessor", which expression shall include its successors where the context so admits) of the one part, and American Mutual Liability Insurance Company a Massachusetts corporation having a usual place of business in Boston in said Commonwealth (hereinafter called the "Lessee", which expression shall include its successors and assigns where the context so admits) of the other part.

WITNESSETH that in consideration of the rent and covenants herein reserved and contained on the part of the Lessee to be paid, performed and observed, and for other valuable consideration paid, the Lessor does hereby demise and lease unto the Lessee a parcel of land lying in Wakefield, Middlesex County, Massachusetts, being bounded and described as follows:

SOUTHWESTERLY	by North Avenue,
NORTHWESTERLY	by parcel I as shown on Land Court plan 25969A and by parcel shown on said plan as Willard Welsh L.C. No. 3695A.
NORTHEASTERLY	by Lowell Street,
SOUTHEASTERLY	by other land of the Lessor,
SOUTHEASTERLY	by Lake Quannapowitt,
SOUTHERLY	by parcel 2 as shown on said plan 25969A, and
SOUTHEASTERLY	by said parcel 2.

Excepting therefrom the land leased by the Lessor to the Lessee by indenture dated July 13, 1955, recorded Middlesex South Deeds Book 8519 Page 453, and noted on Certificate of Title No. 70631.

Intending hereby to lease all of the land and only the land conveyed to the Lessor by deed of Commonwealth of Massachusetts dated July 13, 1950, recorded said Deeds Book 7621, Page 541, excepting the land conveyed by the Lessor to Calvin P. Bartlett by deed dated July 13, 1955,

1-4

325687

recorded said Deeds Book 8519, Page 444, (see L.C. case No. 25969) and filed in the Middlesex South Registry District as doc. No. 296368 (see Certificate of Title No. 70631), and excepting the land leased by indenture dated July 13, 1955, above referred to.

A portion of the land hereby leased is included in Certificate of Title No. 70631.

To have and to hold the premises hereby demised unto the Lessee for the term of ninety-nine (99) years beginning with the date hereof and yielding and paying therefor the rent of One Dollar ($1.00) for said entire term.

And the Lessee covenants with the Lessor that the Lessee during said term shall make no use of the demised premises which shall create a nuisance or be unlawful, and will occupy the same as grounds for the home office building of one or more insurance companies.

The Lessor reserves the right to enter upon said premises for the purpose of installing, maintaining, repairing, and renewing pipes and other vehicles for the transmission of water and sewage.

The Lessor shall have no obligation to maintain any part of the demised premises except vehicles for the transmission of water and sewage installed by the Lessor which shall be maintained by the Lessor.

IN WITNESS WHEREOF the said parties have hereunto set their hands and respective corporate seals the day, month and year first above written.

TOWN OF WAKEFIELD

By [signature]

Burton F. Whitcomb

Herbert R. Waite

[signature]

[signature]

Board of Selectmen

ATTEST: [signature]

Town Clerk

2-4

325687

AMERICAN MUTUAL LIABILITY INSURANCE COMPANY

ATTEST: _______________ By _______________

Clerk thereunto duly authorized

COMMONWEALTH OF MASSACHUSETTS

Middlesex SS. September 10 1957.

Then personally appeared the above-named Lucien J. Colucci, Selectman of the Town of Wakefield, and acknowledged the foregoing instrument to be the free act and deed of said Town, before me.

____
Notary Public

My commission expires Nov. 6, 1959

3-4

DOCUMENT NO. 325687

4-4

325687

Endorsed by Rannafords

Checked by Collins

BOTH WAYS

Middlesex South Registry District

DEC 26 1957

RECEIVED FOR REGISTRATION

12 O'CLOCK 45 M

NOTED ON CERTIFICATE NO. 70631

IN REGISTRATION BOOK 473 PAGE 193

D ENTERED
COUNTY
F DEEDS
DISTRICT

Bailey
REGISTER

Pd. 3.00
Dup. 1.00
4.00

Dup. sent out Jan. 14-1958

DUPLICATE DELIVERED TO

(Box 213)