



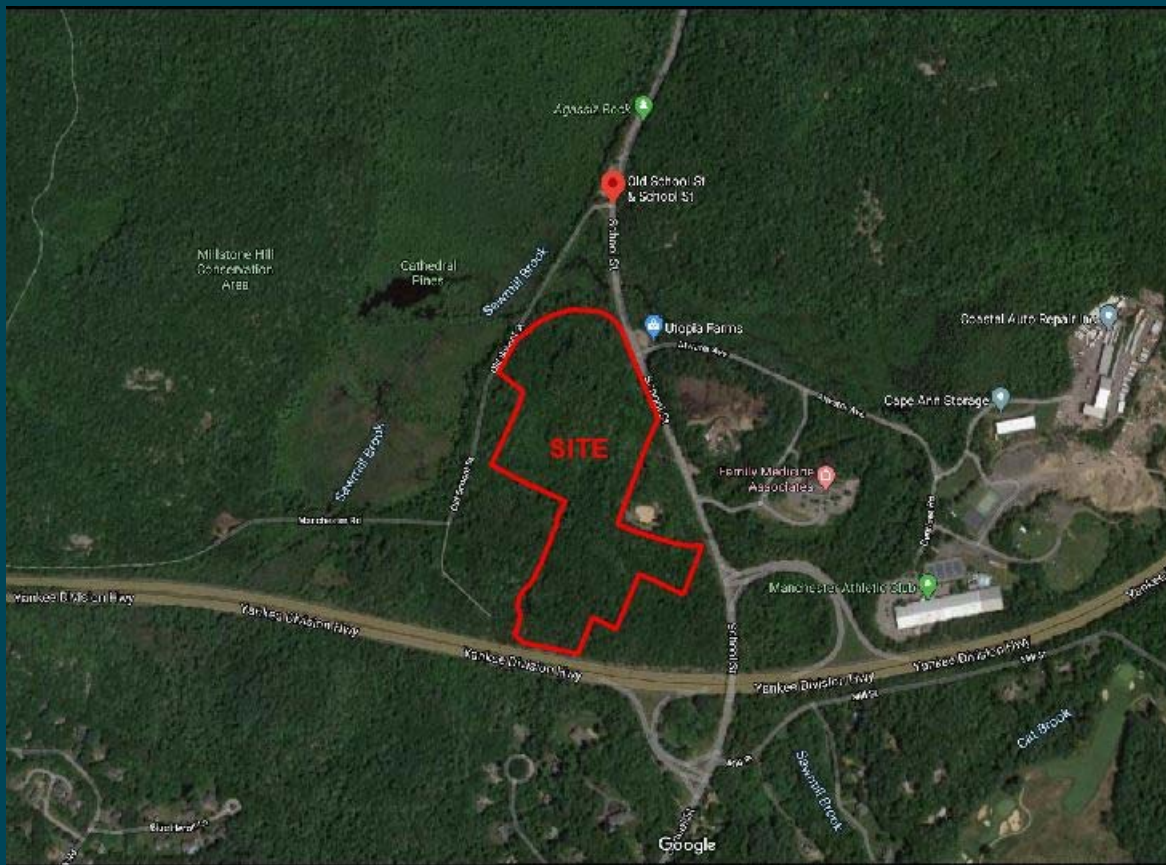
# DRAINAGE REPORT

Site Development

The Sanctuary at Manchester by the Sea

Manchester-by-the-Sea, MA

Prepared: 07/16/2021



*Site Locus – Not to Scale*

**CLIENT:**

SLV School Street, LLC  
257 Hillside Avenue  
Needham, MA 02494

**PREPARED BY:**

Allen & Major Associates, Inc.  
100 Commerce Way, Suite 5  
Woburn, Massachusetts 01801  
EOR: Carlton M. Quinn, PE





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0 School Street  
Manchester-by-the-Sea, MA

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Needham, MA 02494

### **PREPARED BY:**

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Woburn, Massachusetts 01801  
EOR: Carlton M. Quinn, PE

### **ISSUED:**

July 16, 2021

### **REVISED:**

### **A&M PROJECT NO.:**

**2725-01**







## **TABLE OF CONTENTS**

<b>SECTION 1.0 - NARRATIVE .....</b>	<b>7</b>
<b>INTRODUCTION.....</b>	<b>9</b>
<b>SITE CATEGORIZATION FOR STORMWATER REGULATIONS .....</b>	<b>9</b>
<b>SITE LOCATION AND ACCESS .....</b>	<b>9</b>
<b>EXISTING SITE CONDITIONS.....</b>	<b>9</b>
<b>WATERSHED .....</b>	<b>10</b>
<b>EXISTING SOIL CONDITIONS .....</b>	<b>10</b>
<b>FEMA FLOODPLAIN/ENVIRONMENTAL DUE DILIGENCE .....</b>	<b>10</b>
<b>ENVIRONMENTALLY SENSITIVE ZONES.....</b>	<b>10</b>
<b>EXISTING WATERSHED DESCRIPTION.....</b>	<b>11</b>
<b>DRAINAGE ANALYSIS METHODOLOGY.....</b>	<b>11</b>
<b>PROPOSED CONDITIONS – PEAK RATE OF RUNOFF.....</b>	<b>11</b>
<b>MASSDEP STORMWATER PERFORMANCE STANDARDS .....</b>	<b>14</b>
<b>MASSDEP STORMWATER CHECKLIST.....</b>	<b>18</b>
<b>SECTION 2.0 – OPERATION &amp; MAINTENANCE .....</b>	<b>26</b>
<b>OPERATIONS AND MAINTENANCE PLAN.....</b>	<b>28</b>
<b>INTRODUCTION.....</b>	<b>28</b>
<b>DEMOLITION &amp; CONSTRUCTION MAINTENANCE PLAN .....</b>	<b>29</b>
<b>POST CONSTRUCTION MAINTENANCE PLAN.....</b>	<b>30</b>
Inspection and Maintenance Frequency and Corrective Measures.....	30
Monthly Post Construction Inspection (first three months only).....	31
Quarterly Inspections (specifically after foliage and snow season) .....	31
Semi-Annual Inspection (specifically after foliage and snow season).....	31
<b>LANDSCAPE MANAGEMENT PLAN .....</b>	<b>32</b>
<b>OPERATION &amp; MAINTENANCE SUMMARY TABLE .....</b>	<b>34</b>
<b>SNOW STORAGE PLAN .....</b>	<b>36</b>
<b>SNOW DISPOSAL GUIDANCE.....</b>	<b>38</b>
<b>MOSQUITO CONTROL .....</b>	<b>43</b>
<b>SECTION 3.0 - EXHIBITS.....</b>	<b>48</b>
<b>USGS SITE LOCUS MAP .....</b>	<b>50</b>



<b>AERIAL PHOTO .....</b>	<b>52</b>
<b>FEMA FIRM MAP .....</b>	<b>54</b>
<b>MASSDEP WETLANDS &amp; VERBAL POOLS MAP .....</b>	<b>56</b>
<b>NHESP PRIORITY HABITATS MAP.....</b>	<b>58</b>
<b>SECTION 4.0 – HYDRO CAD .....</b>	<b>60</b>
<b>EXISTING HYDROCAD.....</b>	<b>62</b>
<b>PROPOSED HYDROCAD .....</b>	<b>76</b>
<b>SECTION 5.0 – PLANS.....</b>	<b>104</b>
<b>EXISTING WATERSHED .....</b>	<b>106</b>
<b>PROPOSED WATERSHED .....</b>	<b>108</b>
<b>PROPOSED GRADING &amp; DRAINAGE PLAN .....</b>	<b>110</b>
<b>SECTION 6.0 - APPENDIX.....</b>	<b>112</b>
<b>SOIL HSG INFORMATION .....</b>	<b>114</b>
<b>RAINFALL DATA – NRCC EXTREME PRECIPITATION TABLES .....</b>	<b>119</b>
<b>MANNING’S ROUGHNESS COEFFICIENT TABLE.....</b>	<b>120</b>
<b>MASSDEP STANDARD CALCULATIONS.....</b>	<b>121</b>
<b>STORMWATER PIPE SIZING TABLE .....</b>	<b>123</b>
<b>RIP-RAP SIZING SPREADSHEET .....</b>	<b>124</b>
<b>ILLCIT DISCHARGE COMPLIANCE STATEMENT .....</b>	<b>125</b>



**SECTION 1.0 -  
NARRATIVE**





## **INTRODUCTION**

The purpose of this drainage report is to provide an overview of the proposed stormwater management system (SMS) for the site facility development proposed at School Street in Manchester-by-the-Sea. The report will show by means of narrative calculations and exhibits that the proposed stormwater management system will meet or exceed the 10 Massachusetts Department of Environmental Protection (MassDEP) stormwater standards.

The proposed site improvements include construction of a 92,560± square foot (s.f.), multi-family residential building with associated surface and garage parking, building utilities, stormwater management system, landscaping, and grading. The project will be serviced by a privately-owned wastewater treatment facility located on site, public water, and private electric and gas.

The SMS incorporates structural and non-structural Best Management Practices (BMPs) to provide stormwater peak flow mitigation, quality treatment, and conveyance. The SMS includes catch basins with snouts and hoods, drain manholes, hydrodynamic water quality units, a surface detention/infiltration basin equipped with an outlet control structure and a sluice gate to allow for maintenance of the basin when required, rain gardens, and subsurface infiltration systems.

## **SITE CATEGORIZATION FOR STORMWATER REGULATIONS**

The proposed site improvements are considered a new development under the DEP Stormwater Management Standards due to the net increase in impervious area.

## **SITE LOCATION AND ACCESS**

The project site consists of one parcel of land located on School Street, identified on the Town of Manchester Assessors Tax Maps as Map 43 Lot 18. The parcel is comprised of a 23.7± acre parcel (Map 43 Lot 18). The site is currently undeveloped with forested uplands and bordering vegetated wetlands.

Manchester is located in Essex County and is approximately 30 miles north-east of Boston. The site is located approximately 25 miles east/south-east of Interstate 495.

## **EXISTING SITE CONDITIONS**

The Project Site is a 23.7± acre parcel (Map 43 Lot 18) that is currently undeveloped and consists of upland wooded areas, a gravel path, and lowland wetland areas. There are several wetland areas surrounding the Site; these areas were delineated by a wetland specialist and are represented by a several series of wetland flags.

The topography of can be described as a hill or mountain, with the peak/top near the center of the property at El. 151.0±. The perimeter of the site to the west, north, and east



is roughly El. 48.0±. There an on-site depression southwest of the hill/mountain peak, which is at El. 92.0± that keeps a significant amount of water on site.

## **WATERSHED**

The subject property is located within the North Coastal Watershed. The North Coastal Watershed has a total drainage area of 168 square miles, and encompasses all or part of five river sub-basins. The North Coastal also encompasses all or part of 26 Massachusetts municipalities and supports a population of approximately 500,000 people. Dominant resources within the region include a major lobster fisheries and shell fishing, which remains a major commercial and recreational activity. The North Coastal Watershed is not protected under the Watershed Protection Act and has no associated land use restrictions.

## **EXISTING SOIL CONDITIONS**

The on-site soils were identified using the USDA Natural Resources Conservation Services (NRCS) Soil Survey for Essex County. The site soil types and corresponding Hydrologic Soil Groups (HSG) include:

- 102E – Chatfield-Hollis-Rock outcrop complex, 15 to 35 percent slopes, HSG - D.
- 651 – Udorthents, smoothed, 0 to 3 percent slopes no associated HSG, assumed HSG – D.

Udorthents consists of areas where the soil has been altered or obscured by buildings, or paved areas; neither urban land nor Udorthents are assigned a hydrologic soil group (HSG). Soils on-site have an associated HSG rating of "D" which is reserved for soils with little to no infiltration rate. The existing site shows signs of rock outcrops and exposed ledge, while the surficial geology shows potential drumlins and lodgment till in the area. A copy of the soil mapping from the NRCS website is included in the Appendix of this report.

## **FEMA FLOODPLAIN/ENVIRONMENTAL DUE DILIGENCE**

The latest Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) within 25009C432G & 25009C0434G, effective July 16, 2014, was reviewed and it was determined that the 100-year floodplain "Zone A" area is located within the Parcel "L" project site. All proposed work on the site is located within a Zone X (unshaded). Zone "X" (unshaded) areas are areas determined to be out of the 500-year flood zones. See the Existing Conditions Plan prepared by Allen & Major Associates, Inc. and Section 3.0 – Exhibits of this report for a more detailed representation of the FEMA flood zone locations in relation to the site. A Notice of Intent will be filed with the State and the Town.

## **ENVIRONMENTALLY SENSITIVE ZONES**

A review of the latest Massachusetts Natural Heritage Atlas; 14th Edition, reveals that there are no Estimated Habitats nor Priority Habitats located on the subject site.



There are no Areas of Critical Environmental Concern (ACEC) within the Site, per a review of the MassGIS on-line program OLIVER. A review of the Massachusetts Cultural Resource Information System (MACRIS) reveals no entries for the Project Site. The subject property is located within 100' of a bordering vegetated wetland and is located within the 100' riparian zone as illustrated on the site development plans. It should be noted that there is no proposed work within any of these areas.

## **EXISTING WATERSHED DESCRIPTION**

Under existing conditions, the site is divided into five (5) watersheds. Watershed E-1 flows north to Wetland "D" (Study Point #1). Watershed E-2 represents water area that flows to Wetland "F" (Study Point #2). Watershed E-3 flows off-site to the southwest (Study Point #3). Watershed E-4 flows south/southwest to Wetland's "A" (Study Point #4). Watershed E-5 represents an existing depression. The Hydro CAD model shows that no water leaves the site from this watershed and therefore a Study Point is not needed. Existing watersheds consist of gravel paths and wooded terrain as the site is undeveloped. Tc's were calculated using Hydro CAD, using 0.1 hours or 6 minutes as the minimum Tc. See the attached Existing Watershed Plan and Existing Hydro CAD reports.

## **DRAINAGE ANALYSIS METHODOLOGY**

A peak rate of runoff will be determined using techniques and data found in the following:

1. Urban Hydrology for Small Watersheds – Technical Release 55 by the United States Department of Agriculture Soils Conservation Service, June 1986. Runoff curve numbers and 24-hour precipitation values were obtained from this reference.
2. Hydro CAD© Stormwater Modeling System by Hydro CAD Software Solutions LLC, version 10.00, 2013. The Hydro CAD program was used to generate the runoff hydrographs for the watershed areas, to determine discharge/ stage/storage characteristics for the stormwater BMPs, to perform drainage routing and to combine the results of the runoff hydrographs. Hydro CAD uses the TR-20 methodology of the SCS Unit Hydrograph procedure (SCS-UH).
3. Soil Survey of Essex County, Massachusetts by United States Department of Agriculture, NRCS. Soil types and boundaries were obtained from this reference.
4. Cornell University Extreme Precipitation Tables – Northeast Regional Climate Center

## **PROPOSED CONDITIONS – PEAK RATE OF RUNOFF**

The storm water runoff analysis of the existing and proposed conditions includes an estimate of the peak rate of runoff from various rainfall events. Peak runoff rates were developed using TR55 Urban Hydrology for Small Watersheds, developed by the U.S. Department of Commerce, Engineering Division and the Hydro CAD computer program.



Further, the analysis has been prepared in accordance the Town requirements and standard engineering practices. The peak rate of runoff has been estimated for each watershed during the 2, 10, 25, and 100-year storm events.

The subject property's peak flow rates are analyzed at four (4) Study Points. Study Point #1 represents flows discharging to the Wetland "A". Study Point #2 represents flows to Wetland "F"; Study Point #3 represents flows leaving the site to the southwest; and Study Point #4 represents water flowing to Wetland "A". The site is broken into 18 watersheds in order to model the proposed conditions. See the proposed watershed plan and drainage plans for more information.

Watershed P-1 is located on the north of the proposed entry drive and represents water sheet flowing to the Wetland "D". Watershed consists of grass and woods.

Watershed P-2 is located on the west side of the Site and represents water sheet flowing to Wetland "F". Watershed P-2 consists of grass and woods.

Watershed P-3 is located southwest of the WWTF and represents flows leaving the site to the southwest. This watershed consists of grass and a retaining wall.

Watershed P-4 is located southeast, east, and northeast of the proposed development and represents water discharging to Wetland "A". Watershed P-4 consists of mostly woods with grass and a retaining wall.

Watershed P-5 represents the entrance driveway to the Project Site and consists of bituminous pavement and grass.

Watershed P-6 represents the landscaped slope and tiered retaining walls south of the entry drive. This watershed is mostly grass with a small amount of impervious from the retaining walls.

Watershed P-7 represents the 2:1 landscaped slope northwest and west of the proposed building. The watershed is comprised of entirely grass.

Watershed P-8 is the cul-de-sac turnaround area located near the garage entrance and consists of mostly pavement with landscaped grass.

Watershed P-9 is the north courtyard of the proposed building and will be a green roof design.

Watershed P-10, P-11, & P-12 are the proposed building roof areas. P-9 is also considered roof area however it will be a green roof; P-10, P-11, & P-12 will be standard impervious rooftops with flows being conveyed via roof drains and downspouts.

Watershed P-13 is the main surface parking area for the development and consists of impervious asphalt pavement and landscape islands of grass & trees.





Watershed P-14 represents the wastewater treatment facility (WWTF) and the driveway in this area. This watershed will consist of pavement and grass.

Watershed P-15 is the lawn area and fire access drive southeast of the proposed building and will consist of grass and GrassPave2. GrassPave2 is a proprietary pervious surface that allows for H-20 loading to be applied while also remaining permeable. The GrassPave2 system will be used as a fire access road.

Watershed 16 represents the 24-foot-wide entry drive from the WWTF to Detention Pond-1 and consists of pavement and grass.

Watershed 17 represents Detention Pond-1.

Watershed 18 represents the middle section of the access driveway and is comprised entirely of impervious pavement.

### **Peak Flow Rates**

#### **Study Point #1** (Flow to Wetland "D")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CFS)	3.37	6.94	9.92	16.14
Proposed Runoff (CFS)	1.28	4.12	5.72	9.21
REDUCTION	2.09	2.82	4.20	6.93

#### **Study Point #2** (Flow to Wetland "F")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CFS)	0.55	1.15	1.65	2.71
Proposed Runoff (CFS)	0.33	0.67	0.95	2.16
REDUCTION	0.22	0.48	0.70	0.55

#### **Study Point #3** (Flow southwest off site)

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CFS)	0.94	1.91	2.72	4.42
Proposed Runoff (CFS)	0.90	1.77	2.49	3.97
REDUCTION	0.04	0.14	0.23	0.45

#### **Study Point #4** (Flow to Wetland "A")

	2-Year	10-Year	25-Year	100-Year
Existing Runoff (CFS)	4.02	8.40	12.10	19.94
Proposed Runoff (CFS)	3.68	8.29	11.63	18.08
REDUCTION	0.34	0.11	3.81	1.86



## **MASSDEP STORMWATER PERFORMANCE STANDARDS**

The MA DEP Stormwater Management Policy was developed to improve water quality by implementing performance standards for storm water management. The intent is to implement the stormwater management standards through the review of Notice of Intent filings by the issuing authority (Conservation Commission or DEP). The following section outlines how the proposed Stormwater Management System meets the standards set forth by the Policy.

BMP's implemented in the design include –

- Deep-sump, hooded catch basins
- Hydro-dynamic (Proprietary) separators
- Surface Detention/Infiltration systems
- Corrugated Metal Pipe (CMP) Subsurface Infiltration System
- Rain Gardens
- Green Roofs
- Specific maintenance schedule

Stormwater Best Management Practices have been incorporated into the design of the project to mitigate the anticipated pollutant loading. An Operations and Maintenance Plan has been developed for the project, which addresses the long-term maintenance requirements of the proposed system.

Temporary erosion and sedimentation controls will be incorporated into the construction phase of the project. These temporary controls may include straw bale and/or silt fence barriers, inlet sediment traps, slope stabilization, and stabilized construction entrances.

The Massachusetts Department of Environmental Protection has established ten (10) Stormwater Management Standards. A project that meets or exceeds the standards is presumed to satisfy the regulatory requirements regarding stormwater management. The Standards are enumerated below as well as descriptions and supporting calculations as to how the Project will comply with the 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.*

The proposed development will not introduce any new stormwater conveyances (e.g. outfalls) that discharge untreated stormwater directly to or cause erosion in wetlands or waters of the Commonwealth.

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.*



The proposed development will be designed so that the post-development peak discharge rates and do not exceed the pre-development peak discharge rates. See Peak Flow Rates Table above and the attached Hydro CAD reports.

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.*

The existing annual recharge for the site will be exceeded in the developed condition. Existing soils are not conducive for infiltration as they are comprised of HSG-D soils and there is a certainty of exposed ledge and shallow bedrock on site.

Not all proposed impervious areas discharge to an infiltrating BMP however calculations show that the required recharge for the site is exceeded by Underground Infiltration System-1. The subsurface infiltration system will be designed to meet this requirement using the Static Method per the MassDEP Stormwater Management Standards, Volume 3, Chapter 1. See "DEP Calculations" in the Appendix of this report for water quality/recharge calculations.

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:*
  - *Suitable practices for source control and pollution prevention are identified in a long-term pollution prevention plan, and thereafter are implemented and maintained;*
  - *Structural stormwater best management practices are sized to capture the required water quality volume determined in accordance with the Massachusetts Stormwater Handbook; and*
  - *Pretreatment is provided in accordance with the Massachusetts Stormwater Handbook.*

The proposed site is considered a land use with higher potential pollutant loads. With this categorization the 44% TSS removal before it can be discharged to an infiltration system is required for the project. The overall 80% TSS removal standard will be met using some combination of the following: hooded deep-sump catch basins, proprietary hydro-dynamic separators, and a surface detention/infiltration pond with an outlet control structure, and rain gardens.



The water quality volume for the site development will be captured and treated using hooded deep sump catch basins and proprietary hydro-dynamic separators before discharging to either an infiltrating BMP or the abutting wetlands. All systems will be sized to meet the water quality flow rate for the 1" storm event. See "DEP Calculations" in the appendix of this report.

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. If through source control and/or pollution prevention all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, and stormwater runoff, the proponent shall use the specific structural stormwater BMPs determined by the Department to be suitable for such uses as provided in the Massachusetts Stormwater Handbook. Stormwater discharges from land uses with higher potential pollutant loads shall also comply with the requirements of the Massachusetts Clean Waters Act, M.G.L. c. 21, §§ 26-53 and the regulations promulgated thereunder at 314 CMR 3.00, 314 CMR 4.00 and 314 CMR 5.00.*

The proposed development is considered a source of higher potential pollutant loads. The SMS will be designed to treat 1" water quality volume with hydrodynamic separators, deep-sump, hooded catch basins, and a surface & sub-surface detention/infiltration ponds.

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 determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook. A discharge is near a critical area if there is a strong likelihood of a significant impact occurring to said area, taking into account site-specific factors. Stormwater discharges to Outstanding Resource Waters and Special Resource Waters shall be removed and set back from the receiving water or wetland and receive the highest and best practical method of treatment. A "storm water discharge" as defined in 314 CMR 3.04(2)(a)1 or (b) to an Outstanding Resource Water or Special Resource Water shall comply with 314 CMR 3.00 and 314 CMR 4.00. Stormwater discharges to a Zone I or Zone A are prohibited unless essential to the operation of a public water supply.*

The proposed project is not located within a critical area.

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.*

The proposed project is not considered a re-development project under the Stormwater Management Handbook guidelines as there is an increase in the amount of impervious area.

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.*

A plan to control construction-related impacts, including erosion, sedimentation and other pollutant sources during construction and land disturbance activities will be developed. The proponent will prepare and submit a Stormwater Pollution Prevention Plan (SWPPP) prior to commencement of construction activities that will result in the disturbance of one acre of land or more.

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

A Long-Term Operation & Maintenance (O&M) Plan has been developed for the proposed stormwater management system and is included within this document. See Section 2.0 of this report.

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

There are no expected illicit discharges to the stormwater management system. The Applicant has submitted the Illicit Discharge Compliance Statement with this report.

See the next page for the MassDEP Stormwater Checklist.





# 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.<sup>1</sup> 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<sup>2</sup>
- 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.

<sup>1</sup> 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.

<sup>2</sup> 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.





# Checklist for Stormwater Report

## B. Stormwater Checklist and Certification

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

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


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

### Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature



  
Signature and Date

7.16.21

## Checklist

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

- ☒ New development
- ☐ Redevelopment
- ☐ Mix of New Development and Redevelopment





# Checklist for Stormwater Report

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## 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): Surface Detention Pond; Water quality units, CMP detention/infiltration systems.

## Standard 1: No New Untreated Discharges

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



# Checklist for Stormwater Report

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## 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<sup>1</sup>
- ☐ 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.

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<sup>1</sup> 80% TSS removal is required prior to discharge to infiltration BMP if Dynamic Field method is used.



# Checklist for Stormwater Report

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## Checklist (continued)

### Standard 3: Recharge (continued)

- ☒ The infiltration BMP is used to attenuate peak flows during storms greater than or equal to the 10-year 24-hour storm and separation to seasonal high groundwater is less than 4 feet and a mounding analysis is provided.
- ☐ Documentation is provided showing that infiltration BMPs do not adversely impact nearby wetland resource areas.

### Standard 4: Water Quality

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

- Good housekeeping practices;
  - Provisions for storing materials and waste products inside or under cover;
  - Vehicle washing controls;
  - Requirements for routine inspections and maintenance of stormwater BMPs;
  - Spill prevention and response plans;
  - Provisions for maintenance of lawns, gardens, and other landscaped areas;
  - Requirements for storage and use of fertilizers, herbicides, and pesticides;
  - Pet waste management provisions;
  - Provisions for operation and management of septic systems;
  - Provisions for solid waste management;
  - Snow disposal and plowing plans relative to Wetland Resource Areas;
  - Winter Road Salt and/or Sand Use and Storage restrictions;
  - Street sweeping schedules;
  - Provisions for prevention of illicit discharges to the stormwater management system;
  - Documentation that Stormwater BMPs are designed to provide for shutdown and containment in the event of a spill or discharges to or near critical areas or from LUHPPL;
  - Training for staff or personnel involved with implementing Long-Term Pollution Prevention Plan;
  - List of Emergency contacts for implementing Long-Term Pollution Prevention Plan.
- ☒ A Long-Term Pollution Prevention Plan is attached to Stormwater Report and is included as an attachment to the Wetlands Notice of Intent.
  - ☒ Treatment BMPs subject to the 44% TSS removal pretreatment requirement and the one inch rule for calculating the water quality volume are included, and discharge:
    - ☐ is within the Zone II or Interim Wellhead Protection Area
    - ☐ is near or to other critical areas
    - ☐ is within soils with a rapid infiltration rate (greater than 2.4 inches per hour)
    - ☒ involves runoff from land uses with higher potential pollutant loads.
  - ☐ The Required Water Quality Volume is reduced through use of the LID site Design Credits.
  - ☒ Calculations documenting that the treatment train meets the 80% TSS removal requirement and, if applicable, the 44% TSS removal pretreatment requirement, are provided.



# Checklist for Stormwater Report

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## Checklist (continued)

### Standard 4: Water Quality (continued)

- ☒ The BMP is sized (and calculations provided) based on:
  - ☒ The ½" or 1" Water Quality Volume or
  - ☒ The equivalent flow rate associated with the Water Quality Volume and documentation is provided showing that the BMP treats the required water quality volume.
- ☒ The applicant proposes to use proprietary BMPs, and documentation supporting use of proprietary BMP and proposed TSS removal rate is provided. This documentation may be in the form of the propriety BMP checklist found in Volume 2, Chapter 4 of the Massachusetts Stormwater Handbook and submitting copies of the TARP Report, STEP Report, and/or other third party studies verifying performance of the proprietary BMPs.
- ☐ A TMDL exists that indicates a need to reduce pollutants other than TSS and documentation showing that the BMPs selected are consistent with the TMDL is provided.

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

- ☐ The NPDES Multi-Sector General Permit covers the land use and the Stormwater Pollution Prevention Plan (SWPPP) has been included with the Stormwater Report.
- ☐ The NPDES Multi-Sector General Permit covers the land use and the SWPPP will be submitted **prior to** the discharge of stormwater to the post-construction stormwater BMPs.
- ☒ The NPDES Multi-Sector General Permit does **not** cover the land use.
- ☐ LUHPPLs are located at the site and industry specific source control and pollution prevention measures have been proposed to reduce or eliminate the exposure of LUHPPLs to rain, snow, snow melt and runoff, and been included in the long term Pollution Prevention Plan.
- ☐ All exposure has been eliminated.
- ☐ All exposure has **not** been eliminated and all BMPs selected are on MassDEP LUHPPL list.
- ☒ The LUHPPL has the potential to generate runoff with moderate to higher concentrations of oil and grease (e.g. all parking lots with >1000 vehicle trips per day) and the treatment train includes an oil grit separator, a filtering bioretention area, a sand filter or equivalent.

### Standard 6: Critical Areas

- ☐ The discharge is near or to a critical area and the treatment train includes only BMPs that MassDEP has approved for stormwater discharges to or near that particular class of critical area.
- ☐ Critical areas and BMPs are identified in the Stormwater Report.



# Checklist for Stormwater Report

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## 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

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## Checklist (continued)

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

- ☐ The project is highly complex and information is included in the Stormwater Report that explains why it is not possible to submit the Construction Period Pollution Prevention and Erosion and Sedimentation Control Plan with the application. A Construction Period Pollution Prevention and Erosion and Sedimentation Control has **not** been included in the Stormwater Report but will be submitted **before** land disturbance begins.
- ☐ The project is **not** covered by a NPDES Construction General Permit.
- ☐ The project is covered by a NPDES Construction General Permit and a copy of the SWPPP is in the Stormwater Report.
- ☒ The project is covered by a NPDES Construction General Permit but no SWPPP been submitted. The SWPPP will be submitted BEFORE land disturbance begins.

### Standard 9: Operation and Maintenance Plan

- ☒ The Post Construction Operation and Maintenance Plan is included in the Stormwater Report and includes the following information:
  - ☒ Name of the stormwater management system owners;
  - ☒ Party responsible for operation and maintenance;
  - ☒ Schedule for implementation of routine and non-routine maintenance tasks;
  - ☒ Plan showing the location of all stormwater BMPs maintenance access areas;
  - ☒ Description and delineation of public safety features;
  - ☒ Estimated operation and maintenance budget; and
  - ☒ Operation and Maintenance Log Form.
- ☐ The responsible party is **not** the owner of the parcel where the BMP is located and the Stormwater Report includes the following submissions:
  - ☐ A copy of the legal instrument (deed, homeowner's association, utility trust or other legal entity) that establishes the terms of and legal responsibility for the operation and maintenance of the project site stormwater BMPs;
  - ☐ A plan and easement deed that allows site access for the legal entity to operate and maintain BMP functions.

### Standard 10: Prohibition of Illicit Discharges

- ☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;
- ☒ An Illicit Discharge Compliance Statement is attached;
- ☐ NO Illicit Discharge Compliance Statement is attached but will be submitted **prior to** the discharge of any stormwater to post-construction BMPs.



## SECTION 2.0 – OPERATION & MAINTENANCE







## **OPERATIONS AND MAINTENANCE PLAN**

In accordance with the standards set forth by the Stormwater Management Policy issued by the Department of Environmental Protection (DEP), Allen & Major Associates, Inc. (A&M) has prepared the following Operation and Maintenance plan for the drainage improvements located at 0 School Street in Manchester-by-the-Sea, MA (The Sanctuary at Manchester-by-the-Sea).

This plan is broken into two major sections. The first section describes construction-related erosion and sedimentation controls. The second section is devoted to a post-development operation and maintenance plan. An operation and maintenance schedule is included with this report.

**Stormwater Management System Owner:** SLV School Street, LLC.  
257 Hillside Avenue  
Newton, MA 02494

### **Emergency Contact Information:**

SLV School Street, LLC. c/o Geoff Engler	Phone: (617) 276-7261
Allen & Major Associates, Inc. (Civil)	Phone: (781) 935-6889
Manchester-by-the-Sea DPW	Phone: (978) 526-1242
Manchester-by-the-Sea Fire Department	Phone: (978) 526-4040
Manchester-by-the-Sea Con. Commission	Phone: (978) 526-4397

## **INTRODUCTION**

The stormwater management system (SMS) for this project is owned by SLV School Street, LLC. (or current owner), and shall be legally responsible for long-term operation and maintenance for this SMS as outlined in this Operation and Maintenance (O&M) Plan. Should ownership of the SMS change, the succeeding owner will be presented with this O&M Plan and supporting attachments at or before legal conveyance of ownership and will assume the obligations of the O&M Plan.

In the event that the SMS will be operated and maintained by an entity other than that listed in this document, the applicant shall provide a plan and easement deed that provides a right of access for the legal entity to be able to perform said operation and maintenance functions. In the event the SMS will serve multiple lots/owners, the applicant shall also provide 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 entire SMS.

## **DEMOLITION & CONSTRUCTION MAINTENANCE PLAN**

1. Call Digsafe: 1-888-344-7233
2. Contact the Town 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 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.
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 dams 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.

## **POST CONSTRUCTION MAINTENANCE PLAN**

The SMS shall be inspected immediately after construction. 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.

### **Inspection and Maintenance Frequency and Corrective Measures**

The following areas, facilities, and measures will be inspected and the identified deficiencies will be corrected. Clean-out must include the removal and legal disposal of any accumulated sediments, trash, and debris. In any and all cases, operations, inspections, and maintenance activities shall utilize best practical measures to avoid and minimize impacts to wetland resource areas outside the foot print of the SMS.

SMS components that will require continuing inspection as outlined in the document:

- *Deep-Sump Catch Basins*
- *Proprietary Separators*
- *Surface Detention/Infiltration Pond*
- *Outlet Control Structures*
- *Sub-Surface Detention/Infiltration Systems*
- *Rain Gardens*
- *Snow Storage*



**Monthly Post Construction Inspection** (first three months only)

- **Surface Infiltration Systems:** Inspect the infiltration system after all rainfalls greater than 1" to ensure that the system is draining within 72 hours. Repair as required.

**Quarterly Inspections** (specifically after foliage and snow season)

- **Deep Sump Catch Basins:** Inspect catch basins to ensure that the catch basins are working in their intended fashion and that they are free of debris. Structures will be skimmed of floatable debris at each inspection and sediment will be removed at a minimum once per year (typically after snow season) or when sediment has accumulated to within 2 feet of the outlet invert. If the basin outlet is designed with a hood to trap floatable materials (i.e. Snout), check to ensure watertight seal is working.
- **Proprietary Separators:** Separators shall be operated in strict accordance with manufacturer's recommended practices. Available manufacturer specific O&M plans attached as Appendix. Separators shall be inspected to ensure that they are working in their intended fashion and that they are free of debris. Structures shall be cleaned with a vacuum truck at least once annually (typically after snow season) or when sediment has accumulated to a depth of six inches (6"), whichever is more frequent.
- **Surface Infiltration Systems:** The surface ponds will be inspected 24 hours or several days after large rain events (greater than 1.5"), to look for ponded water. Pond should be inspected and the trash removed on a monthly basis. The basin should be mowed a minimum of two (2) times per year and a maximum of once monthly.

**Semi-Annual Inspection** (specifically after foliage and snow season)

- **Culverts:** Inspect culverts to ensure that the culverts are working in their intended fashion and that they are free of debris. Remove any obstructions to flow; remove accumulated sediments and debris at the inlet, at the outlet, and within the conduit and to repair any erosion damage at the culvert's inlet and outlet.
- **Vegetated Areas:** Inspect slopes and embankments early in the growing season to identify active or potential erosion problems. Replant bare areas or areas with sparse growth. Where rill erosion is evident, armor the area with an appropriate lining or divert the erosive flows to on-site areas able to withstand the concentrated flows.
- **Roadway and Parking Surfaces:** Sweep paved areas as soon as possible after snow melt and no less than four times annually. 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.

- **Level Spreaders, Check Dams, Rip-Rap:** These accessories will be inspected for erosion, debris accumulation, and unwanted vegetation. Erosion will be stabilized and sediment, debris, and woody vegetation will be removed.

## **LANDSCAPE MANAGEMENT PLAN**

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 to tailor the specifics of the site. In order to ensure 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.

**Lawn 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.

If possible, try to use 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

## **MANAGEMENT OF DEICING CHEMICALS AND SNOW**

Snow shall not be plowed towards any area protected by the Massachusetts Wetlands Protection Act. Additionally, it is prohibited to dump snow into the infiltration basin or near the abutting vegetated wetlands. Snow shall only be stockpiled on site within the snow storage areas depicted on the Snow Storage Plan. If the stockpiles of snow do not fit within the designated areas, then snow will be disposed off-site. It will be the responsibility of the snow removal contractor to properly dispose of transported snow according to the most recent Superseded Massachusetts Department of Environmental



Protection, Bureau of Resource Protection – Snow Disposal Guideline #BRPG01-01 effective December 23, 2019, 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. A copy of the MassDEP Snow Disposal Guideline #BRPG01-01 has been included at the end of Section 2 for reference.

The site's maintenance staffs (or its designee) will be responsible for the clearing of the sidewalk and building entrances. The site may be required to use a de-icing agent such as potassium chloride (or approved equal) to maintain a safe walking surface; however, these are to be used at the minimum amount practicable. The de-icing agent for the walkways and building entrances will be kept within the storage rooms located within the buildings. De-icing agents will not be stored outside.

### **SPILL PREVENTION AND RESPONSE**

Sources of potential spill hazards include vehicle fluids, liquid fuels, pesticides, paints, solvents, and liquid cleaning products. The majority of the spill hazards would likely occur within the building 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:

- *Spill Hazards of pesticides, paints, and solvents shall be remediated using the Manufacturers' recommended spill cleanup protocol.*
- *Vehicle fluids and liquid fuel spill shall be remediated according to the local and state regulations governing fuel spills.*
- *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.*
- *All spills shall be cleaned up immediately after discovery.*
- *Spills of toxic or hazardous material shall be reported, regardless of size, to the Massachusetts Department of Environmental Protection at 888-304-1133.*
- *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.*

OPERATION & MAINTENANCE PLAN SCHEDULE

Project: The Sanctuary  
Address: 0 School Street  
Manchester-by-the-Sea

ty Responsible for O & M Plan: SLV School Street, LLC.  
Address: 257 Hillside Avenue  
Needham, MA 02494

Date: 7/16/2021  
Revised:

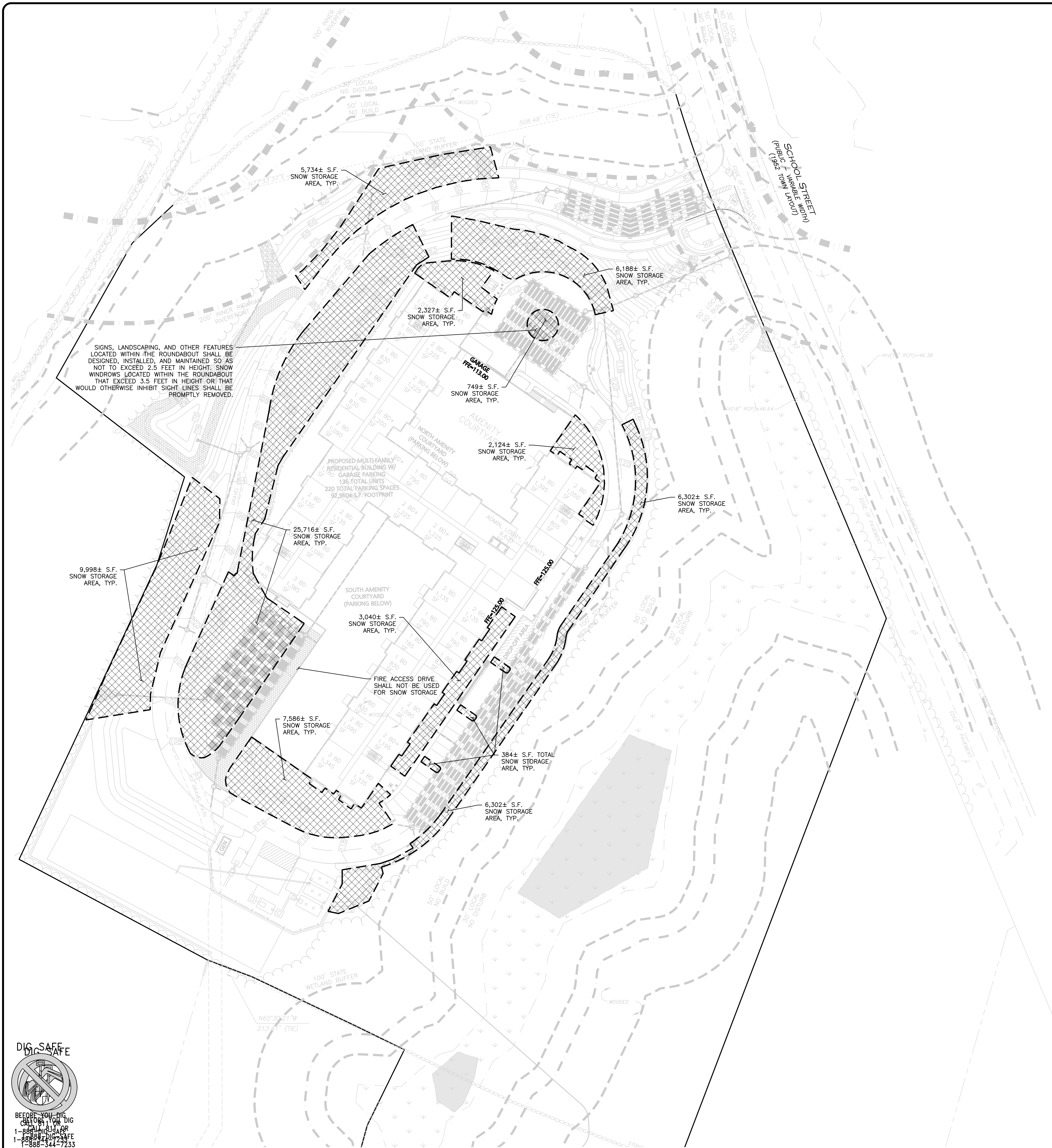
Phone:

Structure or Task	Maintenance Activity	Schedule/Notes	Annual Maintenance Cost	Inspection Performed	
				Date:	By:
Street Sweeping	Sweep, power broom or vacuum paved areas.	Sweep paved areas as needed, but not less than four times annually.	\$2,000		
		Submit information that confirms that all street sweepings have been disposed in accordance with state and local requirements			
Deep Sump Catch Basins(s)	Clam shell or vacuum sumps	Inspect at least twice annually. Clean when sediment is within 2.5 feet of the outlet invert.	\$500		
		Submit information that confirms that all catch basin sediments have been disposed in accordance with state and local requirements			
Storm Water Management System					
Proprietary Separators	See the ConTECH Maintenance package for the inspection and cleaning procedure.	Inspect at least four times annually as well as following storms exceeding 1" of rainfall. Devices shall be cleaned at least once annually or when sediment reaches 6 inches of depth whichever is more frequent. See also note #1 below.	\$250		
		Submit information that confirms that all water quality inlets sediments have been disposed in accordance with state and local requirements			
Rain Gardens	Inspect & remove trash Mulch Remove/Replace dead vegetation Prune Replace media & all vegetation	Monthly during all seasons	\$250		
		Annually every spring			
		Annually. Remove in fall & spring, replace in spring only			
		Annually as-needed, spring or fall			
		Late spring/early summer, as-needed			
Surface Detention/Infiltration Ponds	Inspect monthly and after large storm events to ensure it is draining properly.	On a semi-annual basis.	\$500		
	The surface pond will be inspected 24 hours or several days after large rain events (greater than 1.5"), to look for ponded water. Pond should be inspected and the trashed removed on a monthly basis. The basin should be mowed a minimum of two (2) times per year and a maximum of once monthly.				
Outlet Control Structure(s)	Clam shell or vacuum sumps	Periodic cleaning of Outlet Control Structures as needed.	\$50		
Pool Water Discharge	CB management targeted larviciding treatment to CB's and all storm drains to control mosquitoes in their aquatic stages.	Pool water shall not be or drainage structures under any circumstances.	N/A		
Mosquito Control	CB management targeted larviciding treatment to CB's and all storm drains to control mosquitoes in their aquatic stages.	Surveillance is a non chemical inspection method that involves classification of mosquito breeding sites, larval presents, and survey.	\$100		
Snow Storage	Debris shall be cleared from the site and properly disposed of at the end of the snow season, but shall be cleared no later than May 15.	Avoid dumping snow removal over catch basins, in detention ponds, sediment forebays, rivers, wetlands, and flood plain. It is also prohibited to dump snow in the bioretention basins or gravel	\$500		

Note #1 - During the first year of operation, all of the BMP's shall be inspected during and after large storm events to ensure they are functioning properly. The surface infiltration pond should be fully drained within 72 hours after a rain event. If it is not drained within this time period, the systems shall be evaluated and corrective actions should be implemented.



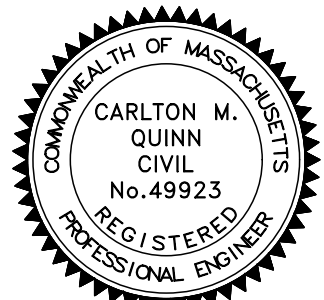




**LEGEND**

SNOW STORAGE AREA

- NOTES:**
1. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY AND HAVE NOT BEEN INDEPENDENTLY VERIFIED BY THE OWNER OR ITS REPRESENTATIVE. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK, AND AGREES TO BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE OCCASIONED BY THE CONTRACTOR'S FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.
  2. THE INFORMATION SHOWN ON THIS PLAN IS THE SOLE PROPERTY OF ALLEN & MAJOR ASSOCIATES, INC. IT'S INTENDED USE IS TO PROVIDE INFORMATION. ANY ALTERATION, MISUSE, OR RECALCULATION OF INFORMATION OR DATA WITHOUT THE EXPRESSED, WRITTEN CONSENT OF ALLEN & MAJOR ASSOCIATES, INC. IS STRICTLY PROHIBITED.
  3. SNOW WILL BE STOCKPILED ON SITE UNTIL THERE IS NOT ENOUGH SPACE. AS NECESSARY, THE SNOW WILL BE REMOVED AND DISPOSED OF OFF-SITE. IT WILL BE THE RESPONSIBILITY OF THE SNOW REMOVAL CONTRACTOR TO PROPERLY DISPOSE OF TRANSPORTED SNOW ACCORDING TO MASSACHUSETTS DEP. BUREAU OF RESOURCE PROTECTION - MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL PROTECTION BUREAU OF WATER RESOURCES SNOW DISPOSAL GUIDANCE EFFECTIVE DATE: DECEMBER 23, 2019, 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.



PROFESSIONAL ENGINEER FOR  
ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION
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APPLICANT/OWNER:

SLV SCHOOL STREET, LLC  
257 HILLSIDE AVENUE  
NEEDHAM, MA 02494

PROJECT:

THE SANCTUARY AT  
MANCHESTER BY THE SEA  
0 SCHOOL STREET  
MANCHESTER-BY-THE-SEA, MA

PROJECT NO.	2725-01	DATE:	07-16-2021
SCALE:	1"=40'	DWG. NAME:	C-2725-01
DESIGNED BY:	CMQ/SIL	CHECKED BY:	CMQ

PREPARED BY:



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ASSOCIATES, INC.**

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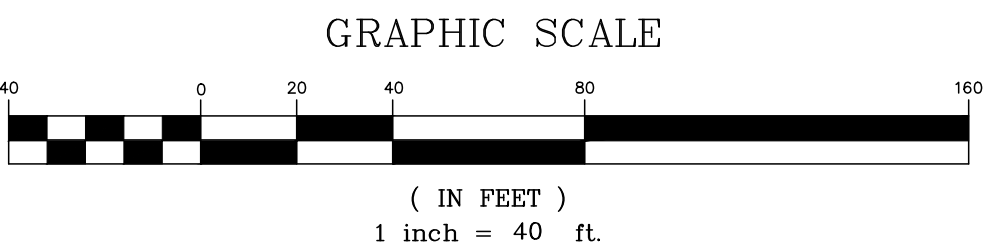
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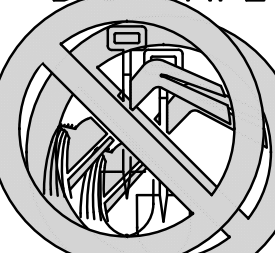
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# Massachusetts Department of Environmental Protection Bureau of Water Resources Snow Disposal Guidance

**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

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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 IWPA's 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**

## 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.<sup>1</sup> The SRMCB is composed of officials from MassDEP, Department of Agricultural Resources, and Department of Conservation and Recreation. The nine (9) Mosquito Control Districts overseen by the SRMCB are located throughout Massachusetts, covering 176 municipalities.

#### Construction Period Best Management Practices for Mosquito Control

To minimize mosquito breeding during construction, it is essential that the following actions be taken to minimize the creation of standing pools by taking the following actions:

- **Minimize Land Disturbance:** Minimizing land disturbance reduces the likelihood of mosquito breeding by reducing silt in runoff that will cause construction period controls to clog and retain standing pools of water for more than 72 hours.
- **Catch Basin inlets:** Inspect and refresh filter fabric, hay bales, filter socks or stone dams on a regular basis to ensure that any stormwater ponded at the inlet drains within 8 hours after precipitation stops. Shorter periods may be necessary to avoid hydroplaning in roads

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<sup>1</sup> 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.

#### Post-Construction Stormwater Treatment Practices

- 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.<sup>2</sup> Alternatively, Altosid, a Methopren product, may be used. Because some practices are designed to dewater between storms, such as dry extended detention and infiltration basins, the Operation and Maintenance Plan should provide that larviciding must be conducted during or immediately after wet weather, when the detention or infiltration basin has a standing pool of water, unless a product is used that can withstand extended dry periods.

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<sup>2</sup> *Bacillus thuringiensis israelensis* or *Bti* is usually applied by helicopter to wetlands and floodplains

## CDS Guide Operation, Design, Performance and Maintenance



## CDS®

Using patented continuous deflective separation technology, the CDS system screens, separates and traps debris, sediment, and oil and grease from stormwater runoff. The indirect screening capability of the system allows for 100% removal of floatables and neutrally buoyant material without blinding. Flow and screening controls physically separate captured solids, and minimize the re-suspension and release of previously trapped pollutants. Inline units can treat up to 6 cfs, and internally bypass flows in excess of 50 cfs (1416 L/s). Available precast or cast-in-place, offline units can treat flows from 1 to 300 cfs (28.3 to 8495 L/s). The pollutant removal capacity of the CDS system has been proven in lab and field testing.

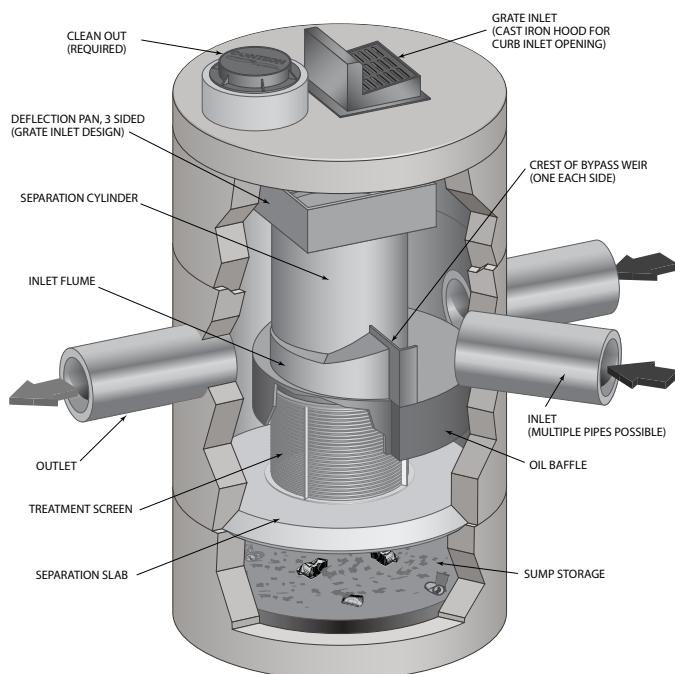
## Operation Overview

Stormwater enters the diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed from the flow. All flows up to the system's treatment design capacity enter the separation chamber and are treated.

Swirl concentration and screen deflection force floatables and solids to the center of the separation chamber where 100% of floatables and neutrally buoyant debris larger than the screen apertures are trapped.

Stormwater then moves through the separation screen, under the oil baffle and exits the system. The separation screen remains clog free due to continuous deflection.

During the flow events exceeding the treatment design capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants are retained in the separation cylinder.



## Design Basics

There are three primary methods of sizing a CDS system. The Water Quality Flow Rate Method determines which model size provides the desired removal efficiency at a given flow rate for a defined particle size. The Rational Rainfall Method™ or the Probabilistic Method is used when a specific removal efficiency of the net annual sediment load is required.

Typically in the United States, CDS systems are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for a gradation with an average particle size (d50) of 125 microns (μm). For some regulatory environments, CDS systems can also be designed to achieve an 80% annual solids load reduction based on an average particle size (d50) of 75 microns (μm) or 50 microns (μm).

### Water Quality Flow Rate Method

In some cases, regulations require that a specific treatment rate, often referred to as the water quality design flow (WQQ), be treated. This WQQ represents the peak flow rate from either an event with a specific recurrence interval, e.g. the six-month storm, or a water quality depth, e.g. 1/2-inch (13 mm) of rainfall.

The CDS is designed to treat all flows up to the WQQ. At influent rates higher than the WQQ, the diversion weir will direct most flow exceeding the WQQ around the separation chamber. This allows removal efficiency to remain relatively constant in the separation chamber and eliminates the risk of washout during bypass flows regardless of influent flow rates.

Treatment flow rates are defined as the rate at which the CDS will remove a specific gradation of sediment at a specific removal efficiency. Therefore the treatment flow rate is variable, based on the gradation and removal efficiency specified by the design engineer.

### Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. The Rational Rainfall Method combines site-specific information with laboratory generated performance data, and local historical precipitation records to estimate removal efficiencies as accurately as possible.

Short duration rain gauge records from across the United States and Canada were analyzed to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes, or hourly, and recorded in 0.01-inch increments. Depths were recorded hourly with 1-mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Rainfall Method. Since most sites are relatively small and highly impervious, the Rational Rainfall Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS system are

determined. Performance efficiency curve determined from full scale laboratory tests on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

### Probabilistic Rational Method

The Probabilistic Rational Method is a sizing program Contech developed to estimate a net annual sediment load reduction for a particular CDS model based on site size, site runoff coefficient, regional rainfall intensity distribution, and anticipated pollutant characteristics.

The Probabilistic Method is an extension of the Rational Method used to estimate peak discharge rates generated by storm events of varying statistical return frequencies (e.g. 2-year storm event). Under the Rational Method, an adjustment factor is used to adjust the runoff coefficient estimated for the 10-year event, correlating a known hydrologic parameter with the target storm event. The rainfall intensities vary depending on the return frequency of the storm event under consideration. In general, these two frequency dependent parameters (rainfall intensity and runoff coefficient) increase as the return frequency increases while the drainage area remains constant.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Method. Since most sites are relatively small and highly impervious, the Rational Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS are determined. Performance efficiency curve on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

### Treatment Flow Rate

The inlet throat area is sized to ensure that the WQQ passes through the separation chamber at a water surface elevation equal to the crest of the diversion weir. The diversion weir bypasses excessive flows around the separation chamber, thus preventing re-suspension or re-entrainment of previously captured particles.

### Hydraulic Capacity

The hydraulic capacity of a CDS system is determined by the length and height of the diversion weir and by the maximum allowable head in the system. Typical configurations allow hydraulic capacities of up to ten times the treatment flow rate. The crest of the diversion weir may be lowered and the inlet throat may be widened to increase the capacity of the system at a given water surface elevation. The unit is designed to meet project specific hydraulic requirements.

## Performance

### Full-Scale Laboratory Test Results

A full-scale CDS system (Model CDS2020-5B) was tested at the facility of University of Florida, Gainesville, FL. This CDS unit was evaluated under controlled laboratory conditions of influent flow rate and addition of sediment.

Two different gradations of silica sand material (UF Sediment & OK-110) were used in the CDS performance evaluation. The particle size distributions (PSDs) of the test materials were analyzed using standard method "Gradation ASTM D-422 "Standard Test Method for Particle-Size Analysis of Soils" by a certified laboratory.

UF Sediment is a mixture of three different products produced by the U.S. Silica Company: "Sil-Co-Sil 106", "#1 DRY" and "20/40 Oil Frac". Particle size distribution analysis shows that the UF Sediment has a very fine gradation ( $d_{50} = 20$  to  $30 \mu\text{m}$ ) covering a wide size range (Coefficient of Uniformity,  $C_u$  averaged at 10.6). In comparison with the hypothetical TSS gradation specified in the NJDEP (New Jersey Department of Environmental Protection) and NJCAT (New Jersey Corporation for Advanced Technology) protocol for lab testing, the UF Sediment covers a similar range of particle size but with a finer  $d_{50}$  ( $d_{50}$  for NJDEP is approximately  $50 \mu\text{m}$ ) (NJDEP, 2003).

The OK-110 silica sand is a commercial product of U.S. Silica Sand. The particle size distribution analysis of this material, also included in Figure 1, shows that 99.9% of the OK-110 sand is finer than 250 microns, with a mean particle size ( $d_{50}$ ) of 106 microns. The PSDs for the test material are shown in Figure 1.

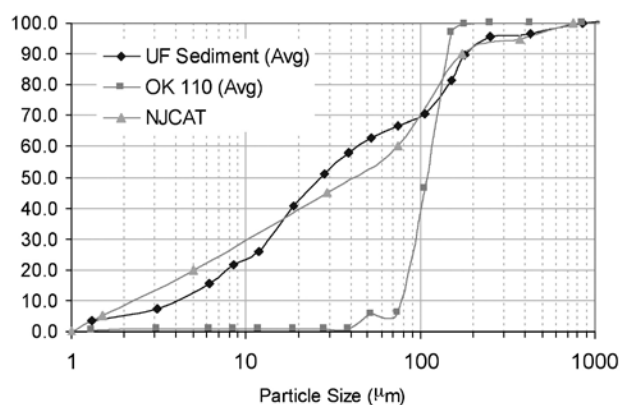


Figure 1. Particle size distributions

Tests were conducted to quantify the performance of a specific CDS unit (1.1 cfs (31.3-L/s) design capacity) at various flow rates, ranging from 1% up to 125% of the treatment design capacity of the unit, using the 2400 micron screen. All tests were conducted with controlled influent concentrations of approximately 200 mg/L. Effluent samples were taken at equal time intervals across the entire duration of each test run. These samples were then processed with a Dekaport Cone sample splitter to obtain representative sub-samples for Suspended Sediment Concentration (SSC) testing using ASTM D3977-97 "Standard Test Methods for Determining Sediment Concentration in Water Samples", and particle size distribution analysis.

## Results and Modeling

Based on the data from the University of Florida, a performance model was developed for the CDS system. A regression analysis was used to develop a fitting curve representative of the scattered data points at various design flow rates. This model, which demonstrated good agreement with the laboratory data, can then be used to predict CDS system performance with respect



to SSC removal for any particle size gradation, assuming the particles are inorganic sandy-silt. Figure 2 shows CDS predictive performance for two typical particle size gradations (NJCAT gradation and OK-110 sand) as a function of operating rate.

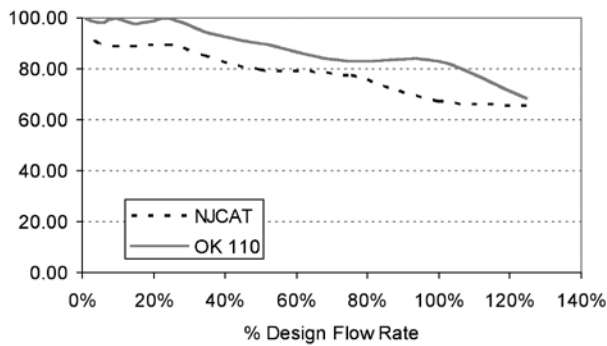


Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

Many regulatory jurisdictions set a performance standard for hydrodynamic devices by stating that the devices shall be capable of achieving an 80% removal efficiency for particles having a mean particle size ( $d_{50}$ ) of 125 microns (e.g. Washington State Department of Ecology — WASDOE - 2008). The model can be used to calculate the expected performance of such a PSD (shown in Figure 3). The model indicates (Figure 4) that the CDS system with 2400 micron screen achieves approximately 80% removal at the design (100%) flow rate, for this particle size distribution ( $d_{50} = 125 \mu m$ ).

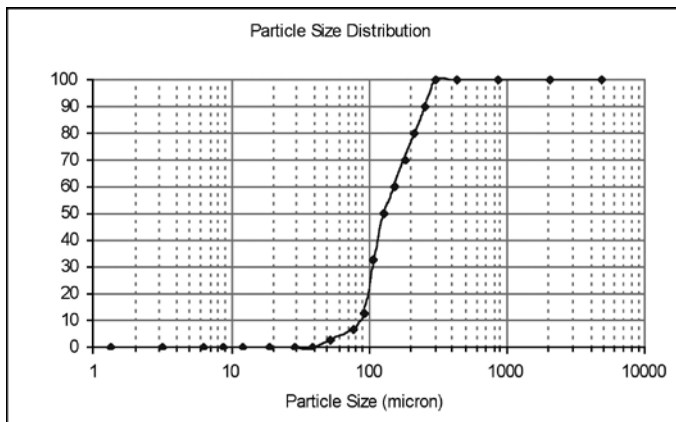


Figure 3. WASDOE PSD

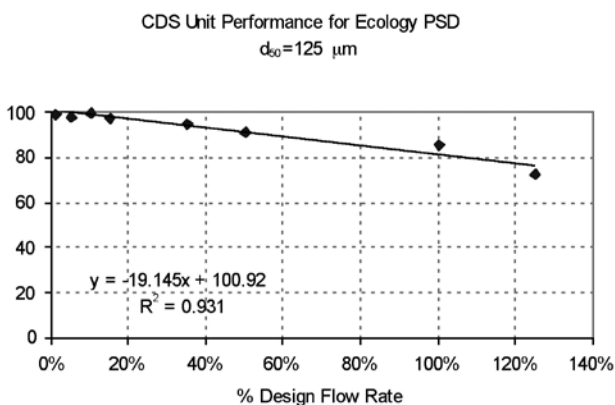


Figure 4. Modeled performance for WASDOE PSD.

## Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit. For example, unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

## Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant transport and deposition may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (e.g. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Installations should also be inspected more frequently where excessive amounts of trash are expected.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. The inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified



during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (cylinder and screen) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained outside the screen. For deep units, a single manhole access point would allow both sump cleanout and access outside the screen.

The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated. If absorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded; however, it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Particles at the top of the pile typically offer less resistance to the end of the rod than consolidated particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine whether the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

## Cleaning

Cleaning of a CDS system should be done during dry weather conditions when no flow is entering the system. The use of a vacuum truck is generally the most effective and convenient method of removing pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be cleaned out if pollutant build-up exists in this area.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use absorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash and debris can be netted out to separate it from the other pollutants. The screen should be cleaned to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure that proper safety precautions have been followed. Confined space entry procedures need to be followed if physical access is required. Disposal of all material removed from the CDS system should be done in accordance with local regulations. In many jurisdictions, disposal of the sediments may be handled in the same manner as the disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

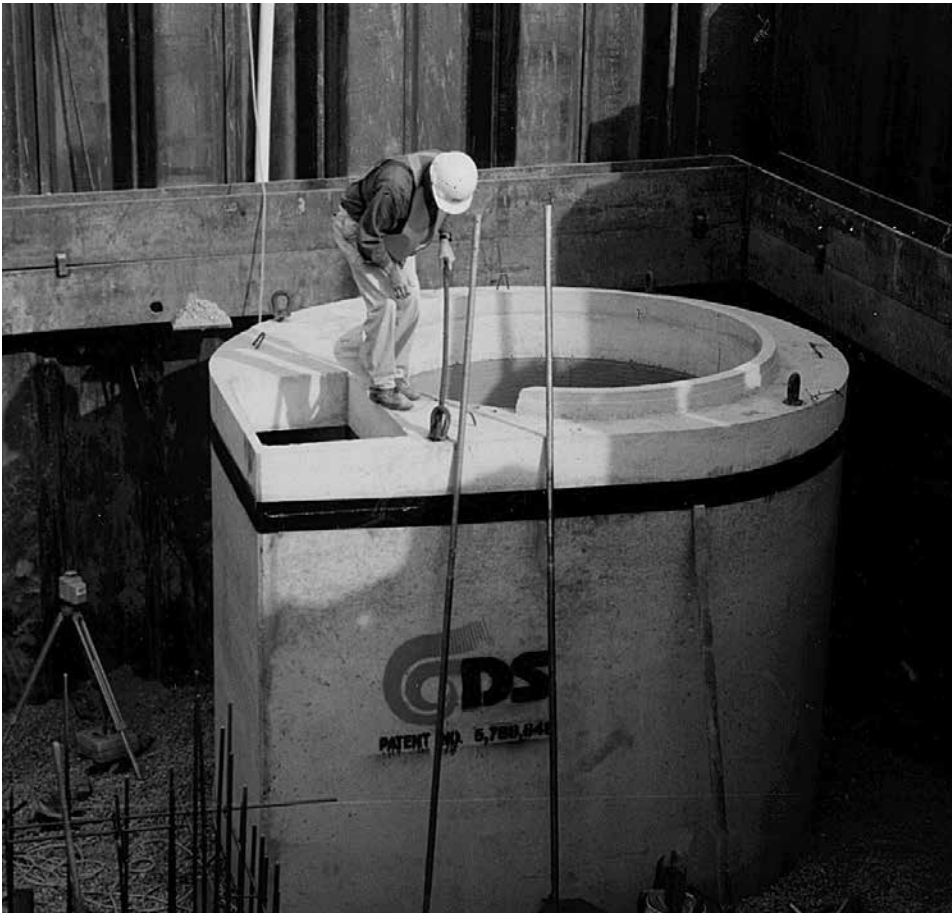




CDS Model	Diameter		Distance from Water Surface to Top of Sediment Pile		Sediment Storage Capacity	
	ft	m	ft	m	y <sup>3</sup>	m <sup>3</sup>
CDS1515	3	0.9	3.0	0.9	0.5	0.4
CDS2015	4	1.2	3.0	0.9	0.9	0.7
CDS2015	5	1.5	3.0	0.9	1.3	1.0
CDS2020	5	1.5	3.5	1.1	1.3	1.0
CDS2025	5	1.5	4.0	1.2	1.3	1.0
CDS3020	6	1.8	4.0	1.2	2.1	1.6
CDS3025	6	1.8	4.0	1.2	2.1	1.6
CDS3030	6	1.8	4.6	1.4	2.1	1.6
CDS3035	6	1.8	5.0	1.5	2.1	1.6
CDS4030	8	2.4	4.6	1.4	5.6	4.3
CDS4040	8	2.4	5.7	1.7	5.6	4.3
CDS4045	8	2.4	6.2	1.9	5.6	4.3
CDS5640	10	3.0	6.3	1.9	8.7	6.7
CDS5653	10	3.0	7.7	2.3	8.7	6.7
CDS5668	10	3.0	9.3	2.8	8.7	6.7
CDS5678	10	3.0	10.3	3.1	8.7	6.7

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Note: To avoid underestimating the volume of sediment in the chamber, carefully lower the measuring device to the top of the sediment pile. Finer silty particles at the top of the pile may be more difficult to feel with a measuring stick. These finer particles typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.



## CDS Inspection & Maintenance Log

CDS Model: \_\_\_\_\_ Location: \_\_\_\_\_

[illegible]

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the difference between these measurements is less than the values listed in table 1 the system should be cleaned out. **Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile.**
2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

## SUPPORT

- Drawings and specifications are available at [www.ContechES.com](http://www.ContechES.com).
- Site-specific design support is available from our engineers.



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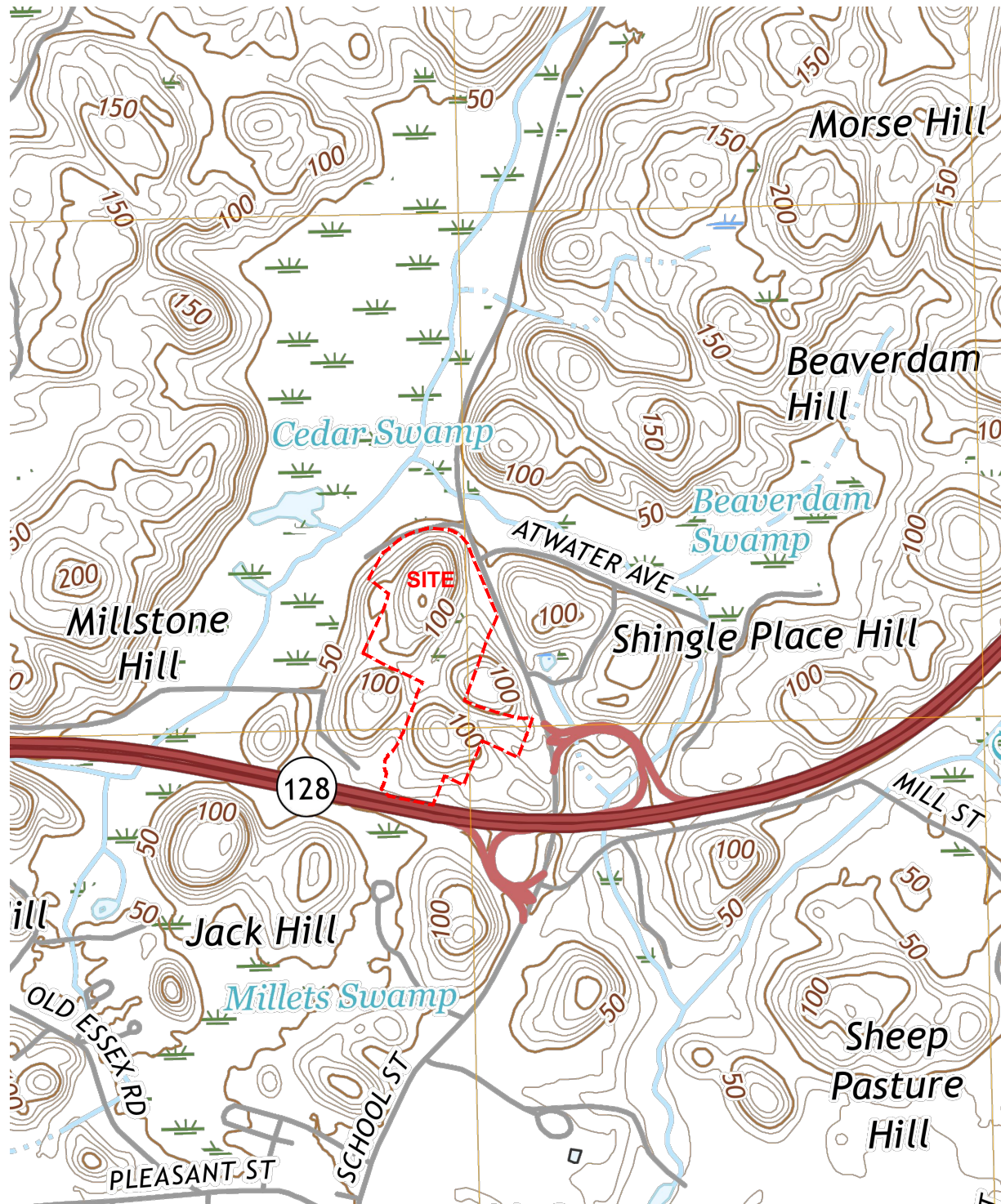
The product(s) described may be protected by one or more of the following US patents: 5,322,629; 5,624,576; 5,707,527; 5,759,415; 5,788,848; 5,985,157; 6,027,639; 6,350,374; 6,406,218; 6,641,720; 6,511,595; 6,649,048; 6,991,114; 6,998,038; 7,186,058; 7,296,692; 7,297,266; related foreign patents or other patents pending.





## SECTION 3.0 - EXHIBITS





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PROJECT:

**MULTI-FAMILY DEVELOPMENT  
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## USGS SITE LOCUS MAP

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SCALE:	1"=500'	DWG. NAME:	EXHIBIT
DESIGNED BY:	SJL	CHECKED BY:	CMQ

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**AERIAL PHOTO**

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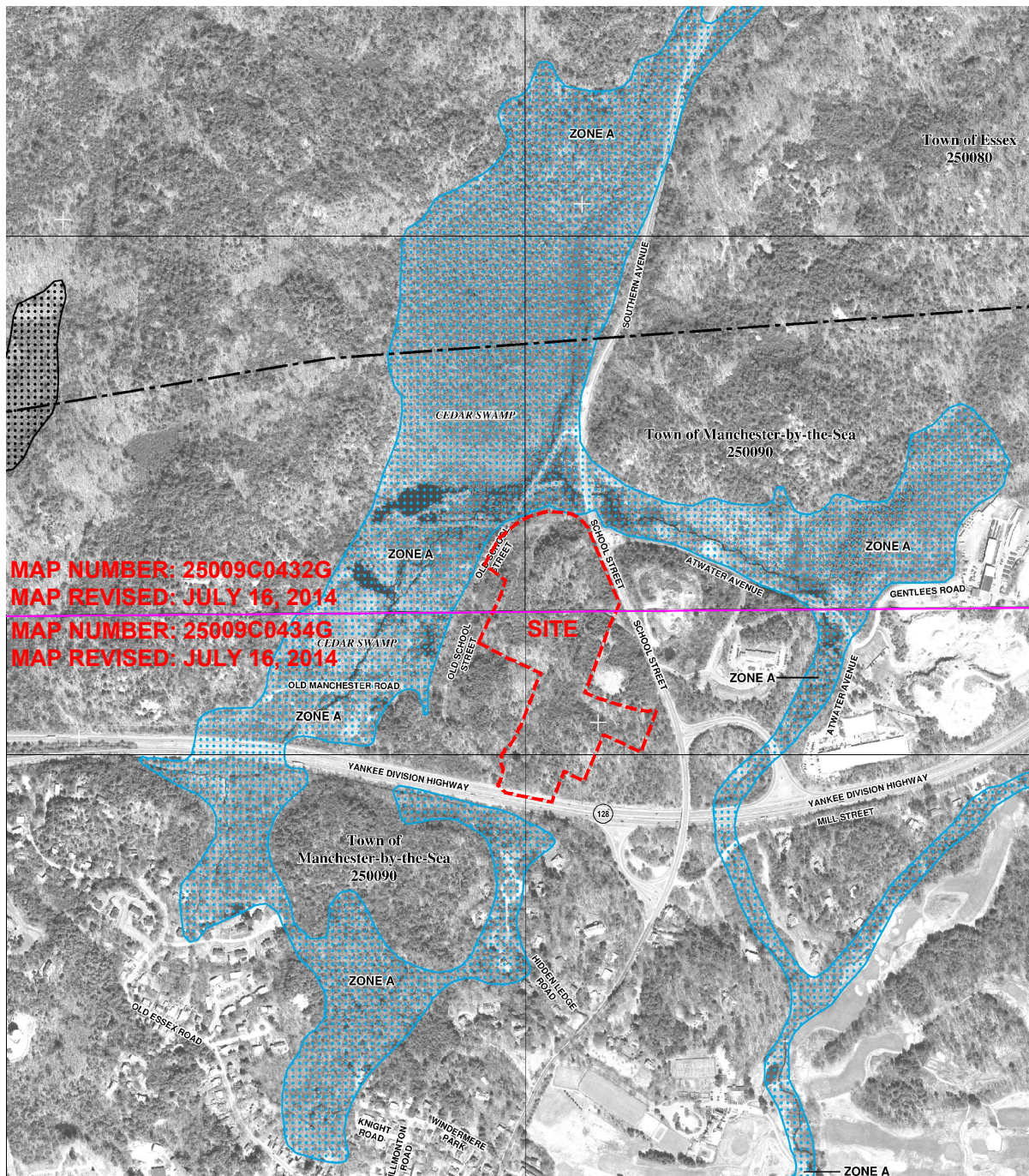
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**EX-2**







MAP NUMBER: 25009C0432G  
 MAP REVISED: JULY 16, 2014  
 MAP NUMBER: 25009C0434G  
 MAP REVISED: JULY 16, 2014

FEMA FLOOD INSURANCE RATE MAP  
 MIDDLESEX COUNTY, MASSACHUSETTS  
 MAP NUMBERS: 25009C0432G & 25009C0434G  
 JULY 16, 2014

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**FEMA FIRM MAP**

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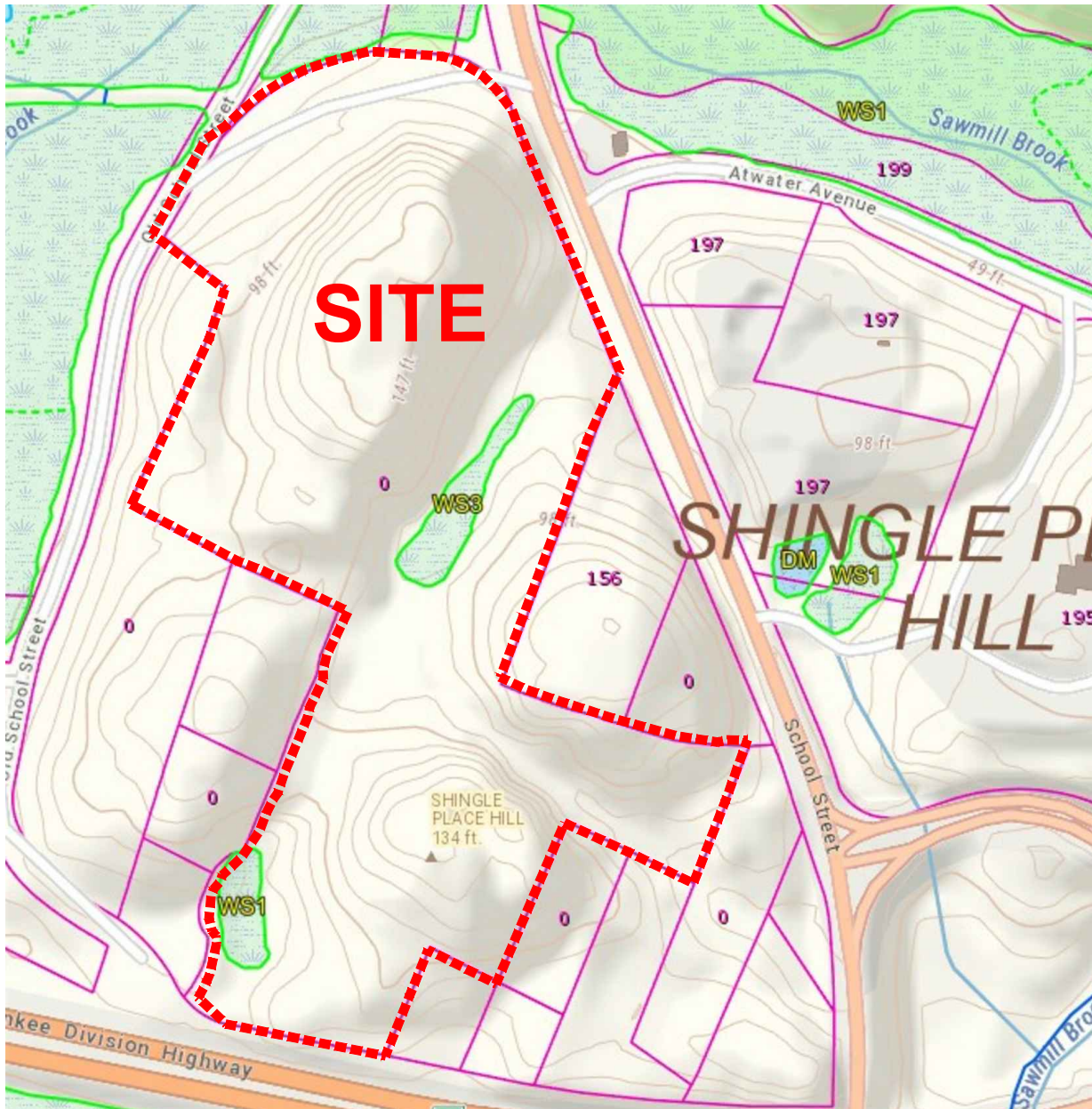
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**EX-3**







## LEGEND

DEP Wetlands Linear Features	
	SHORELINE
	HYDROLOGIC CONNECTION
	MEAN WATER LINE
	APPARENT WETLAND LIMIT

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**MASS DEP WETLANDS & VERNAL POOLS**

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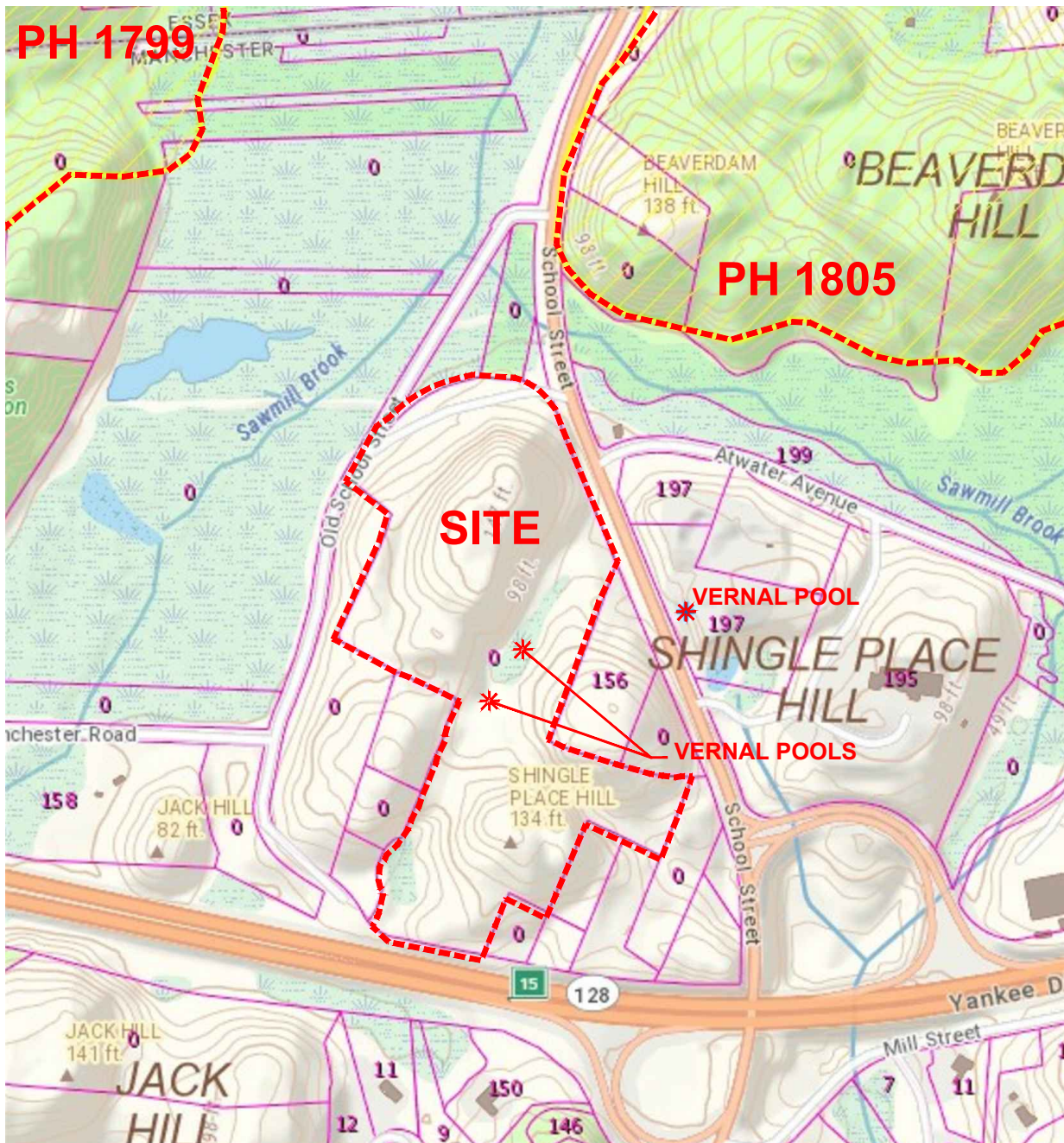
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**EX-4**







NO NHESP PRIORITY HABITATS ON-SITE.

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**NHESP PRIORITY HABITATS**

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**EX-5**







## SECTION 4.0 – HYDRO CAD



**2725-01 - Existing HydroCAD**

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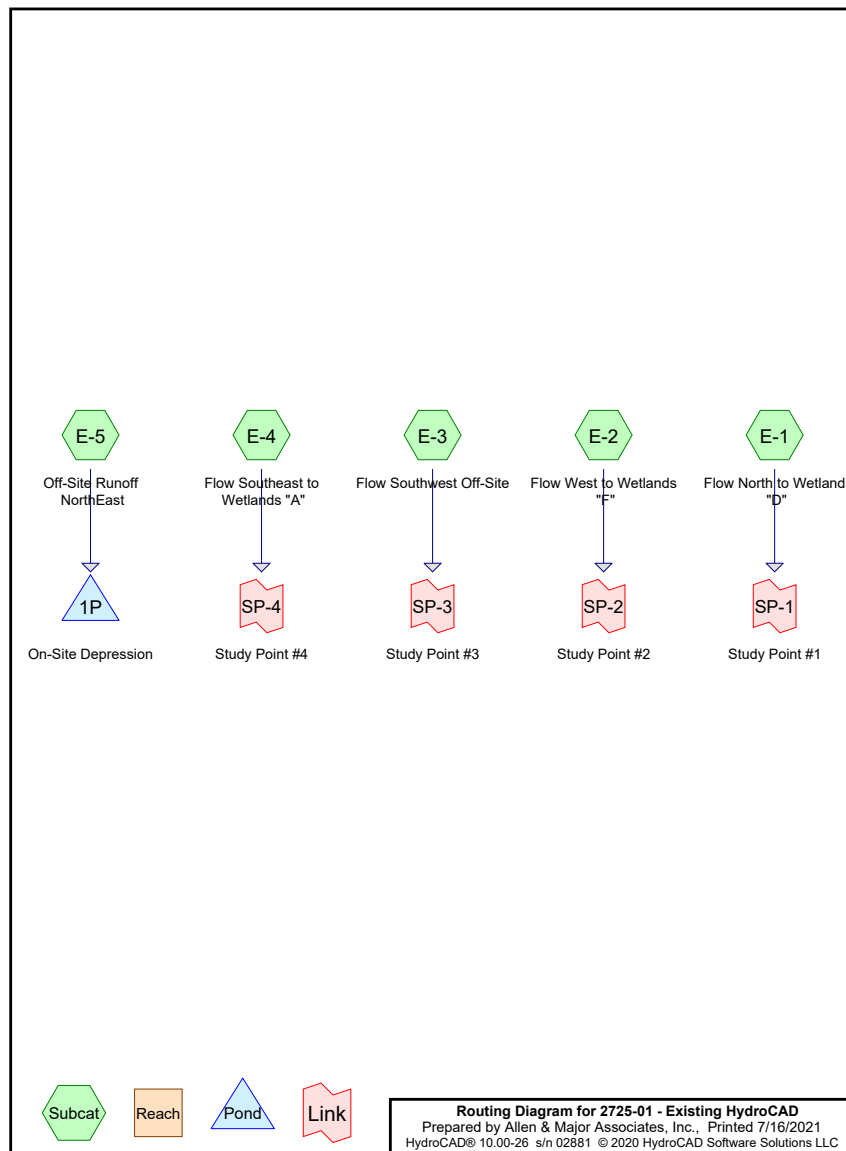
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Page 2

**Area Listing (all nodes)**

Area (sq-ft)	CN	Description (subcatchment-numbers)
9,028	91	Gravel roads, HSG D (E-1, E-3, E-5)
8,184	77	Wetlands, Good, HSG D (E-5)
422,664	77	Woods, Good, HSG D (E-1, E-2, E-3, E-4, E-5)
<b>439,876</b>	<b>77</b>	<b>TOTAL AREA</b>



Soil Listing (all nodes)

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
0	HSG C	
439,876	HSG D	E-1, E-2, E-3, E-4, E-5
0	Other	
439,876		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	Subcatchment Numbers
0	0	0	9,028	0	9,028	Gravel roads	E-1, E-3, E-5
0	0	0	8,184	0	8,184	Wetlands, Good	E-5
0	0	0	422,664	0	422,664	Woods, Good	E-1, E-2, E-3, E-4, E-5
0	0	0	439,876	0	439,876	TOTAL AREA	

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment E-1: Flow North to Wetland "D"	Runoff Area=122,563 sf 0.00% Impervious Runoff Depth=1.30" Flow Length=404' Tc=12.4 min CN=78 Runoff=3.37 cfs 13,306 cf
Subcatchment E-2: Flow West to Wetlands "F"	Runoff Area=17,293 sf 0.00% Impervious Runoff Depth=1.24" Tc=6.0 min CN=77 Runoff=0.55 cfs 1,788 cf
Subcatchment E-3: Flow Southwest Off-Site	Runoff Area=27,755 sf 0.00% Impervious Runoff Depth=1.30" Tc=6.0 min CN=78 Runoff=0.94 cfs 3,013 cf
Subcatchment E-4: Flow Southeast to Wetlands "A"	Runoff Area=185,366 sf 0.00% Impervious Runoff Depth=1.24" Flow Length=300' Tc=20.2 min CN=77 Runoff=4.02 cfs 19,162 cf
Subcatchment E-5: Off-Site Runoff NorthEast	Runoff Area=86,899 sf 0.00% Impervious Runoff Depth=1.30" Flow Length=299' Tc=9.8 min CN=78 Runoff=2.59 cfs 9,434 cf
Pond 1P: On-Site Depression	Peak Elev=95.08' Storage=8,931 cf Inflow=2.59 cfs 9,434 cf Discarded=0.01 cfs 755 cf Primary=0.00 cfs 0 cf Outflow=0.01 cfs 755 cf
Link SP-1: Study Point #1	Inflow=3.37 cfs 13,306 cf Primary=3.37 cfs 13,306 cf
Link SP-2: Study Point #2	Inflow=0.55 cfs 1,788 cf Primary=0.55 cfs 1,788 cf
Link SP-3: Study Point #3	Inflow=0.94 cfs 3,013 cf Primary=0.94 cfs 3,013 cf
Link SP-4: Study Point #4	Inflow=4.02 cfs 19,162 cf Primary=4.02 cfs 19,162 cf
Total Runoff Area = 439,876 sf Runoff Volume = 46,702 cf Average Runoff Depth = 1.27" 100.00% Pervious = 439,876 sf 0.00% Impervious = 0 sf	

Summary for Subcatchment E-1: Flow North to Wetland "D"

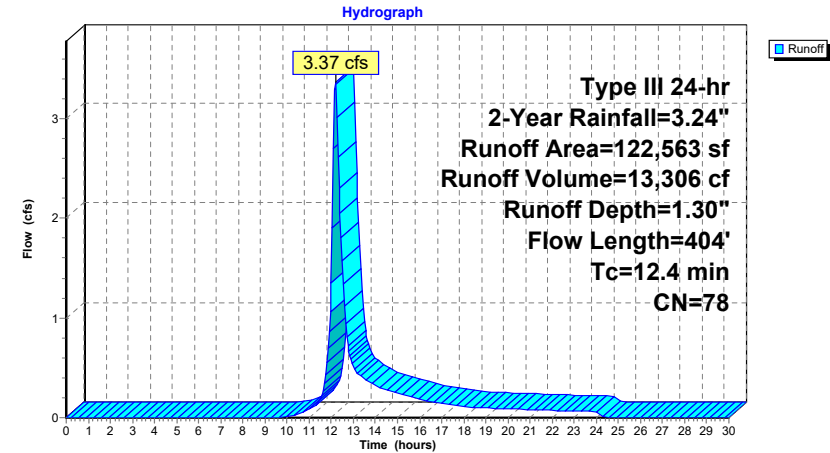
Runoff = 3.37 cfs @ 12.18 hrs, Volume= 13,306 cf, Depth= 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
4,563	91	Gravel roads, HSG D
118,000	77	Woods, Good, HSG D
122,563	78	Weighted Average
122,563		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.2556	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
4.6	354	0.2610	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
12.4	404	Total			

Subcatchment E-1: Flow North to Wetland "D"



Summary for Subcatchment E-2: Flow West to Wetlands "F"

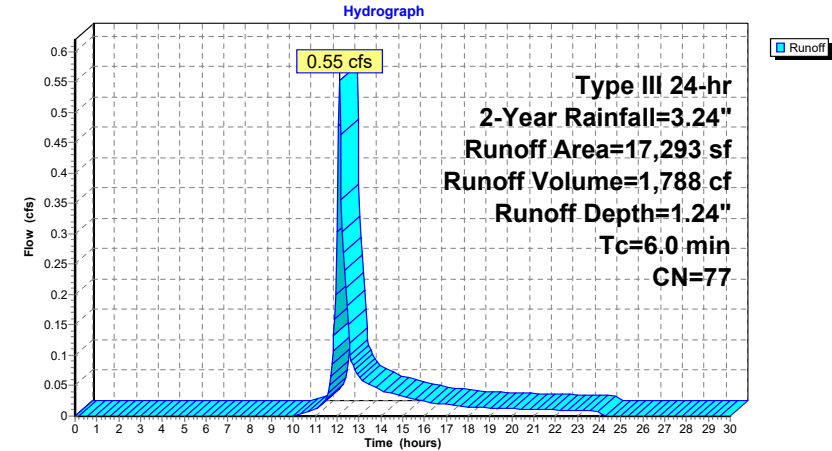
Runoff = 0.55 cfs @ 12.10 hrs, Volume= 1,788 cf, Depth= 1.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
17,293	77	Woods, Good, HSG D
17,293		100.00% Pervious Area

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

Subcatchment E-2: Flow West to Wetlands "F"



Summary for Subcatchment E-3: Flow Southwest Off-Site

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

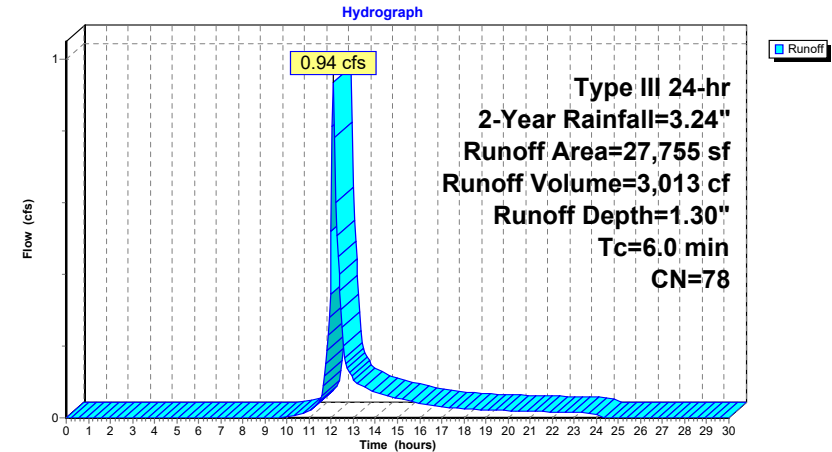
Runoff = 0.94 cfs @ 12.10 hrs, Volume= 3,013 cf, Depth= 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
1,087	91	Gravel roads, HSG D
26,668	77	Woods, Good, HSG D
27,755	78	Weighted Average
27,755		100.00% Pervious Area

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

Subcatchment E-3: Flow Southwest Off-Site



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Type III 24-hr 2-Year Rainfall=3.24"

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Page 9

### Summary for Subcatchment E-4: Flow Southeast to Wetlands "A"

Runoff = 4.02 cfs @ 12.30 hrs, Volume= 19,162 cf, Depth= 1.24"

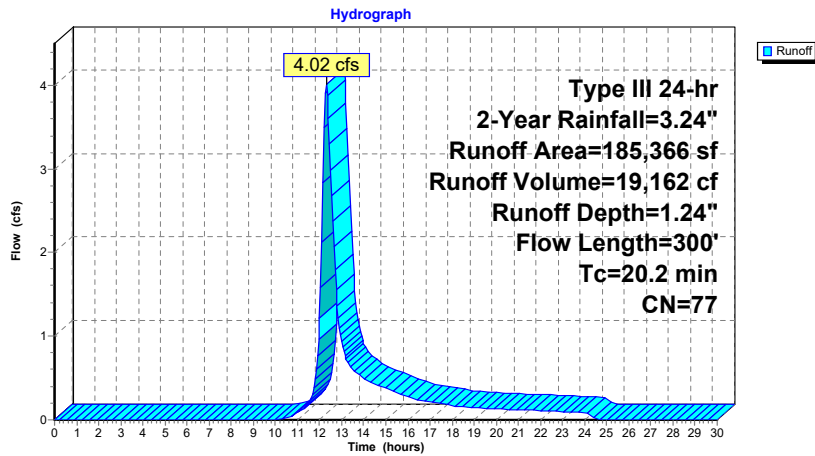
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
185,366	77	Woods, Good, HSG D
185,366		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3	50	0.0350	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	250	0.3200	1.41		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
20.2	300	Total			

### Subcatchment E-4: Flow Southeast to Wetlands "A"



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Page 10

### Summary for Subcatchment E-5: Off-Site Runoff NorthEast

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

Runoff = 2.59 cfs @ 12.15 hrs, Volume= 9,434 cf, Depth= 1.30"

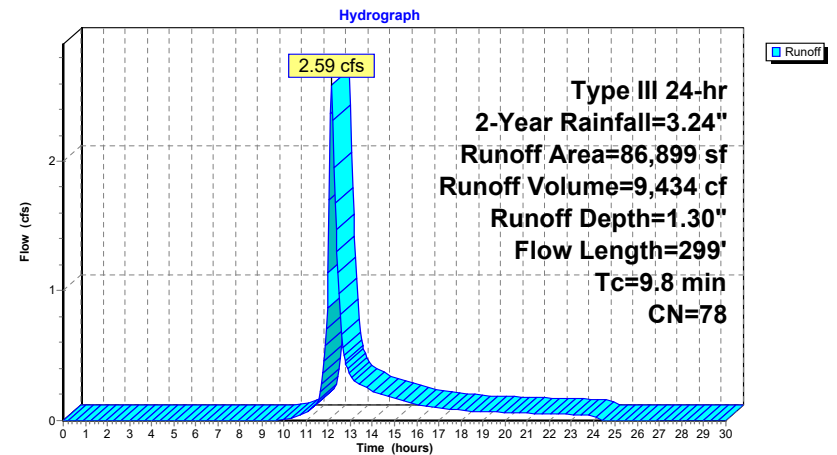
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
3,378	91	Gravel roads, HSG D
75,337	77	Woods, Good, HSG D
8,184	77	Wetlands, Good, HSG D
86,899	78	Weighted Average
86,899		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.3460	0.12		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	249	0.3267	1.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.8	299	Total			

### Subcatchment E-5: Off-Site Runoff NorthEast



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Page 11

### Summary for Pond 1P: On-Site Depression

[92] Warning: Device #2 is above defined storage

Inflow Area = 86,899 sf, 0.00% Impervious, Inflow Depth = 1.30" for 2-Year event  
Inflow = 2.59 cfs @ 12.15 hrs, Volume= 9,434 cf  
Outflow = 0.01 cfs @ 24.18 hrs, Volume= 755 cf, Atten= 100%, Lag= 722.0 min  
Discarded = 0.01 cfs @ 24.18 hrs, Volume= 755 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 95.08' @ 24.18 hrs Surf.Area= 5,886 sf Storage= 8,931 cf

Plug-Flow detention time= 586.7 min calculated for 754 cf (8% of inflow)  
Center-of-Mass det. time= 425.2 min ( 1,277.2 - 852.0 )

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	78,776 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
92.00	52	29.0	0	0	52
93.00	2,124	187.3	836	836	2,779
94.00	3,737	252.7	2,893	3,729	5,079
95.00	5,767	332.6	4,715	8,444	8,812
96.00	7,274	378.0	6,506	14,950	11,404
97.00	8,988	420.3	8,116	23,066	14,121
98.00	10,640	460.0	9,802	32,869	16,936
99.00	12,541	514.7	11,577	44,446	21,207
100.00	17,768	671.0	15,079	59,525	35,967
101.00	20,774	729.5	19,251	78,776	42,524

Device	Routing	Invert	Outlet Devices
#1	Discarded	92.00'	0.090 in/hr Exfiltration (D Soil) over Surface area
#2	Primary	101.00'	100.0' long x 1.0' 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
			Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Discarded OutFlow Max=0.01 cfs @ 24.18 hrs HW=95.08' (Free Discharge)  
1=Exfiltration (D Soil) (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=92.00' (Free Discharge)  
2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

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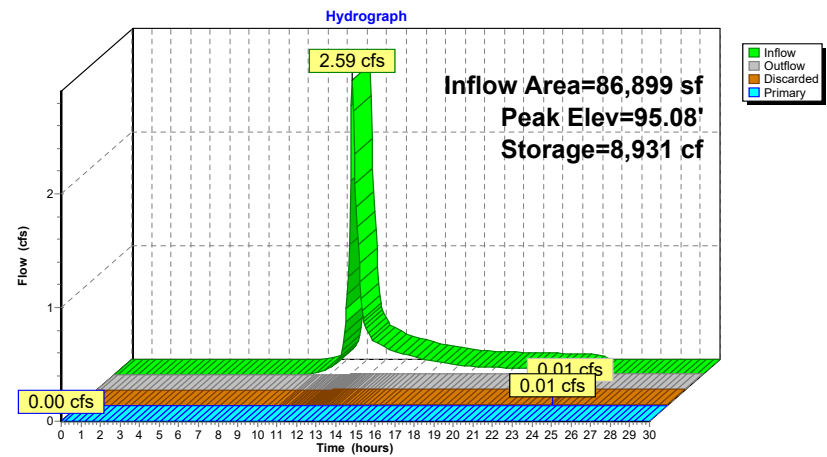
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Page 12

### Pond 1P: On-Site Depression





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Page 13

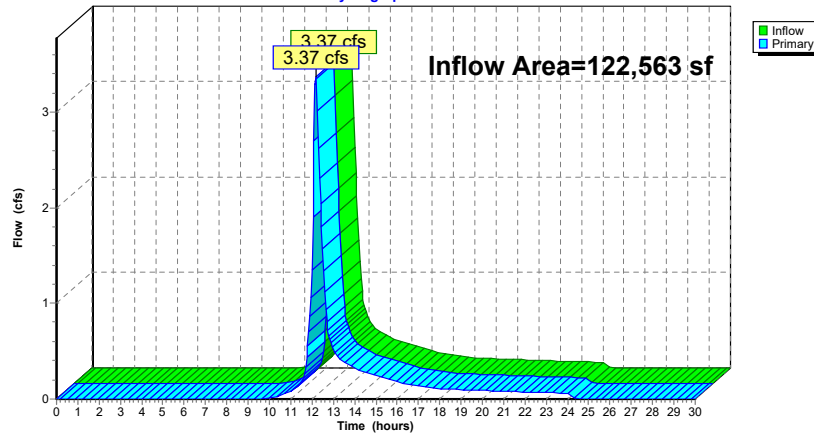
### Summary for Link SP-1: Study Point #1

Inflow Area = 122,563 sf, 0.00% Impervious, Inflow Depth = 1.30" for 2-Year event  
Inflow = 3.37 cfs @ 12.18 hrs, Volume= 13,306 cf  
Primary = 3.37 cfs @ 12.18 hrs, Volume= 13,306 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-1: Study Point #1

Hydrograph



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Page 14

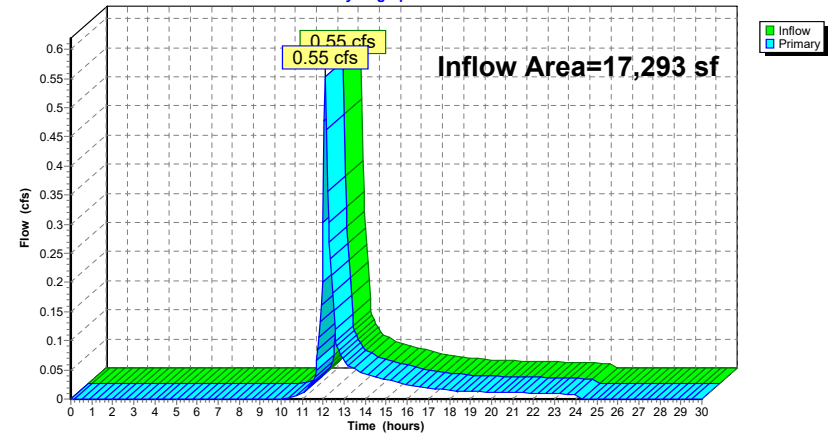
### Summary for Link SP-2: Study Point #2

Inflow Area = 17,293 sf, 0.00% Impervious, Inflow Depth = 1.24" for 2-Year event  
Inflow = 0.55 cfs @ 12.10 hrs, Volume= 1,788 cf  
Primary = 0.55 cfs @ 12.10 hrs, Volume= 1,788 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-2: Study Point #2

Hydrograph



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Page 15

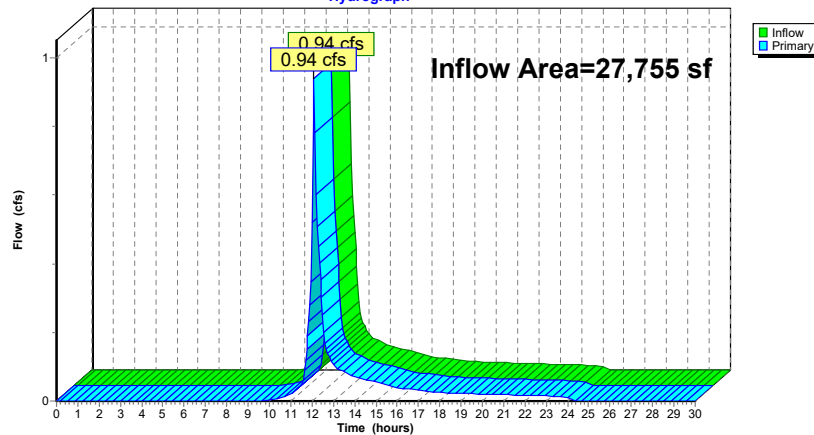
### Summary for Link SP-3: Study Point #3

Inflow Area = 27,755 sf, 0.00% Impervious, Inflow Depth = 1.30" for 2-Year event  
Inflow = 0.94 cfs @ 12.10 hrs, Volume= 3,013 cf  
Primary = 0.94 cfs @ 12.10 hrs, Volume= 3,013 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-3: Study Point #3

Hydrograph



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Page 16

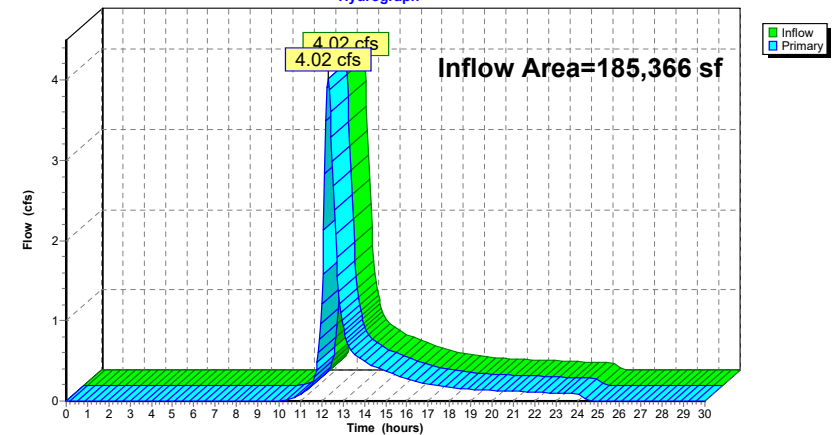
### Summary for Link SP-4: Study Point #4

Inflow Area = 185,366 sf, 0.00% Impervious, Inflow Depth = 1.24" for 2-Year event  
Inflow = 4.02 cfs @ 12.30 hrs, Volume= 19,162 cf  
Primary = 4.02 cfs @ 12.30 hrs, Volume= 19,162 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-4: Study Point #4

Hydrograph



Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment E-1: Flow North to Wetland "D"	Runoff Area=122,563 sf 0.00% Impervious Runoff Depth=2.61" Flow Length=404' Tc=12.4 min CN=78 Runoff=6.94 cfs 26,659 cf
Subcatchment E-2: Flow West to Wetlands "F"	Runoff Area=17,293 sf 0.00% Impervious Runoff Depth=2.52" Tc=6.0 min CN=77 Runoff=1.15 cfs 3,636 cf
Subcatchment E-3: Flow Southwest Off-Site	Runoff Area=27,755 sf 0.00% Impervious Runoff Depth=2.61" Tc=6.0 min CN=78 Runoff=1.91 cfs 6,037 cf
Subcatchment E-4: Flow Southeast to Wetlands "A"	Runoff Area=185,366 sf 0.00% Impervious Runoff Depth=2.52" Flow Length=300' Tc=20.2 min CN=77 Runoff=8.40 cfs 38,972 cf
Subcatchment E-5: Off-Site Runoff NorthEast	Runoff Area=86,899 sf 0.00% Impervious Runoff Depth=2.61" Flow Length=299' Tc=9.8 min CN=78 Runoff=5.30 cfs 18,901 cf
Pond 1P: On-Site Depression	Peak Elev=96.42' Storage=18,188 cf Inflow=5.30 cfs 18,901 cf Discarded=0.02 cfs 1,056 cf Primary=0.00 cfs 0 cf Outflow=0.02 cfs 1,056 cf
Link SP-1: Study Point #1	Inflow=6.94 cfs 26,659 cf Primary=6.94 cfs 26,659 cf
Link SP-2: Study Point #2	Inflow=1.15 cfs 3,636 cf Primary=1.15 cfs 3,636 cf
Link SP-3: Study Point #3	Inflow=1.91 cfs 6,037 cf Primary=1.91 cfs 6,037 cf
Link SP-4: Study Point #4	Inflow=8.40 cfs 38,972 cf Primary=8.40 cfs 38,972 cf
Total Runoff Area = 439,876 sf Runoff Volume = 94,205 cf Average Runoff Depth = 2.57" 100.00% Pervious = 439,876 sf 0.00% Impervious = 0 sf	

Summary for Subcatchment E-1: Flow North to Wetland "D"

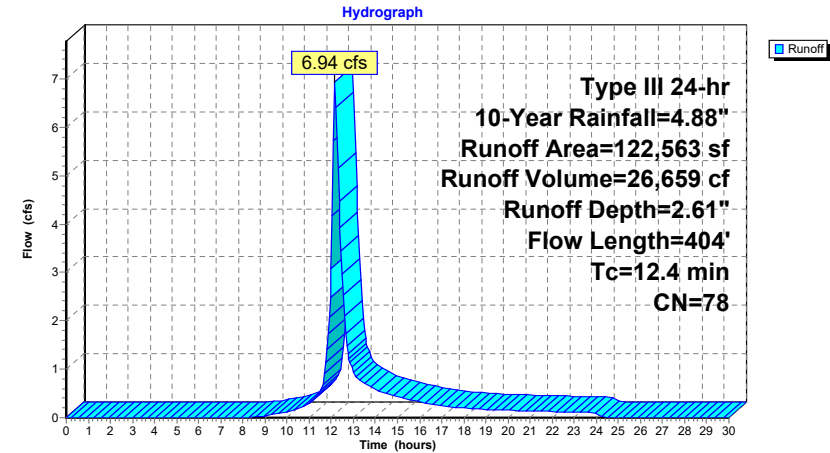
Runoff = 6.94 cfs @ 12.17 hrs, Volume= 26,659 cf, Depth= 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
4,563	91	Gravel roads, HSG D
118,000	77	Woods, Good, HSG D
122,563	78	Weighted Average
122,563		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.2556	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
4.6	354	0.2610	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
12.4	404	Total			

Subcatchment E-1: Flow North to Wetland "D"



Summary for Subcatchment E-2: Flow West to Wetlands "F"

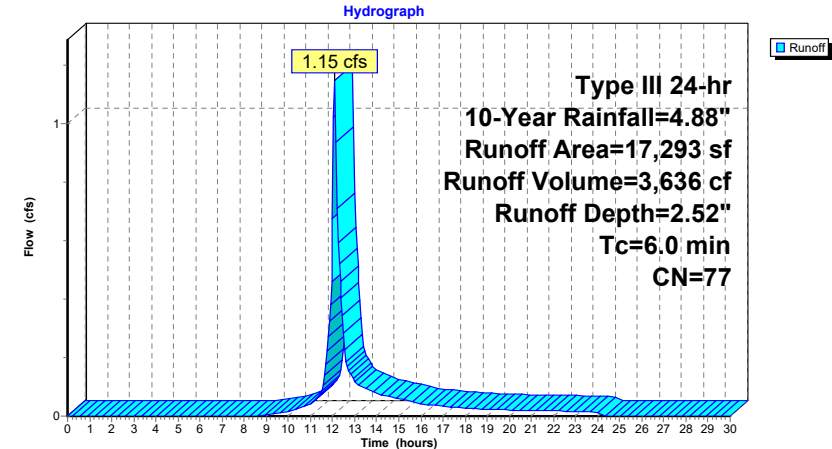
Runoff = 1.15 cfs @ 12.09 hrs, Volume= 3,636 cf, Depth= 2.52"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
17,293	77	Woods, Good, HSG D
17,293		100.00% Pervious Area

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

Subcatchment E-2: Flow West to Wetlands "F"



Summary for Subcatchment E-3: Flow Southwest Off-Site

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

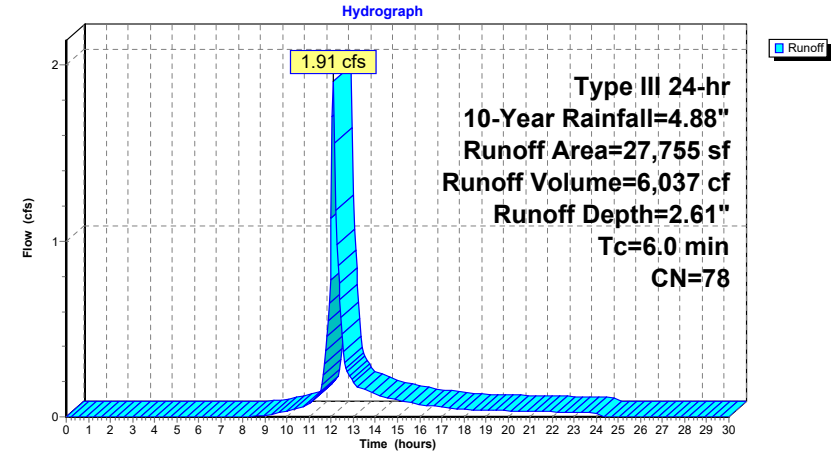
Runoff = 1.91 cfs @ 12.09 hrs, Volume= 6,037 cf, Depth= 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
1,087	91	Gravel roads, HSG D
26,668	77	Woods, Good, HSG D
27,755	78	Weighted Average
27,755		100.00% Pervious Area

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

Subcatchment E-3: Flow Southwest Off-Site



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Page 21

### Summary for Subcatchment E-4: Flow Southeast to Wetlands "A"

Runoff = 8.40 cfs @ 12.28 hrs, Volume= 38,972 cf, Depth= 2.52"

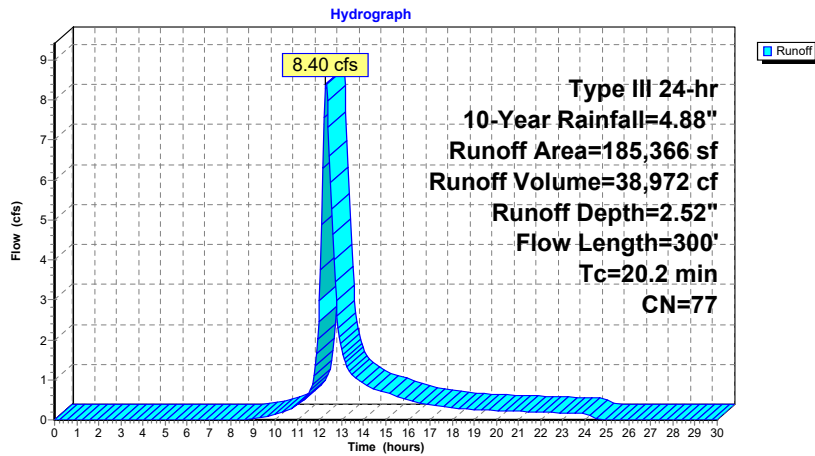
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
185,366	77	Woods, Good, HSG D
185,366		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3	50	0.0350	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	250	0.3200	1.41		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
20.2	300	Total			

### Subcatchment E-4: Flow Southeast to Wetlands "A"



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Page 22

### Summary for Subcatchment E-5: Off-Site Runoff NorthEast

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

Runoff = 5.30 cfs @ 12.14 hrs, Volume= 18,901 cf, Depth= 2.61"

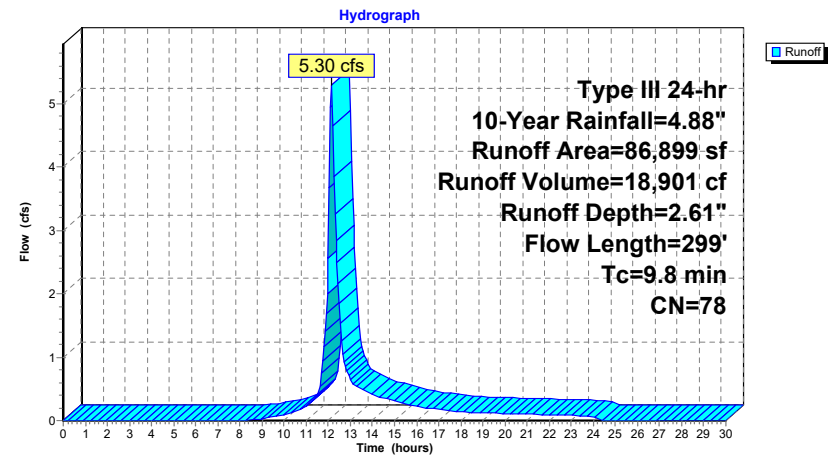
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
3,378	91	Gravel roads, HSG D
75,337	77	Woods, Good, HSG D
8,184	77	Wetlands, Good, HSG D
86,899	78	Weighted Average
86,899		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.3460	0.12		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	249	0.3267	1.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.8	299	Total			

### Subcatchment E-5: Off-Site Runoff NorthEast



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Page 23

### Summary for Pond 1P: On-Site Depression

[92] Warning: Device #2 is above defined storage

Inflow Area = 86,899 sf, 0.00% Impervious, Inflow Depth = 2.61" for 10-Year event  
Inflow = 5.30 cfs @ 12.14 hrs, Volume= 18,901 cf  
Outflow = 0.02 cfs @ 24.20 hrs, Volume= 1,056 cf, Atten= 100%, Lag= 723.4 min  
Discarded = 0.02 cfs @ 24.20 hrs, Volume= 1,056 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 96.42' @ 24.20 hrs Surf.Area= 7,980 sf Storage= 18,188 cf

Plug-Flow detention time= 631.2 min calculated for 1,056 cf (6% of inflow)  
Center-of-Mass det. time= 428.3 min ( 1,260.0 - 831.7 )

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	78,776 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
92.00	52	29.0	0	0	52
93.00	2,124	187.3	836	836	2,779
94.00	3,737	252.7	2,893	3,729	5,079
95.00	5,767	332.6	4,715	8,444	8,812
96.00	7,274	378.0	6,506	14,950	11,404
97.00	8,988	420.3	8,116	23,066	14,121
98.00	10,640	460.0	9,802	32,869	16,936
99.00	12,541	514.7	11,577	44,446	21,207
100.00	17,768	671.0	15,079	59,525	35,967
101.00	20,774	729.5	19,251	78,776	42,524

Device	Routing	Invert	Outlet Devices
#1	Discarded	92.00'	0.090 in/hr Exfiltration (D Soil) over Surface area
#2	Primary	101.00'	100.0' long x 1.0' 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
			Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Discarded OutFlow Max=0.02 cfs @ 24.20 hrs HW=96.42' (Free Discharge)

↳1=Exfiltration (D Soil) (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=92.00' (Free Discharge)

↳2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

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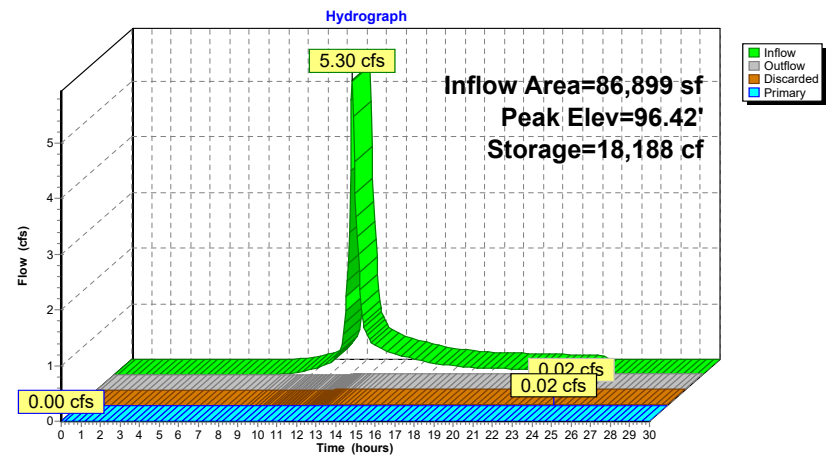
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Page 24

### Pond 1P: On-Site Depression



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Type III 24-hr 10-Year Rainfall=4.88"

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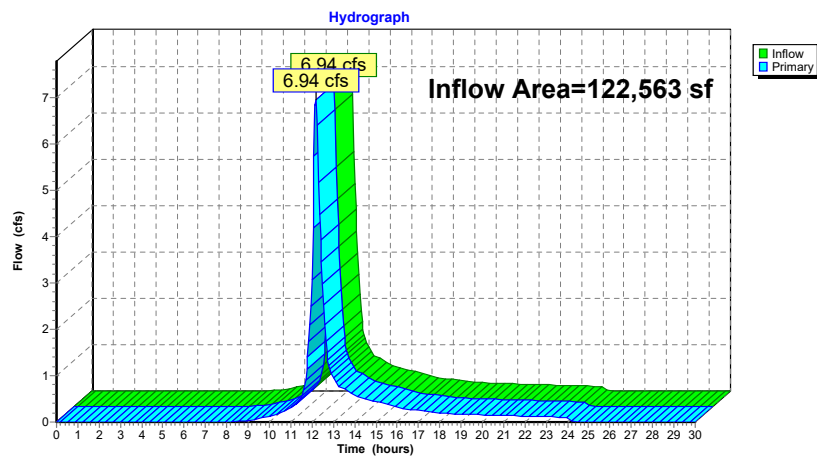
Page 25

### Summary for Link SP-1: Study Point #1

Inflow Area = 122,563 sf, 0.00% Impervious, Inflow Depth = 2.61" for 10-Year event  
Inflow = 6.94 cfs @ 12.17 hrs, Volume= 26,659 cf  
Primary = 6.94 cfs @ 12.17 hrs, Volume= 26,659 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1



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Type III 24-hr 10-Year Rainfall=4.88"

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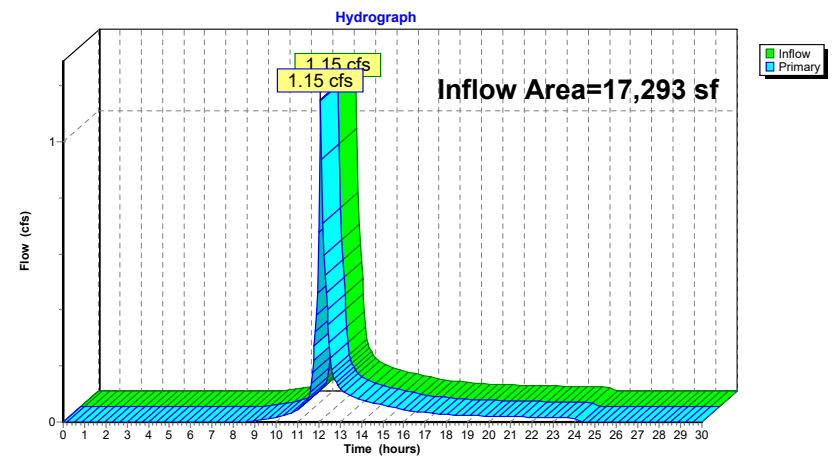
Page 26

### Summary for Link SP-2: Study Point #2

Inflow Area = 17,293 sf, 0.00% Impervious, Inflow Depth = 2.52" for 10-Year event  
Inflow = 1.15 cfs @ 12.09 hrs, Volume= 3,636 cf  
Primary = 1.15 cfs @ 12.09 hrs, Volume= 3,636 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2



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Page 27

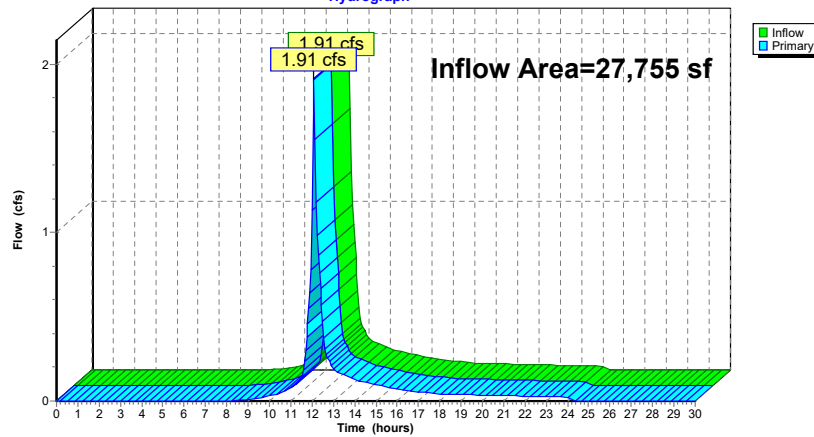
### Summary for Link SP-3: Study Point #3

Inflow Area = 27,755 sf, 0.00% Impervious, Inflow Depth = 2.61" for 10-Year event  
Inflow = 1.91 cfs @ 12.09 hrs, Volume= 6,037 cf  
Primary = 1.91 cfs @ 12.09 hrs, Volume= 6,037 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3

Hydrograph



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Page 28

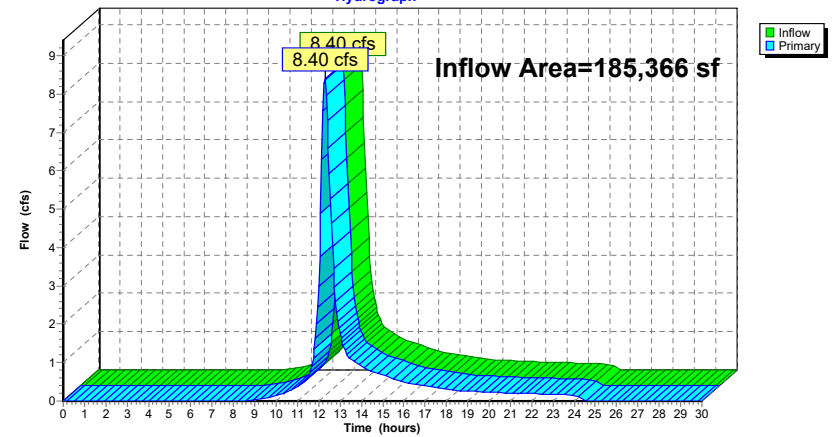
### Summary for Link SP-4: Study Point #4

Inflow Area = 185,366 sf, 0.00% Impervious, Inflow Depth = 2.52" for 10-Year event  
Inflow = 8.40 cfs @ 12.28 hrs, Volume= 38,972 cf  
Primary = 8.40 cfs @ 12.28 hrs, Volume= 38,972 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-4: Study Point #4

Hydrograph





Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment E-1: Flow North to Wetland "D"	Runoff Area=122,563 sf 0.00% Impervious Runoff Depth=3.73" Flow Length=404' Tc=12.4 min CN=78 Runoff=9.92 cfs 38,091 cf
Subcatchment E-2: Flow West to Wetlands "F"	Runoff Area=17,293 sf 0.00% Impervious Runoff Depth=3.63" Tc=6.0 min CN=77 Runoff=1.65 cfs 5,228 cf
Subcatchment E-3: Flow Southwest Off-Site	Runoff Area=27,755 sf 0.00% Impervious Runoff Depth=3.73" Tc=6.0 min CN=78 Runoff=2.72 cfs 8,626 cf
Subcatchment E-4: Flow Southeast to Wetlands "A"	Runoff Area=185,366 sf 0.00% Impervious Runoff Depth=3.63" Flow Length=300' Tc=20.2 min CN=77 Runoff=12.10 cfs 56,042 cf
Subcatchment E-5: Off-Site Runoff NorthEast	Runoff Area=86,899 sf 0.00% Impervious Runoff Depth=3.73" Flow Length=299' Tc=9.8 min CN=78 Runoff=7.56 cfs 27,007 cf
Pond 1P: On-Site Depression	Peak Elev=97.33' Storage=26,139 cf Inflow=7.56 cfs 27,007 cf Discarded=0.02 cfs 1,277 cf Primary=0.00 cfs 0 cf Outflow=0.02 cfs 1,277 cf
Link SP-1: Study Point #1	Inflow=9.92 cfs 38,091 cf Primary=9.92 cfs 38,091 cf
Link SP-2: Study Point #2	Inflow=1.65 cfs 5,228 cf Primary=1.65 cfs 5,228 cf
Link SP-3: Study Point #3	Inflow=2.72 cfs 8,626 cf Primary=2.72 cfs 8,626 cf
Link SP-4: Study Point #4	Inflow=12.10 cfs 56,042 cf Primary=12.10 cfs 56,042 cf
Total Runoff Area = 439,876 sf Runoff Volume = 134,994 cf Average Runoff Depth = 3.68" 100.00% Pervious = 439,876 sf 0.00% Impervious = 0 sf	

Summary for Subcatchment E-1: Flow North to Wetland "D"

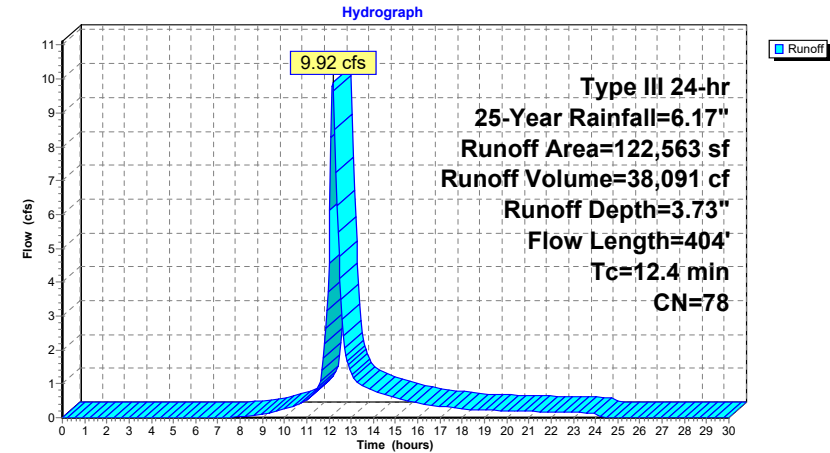
Runoff = 9.92 cfs @ 12.17 hrs, Volume= 38,091 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
4,563	91	Gravel roads, HSG D
118,000	77	Woods, Good, HSG D
122,563	78	Weighted Average
122,563		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.2556	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
4.6	354	0.2610	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
12.4	404	Total			

Subcatchment E-1: Flow North to Wetland "D"



Summary for Subcatchment E-2: Flow West to Wetlands "F"

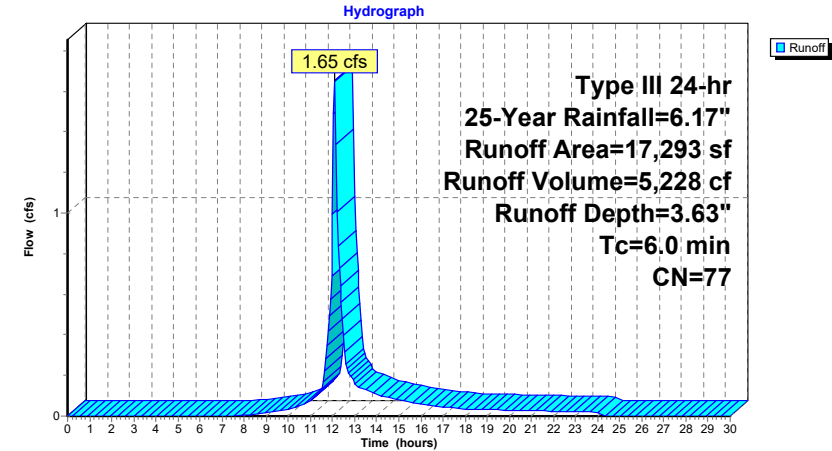
Runoff = 1.65 cfs @ 12.09 hrs, Volume= 5,228 cf, Depth= 3.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
17,293	77	Woods, Good, HSG D
17,293		100.00% Pervious Area

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

Subcatchment E-2: Flow West to Wetlands "F"



Summary for Subcatchment E-3: Flow Southwest Off-Site

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

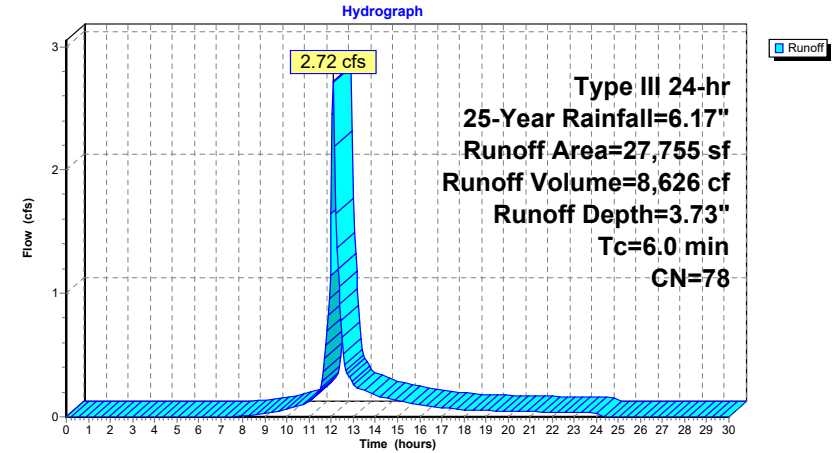
Runoff = 2.72 cfs @ 12.09 hrs, Volume= 8,626 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
1,087	91	Gravel roads, HSG D
26,668	77	Woods, Good, HSG D
27,755	78	Weighted Average
27,755		100.00% Pervious Area

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

Subcatchment E-3: Flow Southwest Off-Site



Summary for Subcatchment E-4: Flow Southeast to Wetlands "A"

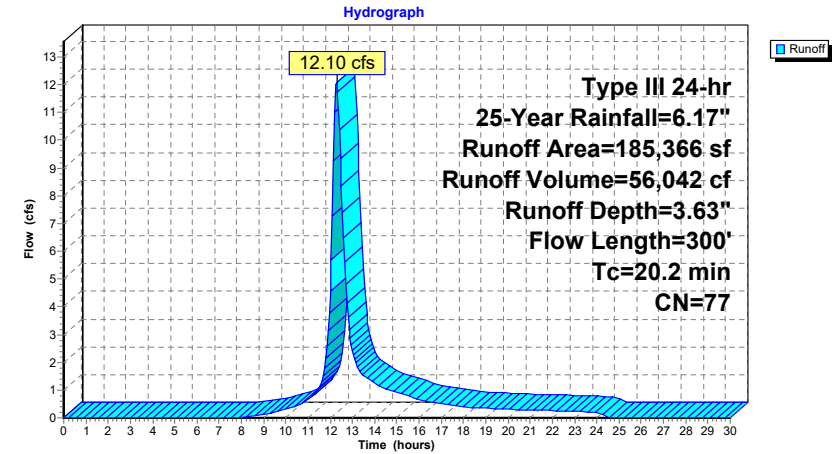
Runoff = 12.10 cfs @ 12.28 hrs, Volume= 56,042 cf, Depth= 3.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
185,366	77	Woods, Good, HSG D
185,366		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3	50	0.0350	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	250	0.3200	1.41		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
20.2	300	Total			

Subcatchment E-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment E-5: Off-Site Runoff NorthEast

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

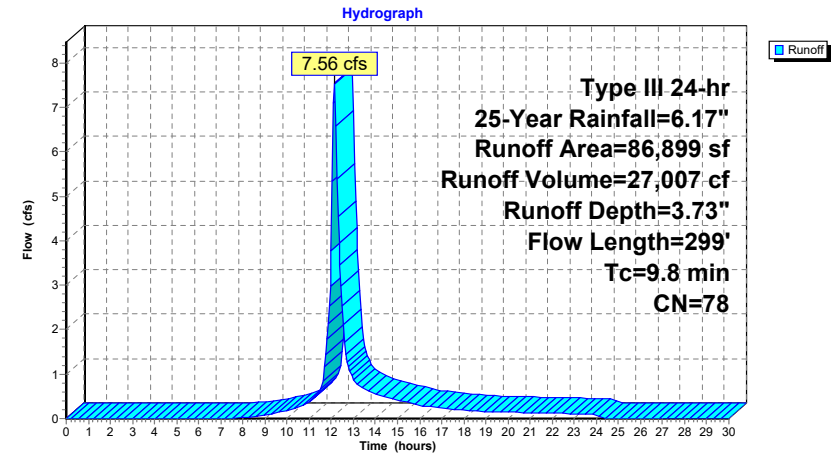
Runoff = 7.56 cfs @ 12.14 hrs, Volume= 27,007 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
3,378	91	Gravel roads, HSG D
75,337	77	Woods, Good, HSG D
8,184	77	Wetlands, Good, HSG D
86,899	78	Weighted Average
86,899		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.3460	0.12		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	249	0.3267	1.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.8	299	Total			

Subcatchment E-5: Off-Site Runoff NorthEast



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Page 35

### Summary for Pond 1P: On-Site Depression

[92] Warning: Device #2 is above defined storage

Inflow Area = 86,899 sf, 0.00% Impervious, Inflow Depth = 3.73" for 25-Year event  
Inflow = 7.56 cfs @ 12.14 hrs, Volume= 27,007 cf  
Outflow = 0.02 cfs @ 24.21 hrs, Volume= 1,277 cf, Atten= 100%, Lag= 724.0 min  
Discarded = 0.02 cfs @ 24.21 hrs, Volume= 1,277 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 97.33' @ 24.21 hrs Surf.Area= 9,521 sf Storage= 26,139 cf

Plug-Flow detention time= 664.6 min calculated for 1,274 cf (5% of inflow)  
Center-of-Mass det. time= 430.6 min ( 1,252.1 - 821.5 )

Volume	Invert	Avail.Storage	Storage Description		
#1	92.00'	78,776 cf	Custom Stage Data (Irregular) Listed below (Recalc)		
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
92.00	52	29.0	0	0	52
93.00	2,124	187.3	836	836	2,779
94.00	3,737	252.7	2,893	3,729	5,079
95.00	5,767	332.6	4,715	8,444	8,812
96.00	7,274	378.0	6,506	14,950	11,404
97.00	8,988	420.3	8,116	23,066	14,121
98.00	10,640	460.0	9,802	32,869	16,936
99.00	12,541	514.7	11,577	44,446	21,207
100.00	17,768	671.0	15,079	59,525	35,967
101.00	20,774	729.5	19,251	78,776	42,524

Device	Routing	Invert	Outlet Devices
#1	Discarded	92.00'	0.090 in/hr Exfiltration (D Soil) over Surface area
#2	Primary	101.00'	100.0' long x 1.0' 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
			Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Discarded OutFlow Max=0.02 cfs @ 24.21 hrs HW=97.33' (Free Discharge)

↳1=Exfiltration (D Soil) (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=92.00' (Free Discharge)

↳2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

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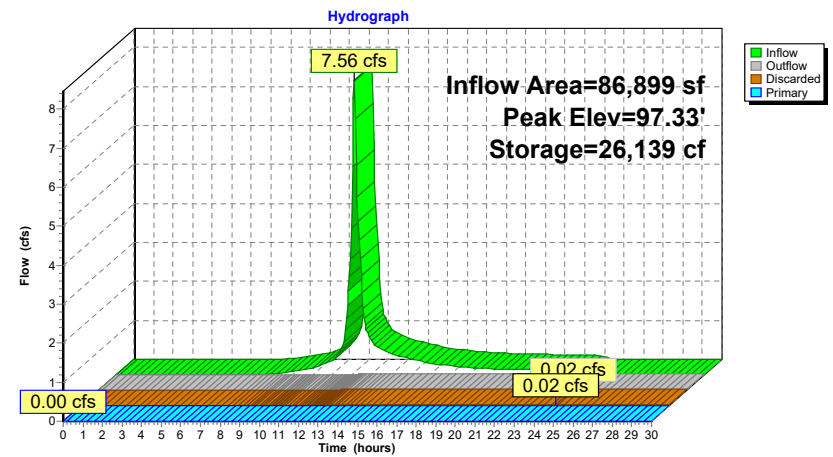
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Page 36

### Pond 1P: On-Site Depression



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Page 37

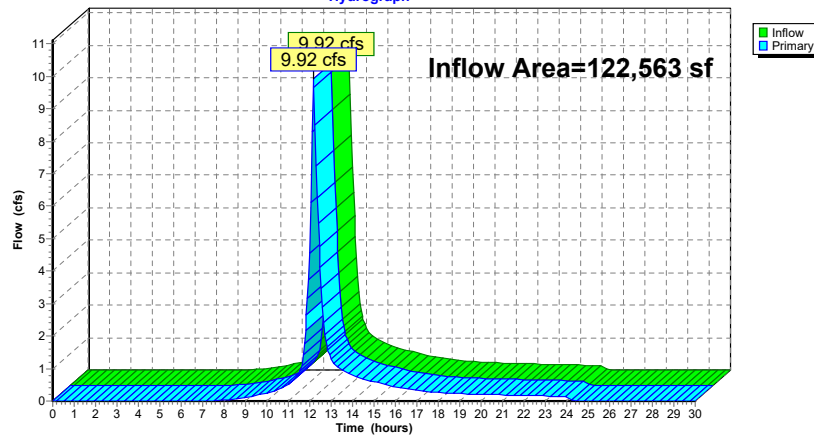
### Summary for Link SP-1: Study Point #1

Inflow Area = 122,563 sf, 0.00% Impervious, Inflow Depth = 3.73" for 25-Year event  
Inflow = 9.92 cfs @ 12.17 hrs, Volume= 38,091 cf  
Primary = 9.92 cfs @ 12.17 hrs, Volume= 38,091 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-1: Study Point #1

Hydrograph



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Page 38

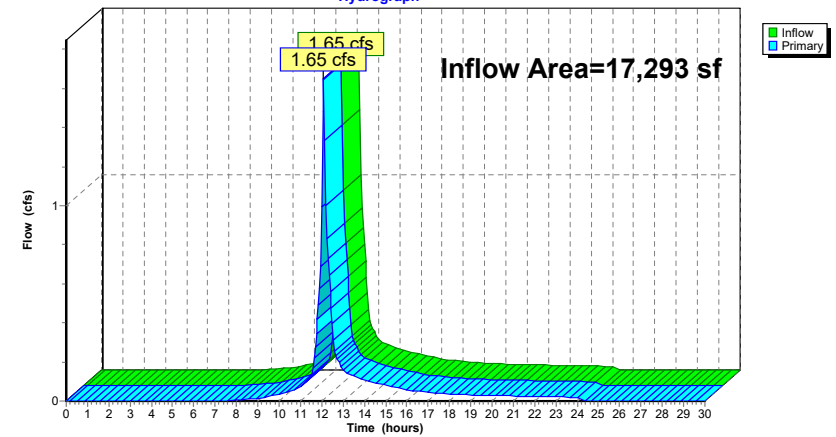
### Summary for Link SP-2: Study Point #2

Inflow Area = 17,293 sf, 0.00% Impervious, Inflow Depth = 3.63" for 25-Year event  
Inflow = 1.65 cfs @ 12.09 hrs, Volume= 5,228 cf  
Primary = 1.65 cfs @ 12.09 hrs, Volume= 5,228 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-2: Study Point #2

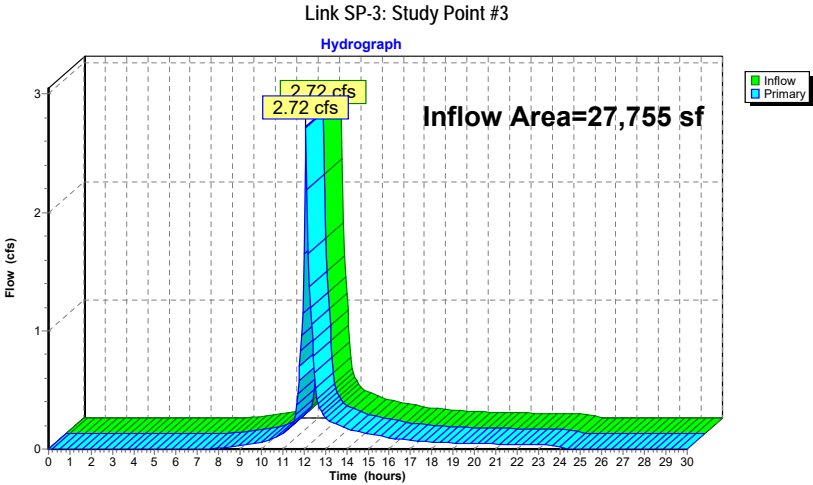
Hydrograph



Summary for Link SP-3: Study Point #3

Inflow Area = 27,755 sf, 0.00% Impervious, Inflow Depth = 3.73" for 25-Year event  
Inflow = 2.72 cfs @ 12.09 hrs, Volume= 8,626 cf  
Primary = 2.72 cfs @ 12.09 hrs, Volume= 8,626 cf, Atten= 0%, Lag= 0.0 min

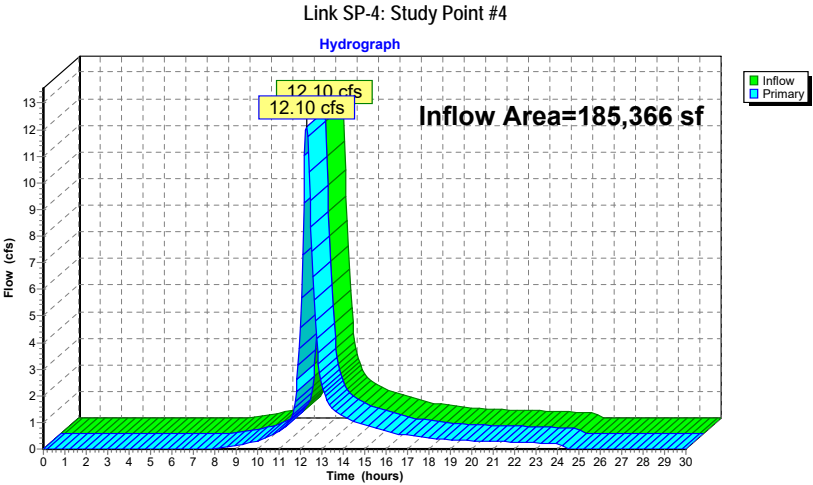
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Summary for Link SP-4: Study Point #4

Inflow Area = 185,366 sf, 0.00% Impervious, Inflow Depth = 3.63" for 25-Year event  
Inflow = 12.10 cfs @ 12.28 hrs, Volume= 56,042 cf  
Primary = 12.10 cfs @ 12.28 hrs, Volume= 56,042 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment E-1: Flow North to Wetland "D"	Runoff Area=122,563 sf 0.00% Impervious Runoff Depth=6.13" Flow Length=404' Tc=12.4 min CN=78 Runoff=16.14 cfs 62,659 cf
Subcatchment E-2: Flow West to Wetlands "F"	Runoff Area=17,293 sf 0.00% Impervious Runoff Depth=6.01" Tc=6.0 min CN=77 Runoff=2.71 cfs 8,665 cf
Subcatchment E-3: Flow Southwest Off-Site	Runoff Area=27,755 sf 0.00% Impervious Runoff Depth=6.13" Tc=6.0 min CN=78 Runoff=4.42 cfs 14,190 cf
Subcatchment E-4: Flow Southeast to Wetlands "A"	Runoff Area=185,366 sf 0.00% Impervious Runoff Depth=6.01" Flow Length=300' Tc=20.2 min CN=77 Runoff=19.94 cfs 92,883 cf
Subcatchment E-5: Off-Site Runoff NorthEast	Runoff Area=86,899 sf 0.00% Impervious Runoff Depth=6.13" Flow Length=299' Tc=9.8 min CN=78 Runoff=12.27 cfs 44,426 cf
Pond 1P: On-Site Depression	Peak Elev=98.91' Storage=43,273 cf Inflow=12.27 cfs 44,426 cf Discarded=0.03 cfs 1,682 cf Primary=0.00 cfs 0 cf Outflow=0.03 cfs 1,682 cf
Link SP-1: Study Point #1	Inflow=16.14 cfs 62,659 cf Primary=16.14 cfs 62,659 cf
Link SP-2: Study Point #2	Inflow=2.71 cfs 8,665 cf Primary=2.71 cfs 8,665 cf
Link SP-3: Study Point #3	Inflow=4.42 cfs 14,190 cf Primary=4.42 cfs 14,190 cf
Link SP-4: Study Point #4	Inflow=19.94 cfs 92,883 cf Primary=19.94 cfs 92,883 cf
Total Runoff Area = 439,876 sf Runoff Volume = 222,824 cf Average Runoff Depth = 6.08" 100.00% Pervious = 439,876 sf 0.00% Impervious = 0 sf	

Summary for Subcatchment E-1: Flow North to Wetland "D"

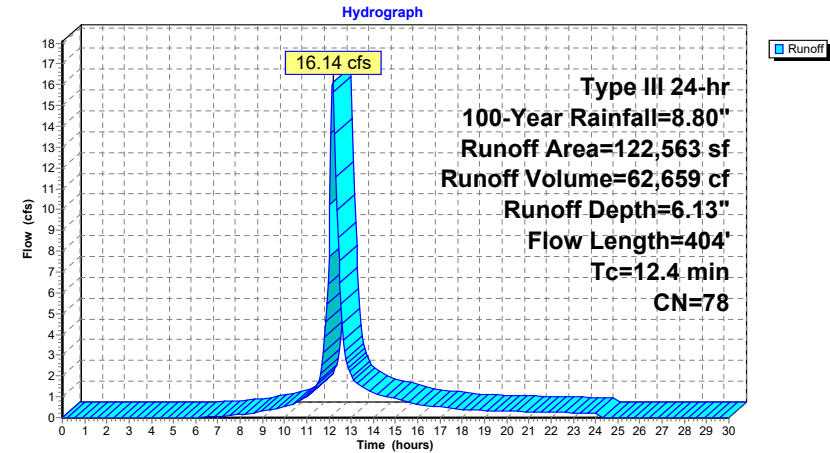
Runoff = 16.14 cfs @ 12.17 hrs, Volume= 62,659 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
4,563	91	Gravel roads, HSG D
118,000	77	Woods, Good, HSG D
122,563	78	Weighted Average
122,563		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.2556	0.11		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
4.6	354	0.2610	1.28		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
12.4	404	Total			

Subcatchment E-1: Flow North to Wetland "D"





Summary for Subcatchment E-2: Flow West to Wetlands "F"

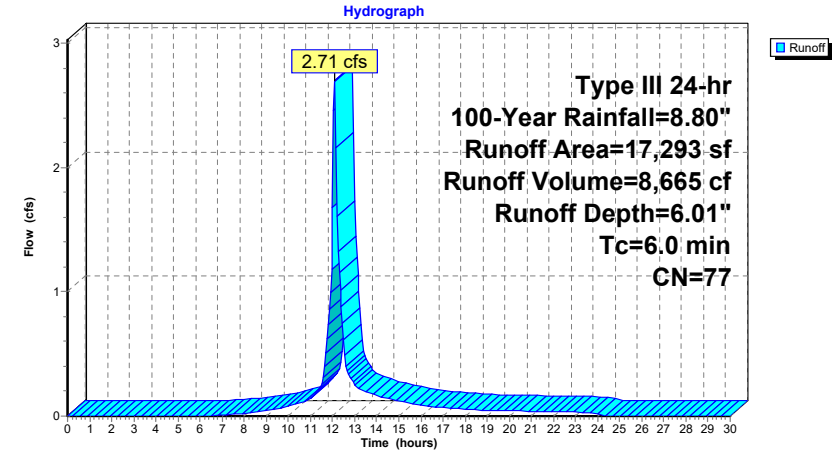
Runoff = 2.71 cfs @ 12.09 hrs, Volume= 8,665 cf, Depth= 6.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
17,293	77	Woods, Good, HSG D
17,293		100.00% Pervious Area

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

Subcatchment E-2: Flow West to Wetlands "F"



Summary for Subcatchment E-3: Flow Southwest Off-Site

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

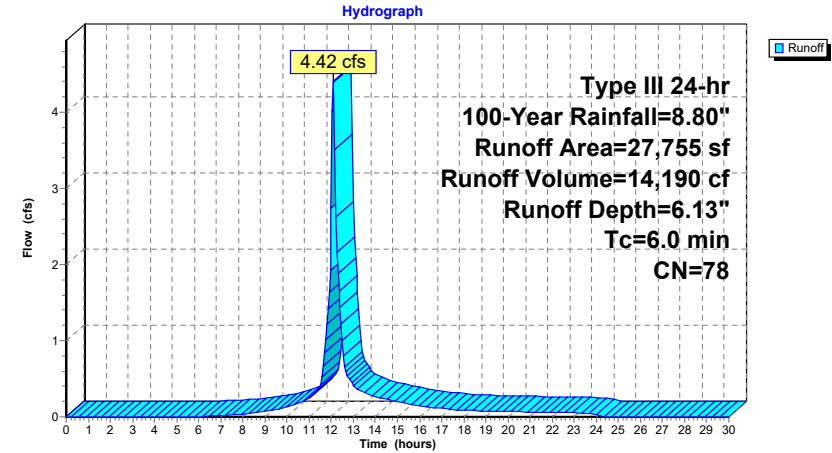
Runoff = 4.42 cfs @ 12.09 hrs, Volume= 14,190 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
1,087	91	Gravel roads, HSG D
26,668	77	Woods, Good, HSG D
27,755	78	Weighted Average
27,755		100.00% Pervious Area

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

Subcatchment E-3: Flow Southwest Off-Site



Summary for Subcatchment E-4: Flow Southeast to Wetlands "A"

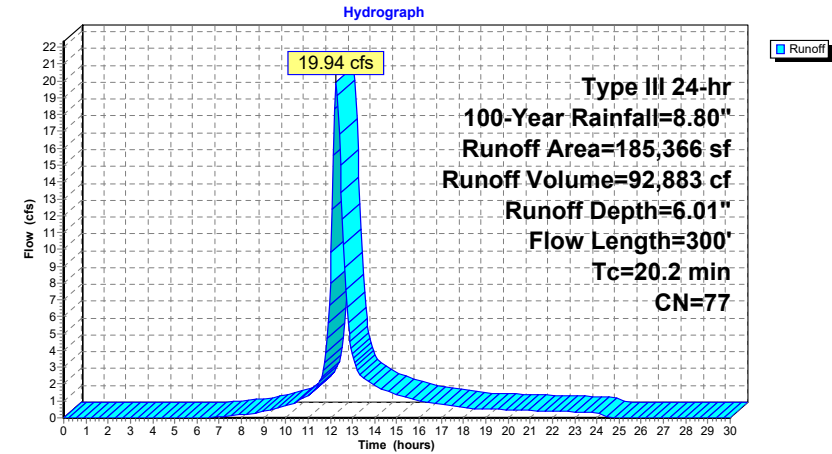
Runoff = 19.94 cfs @ 12.27 hrs, Volume= 92,883 cf, Depth= 6.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
185,366	77	Woods, Good, HSG D
185,366		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
17.3	50	0.0350	0.05		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	250	0.3200	1.41		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
20.2	300	Total			

Subcatchment E-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment E-5: Off-Site Runoff NorthEast

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

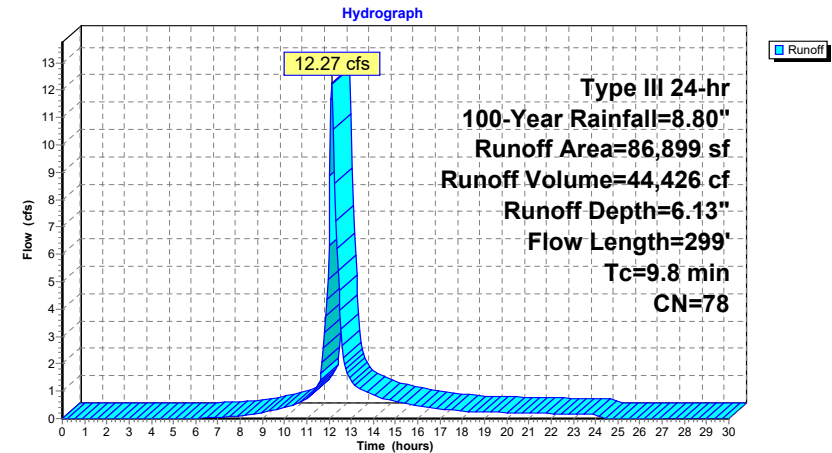
Runoff = 12.27 cfs @ 12.14 hrs, Volume= 44,426 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
3,378	91	Gravel roads, HSG D
75,337	77	Woods, Good, HSG D
8,184	77	Wetlands, Good, HSG D
86,899	78	Weighted Average
86,899		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.9	50	0.3460	0.12		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.9	249	0.3267	1.43		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
9.8	299	Total			

Subcatchment E-5: Off-Site Runoff NorthEast



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Page 47

### Summary for Pond 1P: On-Site Depression

[92] Warning: Device #2 is above defined storage

Inflow Area = 86,899 sf, 0.00% Impervious, Inflow Depth = 6.13" for 100-Year event  
Inflow = 12.27 cfs @ 12.14 hrs, Volume= 44,426 cf  
Outflow = 0.03 cfs @ 24.22 hrs, Volume= 1,682 cf, Atten= 100%, Lag= 724.7 min  
Discarded = 0.03 cfs @ 24.22 hrs, Volume= 1,682 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 98.91' @ 24.22 hrs Surf.Area= 12,355 sf Storage= 43,273 cf

Plug-Flow detention time= 720.8 min calculated for 1,682 cf (4% of inflow)  
Center-of-Mass det. time= 433.0 min ( 1,240.4 - 807.4 )

Volume	Invert	Avail.Storage	Storage Description
#1	92.00'	78,776 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
92.00	52	29.0	0	0	52
93.00	2,124	187.3	836	836	2,779
94.00	3,737	252.7	2,893	3,729	5,079
95.00	5,767	332.6	4,715	8,444	8,812
96.00	7,274	378.0	6,506	14,950	11,404
97.00	8,988	420.3	8,116	23,066	14,121
98.00	10,640	460.0	9,802	32,869	16,936
99.00	12,541	514.7	11,577	44,446	21,207
100.00	17,768	671.0	15,079	59,525	35,967
101.00	20,774	729.5	19,251	78,776	42,524

Device	Routing	Invert	Outlet Devices
#1	Discarded	92.00'	0.090 in/hr Exfiltration (D Soil) over Surface area
#2	Primary	101.00'	100.0' long x 1.0' 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
			Coef. (English) 2.69 2.72 2.75 2.85 2.98 3.08 3.20 3.28 3.31 3.30 3.31 3.32

Discarded OutFlow Max=0.03 cfs @ 24.22 hrs HW=98.91' (Free Discharge)

↳1=Exfiltration (D Soil) (Exfiltration Controls 0.03 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=92.00' (Free Discharge)

↳2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

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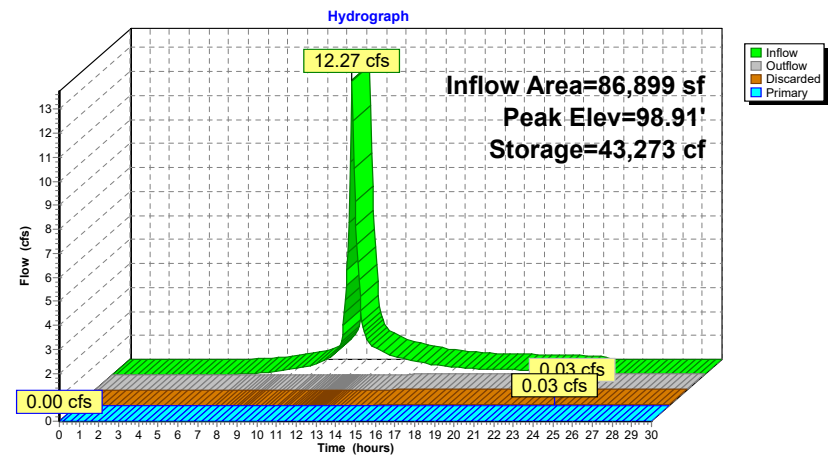
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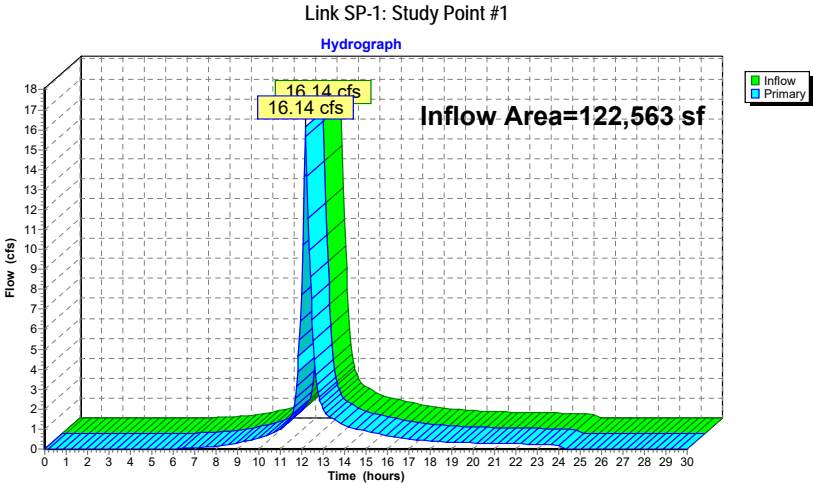
Page 48

### Pond 1P: On-Site Depression



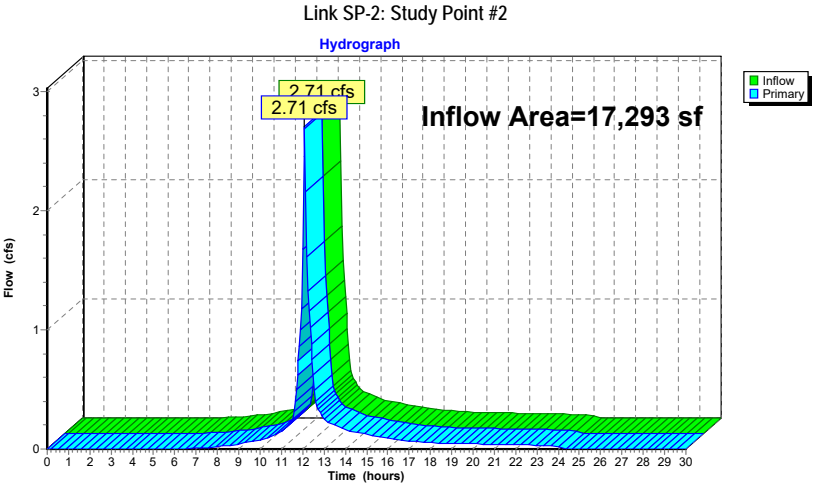
Summary for Link SP-1: Study Point #1

Inflow Area = 122,563 sf, 0.00% Impervious, Inflow Depth = 6.13" for 100-Year event  
Inflow = 16.14 cfs @ 12.17 hrs, Volume= 62,659 cf  
Primary = 16.14 cfs @ 12.17 hrs, Volume= 62,659 cf, Atten= 0%, Lag= 0.0 min  
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Summary for Link SP-2: Study Point #2

Inflow Area = 17,293 sf, 0.00% Impervious, Inflow Depth = 6.01" for 100-Year event  
Inflow = 2.71 cfs @ 12.09 hrs, Volume= 8,665 cf  
Primary = 2.71 cfs @ 12.09 hrs, Volume= 8,665 cf, Atten= 0%, Lag= 0.0 min  
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



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Page 51

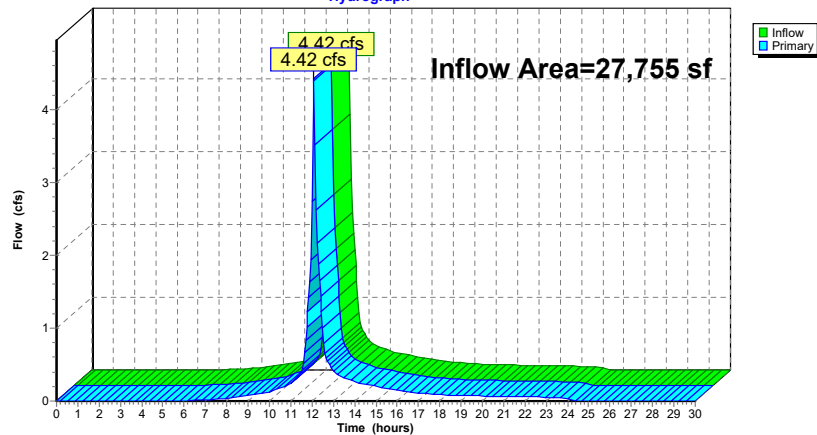
### Summary for Link SP-3: Study Point #3

Inflow Area = 27,755 sf, 0.00% Impervious, Inflow Depth = 6.13" for 100-Year event  
Inflow = 4.42 cfs @ 12.09 hrs, Volume= 14,190 cf  
Primary = 4.42 cfs @ 12.09 hrs, Volume= 14,190 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-3: Study Point #3

Hydrograph



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Page 52

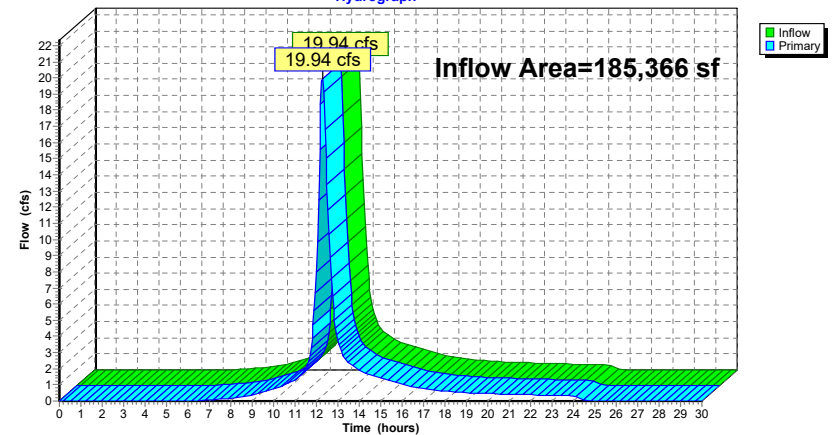
### Summary for Link SP-4: Study Point #4

Inflow Area = 185,366 sf, 0.00% Impervious, Inflow Depth = 6.01" for 100-Year event  
Inflow = 19.94 cfs @ 12.27 hrs, Volume= 92,883 cf  
Primary = 19.94 cfs @ 12.27 hrs, Volume= 92,883 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-4: Study Point #4

Hydrograph



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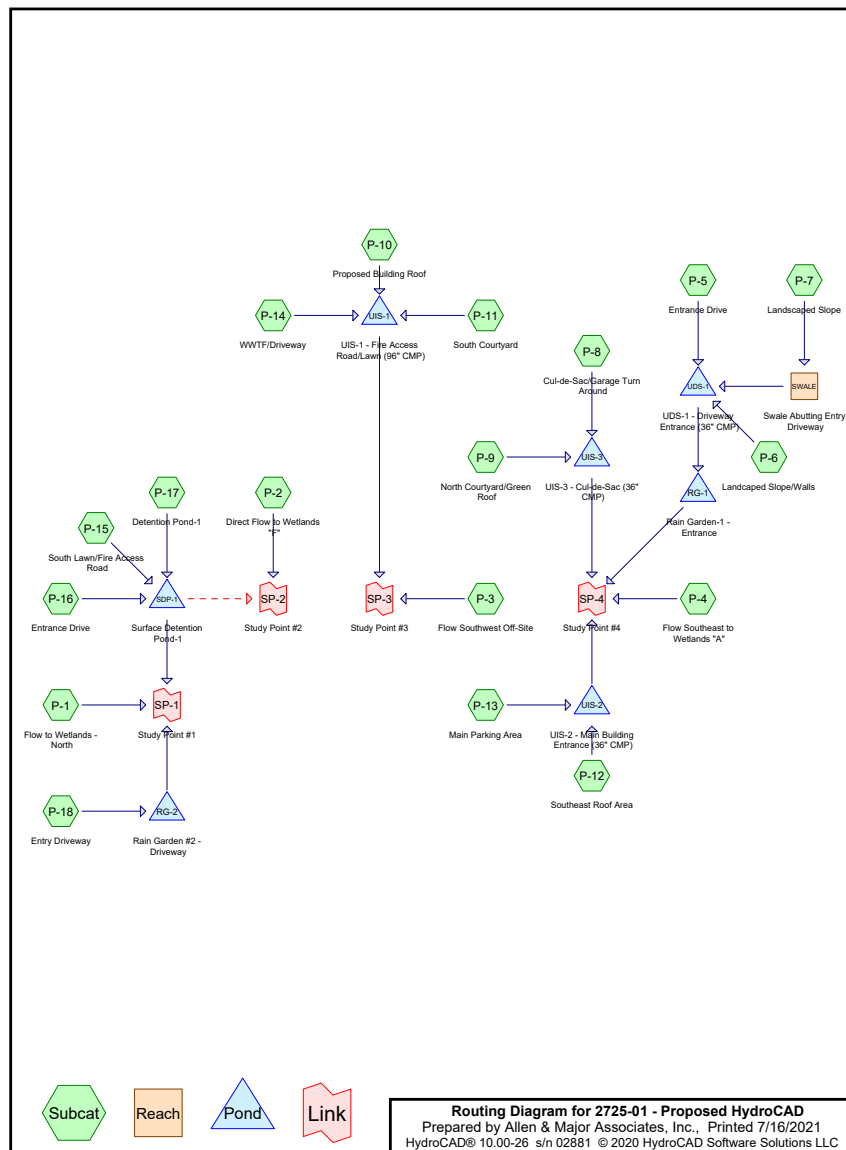
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Page 2

**Area Listing (all nodes)**

Area (sq-ft)	CN	Description (subcatchment-numbers)
164,020	80	>75% Grass cover, Good, HSG D (P-1, P-13, P-14, P-15, P-16, P-2, P-3, P-4, P-5, P-6, P-7, P-8, P-9)
6,865	73	Brush, Good, HSG D (P-17)
7,708	80	GrassPave-2 (P-14, P-15)
4,872	91	Gravel roads, HSG D (P-17)
35,808	98	Paved parking, HSG D (P-14, P-5, P-7, P-8)
50,089	98	Unconnected pavement, HSG D (P-11, P-13, P-16, P-18, P-3, P-4, P-6)
62,654	98	Unconnected roofs, HSG D (P-10, P-12, P-9)
107,852	77	Woods, Good, HSG D (P-1, P-2, P-3, P-4)
<b>439,868</b>	<b>85</b>	<b>TOTAL AREA</b>



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Page 3

**Soil Listing (all nodes)**

Area (sq-ft)	Soil Group	Subcatchment Numbers
0	HSG A	
0	HSG B	
0	HSG C	
432,160	HSG D	P-1, P-10, P-11, P-12, P-13, P-14, P-15, P-16, P-17, P-18, P-2, P-3, P-4, P-5, P-6, P-7, P-8, P-9
7,708	Other	P-14, P-15
<b>439,868</b>		<b>TOTAL AREA</b>

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Page 4

**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	Subcatchment Numbers
0	0	0	164,020	0	164,020	>75% Grass cover, Good	P-1, P-13, P-14, P-15, P-16, P-2, P-3, P-4, P-5, P-6, P-7, P-8, P-9
0	0	0	6,865	0	6,865	Brush, Good	P-17
0	0	0	0	7,708	7,708	GrassPave-2	P-14, P-15
0	0	0	4,872	0	4,872	Gravel roads	P-17
0	0	0	35,808	0	35,808	Paved parking	P-14, P-5, P-7, P-8
0	0	0	50,089	0	50,089	Unconnected pavement	P-11, P-13, P-16, P-18, P-3, P-4, P-6
0	0	0	62,654	0	62,654	Unconnected roofs	P-10, P-12, P-9
0	0	0	107,852	0	107,852	Woods, Good	P-1, P-2, P-3, P-4
<b>0</b>	<b>0</b>	<b>0</b>	<b>432,160</b>	<b>7,708</b>	<b>439,868</b>	<b>TOTAL AREA</b>	



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Page 5

**Pipe Listing (all nodes)**

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	RG-1	51.00	50.50	100.0	0.0050	0.013	24.0	0.0	0.0
2	SDP-1	78.00	77.00	100.0	0.0100	0.013	15.0	0.0	0.0
3	UDS-1	47.00	46.00	100.0	0.0100	0.012	18.0	0.0	0.0
4	UIS-1	103.00	102.00	100.0	0.0100	0.013	12.0	0.0	0.0
5	UIS-2	117.00	116.00	100.0	0.0100	0.012	15.0	0.0	0.0
6	UIS-3	107.00	102.00	100.0	0.0500	0.013	12.0	0.0	0.0

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Page 6

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North	Runoff Area=17,171 sf 0.00% Impervious Runoff Depth=0.07" Tc=6.0 min CN=79 Runoff=0.01 cfs 100 cf
Subcatchment P-10: Proposed Building Roof	Runoff Area=30,342 sf 100.00% Impervious Runoff Depth=0.79" Tc=6.0 min CN=98 Runoff=0.61 cfs 2,000 cf
Subcatchment P-11: South Courtyard	Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=0.79" Tc=6.0 min CN=98 Runoff=0.40 cfs 1,330 cf
Subcatchment P-12: Southeast Roof Area	Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=0.79" Tc=6.0 min CN=98 Runoff=0.54 cfs 1,796 cf
Subcatchment P-13: Main Parking Area	Runoff Area=17,700 sf 76.07% Impervious Runoff Depth=0.50" Tc=6.0 min CN=94 Runoff=0.24 cfs 743 cf
Subcatchment P-14: WWTF/Driveway	Runoff Area=19,605 sf 33.29% Impervious Runoff Depth=0.20" Tc=6.0 min CN=86 Runoff=0.08 cfs 323 cf
Subcatchment P-15: South Lawn/Fire Access Road	Runoff Area=18,445 sf 0.00% Impervious Runoff Depth=0.08" Tc=6.0 min CN=80 Runoff=0.02 cfs 128 cf
Subcatchment P-16: Entrance Drive	Runoff Area=20,820 sf 44.13% Impervious Runoff Depth=0.25" Tc=6.0 min CN=88 Runoff=0.12 cfs 439 cf
Subcatchment P-17: Detention Pond-1	Runoff Area=11,737 sf 0.00% Impervious Runoff Depth=0.08" Tc=6.0 min CN=80 Runoff=0.01 cfs 82 cf
Subcatchment P-18: Entry Driveway	Runoff Area=5,160 sf 100.00% Impervious Runoff Depth=0.79" Tc=6.0 min CN=98 Runoff=0.10 cfs 340 cf
Subcatchment P-2: Direct Flow to Wetlands "F"	Runoff Area=9,691 sf 0.00% Impervious Runoff Depth=0.06" Tc=6.0 min CN=78 Runoff=0.00 cfs 47 cf
Subcatchment P-3: Flow Southwest Off-Site	Runoff Area=27,985 sf 1.79% Impervious Runoff Depth=0.08" Flow Length=194' Slope=0.0100 ' Tc=10.9 min CN=80 Runoff=0.02 cfs 194 cf
Subcatchment P-4: Flow Southeast to Wetlands "A"	Runoff Area=117,759 sf 0.54% Impervious Runoff Depth=0.06" Flow Length=186' Tc=14.0 min CN=78 Runoff=0.05 cfs 573 cf
Subcatchment P-5: Entrance Drive	Runoff Area=14,879 sf 78.94% Impervious Runoff Depth=0.50" Tc=6.0 min CN=94 Runoff=0.20 cfs 625 cf
Subcatchment P-6: Landcaped Slope/Walls	Runoff Area=18,477 sf 5.22% Impervious Runoff Depth=0.08" Tc=6.0 min UI Adjusted CN=80 Runoff=0.02 cfs 128 cf
Subcatchment P-7: Landscaped Slope	Runoff Area=24,884 sf 3.17% Impervious Runoff Depth=0.10" Tc=6.0 min CN=81 Runoff=0.03 cfs 203 cf

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Page 7

Subcatchment P-8: Cul-de-Sac/Garage Turn Around      Runoff Area=22,451 sf    74.60% Impervious    Runoff Depth=0.45"  
Tc=6.0 min    CN=93    Runoff=0.27 cfs    843 cf

Subcatchment P-9: North Courtyard/Green Roof      Runoff Area=15,328 sf    33.00% Impervious    Runoff Depth=0.20"  
Tc=6.0 min    CN=86    Runoff=0.06 cfs    252 cf

Reach SWALE: Swale Abutting Entry Driveway      Avg. Flow Depth=0.02'    Max Vel=0.67 fps    Inflow=0.03 cfs    203 cf  
n=0.040    L=427.0'    S=0.0749 /'    Capacity=16.60 cfs    Outflow=0.02 cfs    203 cf

Pond RG-1: Rain Garden-1 - Entrance      Peak Elev=50.50'    Storage=950 cf    Inflow=0.09 cfs    950 cf  
24.0" Round Culvert    n=0.013    L=100.0'    S=0.0050 /'    Outflow=0.00 cfs    0 cf

Pond RG-2: Rain Garden #2 - Driveway      Peak Elev=162.49'    Storage=340 cf    Inflow=0.10 cfs    340 cf  
Outflow=0.00 cfs    0 cf

Pond SDP-1: Surface Detention Pond-1      Peak Elev=76.91'    Storage=648 cf    Inflow=0.14 cfs    648 cf  
Primary=0.00 cfs    0 cf    Secondary=0.00 cfs    0 cf    Outflow=0.00 cfs    0 cf

Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)      Peak Elev=47.16'    Storage=228 cf    Inflow=0.21 cfs    956 cf  
Outflow=0.09 cfs    950 cf

Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)      Peak Elev=102.08'    Storage=3,653 cf    Inflow=1.09 cfs    3,653 cf  
Outflow=0.00 cfs    0 cf

Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)      Peak Elev=117.37'    Storage=972 cf    Inflow=0.78 cfs    2,539 cf  
Discarded=0.08 cfs    2,539 cf    Primary=0.00 cfs    0 cf    Outflow=0.08 cfs    2,539 cf

Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)      Peak Elev=107.10'    Storage=206 cf    Inflow=0.33 cfs    1,095 cf  
Discarded=0.12 cfs    1,095 cf    Primary=0.00 cfs    0 cf    Outflow=0.12 cfs    1,095 cf

Link SP-1: Study Point #1      Inflow=0.01 cfs    100 cf  
Primary=0.01 cfs    100 cf

Link SP-2: Study Point #2      Inflow=0.00 cfs    47 cf  
Primary=0.00 cfs    47 cf

Link SP-3: Study Point #3      Inflow=0.02 cfs    194 cf  
Primary=0.02 cfs    194 cf

Link SP-4: Study Point #4      Inflow=0.05 cfs    573 cf  
Primary=0.05 cfs    573 cf

Total Runoff Area = 439,868 sf    Runoff Volume = 10,146 cf    Average Runoff Depth = 0.28"  
66.23% Pervious = 291,317 sf    33.77% Impervious = 148,551 sf

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Page 8

### Summary for Subcatchment P-1: Flow to Wetlands - North

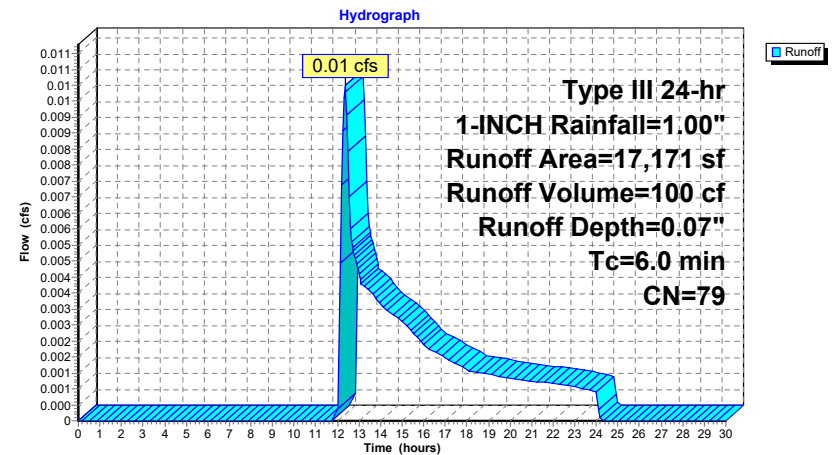
Runoff = 0.01 cfs @ 12.36 hrs, Volume= 100 cf, Depth= 0.07"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
12,252	80	>75% Grass cover, Good, HSG D
4,919	77	Woods, Good, HSG D
17,171	79	Weighted Average
17,171		100.00% Pervious Area

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

### Subcatchment P-1: Flow to Wetlands - North



Summary for Subcatchment P-10: Proposed Building Roof

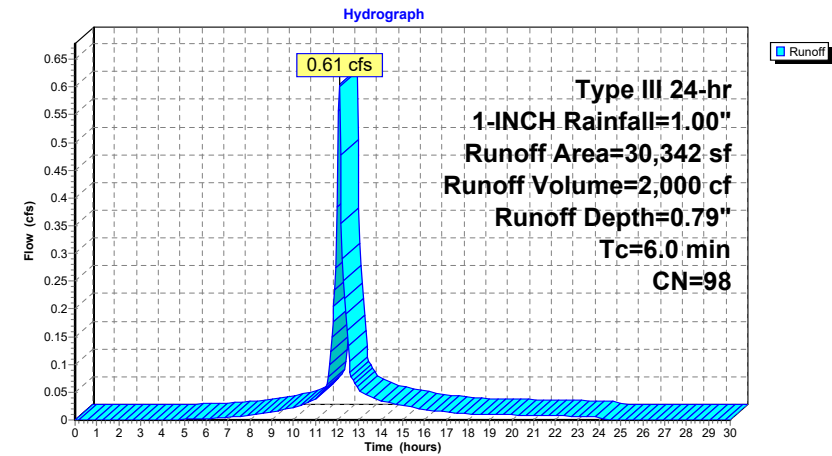
Runoff = 0.61 cfs @ 12.09 hrs, Volume= 2,000 cf, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
30,342	98	Unconnected roofs, HSG D
30,342		100.00% Impervious Area
30,342		100.00% Unconnected

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

Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

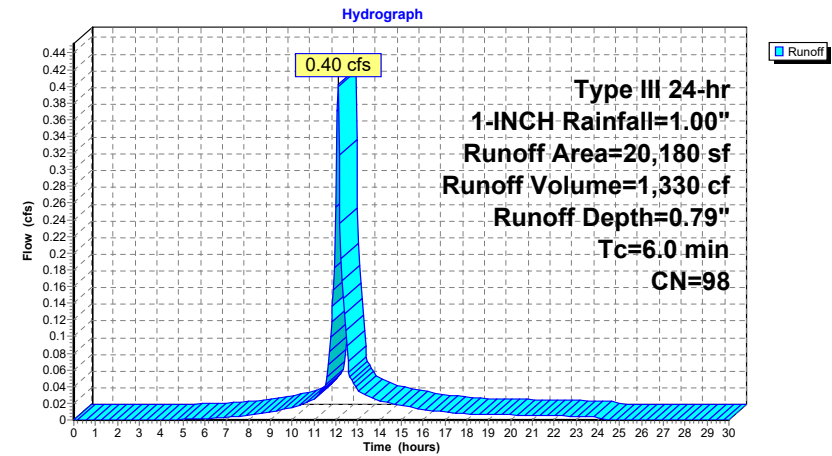
Runoff = 0.40 cfs @ 12.09 hrs, Volume= 1,330 cf, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

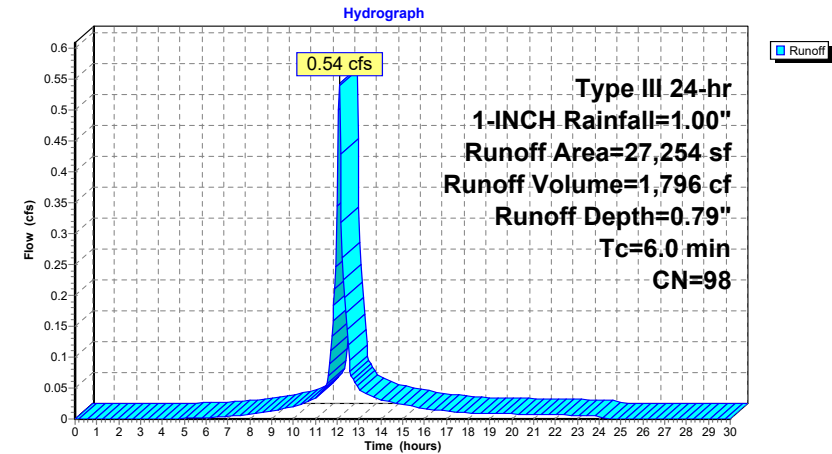
Runoff = 0.54 cfs @ 12.09 hrs, Volume= 1,796 cf, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

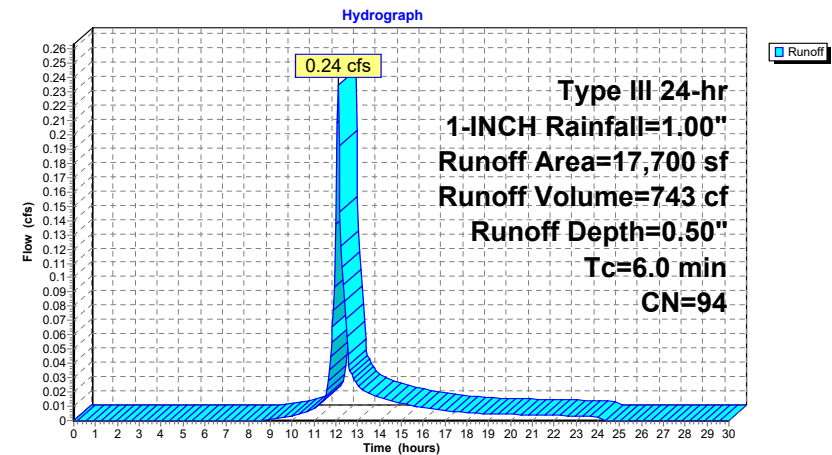
Runoff = 0.24 cfs @ 12.09 hrs, Volume= 743 cf, Depth= 0.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
13,464	98	Unconnected pavement, HSG D
4,236	80	>75% Grass cover, Good, HSG D
17,700	94	Weighted Average
4,236		23.93% Pervious Area
13,464		76.07% Impervious Area
13,464		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area



Summary for Subcatchment P-14: WWTF/Driveway

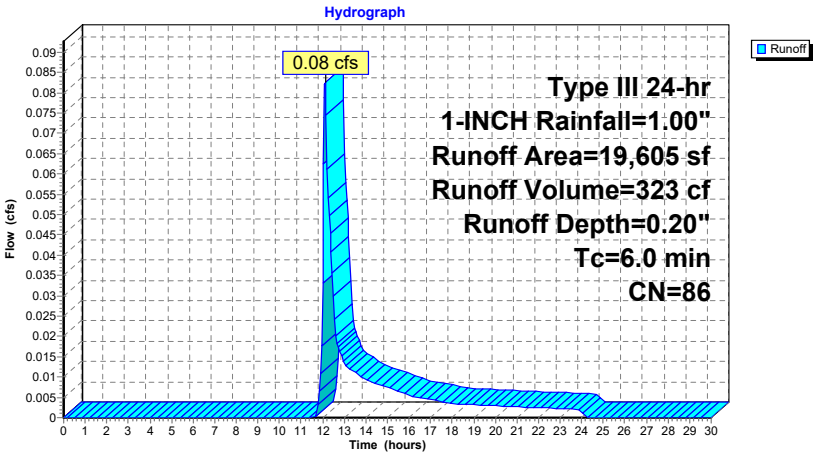
Runoff = 0.08 cfs @ 12.11 hrs, Volume= 323 cf, Depth= 0.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
6,526	98	Paved parking, HSG D
9,225	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
19,605	86	Weighted Average
13,079		66.71% Pervious Area
6,526		33.29% Impervious Area

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

Subcatchment P-14: WWTF/Driveway



Summary for Subcatchment P-15: South Lawn/Fire Access Road

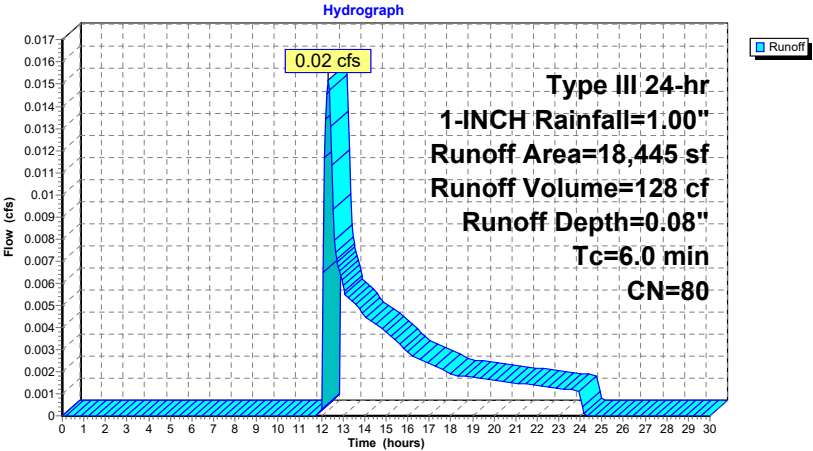
Runoff = 0.02 cfs @ 12.32 hrs, Volume= 128 cf, Depth= 0.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
14,591	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
18,445	80	Weighted Average
18,445		100.00% Pervious Area

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

Subcatchment P-15: South Lawn/Fire Access Road



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Page 15

### Summary for Subcatchment P-16: Entrance Drive

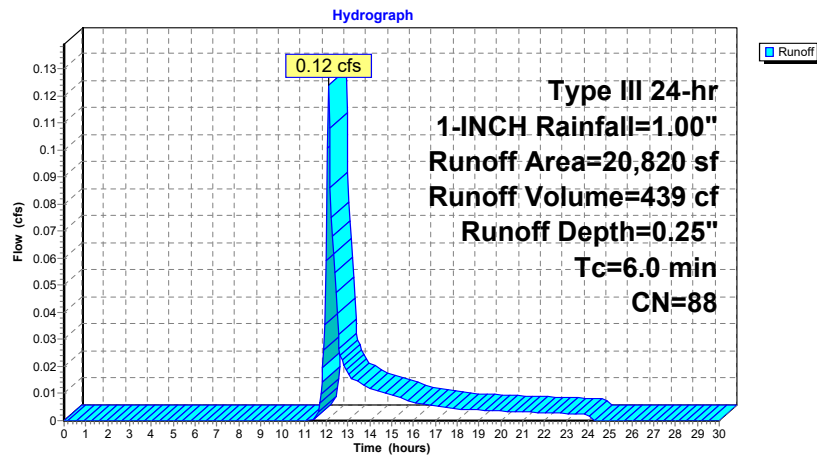
Runoff = 0.12 cfs @ 12.10 hrs, Volume= 439 cf, Depth= 0.25"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
9,187	98	Unconnected pavement, HSG D
11,633	80	>75% Grass cover, Good, HSG D
20,820	88	Weighted Average
11,633		55.87% Pervious Area
9,187		44.13% Impervious Area
9,187		100.00% Unconnected

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

### Subcatchment P-16: Entrance Drive



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Page 16

### Summary for Subcatchment P-17: Detention Pond-1

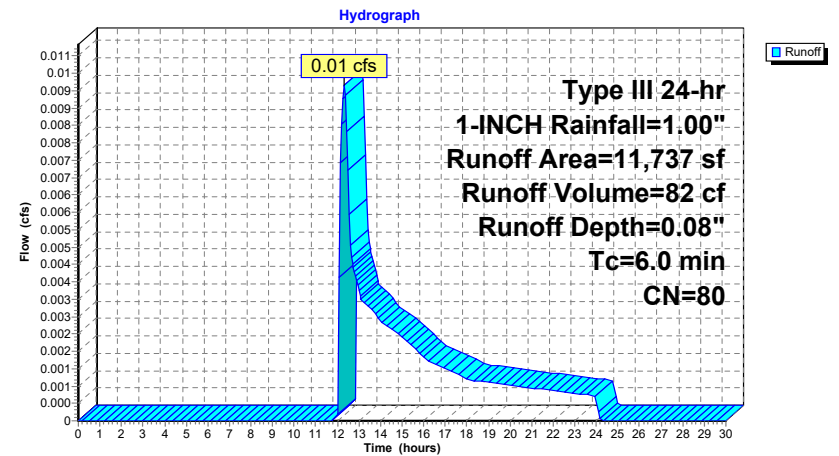
Runoff = 0.01 cfs @ 12.32 hrs, Volume= 82 cf, Depth= 0.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
4,872	91	Gravel roads, HSG D
6,865	73	Brush, Good, HSG D
11,737	80	Weighted Average
11,737		100.00% Pervious Area

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

### Subcatchment P-17: Detention Pond-1



Summary for Subcatchment P-18: Entry Driveway

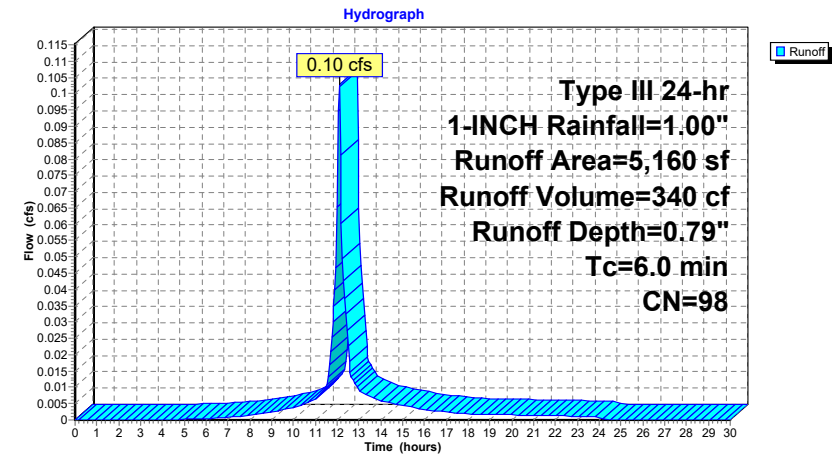
Runoff = 0.10 cfs @ 12.09 hrs, Volume= 340 cf, Depth= 0.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
5,160	98	Unconnected pavement, HSG D
5,160		100.00% Impervious Area
5,160		100.00% Unconnected

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

Subcatchment P-18: Entry Driveway



Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

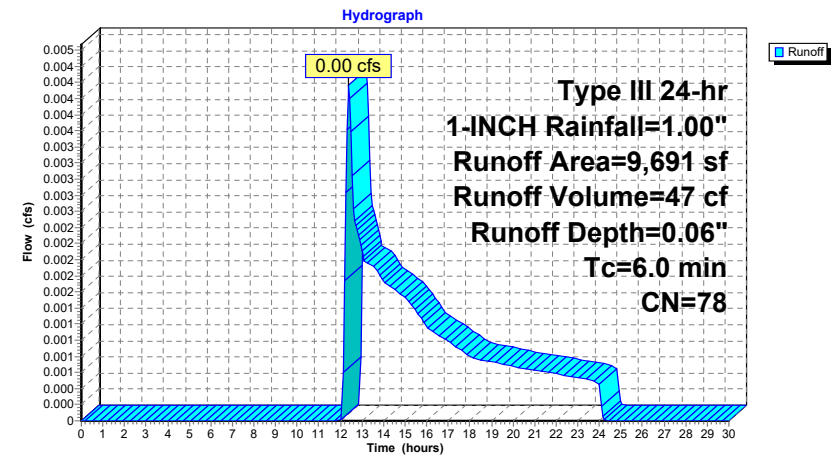
Runoff = 0.00 cfs @ 12.39 hrs, Volume= 47 cf, Depth= 0.06"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
1,678	80	>75% Grass cover, Good, HSG D
8,013	77	Woods, Good, HSG D
9,691	78	Weighted Average
9,691		100.00% Pervious Area

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

Subcatchment P-2: Direct Flow to Wetlands "F"





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Page 19

## Summary for Subcatchment P-3: Flow Southwest Off-Site

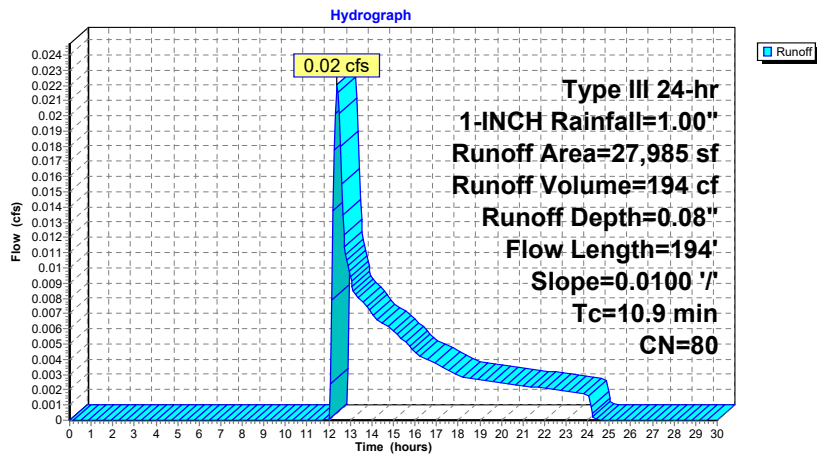
Runoff = 0.02 cfs @ 12.40 hrs, Volume= 194 cf, Depth= 0.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
24,995	80	>75% Grass cover, Good, HSG D
2,490	77	Woods, Good, HSG D
500	98	Unconnected pavement, HSG D
27,985	80	Weighted Average
27,485		98.21% Pervious Area
500		1.79% Impervious Area
500		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0100	0.11		Sheet Flow, Grass: Short n= 0.150 P2= 3.16"
3.4	144	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
10.9	194	Total			

## Subcatchment P-3: Flow Southwest Off-Site



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Page 20

## Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

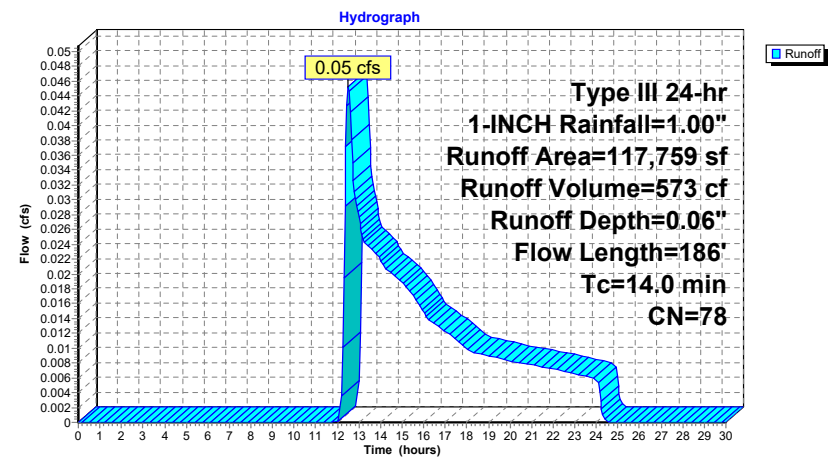
Runoff = 0.05 cfs @ 12.52 hrs, Volume= 573 cf, Depth= 0.06"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
92,430	77	Woods, Good, HSG D
24,696	80	>75% Grass cover, Good, HSG D
633	98	Unconnected pavement, HSG D
117,759	78	Weighted Average
117,126		99.46% Pervious Area
633		0.54% Impervious Area
633		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

## Subcatchment P-4: Flow Southeast to Wetlands "A"



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Page 21

### Summary for Subcatchment P-5: Entrance Drive

Runoff = 0.20 cfs @ 12.09 hrs, Volume= 625 cf, Depth= 0.50"

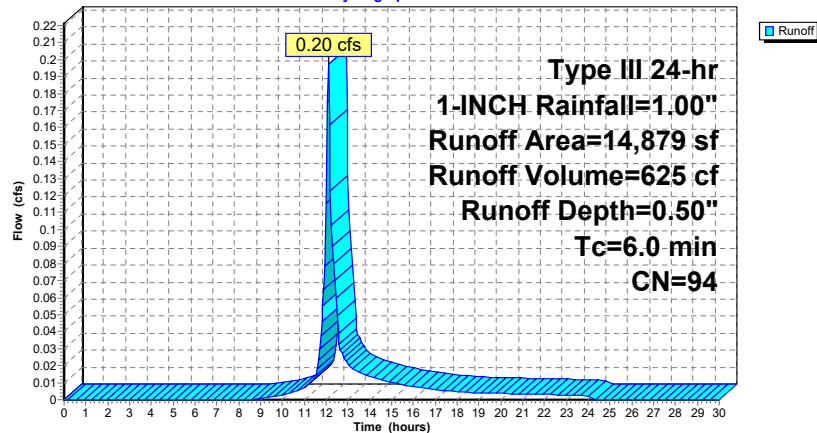
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
11,745	98	Paved parking, HSG D
3,134	80	>75% Grass cover, Good, HSG D
14,879	94	Weighted Average
3,134		21.06% Pervious Area
11,745		78.94% Impervious Area

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

### Subcatchment P-5: Entrance Drive

#### Hydrograph



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Page 22

### Summary for Subcatchment P-6: Landcaped Slope/Walls

Runoff = 0.02 cfs @ 12.32 hrs, Volume= 128 cf, Depth= 0.08"

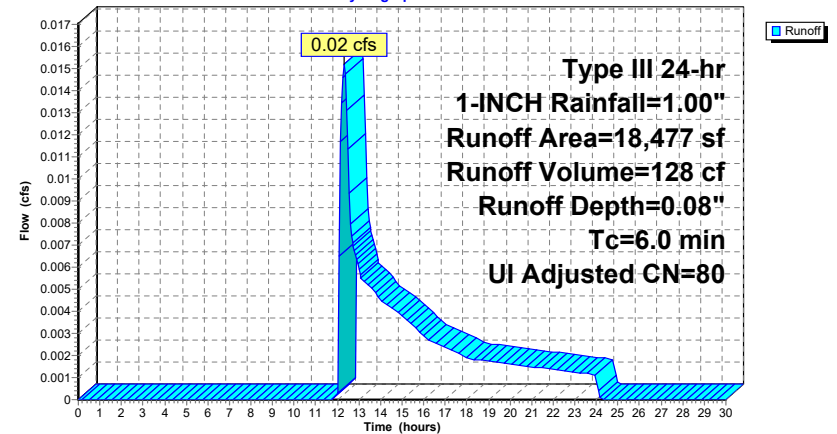
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Adj	Description
17,512	80		>75% Grass cover, Good, HSG D
965	98		Unconnected pavement, HSG D
18,477	81	80	Weighted Average, UI Adjusted
17,512			94.78% Pervious Area
965			5.22% Impervious Area
965			100.00% Unconnected

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

### Subcatchment P-6: Landcaped Slope/Walls

#### Hydrograph



Summary for Subcatchment P-7: Landscaped Slope

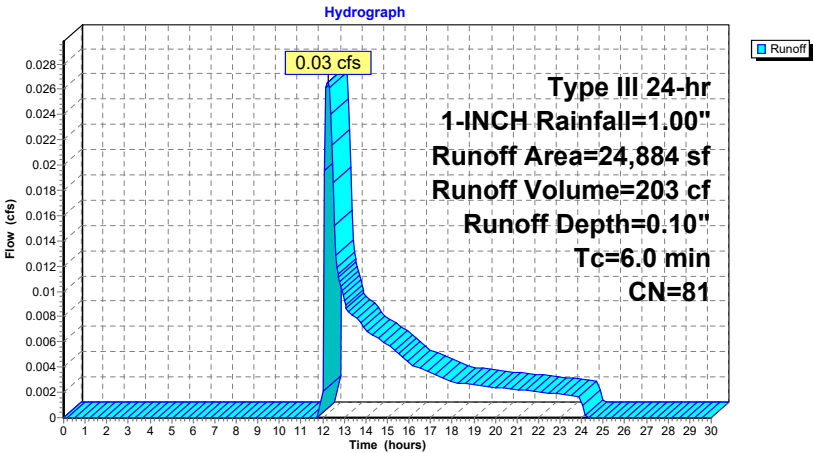
Runoff = 0.03 cfs @ 12.27 hrs, Volume= 203 cf, Depth= 0.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
788	98	Paved parking, HSG D
24,096	80	>75% Grass cover, Good, HSG D
24,884	81	Weighted Average
24,096		96.83% Pervious Area
788		3.17% Impervious Area

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

Subcatchment P-7: Landscaped Slope



Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

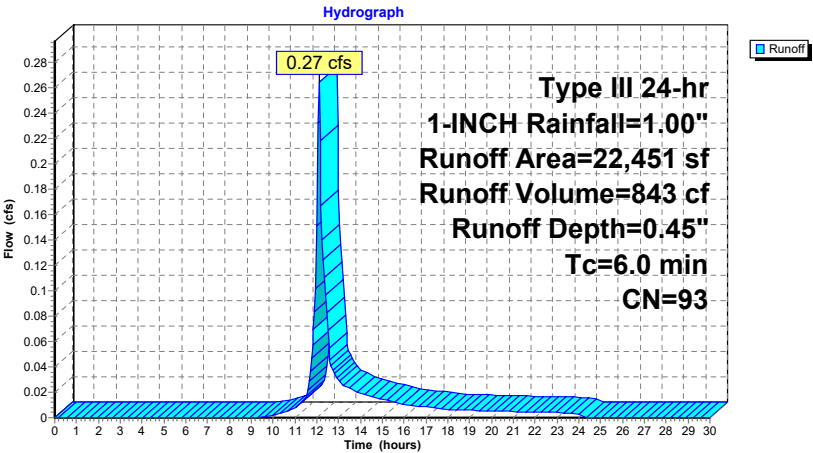
Runoff = 0.27 cfs @ 12.10 hrs, Volume= 843 cf, Depth= 0.45"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
16,749	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,451	93	Weighted Average
5,702		25.40% Pervious Area
16,749		74.60% Impervious Area

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

Subcatchment P-8: Cul-de-Sac/Garage Turn Around



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Page 25

### Summary for Subcatchment P-9: North Courtyard/Green Roof

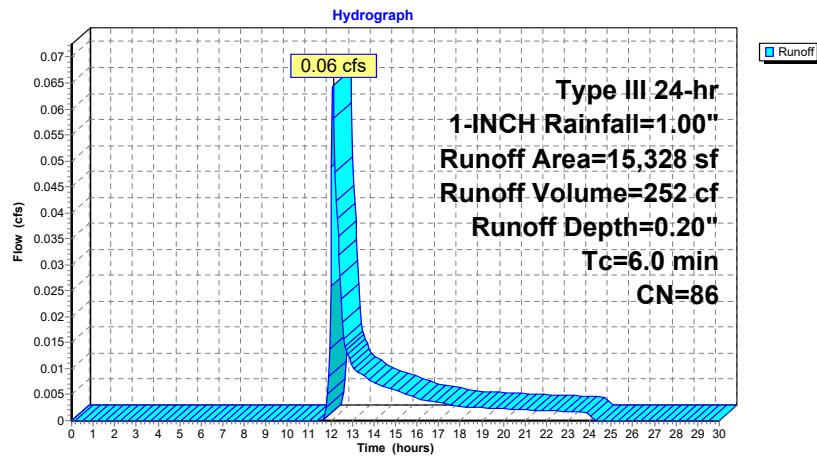
Runoff = 0.06 cfs @ 12.11 hrs, Volume= 252 cf, Depth= 0.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 1-INCH Rainfall=1.00"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

### Subcatchment P-9: North Courtyard/Green Roof



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Page 26

### Summary for Reach SWALE: Swale Abutting Entry Driveway

Inflow Area = 24,884 sf, 3.17% Impervious, Inflow Depth = 0.10" for 1-INCH event  
Inflow = 0.03 cfs @ 12.27 hrs, Volume= 203 cf  
Outflow = 0.02 cfs @ 12.42 hrs, Volume= 203 cf, Atten= 13%, Lag= 9.1 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Max. Velocity= 0.67 fps, Min. Travel Time= 10.6 min

Avg. Velocity = 0.41 fps, Avg. Travel Time= 17.5 min

Peak Storage= 15 cf @ 12.42 hrs

Average Depth at Peak Storage= 0.02'

Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 16.60 cfs

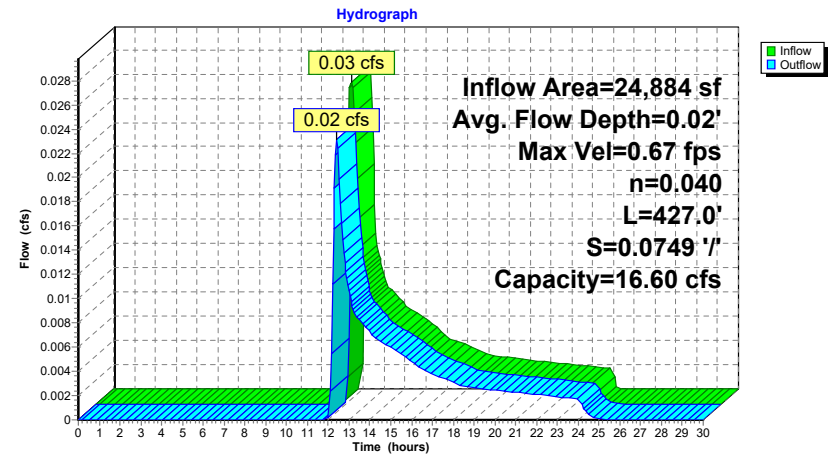
2.00' x 0.75' deep channel, n= 0.040 Earth, cobble bottom, clean sides

Side Slope Z-value= 2.0 ' Top Width= 5.00'

Length= 427.0' Slope= 0.0749 ' /'

Inlet Invert= 99.50', Outlet Invert= 67.50'

### Reach SWALE: Swale Abutting Entry Driveway



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Page 27

### Summary for Pond RG-1: Rain Garden-1 - Entrance

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth > 0.20" for 1-INCH event  
Inflow = 0.09 cfs @ 12.47 hrs, Volume= 950 cf  
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 2  
Peak Elev= 50.50' @ 30.00 hrs Surf.Area= 861 sf Storage= 950 cf

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

Volume	Invert	Avail.Storage	Storage Description			
#1	49.00'	2,031 cf	Rain Garden (Irregular) Listed below (Recalc)			
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)	
49.00	425	82.3	0	0	425	
50.00	701	101.5	557	557	720	
51.00	1,034	120.4	862	1,419	1,072	
51.50	1,423	139.2	612	2,031	1,466	

Device	Routing	Invert	Outlet Devices			
#1	Primary	51.00'	24.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 51.00' / 50.50' S= 0.0050 '/ S= 0.0050 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf			

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=49.00' (Free Discharge)  
1=Culvert ( Controls 0.00 cfs)

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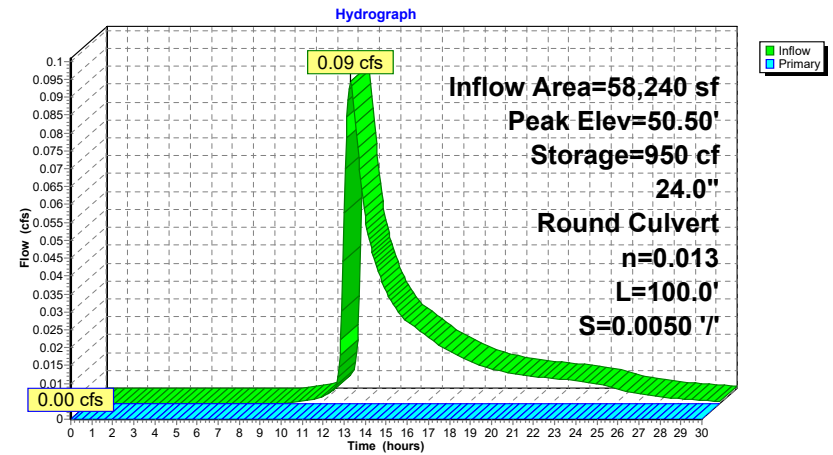
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Page 28

### Pond RG-1: Rain Garden-1 - Entrance



Summary for Pond RG-2: Rain Garden #2 - Driveway

Inflow Area = 5,160 sf,100.00% Impervious, Inflow Depth = 0.79" for 1-INCH event  
Inflow = 0.10 cfs @ 12.09 hrs, Volume= 340 cf  
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 162.49' @ 24.40 hrs Surf.Area= 830 sf Storage= 340 cf

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

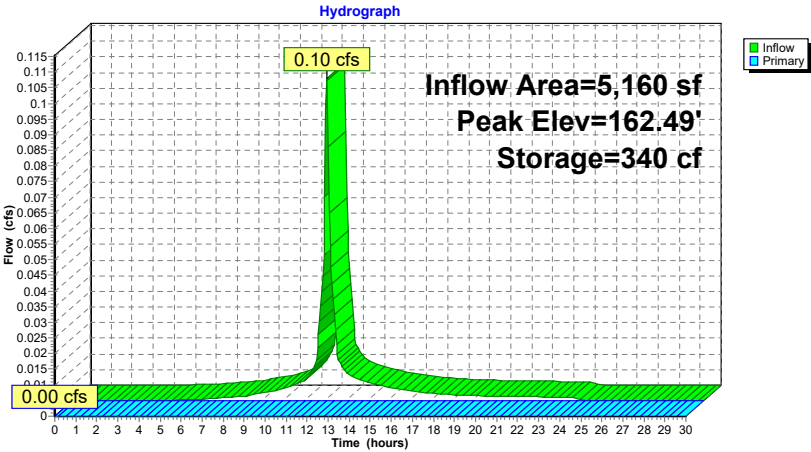
Volume	Invert	Avail.Storage	Storage Description		
#1	162.00'	3,504 cf	Custom Stage Data (Irregular) Listed below (Recalc)		

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
162.00	564	214.6	0	0	564
164.00	1,965	252.4	2,388	2,388	2,044
164.50	2,509	276.8	1,116	3,504	3,080

Device	Routing	Invert	Outlet Devices														
#1	Primary	163.50'	10.0' long x 5.0' 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) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70														
			2.74 2.79 2.88														

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=162.00' (Free Discharge)  
1=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

Pond RG-2: Rain Garden #2 - Driveway



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Page 31

### Summary for Pond SDP-1: Surface Detention Pond-1

Inflow Area = 51,002 sf, 18.01% Impervious, Inflow Depth = 0.15" for 1-INCH event  
Inflow = 0.14 cfs @ 12.12 hrs, Volume= 648 cf  
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf  
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 76.91' @ 24.40 hrs Surf.Area= 908 sf Storage= 648 cf

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

Volume	Invert	Avail.Storage	Storage Description
#1	76.00'	8,088 cf	Surface Detention Pond (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
76.00	531	104.1	0	0	531
78.00	1,488	192.6	1,939	1,939	2,642
80.00	2,756	230.3	4,179	6,118	3,979
80.50	5,256	368.3	1,970	8,088	10,554

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.50'	10.0' long x 10.0' breadth Emergency OverFlow 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
#2	Primary	78.00'	15.0" Round Culvert L= 100.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 78.00' / 77.00' S= 0.0100 '/ S Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=76.00' (Free Discharge)  
2=Culvert ( Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=76.00' (Free Discharge)  
1=Emergency OverFlow Weir ( Controls 0.00 cfs)

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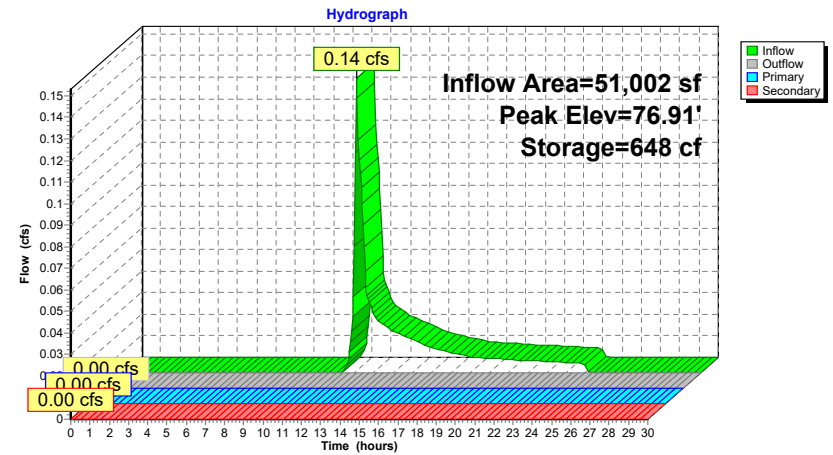
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Page 32

### Pond SDP-1: Surface Detention Pond-1



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Page 33

### Summary for Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth = 0.20" for 1-INCH event  
Inflow = 0.21 cfs @ 12.10 hrs, Volume= 956 cf  
Outflow = 0.09 cfs @ 12.47 hrs, Volume= 950 cf, Atten= 56%, Lag= 22.3 min  
Primary = 0.09 cfs @ 12.47 hrs, Volume= 950 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 47.16' @ 12.47 hrs Surf.Area= 3,520 sf Storage= 228 cf

Plug-Flow detention time= 81.6 min calculated for 948 cf (99% of inflow)  
Center-of-Mass det. time= 78.3 min (952.9 - 874.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	47.00'	3,452 cf	<b>27.50'W x 128.00'L x 4.00'H Field A</b> 14,080 cf Overall - 5,450 cf Embedded = 8,630 cf x 40.0% Voids
#2A	47.50'	5,450 cf	<b>CMP Round 36 x 36</b> Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 36 Chambers in 6 Rows 25.50' Header x 7.07 sf x 2 = 360.5 cf Inside
			8,902 cf Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	47.00'	<b>18.0" Round Culvert</b> L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.00' / 46.00' S= 0.0100 'f Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.77 sf
#2	Device 1	51.00'	<b>5.0' long x 0.5' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Device 1	47.00'	<b>8.0" Vert. 8" Orifice</b> C= 0.600

**Primary OutFlow** Max=0.09 cfs @ 12.47 hrs HW=47.16' (Free Discharge)

- 1=Culvert (Passes 0.09 cfs of 0.11 cfs potential flow)
- 2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)
- 3=8" Orifice (Orifice Controls 0.09 cfs @ 1.37 fps)

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Page 34

### Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP) - Chamber Wizard Field A

**Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)**

Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf

Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

6 Chambers/Row x 20.00' Long +3.00' Header x 2 = 126.00' Row Length +12.0" End Stone x 2 = 128.00' Base Length  
6 Rows x 36.0" Wide + 18.0" Spacing x 5 + 12.0" Side Stone x 2 = 27.50' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

36 Chambers x 141.4 cf + 25.50' Header x 7.07 sf x 2 = 5,449.9 cf Chamber Storage

14,080.0 cf Field - 5,449.9 cf Chambers = 8,630.1 cf Stone x 40.0% Voids = 3,452.0 cf Stone Storage

Chamber Storage + Stone Storage = 8,901.9 cf = 0.204 af

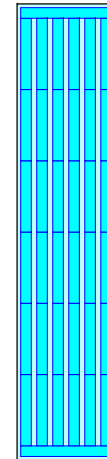
Overall Storage Efficiency = 63.2%

Overall System Size = 128.00' x 27.50' x 4.00'

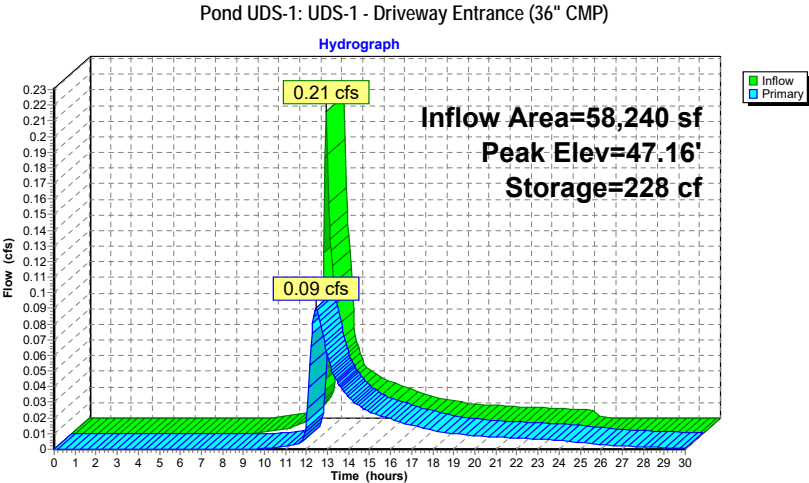
36 Chambers

521.5 cy Field

319.6 cy Stone







Summary for Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)

Inflow Area = 70,127 sf, 81.35% Impervious, Inflow Depth = 0.63" for 1-INCH event  
Inflow = 1.09 cfs @ 12.09 hrs, Volume= 3,653 cf  
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 102.08' @ 24.40 hrs Surf.Area= 7,020 sf Storage= 3,653 cf  
Flood Elev= 109.25' Surf.Area= 7,020 sf Storage= 42,647 cf

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

Volume	Invert	Avail.Storage	Storage Description
#1A	101.00'	12,163 cf	54.00'W x 130.00'L x 9.00'H Field A 63,180 cf Overall - 32,773 cf Embedded = 30,407 cf x 40.0% Voids
#2A	101.50'	32,773 cf	CMP Round 96 x 30 Inside #1 Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 30 Chambers in 5 Rows 52.00' Header x 50.27 sf x 1 = 2,613.8 cf Inside
44,936 cf			Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.00' S= 0.0100 ' S= 0.0100 ' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	109.25'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=101.00' (Free Discharge)  
1=Culvert ( Controls 0.00 cfs)  
2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96 (Round Corrugated Metal Pipe)  
Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf  
Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

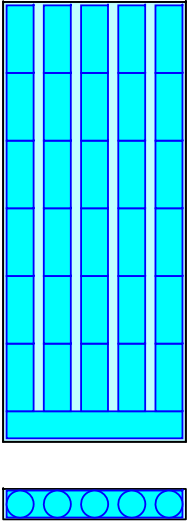
6 Chambers/Row x 20.00' Long +8.00' Header x 1 = 128.00' Row Length +12.0" End Stone x 2 = 130.00' Base Length  
5 Rows x 96.0" Wide + 36.0" Spacing x 4 + 12.0" Side Stone x 2 = 54.00' Base Width  
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

30 Chambers x 1,005.3 cf + 52.00' Header x 50.27 sf = 32,773.1 cf Chamber Storage

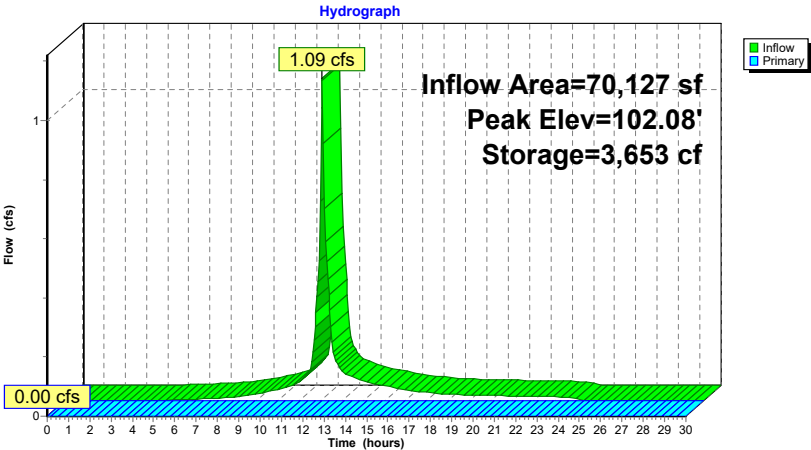
63,180.0 cf Field - 32,773.1 cf Chambers = 30,406.9 cf Stone x 40.0% Voids = 12,162.8 cf Stone Storage

Chamber Storage + Stone Storage = 44,935.9 cf = 1.032 af  
Overall Storage Efficiency = 71.1%  
Overall System Size = 130.00' x 54.00' x 9.00'

30 Chambers  
2,340.0 cy Field  
1,126.2 cy Stone



Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)



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Page 39

### Summary for Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)

Inflow Area = 44,954 sf, 90.58% Impervious, Inflow Depth = 0.68" for 1-INCH event  
Inflow = 0.78 cfs @ 12.09 hrs, Volume= 2,539 cf  
Outflow = 0.08 cfs @ 12.89 hrs, Volume= 2,539 cf, Atten= 89%, Lag= 48.0 min  
Discarded = 0.08 cfs @ 12.89 hrs, Volume= 2,539 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 117.37' @ 12.89 hrs Surf.Area= 6,624 sf Storage= 972 cf

Plug-Flow detention time= 99.6 min calculated for 2,539 cf (100% of inflow)  
Center-of-Mass det. time= 99.4 min ( 900.4 - 801.0 )

Volume	Invert	Avail. Storage	Storage Description
#1A	117.00'	6,521 cf	23.00'W x 288.00'L x 4.00'H Field A 26,496 cf Overall - 10,193 cf Embedded = 16,303 cf x 40.0% Voids
#2A	117.50'	10,193 cf	CMP Round 36 x 70 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 70 Chambers in 5 Rows 21.00' Header x 7.07 sf x 2 = 296.9 cf Inside
		16,714 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	117.00'	15.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 117.00' / 116.00' S= 0.0100 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.23 sf
#2	Discarded	117.00'	0.520 in/hr Exfiltration over Wetted area
#3	Device 1	120.45'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.08 cfs @ 12.89 hrs HW=117.37' (Free Discharge)  
└─2=Exfiltration (Exfiltration Controls 0.08 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=117.00' (Free Discharge)  
└─1=Culvert ( Controls 0.00 cfs)  
└─3=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

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Page 40

### Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)

Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf

Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

14 Chambers/Row x 20.00' Long +3.00' Header x 2 = 286.00' Row Length +12.0" End Stone x 2 = 288.00' Base Length  
5 Rows x 36.0" Wide + 18.0" Spacing x 4 + 12.0" Side Stone x 2 = 23.00' Base Width  
6.0' Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

70 Chambers x 141.4 cf + 21.00' Header x 7.07 sf x 2 = 10,192.9 cf Chamber Storage

26,496.0 cf Field - 10,192.9 cf Chambers = 16,303.1 cf Stone x 40.0% Voids = 6,521.2 cf Stone Storage

Chamber Storage + Stone Storage = 16,714.1 cf = 0.384 af

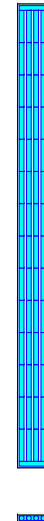
Overall Storage Efficiency = 63.1%

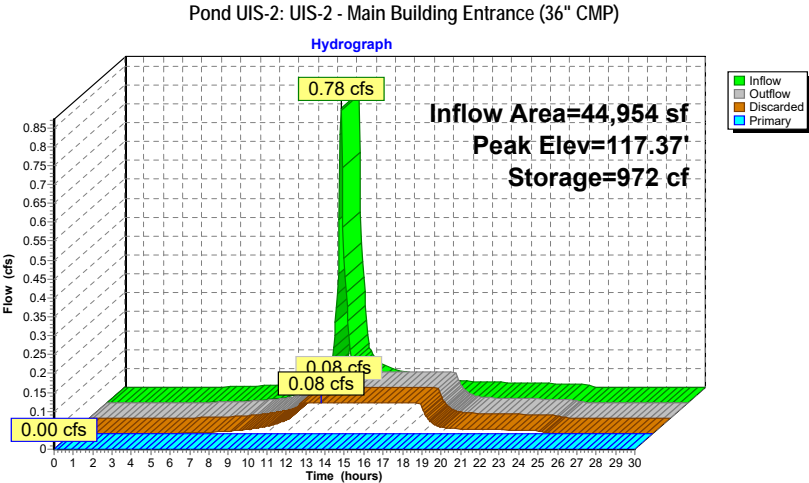
Overall System Size = 288.00' x 23.00' x 4.00'

70 Chambers

981.3 cy Field

603.8 cy Stone





Summary for Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)

Inflow Area = 37,779 sf, 57.72% Impervious, Inflow Depth = 0.35" for 1-INCH event  
Inflow = 0.33 cfs @ 12.10 hrs, Volume= 1,095 cf  
Outflow = 0.12 cfs @ 12.43 hrs, Volume= 1,095 cf, Atten= 64%, Lag= 20.0 min  
Discarded = 0.12 cfs @ 12.43 hrs, Volume= 1,095 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 107.10' @ 12.43 hrs Surf.Area= 4,930 sf Storage= 206 cf  
Flood Elev= 108.50' Surf.Area= 4,930 sf Storage= 4,321 cf

Plug-Flow detention time= 15.6 min calculated for 1,093 cf (100% of inflow)  
Center-of-Mass det. time= 15.6 min ( 868.3 - 852.7 )

Volume	Invert	Avail.Storage	Storage Description
#1A	107.00'	4,775 cf	72.50'W x 68.00'L x 4.00'H Field A 19,720 cf Overall - 7,783 cf Embedded = 11,937 cf x 40.0% Voids
#2A	107.50'	7,783 cf	CMP Round 36 x 48 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 48 Chambers in 16 Rows 70.50' Header x 7.07 sf x 2 = 996.7 cf Inside
		12,558 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	107.00'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 107.00' / 102.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	108.50'	4.0" Vert. Orifice/Grate C= 0.600
#3	Discarded	107.00'	1.020 in/hr Exfiltration over Wetted area

Discarded OutFlow Max=0.12 cfs @ 12.43 hrs HW=107.10' (Free Discharge)  
3=Exfiltration (Exfiltration Controls 0.12 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=107.00' (Free Discharge)  
1=Culvert ( Controls 0.00 cfs)  
2=Orifice/Grate ( Controls 0.00 cfs)

Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)  
Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf  
Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

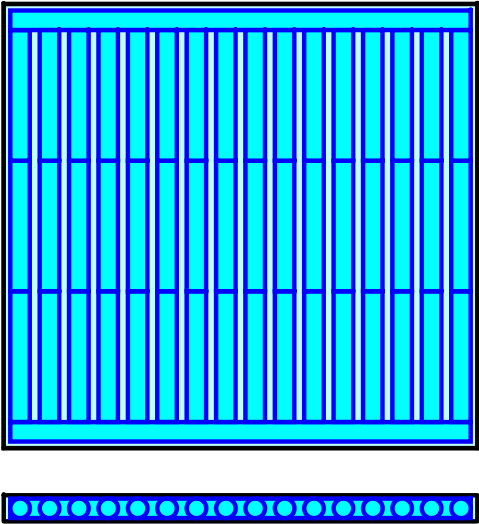
3 Chambers/Row x 20.00' Long +3.00' Header x 2 = 66.00' Row Length +12.0" End Stone x 2 = 68.00' Base Length  
16 Rows x 36.0" Wide + 18.0" Spacing x 15 + 12.0" Side Stone x 2 = 72.50' Base Width  
6.0' Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

48 Chambers x 141.4 cf + 70.50' Header x 7.07 sf x 2 = 7,782.5 cf Chamber Storage

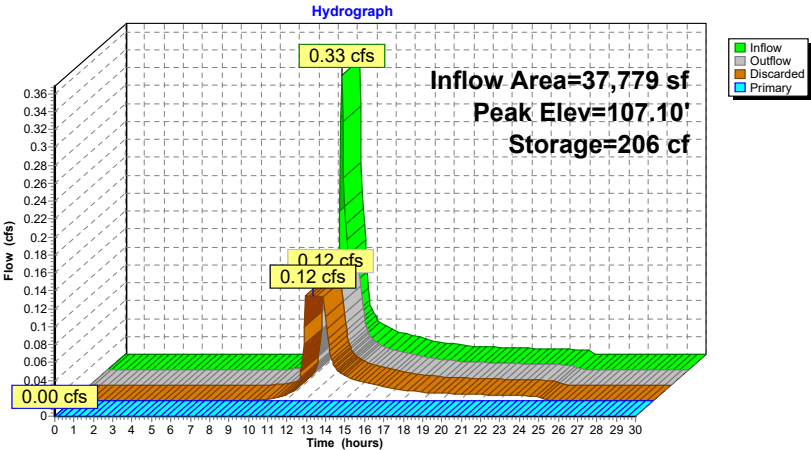
19,720.0 cf Field - 7,782.5 cf Chambers = 11,937.5 cf Stone x 40.0% Voids = 4,775.0 cf Stone Storage

Chamber Storage + Stone Storage = 12,557.5 cf = 0.288 af  
Overall Storage Efficiency = 63.7%  
Overall System Size = 68.00' x 72.50' x 4.00'

48 Chambers  
730.4 cy Field  
442.1 cy Stone



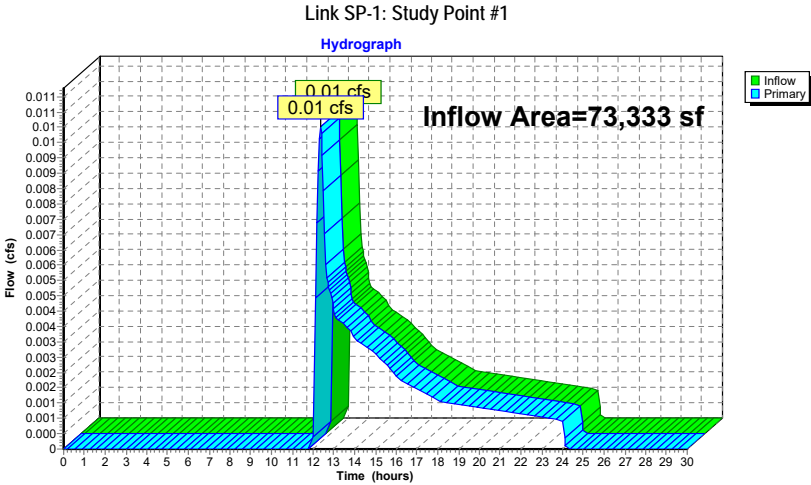
Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)



Summary for Link SP-1: Study Point #1

Inflow Area = 73,333 sf, 19.56% Impervious, Inflow Depth = 0.02" for 1-INCH event  
Inflow = 0.01 cfs @ 12.36 hrs, Volume= 100 cf  
Primary = 0.01 cfs @ 12.36 hrs, Volume= 100 cf, Atten= 0%, Lag= 0.0 min

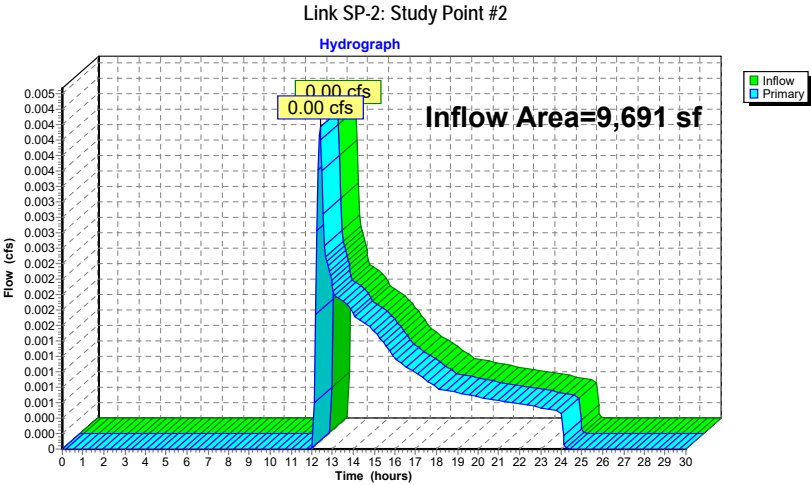
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Summary for Link SP-2: Study Point #2

Inflow Area = 9,691 sf, 0.00% Impervious, Inflow Depth = 0.06" for 1-INCH event  
Inflow = 0.00 cfs @ 12.39 hrs, Volume= 47 cf  
Primary = 0.00 cfs @ 12.39 hrs, Volume= 47 cf, Atten= 0%, Lag= 0.0 min

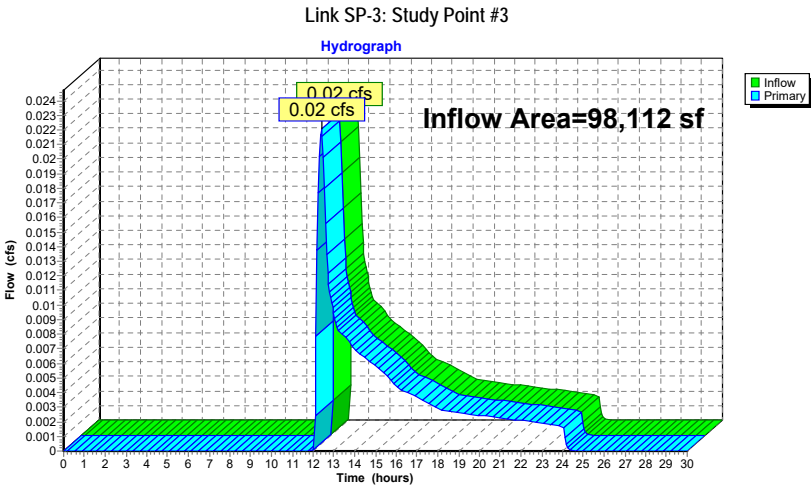
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Summary for Link SP-3: Study Point #3

Inflow Area = 98,112 sf, 58.66% Impervious, Inflow Depth = 0.02" for 1-INCH event  
Inflow = 0.02 cfs @ 12.40 hrs, Volume= 194 cf  
Primary = 0.02 cfs @ 12.40 hrs, Volume= 194 cf, Atten= 0%, Lag= 0.0 min

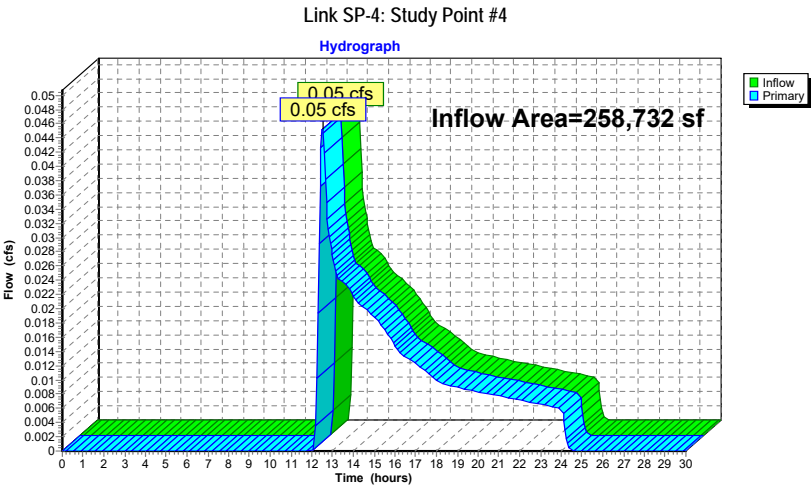
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Summary for Link SP-4: Study Point #4

Inflow Area = 258,732 sf, 29.63% Impervious, Inflow Depth = 0.03" for 1-INCH event  
Inflow = 0.05 cfs @ 12.52 hrs, Volume= 573 cf  
Primary = 0.05 cfs @ 12.52 hrs, Volume= 573 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



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Page 49

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North	Runoff Area=17,171 sf 0.00% Impervious Runoff Depth=1.37" Tc=6.0 min CN=79 Runoff=0.61 cfs 1,956 cf
Subcatchment P-10: Proposed Building Roof	Runoff Area=30,342 sf 100.00% Impervious Runoff Depth=3.01" Tc=6.0 min CN=98 Runoff=2.14 cfs 7,604 cf
Subcatchment P-11: South Courtyard	Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=3.01" Tc=6.0 min CN=98 Runoff=1.42 cfs 5,057 cf
Subcatchment P-12: Southeast Roof Area	Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=3.01" Tc=6.0 min CN=98 Runoff=1.92 cfs 6,830 cf
Subcatchment P-13: Main Parking Area	Runoff Area=17,700 sf 76.07% Impervious Runoff Depth=2.58" Tc=6.0 min CN=94 Runoff=1.15 cfs 3,809 cf
Subcatchment P-14: WWTF/Driveway	Runoff Area=19,605 sf 33.29% Impervious Runoff Depth=1.87" Tc=6.0 min CN=86 Runoff=0.97 cfs 3,055 cf
Subcatchment P-15: South Lawn/Fire Access Road	Runoff Area=18,445 sf 0.00% Impervious Runoff Depth=1.43" Tc=6.0 min CN=80 Runoff=0.69 cfs 2,202 cf
Subcatchment P-16: Entrance Drive	Runoff Area=20,820 sf 44.13% Impervious Runoff Depth=2.03" Tc=6.0 min CN=88 Runoff=1.11 cfs 3,527 cf
Subcatchment P-17: Detention Pond-1	Runoff Area=11,737 sf 0.00% Impervious Runoff Depth=1.43" Tc=6.0 min CN=80 Runoff=0.44 cfs 1,401 cf
Subcatchment P-18: Entry Driveway	Runoff Area=5,160 sf 100.00% Impervious Runoff Depth=3.01" Tc=6.0 min CN=98 Runoff=0.36 cfs 1,293 cf
Subcatchment P-2: Direct Flow to Wetlands "F"	Runoff Area=9,691 sf 0.00% Impervious Runoff Depth=1.30" Tc=6.0 min CN=78 Runoff=0.33 cfs 1,052 cf
Subcatchment P-3: Flow Southwest Off-Site	Runoff Area=27,985 sf 1.79% Impervious Runoff Depth=1.43" Flow Length=194' Slope=0.0100 'ft Tc=10.9 min CN=80 Runoff=0.90 cfs 3,341 cf
Subcatchment P-4: Flow Southeast to Wetlands "A"	Runoff Area=117,759 sf 0.54% Impervious Runoff Depth=1.30" Flow Length=186' Tc=14.0 min CN=78 Runoff=3.11 cfs 12,784 cf
Subcatchment P-5: Entrance Drive	Runoff Area=14,879 sf 78.94% Impervious Runoff Depth=2.58" Tc=6.0 min CN=94 Runoff=0.97 cfs 3,202 cf
Subcatchment P-6: Landcaped Slope/Walls	Runoff Area=18,477 sf 5.22% Impervious Runoff Depth=1.43" Tc=6.0 min UI Adjusted CN=80 Runoff=0.69 cfs 2,206 cf
Subcatchment P-7: Landscaped Slope	Runoff Area=24,884 sf 3.17% Impervious Runoff Depth=1.50" Tc=6.0 min CN=81 Runoff=0.98 cfs 3,112 cf

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Page 50

Subcatchment P-8: Cul-de-Sac/Garage Turn Around	Runoff Area=22,451 sf 74.60% Impervious Runoff Depth=2.48" Tc=6.0 min CN=93 Runoff=1.42 cfs 4,648 cf
Subcatchment P-9: North Courtyard/Green Roof	Runoff Area=15,328 sf 33.00% Impervious Runoff Depth=1.87" Tc=6.0 min CN=86 Runoff=0.76 cfs 2,389 cf
Reach SWALE: Swale Abutting Entry Driveway	Avg. Flow Depth=0.15' Max Vel=2.60 fps Inflow=0.98 cfs 3,112 cf n=0.040 L=427.0' S=0.0749 'ft Capacity=16.60 cfs Outflow=0.91 cfs 3,112 cf
Pond RG-1: Rain Garden-1 - Entrance	Peak Elev=51.53' Storage=2,031 cf Inflow=1.29 cfs 8,509 cf 24.0" Round Culvert n=0.013 L=100.0' S=0.0050 'ft Outflow=1.22 cfs 7,032 cf
Pond RG-2: Rain Garden #2 - Driveway	Peak Elev=163.35' Storage=1,293 cf Inflow=0.36 cfs 1,293 cf Outflow=0.00 cfs 0 cf
Pond SDP-1: Surface Detention Pond-1	Peak Elev=78.47' Storage=2,702 cf Inflow=2.24 cfs 7,131 cf Primary=0.99 cfs 5,175 cf Secondary=0.00 cfs 0 cf Outflow=0.99 cfs 5,175 cf
Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)	Peak Elev=47.93' Storage=1,589 cf Inflow=2.55 cfs 8,520 cf Outflow=1.29 cfs 8,509 cf
Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)	Peak Elev=104.35' Storage=15,716 cf Inflow=4.53 cfs 15,716 cf Outflow=0.00 cfs 0 cf
Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)	Peak Elev=118.62' Storage=6,356 cf Inflow=3.07 cfs 10,640 cf Discarded=0.09 cfs 7,435 cf Primary=0.00 cfs 0 cf Outflow=0.09 cfs 7,435 cf
Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)	Peak Elev=108.23' Storage=3,317 cf Inflow=2.18 cfs 7,036 cf Discarded=0.12 cfs 7,036 cf Primary=0.00 cfs 0 cf Outflow=0.12 cfs 7,036 cf
Link SP-1: Study Point #1	Inflow=1.28 cfs 7,131 cf Primary=1.28 cfs 7,131 cf
Link SP-2: Study Point #2	Inflow=0.33 cfs 1,052 cf Primary=0.33 cfs 1,052 cf
Link SP-3: Study Point #3	Inflow=0.90 cfs 3,341 cf Primary=0.90 cfs 3,341 cf
Link SP-4: Study Point #4	Inflow=3.68 cfs 19,816 cf Primary=3.68 cfs 19,816 cf

Total Runoff Area = 439,868 sf Runoff Volume = 69,470 cf Average Runoff Depth = 1.90"  
66.23% Pervious = 291,317 sf 33.77% Impervious = 148,551 sf



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Type III 24-hr 2-Year Rainfall=3.24"

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Page 51

### Summary for Subcatchment P-1: Flow to Wetlands - North

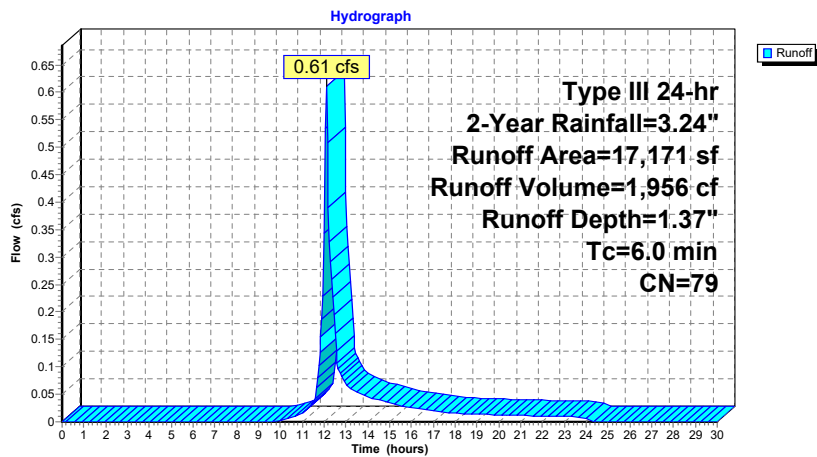
Runoff = 0.61 cfs @ 12.10 hrs, Volume= 1,956 cf, Depth= 1.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
12,252	80	>75% Grass cover, Good, HSG D
4,919	77	Woods, Good, HSG D
17,171	79	Weighted Average
17,171		100.00% Pervious Area

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

### Subcatchment P-1: Flow to Wetlands - North



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Page 52

### Summary for Subcatchment P-10: Proposed Building Roof

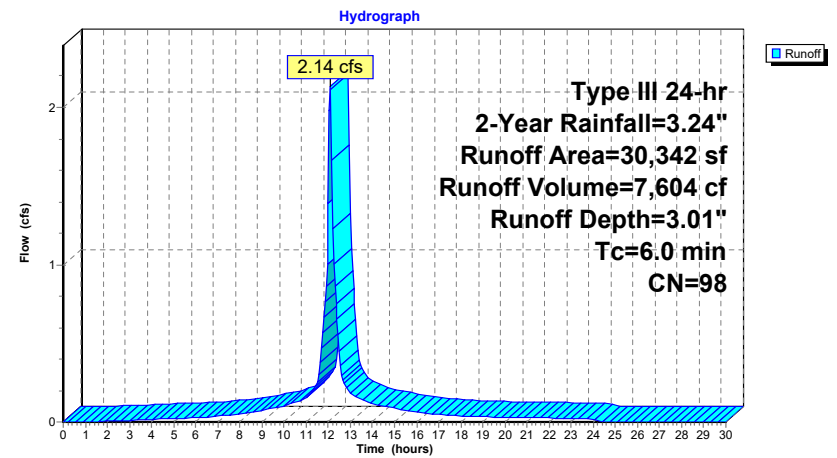
Runoff = 2.14 cfs @ 12.09 hrs, Volume= 7,604 cf, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
30,342	98	Unconnected roofs, HSG D
30,342		100.00% Impervious Area
30,342		100.00% Unconnected

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

### Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

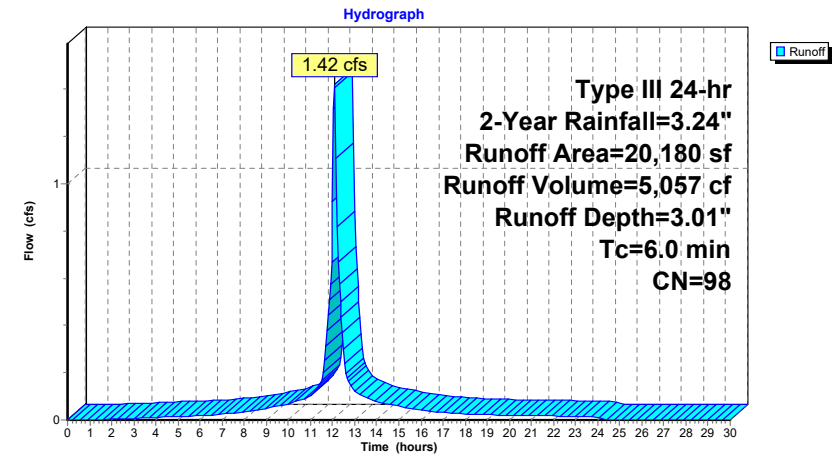
Runoff = 1.42 cfs @ 12.09 hrs, Volume= 5,057 cf, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

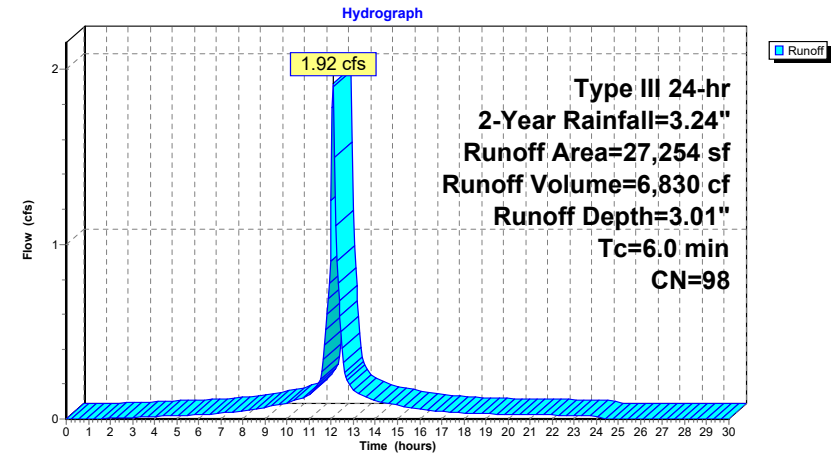
Runoff = 1.92 cfs @ 12.09 hrs, Volume= 6,830 cf, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

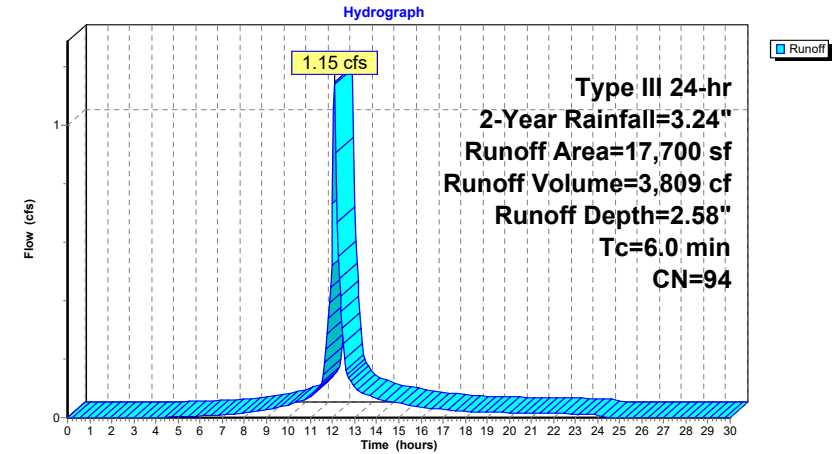
Runoff = 1.15 cfs @ 12.09 hrs, Volume= 3,809 cf, Depth= 2.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
13,464	98	Unconnected pavement, HSG D
4,236	80	>75% Grass cover, Good, HSG D
17,700	94	Weighted Average
4,236		23.93% Pervious Area
13,464		76.07% Impervious Area
13,464		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area



Summary for Subcatchment P-14: WWTF/Driveway

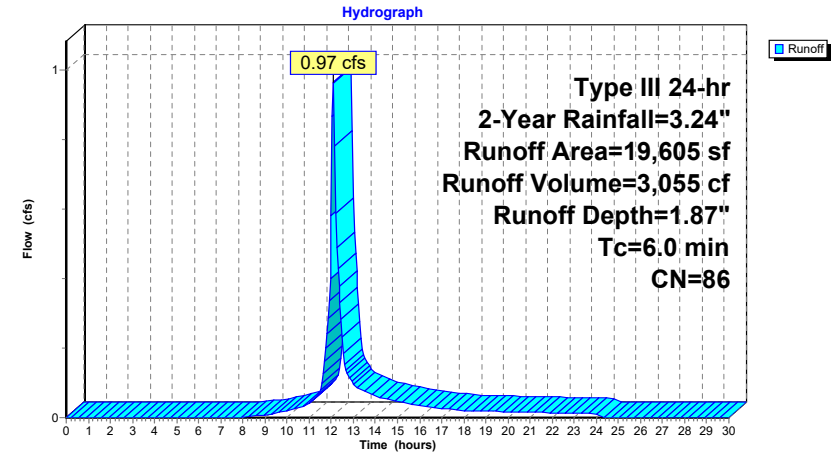
Runoff = 0.97 cfs @ 12.09 hrs, Volume= 3,055 cf, Depth= 1.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
6,526	98	Paved parking, HSG D
9,225	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
19,605	86	Weighted Average
13,079		66.71% Pervious Area
6,526		33.29% Impervious Area

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

Subcatchment P-14: WWTF/Driveway



Summary for Subcatchment P-15: South Lawn/Fire Access Road

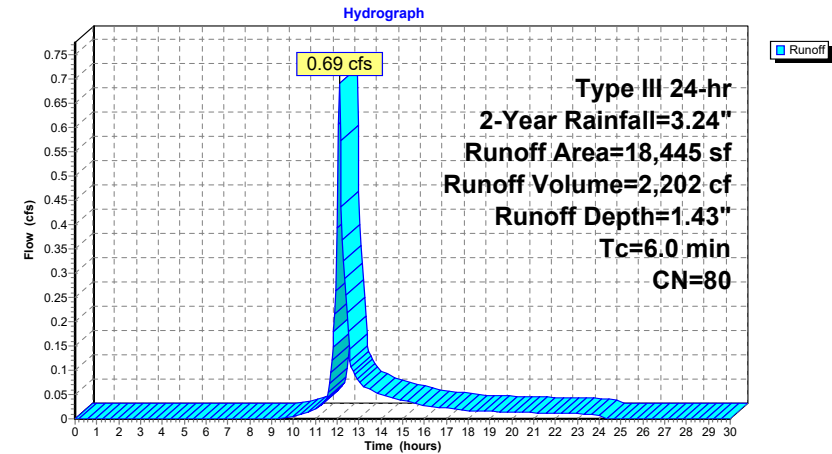
Runoff = 0.69 cfs @ 12.10 hrs, Volume= 2,202 cf, Depth= 1.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
14,591	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
18,445	80	Weighted Average
18,445		100.00% Pervious Area

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

Subcatchment P-15: South Lawn/Fire Access Road



Summary for Subcatchment P-16: Entrance Drive

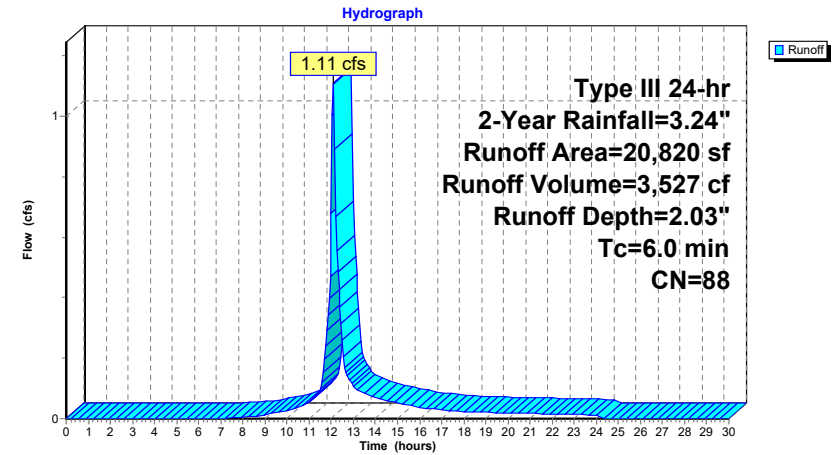
Runoff = 1.11 cfs @ 12.09 hrs, Volume= 3,527 cf, Depth= 2.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
9,187	98	Unconnected pavement, HSG D
11,633	80	>75% Grass cover, Good, HSG D
20,820	88	Weighted Average
11,633		55.87% Pervious Area
9,187		44.13% Impervious Area
9,187		100.00% Unconnected

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

Subcatchment P-16: Entrance Drive



Summary for Subcatchment P-17: Detention Pond-1

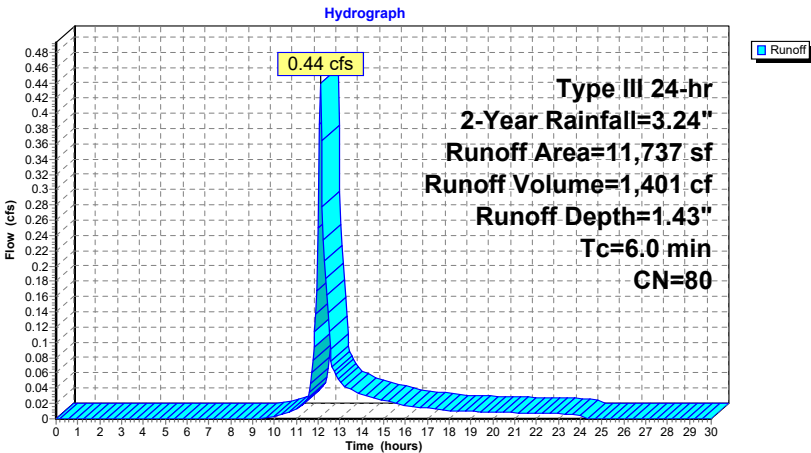
Runoff = 0.44 cfs @ 12.10 hrs, Volume= 1,401 cf, Depth= 1.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
4,872	91	Gravel roads, HSG D
6,865	73	Brush, Good, HSG D
11,737	80	Weighted Average
11,737		100.00% Pervious Area

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

Subcatchment P-17: Detention Pond-1



Summary for Subcatchment P-18: Entry Driveway

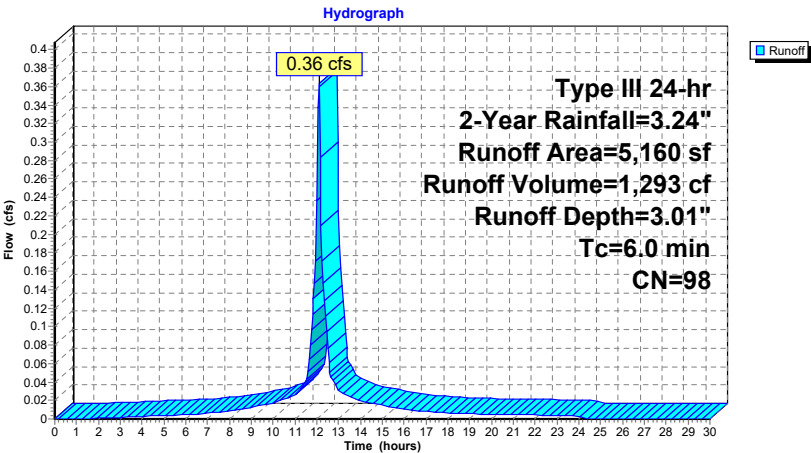
Runoff = 0.36 cfs @ 12.09 hrs, Volume= 1,293 cf, Depth= 3.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
5,160	98	Unconnected pavement, HSG D
5,160		100.00% Impervious Area
5,160		100.00% Unconnected

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

Subcatchment P-18: Entry Driveway



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Page 61

## Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

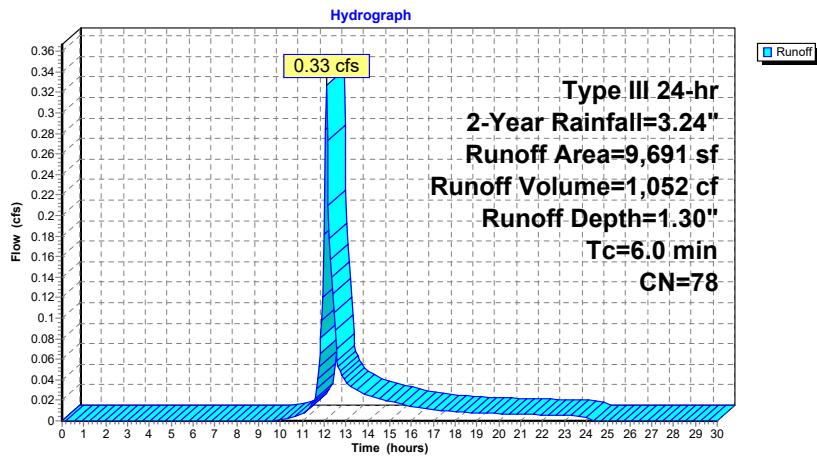
Runoff = 0.33 cfs @ 12.10 hrs, Volume= 1,052 cf, Depth= 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
1,678	80	>75% Grass cover, Good, HSG D
8,013	77	Woods, Good, HSG D
9,691	78	Weighted Average
9,691		100.00% Pervious Area

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

## Subcatchment P-2: Direct Flow to Wetlands "F"



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Page 62

## Summary for Subcatchment P-3: Flow Southwest Off-Site

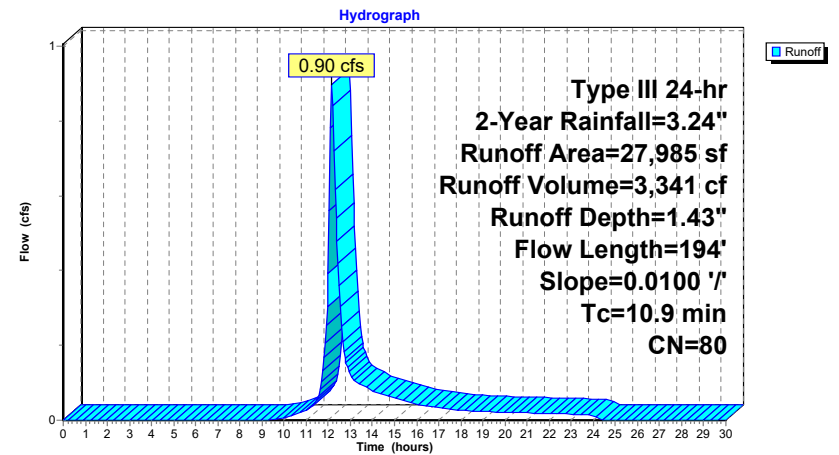
Runoff = 0.90 cfs @ 12.16 hrs, Volume= 3,341 cf, Depth= 1.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
24,995	80	>75% Grass cover, Good, HSG D
2,490	77	Woods, Good, HSG D
500	98	Unconnected pavement, HSG D
27,985	80	Weighted Average
27,485		98.21% Pervious Area
500		1.79% Impervious Area
500		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0100	0.11		Sheet Flow, Grass: Short n= 0.150 P2= 3.16"
3.4	144	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
10.9	194				Total

## Subcatchment P-3: Flow Southwest Off-Site



Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

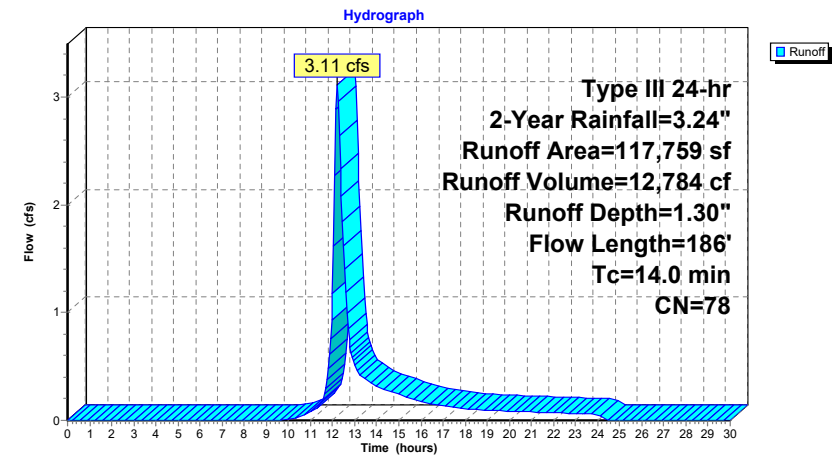
Runoff = 3.11 cfs @ 12.20 hrs, Volume= 12,784 cf, Depth= 1.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
92,430	77	Woods, Good, HSG D
24,696	80	>75% Grass cover, Good, HSG D
633	98	Unconnected pavement, HSG D
117,759	78	Weighted Average
117,126		99.46% Pervious Area
633		0.54% Impervious Area
633		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

Subcatchment P-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment P-5: Entrance Drive

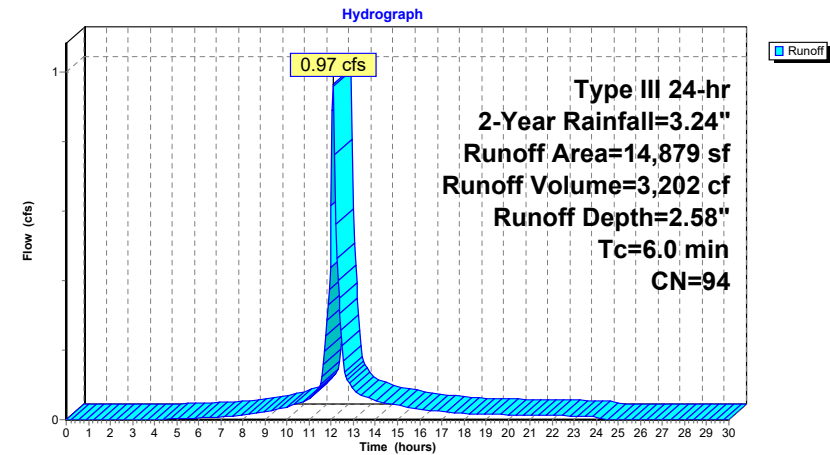
Runoff = 0.97 cfs @ 12.09 hrs, Volume= 3,202 cf, Depth= 2.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
11,745	98	Paved parking, HSG D
3,134	80	>75% Grass cover, Good, HSG D
14,879	94	Weighted Average
3,134		21.06% Pervious Area
11,745		78.94% Impervious Area

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

Subcatchment P-5: Entrance Drive



Summary for Subcatchment P-6: Landcaped Slope/Walls

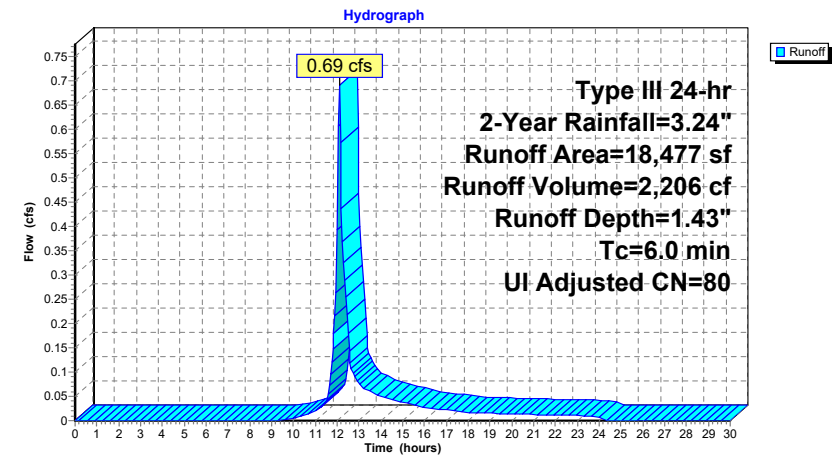
Runoff = 0.69 cfs @ 12.10 hrs, Volume= 2,206 cf, Depth= 1.43"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Adj	Description
17,512	80		>75% Grass cover, Good, HSG D
965	98		Unconnected pavement, HSG D
18,477	81	80	Weighted Average, UI Adjusted
17,512			94.78% Pervious Area
965			5.22% Impervious Area
965			100.00% Unconnected

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

Subcatchment P-6: Landcaped Slope/Walls



Summary for Subcatchment P-7: Landscaped Slope

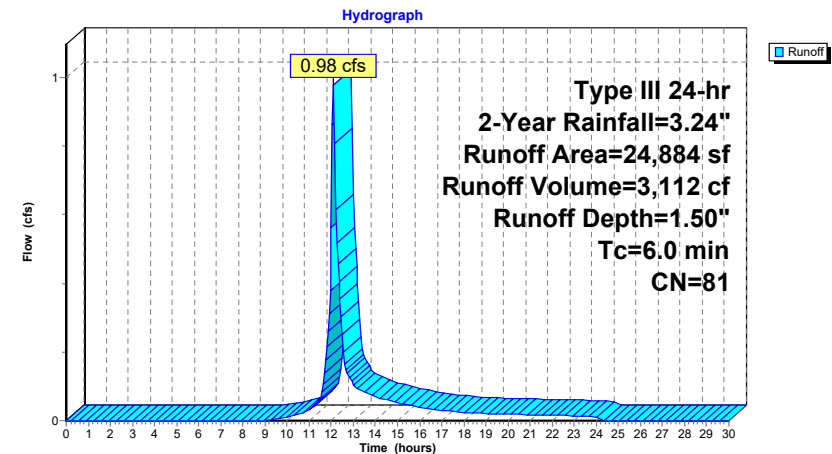
Runoff = 0.98 cfs @ 12.10 hrs, Volume= 3,112 cf, Depth= 1.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
788	98	Paved parking, HSG D
24,096	80	>75% Grass cover, Good, HSG D
24,884	81	Weighted Average
24,096		96.83% Pervious Area
788		3.17% Impervious Area

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

Subcatchment P-7: Landscaped Slope





Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

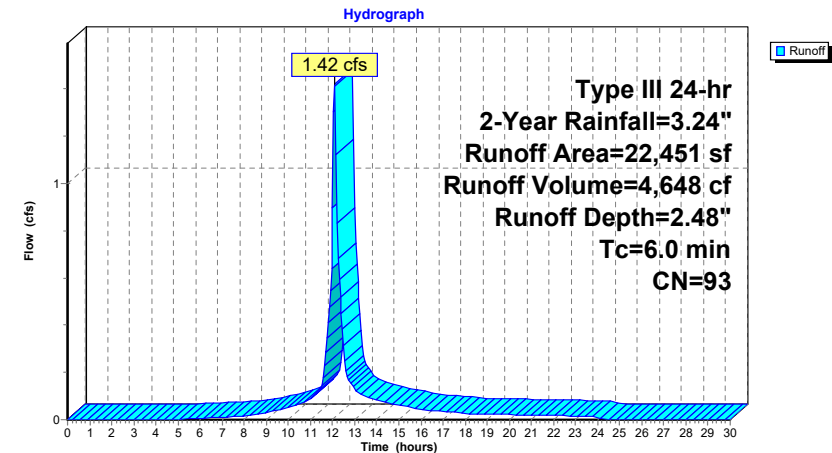
Runoff = 1.42 cfs @ 12.09 hrs, Volume= 4,648 cf, Depth= 2.48"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
16,749	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,451	93	Weighted Average
5,702		25.40% Pervious Area
16,749		74.60% Impervious Area

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

Subcatchment P-8: Cul-de-Sac/Garage Turn Around



Summary for Subcatchment P-9: North Courtyard/Green Roof

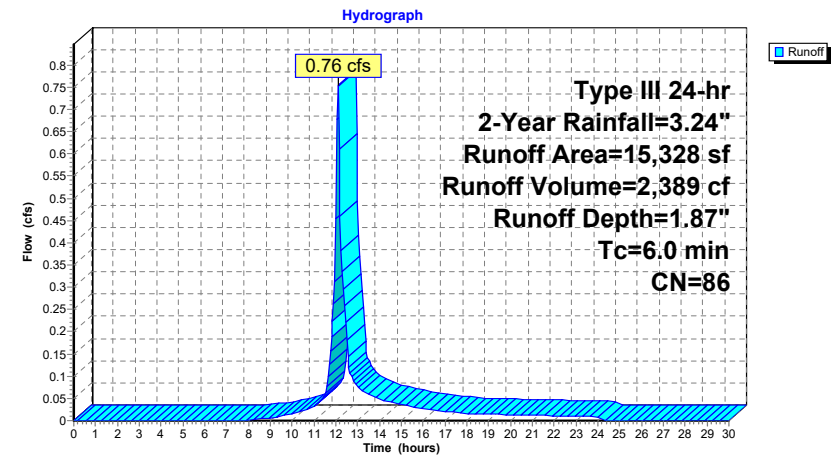
Runoff = 0.76 cfs @ 12.09 hrs, Volume= 2,389 cf, Depth= 1.87"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 2-Year Rainfall=3.24"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

Subcatchment P-9: North Courtyard/Green Roof



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Page 69

### Summary for Reach SWALE: Swale Abutting Entry Driveway

Inflow Area = 24,884 sf, 3.17% Impervious, Inflow Depth = 1.50" for 2-Year event  
Inflow = 0.98 cfs @ 12.10 hrs, Volume= 3,112 cf  
Outflow = 0.91 cfs @ 12.13 hrs, Volume= 3,112 cf, Atten= 7%, Lag= 1.8 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Max. Velocity= 2.60 fps, Min. Travel Time= 2.7 min

Avg. Velocity= 0.76 fps, Avg. Travel Time= 9.4 min

Peak Storage= 149 cf @ 12.13 hrs

Average Depth at Peak Storage= 0.15'

Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 16.60 cfs

2.00' x 0.75' deep channel, n= 0.040 Earth, cobble bottom, clean sides

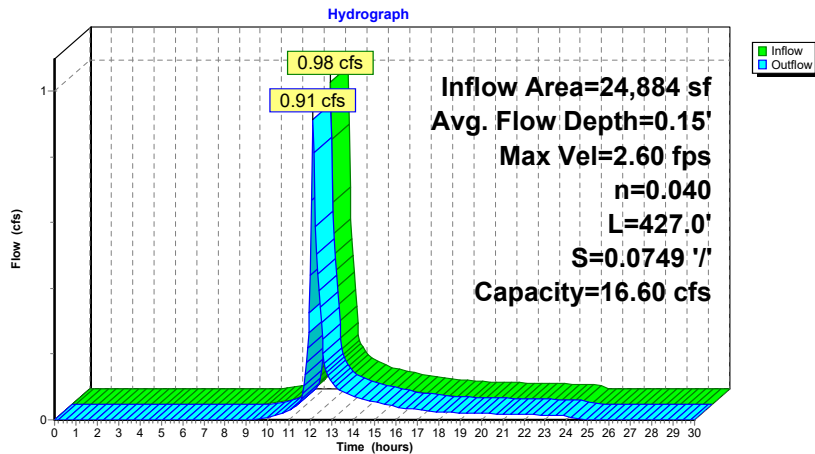
Side Slope Z-value= 2.0 '1' Top Width= 5.00'

Length= 427.0' Slope= 0.0749 '1'

Inlet Invert= 99.50', Outlet Invert= 67.50'



Reach SWALE: Swale Abutting Entry Driveway



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Page 70

### Summary for Pond RG-1: Rain Garden-1 - Entrance

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth > 1.75" for 2-Year event  
Inflow = 1.29 cfs @ 12.28 hrs, Volume= 8,509 cf  
Outflow = 1.22 cfs @ 12.42 hrs, Volume= 7,032 cf, Atten= 5%, Lag= 7.8 min  
Primary = 1.22 cfs @ 12.42 hrs, Volume= 7,032 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 2

Peak Elev= 51.53' @ 12.42 hrs Surf.Area= 1,423 sf Storage= 2,031 cf

Plug-Flow detention time= 130.2 min calculated for 7,020 cf (83% of inflow)

Center-of-Mass det. time= 53.4 min ( 906.7 - 853.3 )

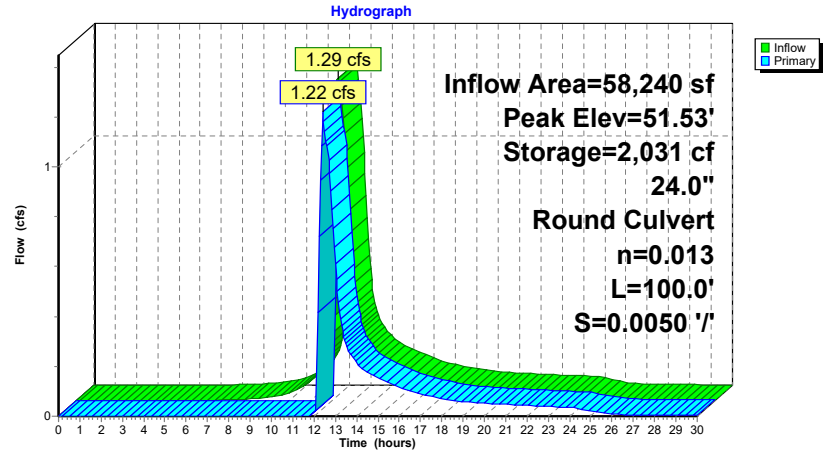
Volume	Invert	Avail.Storage	Storage Description		
#1	49.00'	2,031 cf	Rain Garden (Irregular) Listed below (Recalc)		
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
49.00	425	82.3	0	0	425
50.00	701	101.5	557	557	720
51.00	1,034	120.4	862	1,419	1,072
51.50	1,423	139.2	612	2,031	1,466

Device	Routing	Invert	Outlet Devices	
#1	Primary	51.00'	24.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 51.00' / 50.50' S= 0.0050 '1' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf	

Primary OutFlow Max=1.21 cfs @ 12.42 hrs HW=51.52' (Free Discharge)

1=Culvert (Barrel Controls 1.21 cfs @ 2.78 fps)

Pond RG-1: Rain Garden-1 - Entrance



Summary for Pond RG-2: Rain Garden #2 - Driveway

Inflow Area = 5,160 sf, 100.00% Impervious, Inflow Depth = 3.01" for 2-Year event  
Inflow = 0.36 cfs @ 12.09 hrs, Volume= 1,293 cf  
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

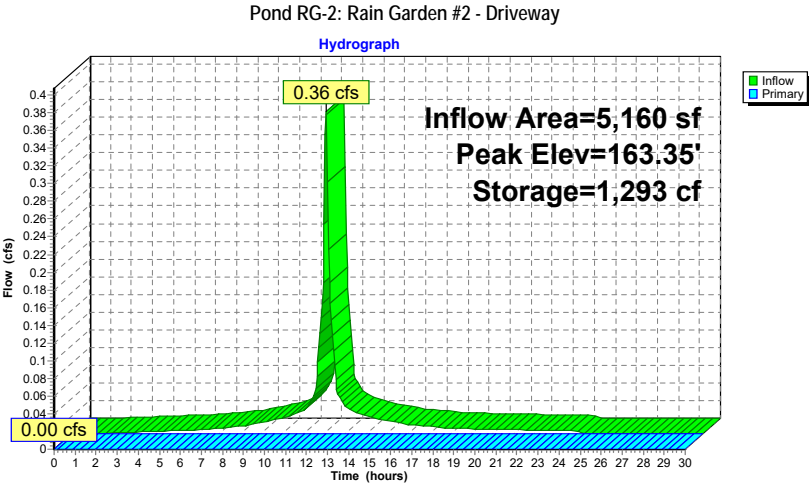
Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 163.35' @ 24.40 hrs Surf.Area= 1,417 sf Storage= 1,293 cf

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

Volume	Invert	Avail.Storage	Storage Description		
#1	162.00'	3,504 cf	Custom Stage Data (Irregular) Listed below (Recalc)		
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
162.00	564	214.6	0	0	564
164.00	1,965	252.4	2,388	2,388	2,044
164.50	2,509	276.8	1,116	3,504	3,080

Device	Routing	Invert	Outlet Devices												
#1	Primary	163.50'	10.0' long x 5.0' 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
				4.50	5.00	5.50									
			Coef. (English)	2.34	2.50	2.70	2.68	2.68	2.66	2.65	2.65	2.65	2.65	2.67	2.66
				2.74	2.79	2.88									

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=162.00' (Free Discharge)  
1=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)



Summary for Pond SDP-1: Surface Detention Pond-1

Inflow Area = 51,002 sf, 18.01% Impervious, Inflow Depth = 1.68" for 2-Year event  
Inflow = 2.24 cfs @ 12.09 hrs, Volume= 7,131 cf  
Outflow = 0.99 cfs @ 12.32 hrs, Volume= 5,175 cf, Atten= 56%, Lag= 13.3 min  
Primary = 0.99 cfs @ 12.32 hrs, Volume= 5,175 cf  
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 78.47' @ 12.32 hrs Surf.Area= 1,752 sf Storage= 2,702 cf

Plug-Flow detention time= 172.4 min calculated for 5,167 cf (72% of inflow)  
Center-of-Mass det. time= 80.4 min ( 908.9 - 828.5 )

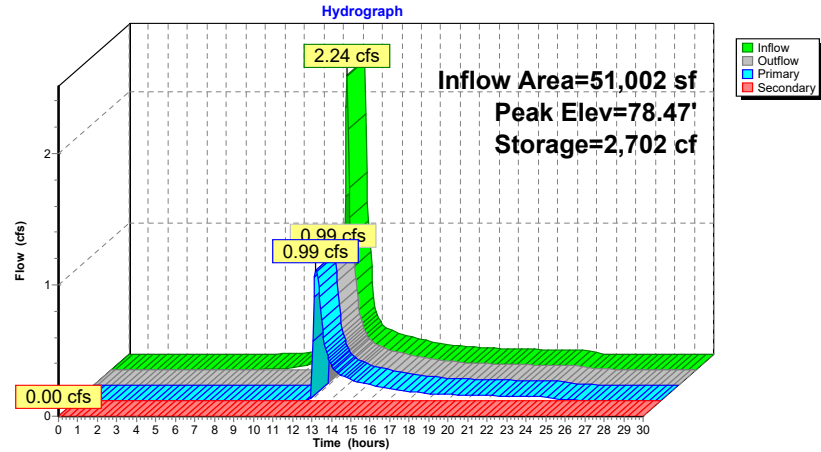
Volume	Invert	Avail.Storage	Storage Description		
#1	76.00'	8,088 cf	Surface Detention Pond (Irregular) Listed below (Recalc)		
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
76.00	531	104.1	0	0	531
78.00	1,488	192.6	1,939	1,939	2,642
80.00	2,756	230.3	4,179	6,118	3,979
80.50	5,256	368.3	1,970	8,088	10,554

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.50'	10.0' long x 10.0' breadth Emergency OverFlow 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
#2	Primary	78.00'	15.0" Round Culvert L= 100.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 78.00' / 77.00' S= 0.0100 '/ S Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=0.99 cfs @ 12.32 hrs HW=78.47' (Free Discharge)  
2=Culvert (Inlet Controls 0.99 cfs @ 2.33 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=76.00' (Free Discharge)  
1=Emergency OverFlow Weir ( Controls 0.00 cfs)

Pond SDP-1: Surface Detention Pond-1



Summary for Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth = 1.76" for 2-Year event  
Inflow = 2.55 cfs @ 12.10 hrs, Volume= 8,520 cf  
Outflow = 1.29 cfs @ 12.28 hrs, Volume= 8,509 cf, Atten= 49%, Lag= 11.0 min  
Primary = 1.29 cfs @ 12.28 hrs, Volume= 8,509 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 47.93' @ 12.29 hrs Surf.Area= 3,520 sf Storage= 1,589 cf

Plug-Flow detention time= 31.7 min calculated for 8,509 cf (100% of inflow)  
Center-of-Mass det. time= 30.8 min ( 853.3 - 822.4 )

Volume	Invert	Avail.Storage	Storage Description
#1A	47.00'	3,452 cf	27.50'W x 128.00'L x 4.00'H Field A 14,080 cf Overall - 5,450 cf Embedded = 8,630 cf x 40.0% Voids
#2A	47.50'	5,450 cf	CMP Round 36 x 36 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 36 Chambers in 6 Rows 25.50' Header x 7.07 sf x 2 = 360.5 cf Inside
8,902 cf			Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	47.00'	18.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.00' / 46.00' S= 0.0100 /' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.77 sf
#2	Device 1	51.00'	5.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Device 1	47.00'	8.0" Vert. 8" Orifice C= 0.600

Primary OutFlow Max=1.29 cfs @ 12.28 hrs HW=47.92' (Free Discharge)  
1=Culvert (Passes 1.29 cfs of 2.96 cfs potential flow)  
2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)  
3=8" Orifice (Orifice Controls 1.29 cfs @ 3.70 fps)

Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)  
Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf  
Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

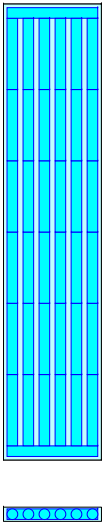
6 Chambers/Row x 20.00' Long +3.00' Header x 2 = 126.00' Row Length +12.0" End Stone x 2 = 128.00' Base Length  
6 Rows x 36.0" Wide + 18.0" Spacing x 5 + 12.0" Side Stone x 2 = 27.50' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

36 Chambers x 141.4 cf + 25.50' Header x 7.07 sf x 2 = 5,449.9 cf Chamber Storage

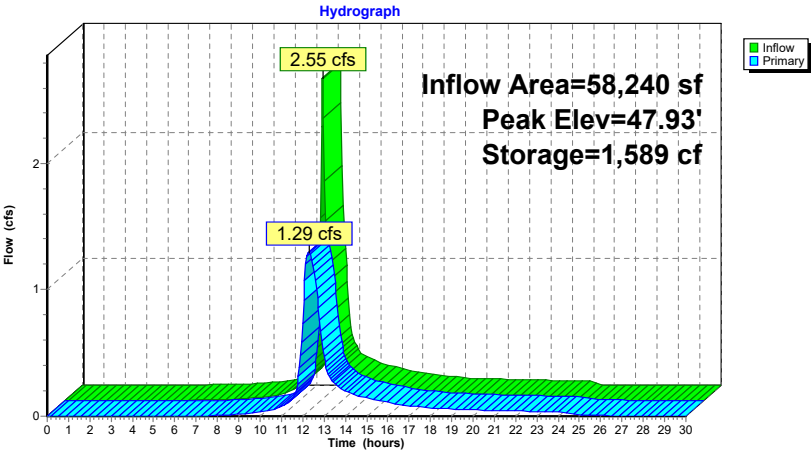
14,080.0 cf Field - 5,449.9 cf Chambers = 8,630.1 cf Stone x 40.0% Voids = 3,452.0 cf Stone Storage

Chamber Storage + Stone Storage = 8,901.9 cf = 0.204 af  
Overall Storage Efficiency = 63.2%  
Overall System Size = 128.00' x 27.50' x 4.00'

36 Chambers  
521.5 cy Field  
319.6 cy Stone



Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)



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The Sanctuary, Manchester-by-the-Sea, MA  
Type III 24-hr 2-Year Rainfall=3.24"

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Page 79

### Summary for Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)

Inflow Area = 70,127 sf, 81.35% Impervious, Inflow Depth = 2.69" for 2-Year event  
Inflow = 4.53 cfs @ 12.09 hrs, Volume= 15,716 cf  
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 104.35' @ 24.40 hrs Surf.Area= 7,020 sf Storage= 15,716 cf  
Flood Elev= 109.25' Surf.Area= 7,020 sf Storage= 42,647 cf

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

Volume	Invert	Avail.Storage	Storage Description
#1A	101.00'	12,163 cf	<b>54.00'W x 130.00'L x 9.00'H Field A</b> 63,180 cf Overall - 32,773 cf Embedded = 30,407 cf x 40.0% Voids
#2A	101.50'	32,773 cf	<b>CMP Round 96</b> x 30 Inside #1 Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 30 Chambers in 5 Rows 52.00' Header x 50.27 sf x 1 = 2,613.8 cf Inside
		44,936 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	<b>12.0" Round Culvert</b> L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.00' S= 0.0100 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	109.25'	<b>4.0' long x 0.5' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=101.00' (Free Discharge)

1=Culvert ( Controls 0.00 cfs)

2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

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Type III 24-hr 2-Year Rainfall=3.24"

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Page 80

### Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96 (Round Corrugated Metal Pipe)

Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf

Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

6 Chambers/Row x 20.00' Long +8.00' Header x 1 = 128.00' Row Length +12.0" End Stone x 2 = 130.00' Base Length  
5 Rows x 96.0" Wide + 36.0" Spacing x 4 + 12.0" Side Stone x 2 = 54.00' Base Width  
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

30 Chambers x 1,005.3 cf + 52.00' Header x 50.27 sf = 32,773.1 cf Chamber Storage

63,180.0 cf Field - 32,773.1 cf Chambers = 30,406.9 cf Stone x 40.0% Voids = 12,162.8 cf Stone Storage

Chamber Storage + Stone Storage = 44,935.9 cf = 1.032 af

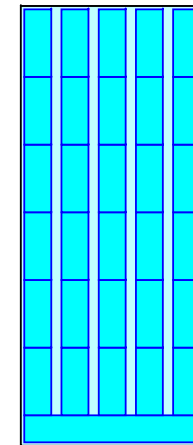
Overall Storage Efficiency = 71.1%

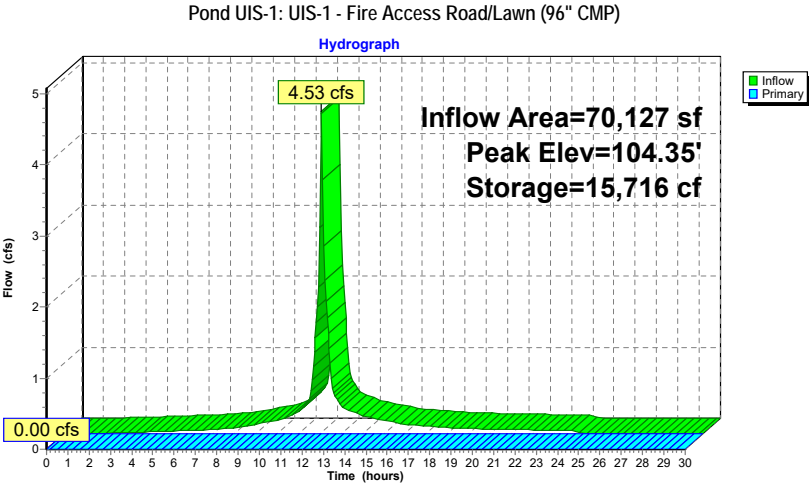
Overall System Size = 130.00' x 54.00' x 9.00'

30 Chambers

2,340.0 cy Field

1,126.2 cy Stone





Summary for Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)

Inflow Area = 44,954 sf, 90.58% Impervious, Inflow Depth = 2.84" for 2-Year event  
Inflow = 3.07 cfs @ 12.09 hrs, Volume= 10,640 cf  
Outflow = 0.09 cfs @ 15.94 hrs, Volume= 7,435 cf, Atten= 97%, Lag= 231.4 min  
Discarded = 0.09 cfs @ 15.94 hrs, Volume= 7,435 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 118.62' @ 15.94 hrs Surf.Area= 6,624 sf Storage= 6,356 cf

Plug-Flow detention time= 429.8 min calculated for 7,435 cf (70% of inflow)  
Center-of-Mass det. time= 336.3 min ( 1,103.3 - 767.1 )

Volume	Invert	Avail. Storage	Storage Description
#1A	117.00'	6,521 cf	23.00'W x 288.00'L x 4.00'H Field A 26,496 cf Overall - 10,193 cf Embedded = 16,303 cf x 40.0% Voids
#2A	117.50'	10,193 cf	CMP Round 36 x 70 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 70 Chambers in 5 Rows 21.00' Header x 7.07 sf x 2 = 296.9 cf Inside
		16,714 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	117.00'	15.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 117.00' / 116.00' S= 0.0100 ' S= 0.0100 ' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.23 sf
#2	Discarded	117.00'	0.520 in/hr Exfiltration over Wetted area
#3	Device 1	120.45'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.09 cfs @ 15.94 hrs HW=118.62' (Free Discharge)  
2=Exfiltration (Exfiltration Controls 0.09 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=117.00' (Free Discharge)  
1=Culvert ( Controls 0.00 cfs)  
3=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)



Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)  
Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf  
Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

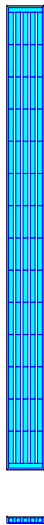
14 Chambers/Row x 20.00' Long +3.00' Header x 2 = 286.00' Row Length +12.0" End Stone x 2 = 288.00' Base Length  
5 Rows x 36.0" Wide + 18.0" Spacing x 4 + 12.0" Side Stone x 2 = 23.00' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

70 Chambers x 141.4 cf + 21.00' Header x 7.07 sf x 2 = 10,192.9 cf Chamber Storage

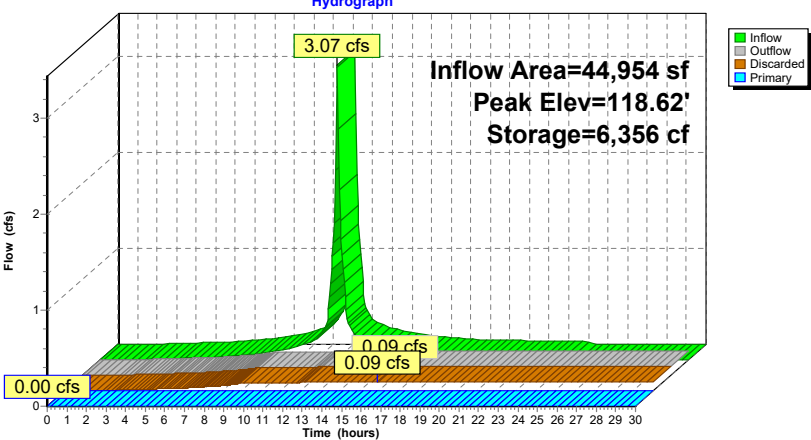
26,496.0 cf Field - 10,192.9 cf Chambers = 16,303.1 cf Stone x 40.0% Voids = 6,521.2 cf Stone Storage

Chamber Storage + Stone Storage = 16,714.1 cf = 0.384 af  
Overall Storage Efficiency = 63.1%  
Overall System Size = 288.00' x 23.00' x 4.00'

70 Chambers  
981.3 cy Field  
603.8 cy Stone



Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)



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Page 85

### Summary for Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)

Inflow Area = 37,779 sf, 57.72% Impervious, Inflow Depth = 2.23" for 2-Year event  
Inflow = 2.18 cfs @ 12.09 hrs, Volume= 7,036 cf  
Outflow = 0.12 cfs @ 14.11 hrs, Volume= 7,036 cf, Atten= 94%, Lag= 121.4 min  
Discarded = 0.12 cfs @ 14.11 hrs, Volume= 7,036 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 108.23' @ 14.11 hrs Surf.Area= 4,930 sf Storage= 3,317 cf  
Flood Elev= 108.50' Surf.Area= 4,930 sf Storage= 4,321 cf

Plug-Flow detention time= 250.5 min calculated for 7,036 cf (100% of inflow)  
Center-of-Mass det. time= 250.3 min (1,052.6 - 802.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	107.00'	4,775 cf	<b>72.50'W x 68.00'L x 4.00'H Field A</b> 19,720 cf Overall - 7,783 cf Embedded = 11,937 cf x 40.0% Voids
#2A	107.50'	7,783 cf	<b>CMP Round 36" x 48" Inside #1</b> Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 48 Chambers in 16 Rows 70.50' Header x 7.07 sf x 2 = 996.7 cf Inside
12,558 cf			Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	107.00'	<b>12.0" Round Culvert</b> L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 107.00' / 102.00' S= 0.0500 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	108.50'	<b>4.0" Vert. Orifice/Grate</b> C= 0.600
#3	Discarded	107.00'	<b>1.020 in/hr Exfiltration over Wetted area</b>

**Discarded OutFlow** Max=0.12 cfs @ 14.11 hrs HW=108.23' (Free Discharge)  
↳ **3=Exfiltration** (Exfiltration Controls 0.12 cfs)

**Primary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=107.00' (Free Discharge)  
↳ **1=Culvert** (Controls 0.00 cfs)  
↳ **2=Orifice/Grate** (Controls 0.00 cfs)

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Page 86

### Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP) - Chamber Wizard Field A

**Chamber Model = CMP Round 36" (Round Corrugated Metal Pipe)**

Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf

Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

3 Chambers/Row x 20.00' Long +3.00' Header x 2 = 66.00' Row Length +12.0" End Stone x 2 = 68.00' Base Length  
16 Rows x 36.0" Wide + 18.0" Spacing x 15 + 12.0" Side Stone x 2 = 72.50' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

48 Chambers x 141.4 cf + 70.50' Header x 7.07 sf x 2 = 7,782.5 cf Chamber Storage

19,720.0 cf Field - 7,782.5 cf Chambers = 11,937.5 cf Stone x 40.0% Voids = 4,775.0 cf Stone Storage

Chamber Storage + Stone Storage = 12,557.5 cf = 0.288 af

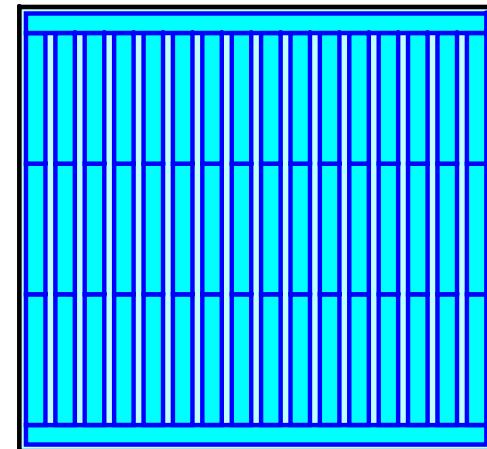
Overall Storage Efficiency = 63.7%

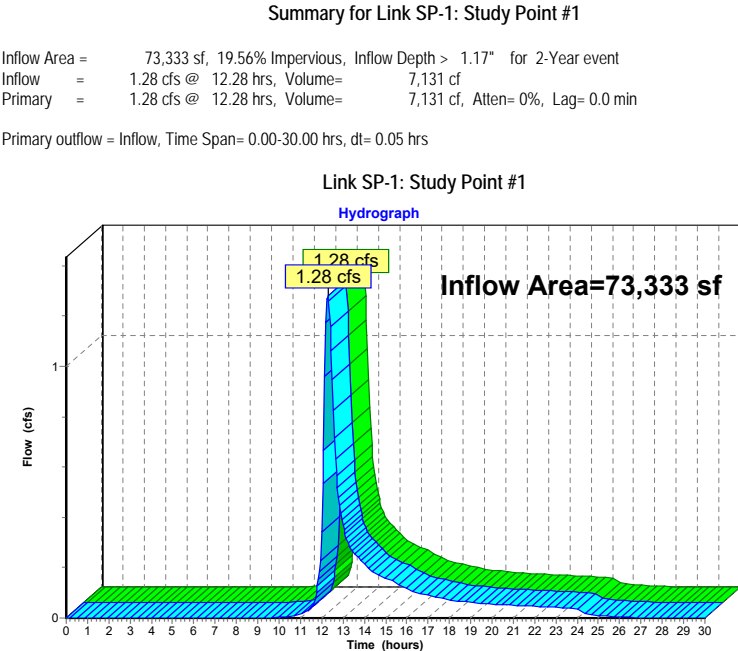
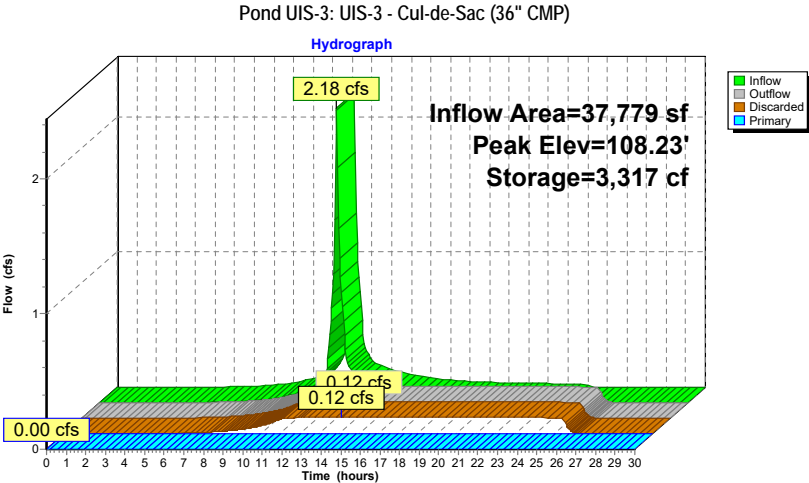
Overall System Size = 68.00' x 72.50' x 4.00'

48 Chambers

730.4 cy Field

442.1 cy Stone





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Type III 24-hr 2-Year Rainfall=3.24"

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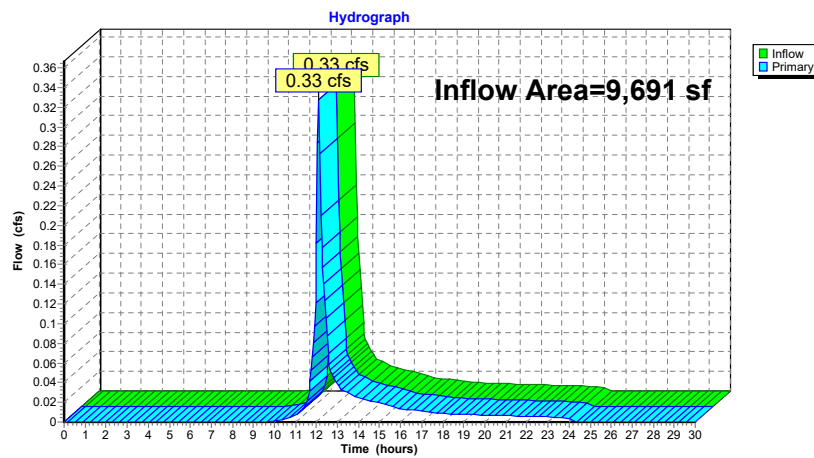
Page 89

### Summary for Link SP-2: Study Point #2

Inflow Area = 9,691 sf, 0.00% Impervious, Inflow Depth = 1.30" for 2-Year event  
Inflow = 0.33 cfs @ 12.10 hrs, Volume= 1,052 cf  
Primary = 0.33 cfs @ 12.10 hrs, Volume= 1,052 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2



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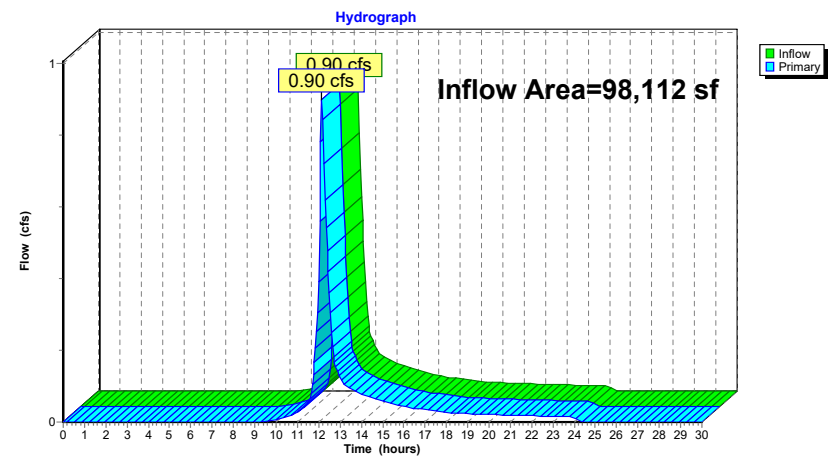
Page 90

### Summary for Link SP-3: Study Point #3

Inflow Area = 98,112 sf, 58.66% Impervious, Inflow Depth = 0.41" for 2-Year event  
Inflow = 0.90 cfs @ 12.16 hrs, Volume= 3,341 cf  
Primary = 0.90 cfs @ 12.16 hrs, Volume= 3,341 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-3: Study Point #3



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Page 91

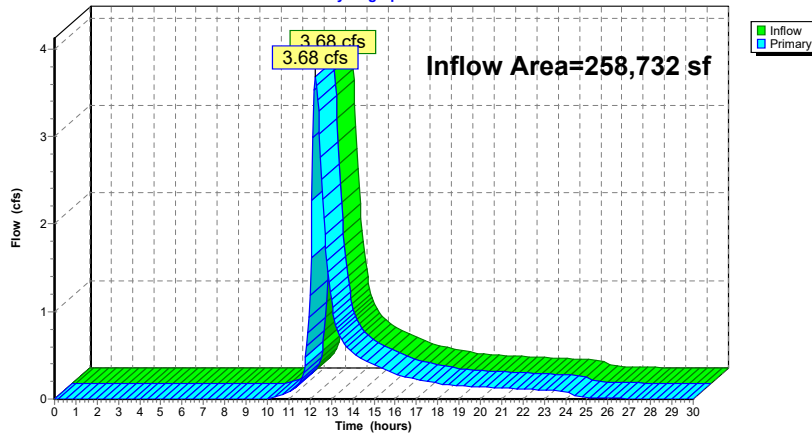
### Summary for Link SP-4: Study Point #4

Inflow Area = 258,732 sf, 29.63% Impervious, Inflow Depth > 0.92" for 2-Year event  
Inflow = 3.68 cfs @ 12.26 hrs, Volume= 19,816 cf  
Primary = 3.68 cfs @ 12.26 hrs, Volume= 19,816 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-4: Study Point #4

Hydrograph



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Page 92

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North	Runoff Area=17,171 sf 0.00% Impervious Runoff Depth=2.70" Tc=6.0 min CN=79 Runoff=1.22 cfs 3,862 cf
Subcatchment P-10: Proposed Building Roof	Runoff Area=30,342 sf 100.00% Impervious Runoff Depth=4.64" Tc=6.0 min CN=98 Runoff=3.25 cfs 11,741 cf
Subcatchment P-11: South Courtyard	Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=4.64" Tc=6.0 min CN=98 Runoff=2.16 cfs 7,809 cf
Subcatchment P-12: Southeast Roof Area	Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=4.64" Tc=6.0 min CN=98 Runoff=2.92 cfs 10,546 cf
Subcatchment P-13: Main Parking Area	Runoff Area=17,700 sf 76.07% Impervious Runoff Depth=4.19" Tc=6.0 min CN=94 Runoff=1.82 cfs 6,180 cf
Subcatchment P-14: WWTF/Driveway	Runoff Area=19,605 sf 33.29% Impervious Runoff Depth=3.36" Tc=6.0 min CN=86 Runoff=1.71 cfs 5,482 cf
Subcatchment P-15: South Lawn/Fire Access Road	Runoff Area=18,445 sf 0.00% Impervious Runoff Depth=2.79" Tc=6.0 min CN=80 Runoff=1.36 cfs 4,286 cf
Subcatchment P-16: Entrance Drive	Runoff Area=20,820 sf 44.13% Impervious Runoff Depth=3.56" Tc=6.0 min CN=88 Runoff=1.91 cfs 6,168 cf
Subcatchment P-17: Detention Pond-1	Runoff Area=11,737 sf 0.00% Impervious Runoff Depth=2.79" Tc=6.0 min CN=80 Runoff=0.86 cfs 2,727 cf
Subcatchment P-18: Entry Driveway	Runoff Area=5,160 sf 100.00% Impervious Runoff Depth=4.64" Tc=6.0 min CN=98 Runoff=0.55 cfs 1,997 cf
Subcatchment P-2: Direct Flow to Wetlands "F"	Runoff Area=9,691 sf 0.00% Impervious Runoff Depth=2.61" Tc=6.0 min CN=78 Runoff=0.67 cfs 2,108 cf
Subcatchment P-3: Flow Southwest Off-Site	Runoff Area=27,985 sf 1.79% Impervious Runoff Depth=2.79" Flow Length=194' Slope=0.0100 '/' Tc=10.9 min CN=80 Runoff=1.77 cfs 6,503 cf
Subcatchment P-4: Flow Southeast to Wetlands "A"	Runoff Area=117,759 sf 0.54% Impervious Runoff Depth=2.61" Flow Length=186' Tc=14.0 min CN=78 Runoff=6.38 cfs 25,614 cf
Subcatchment P-5: Entrance Drive	Runoff Area=14,879 sf 78.94% Impervious Runoff Depth=4.19" Tc=6.0 min CN=94 Runoff=1.53 cfs 5,195 cf
Subcatchment P-6: Landcaped Slope/Walls	Runoff Area=18,477 sf 5.22% Impervious Runoff Depth=2.79" Tc=6.0 min UI Adjusted CN=80 Runoff=1.36 cfs 4,293 cf
Subcatchment P-7: Landscaped Slope	Runoff Area=24,884 sf 3.17% Impervious Runoff Depth=2.88" Tc=6.0 min CN=81 Runoff=1.89 cfs 5,971 cf

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Page 93

Subcatchment P-8: Cul-de-Sac/Garage Turn Around	Runoff Area=22,451 sf 74.60% Impervious Runoff Depth=4.08" Tc=6.0 min CN=93 Runoff=2.27 cfs 7,634 cf
Subcatchment P-9: North Courtyard/Green Roof	Runoff Area=15,328 sf 33.00% Impervious Runoff Depth=3.36" Tc=6.0 min CN=86 Runoff=1.34 cfs 4,286 cf
Reach SWALE: Swale Abutting Entry Driveway	Avg. Flow Depth=0.23' Max Vel=3.27 fps Inflow=1.89 cfs 5,971 cf n=0.040 L=427.0' S=0.0749 ' Capacity=16.60 cfs Outflow=1.81 cfs 5,971 cf
Pond RG-1: Rain Garden-1 - Entrance	Peak Elev=51.68' Storage=2,031 cf Inflow=1.88 cfs 15,447 cf 24.0" Round Culvert n=0.013 L=100.0' S=0.0050 ' Outflow=1.99 cfs 14,386 cf
Pond RG-2: Rain Garden #2 - Driveway	Peak Elev=163.51' Storage=1,529 cf Inflow=0.55 cfs 1,997 cf Outflow=0.03 cfs 482 cf
Pond SDP-1: Surface Detention Pond-1	Peak Elev=78.92' Storage=3,538 cf Inflow=4.12 cfs 13,181 cf Primary=3.14 cfs 11,225 cf Secondary=0.00 cfs 0 cf Outflow=3.14 cfs 11,225 cf
Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)	Peak Elev=48.59' Storage=3,300 cf Inflow=4.65 cfs 15,459 cf Outflow=1.88 cfs 15,447 cf
Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)	Peak Elev=105.93' Storage=25,031 cf Inflow=7.11 cfs 25,031 cf Outflow=0.00 cfs 0 cf
Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)	Peak Elev=119.55' Storage=11,197 cf Inflow=4.73 cfs 16,726 cf Discarded=0.10 cfs 8,419 cf Primary=0.00 cfs 0 cf Outflow=0.10 cfs 8,419 cf
Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)	Peak Elev=108.85' Storage=5,679 cf Inflow=3.60 cfs 11,919 cf Discarded=0.13 cfs 9,743 cf Primary=0.18 cfs 1,948 cf Outflow=0.31 cfs 11,691 cf
Link SP-1: Study Point #1	Inflow=4.12 cfs 15,568 cf Primary=4.12 cfs 15,568 cf
Link SP-2: Study Point #2	Inflow=0.67 cfs 2,108 cf Primary=0.67 cfs 2,108 cf
Link SP-3: Study Point #3	Inflow=1.77 cfs 6,503 cf Primary=1.77 cfs 6,503 cf
Link SP-4: Study Point #4	Inflow=8.29 cfs 41,948 cf Primary=8.29 cfs 41,948 cf

Total Runoff Area = 439,868 sf Runoff Volume = 122,399 cf Average Runoff Depth = 3.34"  
66.23% Pervious = 291,317 sf 33.77% Impervious = 148,551 sf

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Page 94

### Summary for Subcatchment P-1: Flow to Wetlands - North

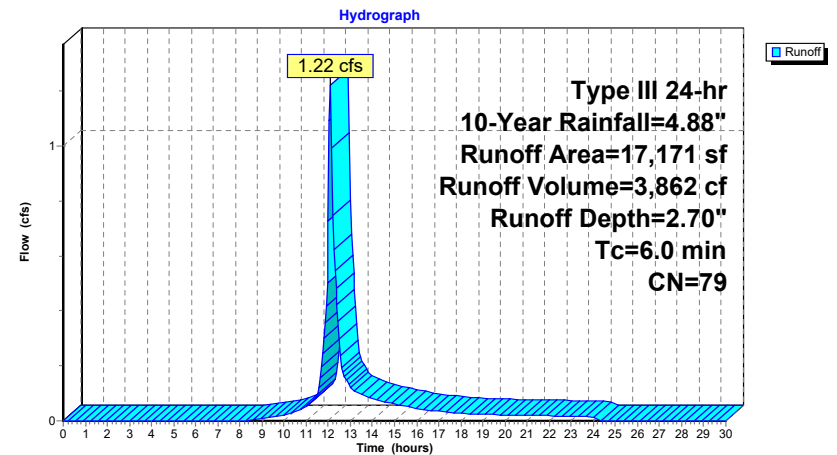
Runoff = 1.22 cfs @ 12.09 hrs, Volume= 3,862 cf, Depth= 2.70"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
12,252	80	>75% Grass cover, Good, HSG D
4,919	77	Woods, Good, HSG D
17,171	79	Weighted Average
17,171		100.00% Pervious Area

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

### Subcatchment P-1: Flow to Wetlands - North



Summary for Subcatchment P-10: Proposed Building Roof

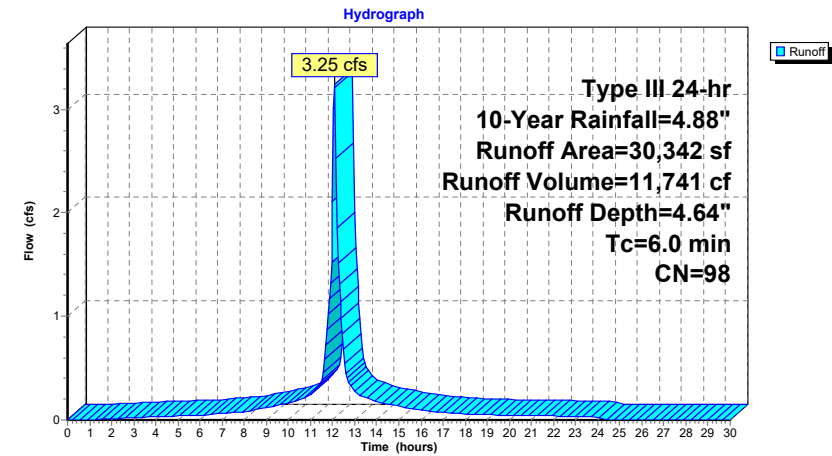
Runoff = 3.25 cfs @ 12.09 hrs, Volume= 11,741 cf, Depth= 4.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
30,342	98	Unconnected roofs, HSG D
30,342		100.00% Impervious Area
30,342		100.00% Unconnected

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

Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

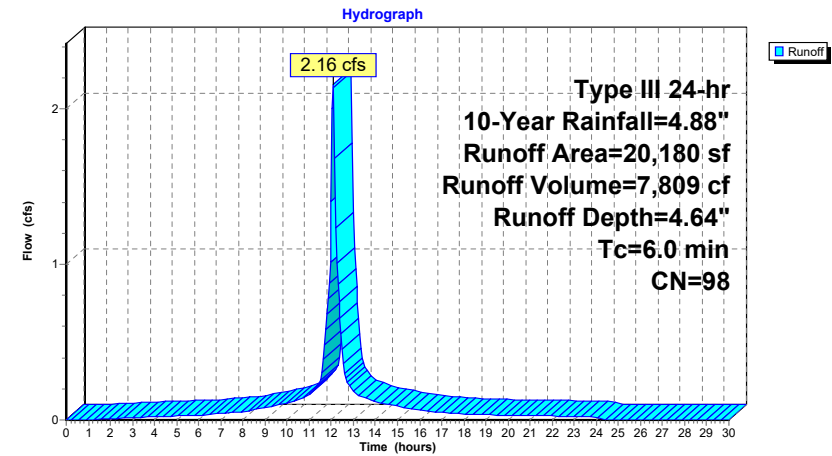
Runoff = 2.16 cfs @ 12.09 hrs, Volume= 7,809 cf, Depth= 4.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

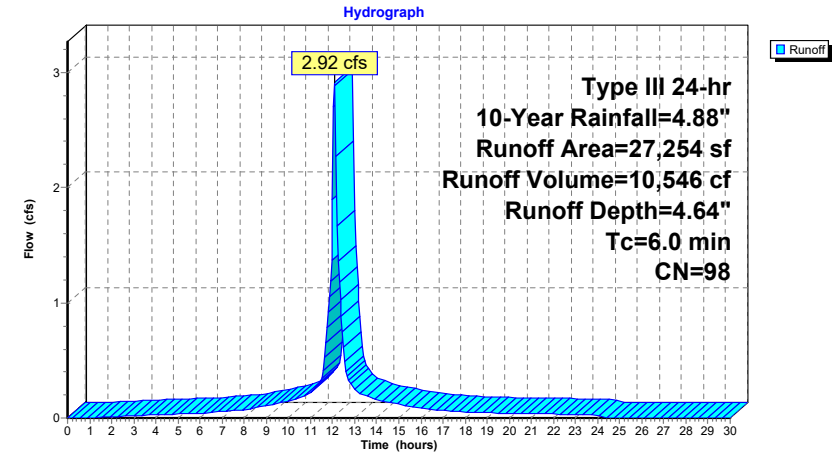
Runoff = 2.92 cfs @ 12.09 hrs, Volume= 10,546 cf, Depth= 4.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

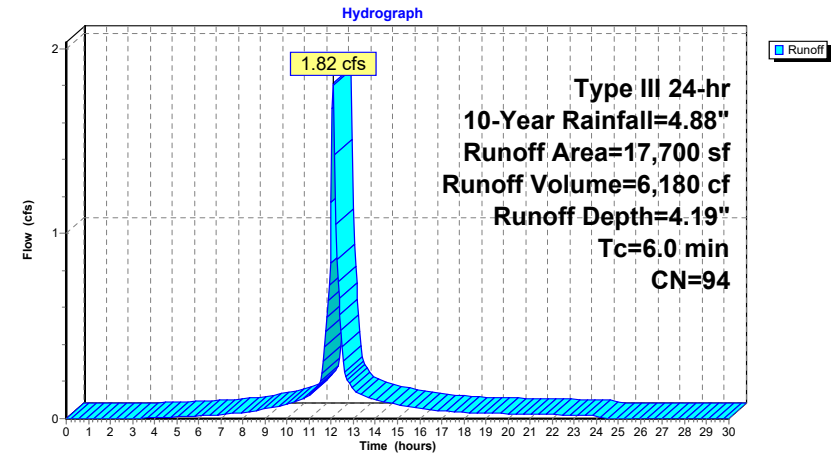
Runoff = 1.82 cfs @ 12.09 hrs, Volume= 6,180 cf, Depth= 4.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
13,464	98	Unconnected pavement, HSG D
4,236	80	>75% Grass cover, Good, HSG D
17,700	94	Weighted Average
4,236		23.93% Pervious Area
13,464		76.07% Impervious Area
13,464		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area





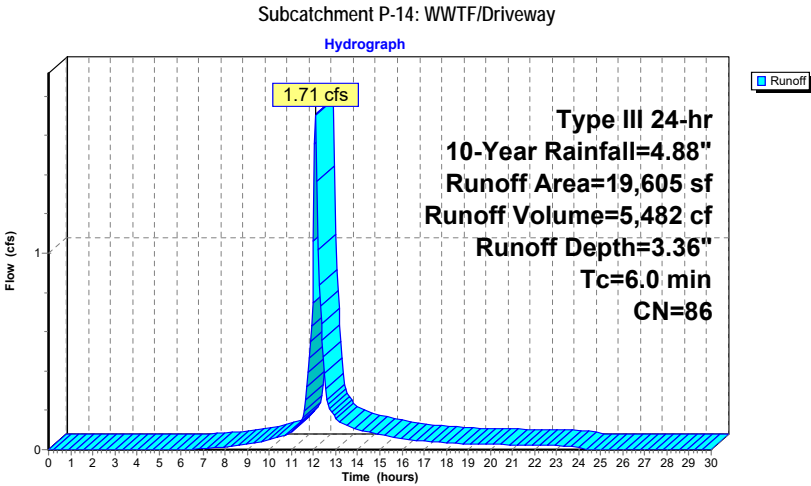
Summary for Subcatchment P-14: WWTF/Driveway

Runoff = 1.71 cfs @ 12.09 hrs, Volume= 5,482 cf, Depth= 3.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
6,526	98	Paved parking, HSG D
9,225	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
19,605	86	Weighted Average
13,079		66.71% Pervious Area
6,526		33.29% Impervious Area

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



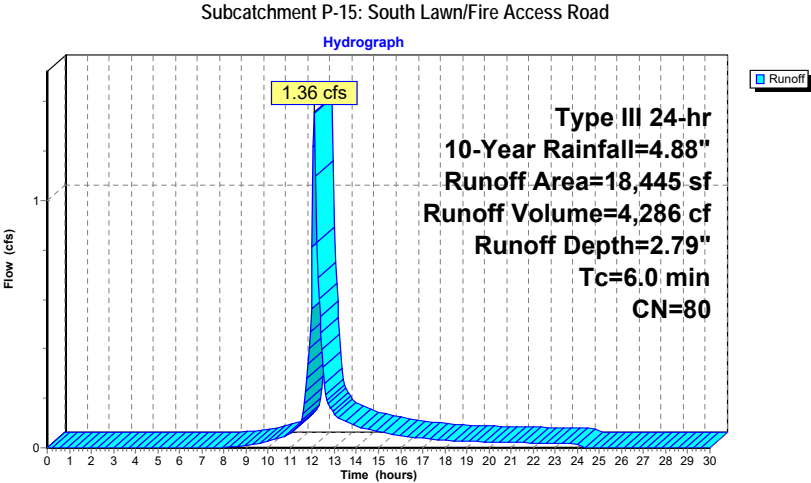
Summary for Subcatchment P-15: South Lawn/Fire Access Road

Runoff = 1.36 cfs @ 12.09 hrs, Volume= 4,286 cf, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
14,591	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
18,445	80	Weighted Average
18,445		100.00% Pervious Area

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



Summary for Subcatchment P-16: Entrance Drive

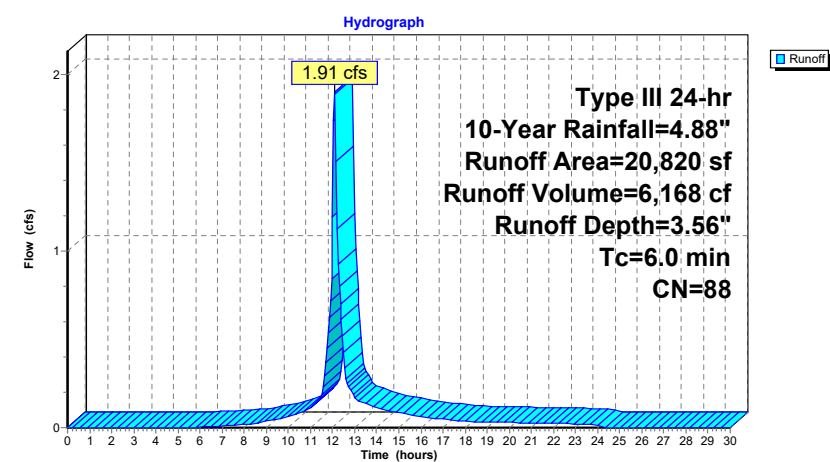
Runoff = 1.91 cfs @ 12.09 hrs, Volume= 6,168 cf, Depth= 3.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
9,187	98	Unconnected pavement, HSG D
11,633	80	>75% Grass cover, Good, HSG D
20,820	88	Weighted Average
11,633		55.87% Pervious Area
9,187		44.13% Impervious Area
9,187		100.00% Unconnected

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

Subcatchment P-16: Entrance Drive



Summary for Subcatchment P-17: Detention Pond-1

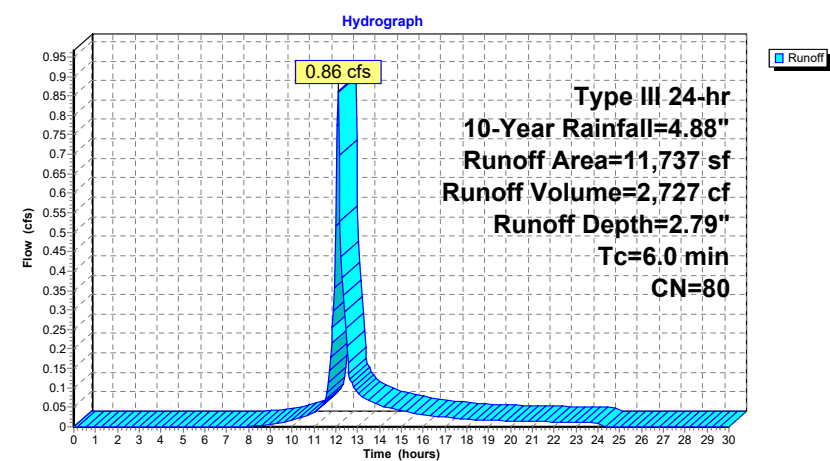
Runoff = 0.86 cfs @ 12.09 hrs, Volume= 2,727 cf, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
4,872	91	Gravel roads, HSG D
6,865	73	Brush, Good, HSG D
11,737	80	Weighted Average
11,737		100.00% Pervious Area

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

Subcatchment P-17: Detention Pond-1



Summary for Subcatchment P-18: Entry Driveway

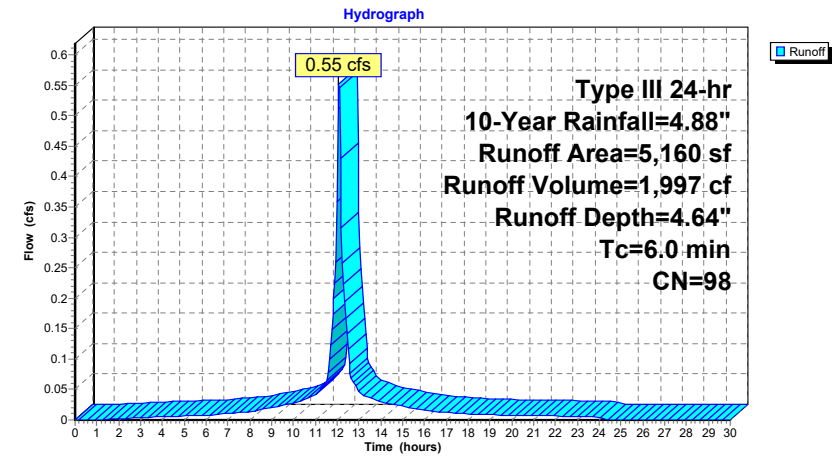
Runoff = 0.55 cfs @ 12.09 hrs, Volume= 1,997 cf, Depth= 4.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
5,160	98	Unconnected pavement, HSG D
5,160		100.00% Impervious Area
5,160		100.00% Unconnected

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

Subcatchment P-18: Entry Driveway



Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

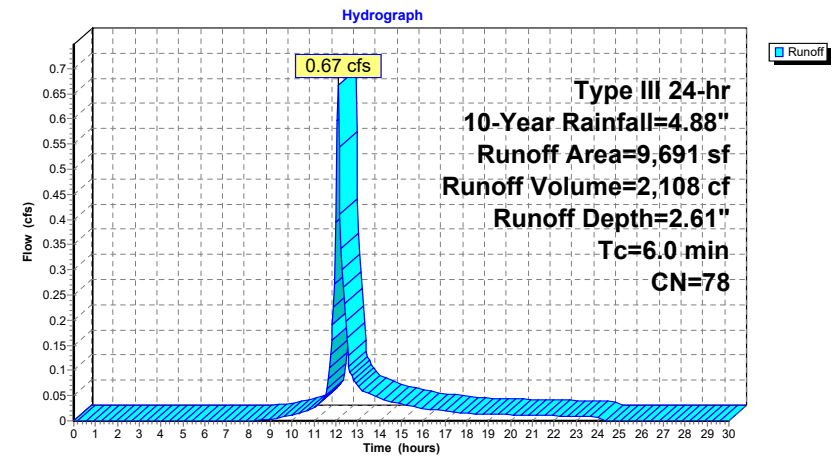
Runoff = 0.67 cfs @ 12.09 hrs, Volume= 2,108 cf, Depth= 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
1,678	80	>75% Grass cover, Good, HSG D
8,013	77	Woods, Good, HSG D
9,691	78	Weighted Average
9,691		100.00% Pervious Area

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

Subcatchment P-2: Direct Flow to Wetlands "F"



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Page 105

## Summary for Subcatchment P-3: Flow Southwest Off-Site

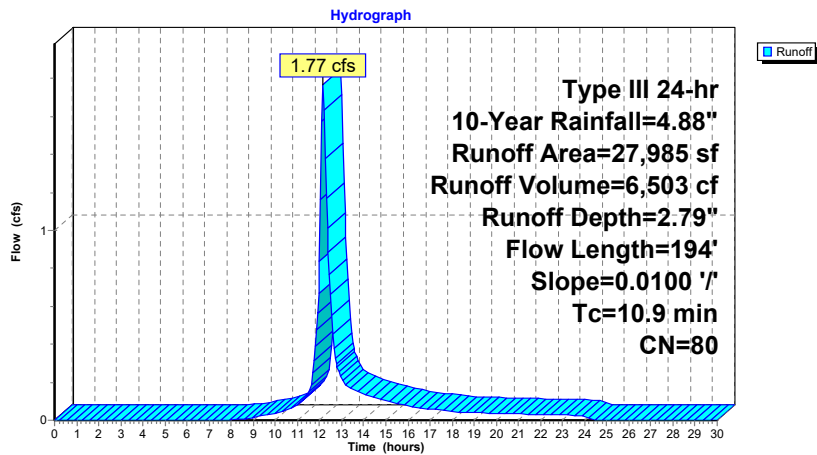
Runoff = 1.77 cfs @ 12.15 hrs, Volume= 6,503 cf, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
24,995	80	>75% Grass cover, Good, HSG D
2,490	77	Woods, Good, HSG D
500	98	Unconnected pavement, HSG D
27,985	80	Weighted Average
27,485		98.21% Pervious Area
500		1.79% Impervious Area
500		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0100	0.11		Sheet Flow, Grass: Short n= 0.150 P2= 3.16"
3.4	144	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
10.9	194	Total			

## Subcatchment P-3: Flow Southwest Off-Site



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Page 106

## Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

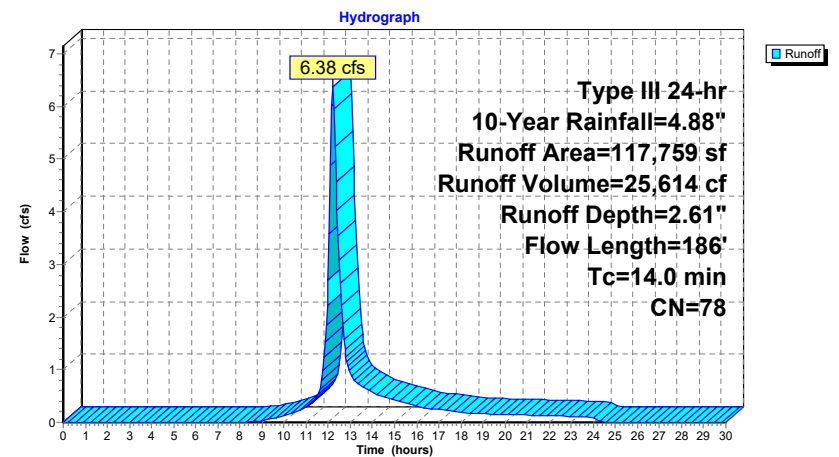
Runoff = 6.38 cfs @ 12.20 hrs, Volume= 25,614 cf, Depth= 2.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
92,430	77	Woods, Good, HSG D
24,696	80	>75% Grass cover, Good, HSG D
633	98	Unconnected pavement, HSG D
117,759	78	Weighted Average
117,126		99.46% Pervious Area
633		0.54% Impervious Area
633		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

## Subcatchment P-4: Flow Southeast to Wetlands "A"



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Page 107

## Summary for Subcatchment P-5: Entrance Drive

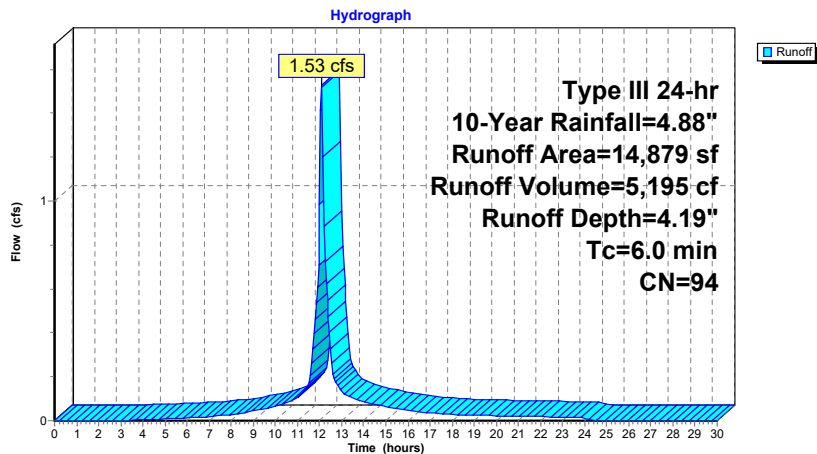
Runoff = 1.53 cfs @ 12.09 hrs, Volume= 5,195 cf, Depth= 4.19"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
11,745	98	Paved parking, HSG D
3,134	80	>75% Grass cover, Good, HSG D
14,879	94	Weighted Average
3,134		21.06% Pervious Area
11,745		78.94% Impervious Area

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

## Subcatchment P-5: Entrance Drive



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Page 108

## Summary for Subcatchment P-6: Landcaped Slope/Walls

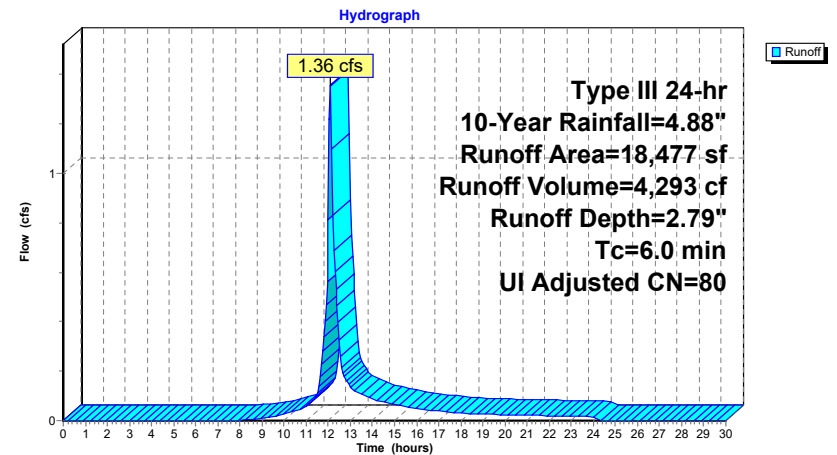
Runoff = 1.36 cfs @ 12.09 hrs, Volume= 4,293 cf, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Adj	Description
17,512	80		>75% Grass cover, Good, HSG D
965	98		Unconnected pavement, HSG D
18,477	81	80	Weighted Average, UI Adjusted
17,512			94.78% Pervious Area
965			5.22% Impervious Area
965			100.00% Unconnected

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

## Subcatchment P-6: Landcaped Slope/Walls



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Page 109

### Summary for Subcatchment P-7: Landscaped Slope

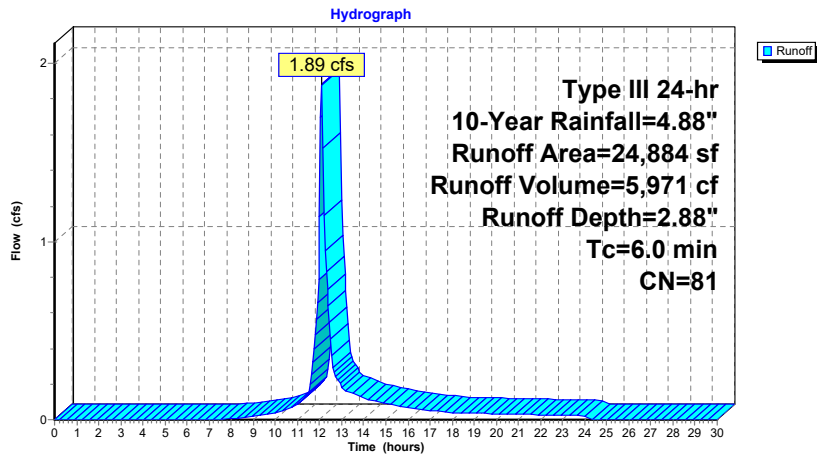
Runoff = 1.89 cfs @ 12.09 hrs, Volume= 5,971 cf, Depth= 2.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
788	98	Paved parking, HSG D
24,096	80	>75% Grass cover, Good, HSG D
24,884	81	Weighted Average
24,096		96.83% Pervious Area
788		3.17% Impervious Area

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

### Subcatchment P-7: Landscaped Slope



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Page 110

### Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

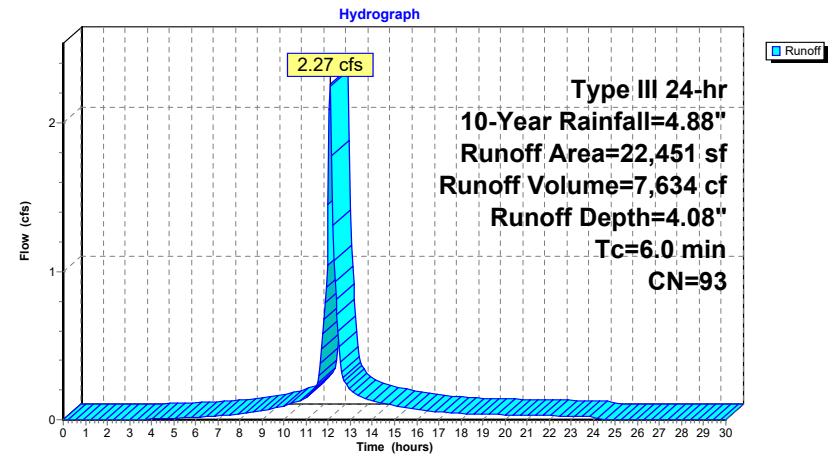
Runoff = 2.27 cfs @ 12.09 hrs, Volume= 7,634 cf, Depth= 4.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
16,749	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,451	93	Weighted Average
5,702		25.40% Pervious Area
16,749		74.60% Impervious Area

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

### Subcatchment P-8: Cul-de-Sac/Garage Turn Around



Summary for Subcatchment P-9: North Courtyard/Green Roof

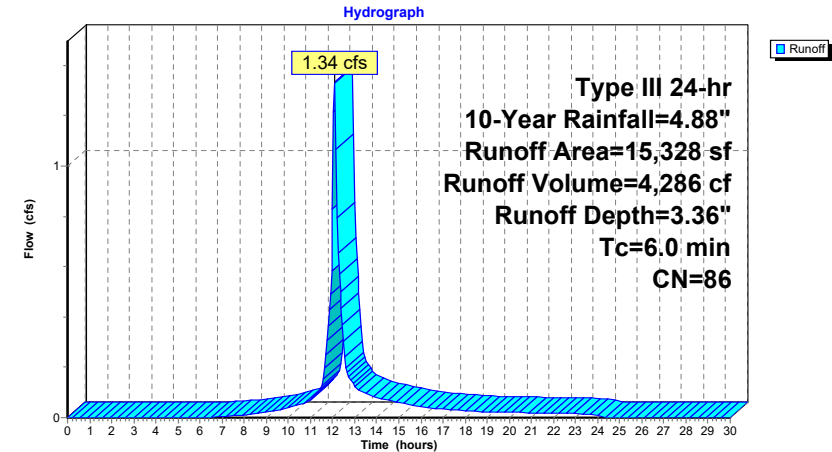
Runoff = 1.34 cfs @ 12.09 hrs, Volume= 4,286 cf, Depth= 3.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 10-Year Rainfall=4.88"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

Subcatchment P-9: North Courtyard/Green Roof



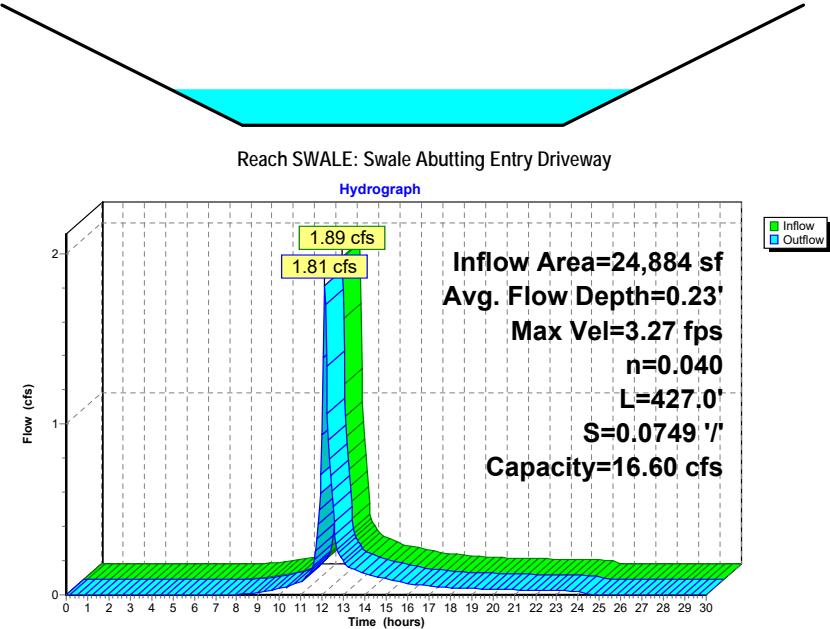
Summary for Reach SWALE: Swale Abutting Entry Driveway

Inflow Area = 24,884 sf, 3.17% Impervious, Inflow Depth = 2.88" for 10-Year event  
Inflow = 1.89 cfs @ 12.09 hrs, Volume= 5,971 cf  
Outflow = 1.81 cfs @ 12.12 hrs, Volume= 5,971 cf, Atten= 4%, Lag= 1.5 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Max. Velocity= 3.27 fps, Min. Travel Time= 2.2 min  
Avg. Velocity = 0.91 fps, Avg. Travel Time= 7.8 min

Peak Storage= 236 cf @ 12.12 hrs  
Average Depth at Peak Storage= 0.23'  
Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 16.60 cfs

2.00' x 0.75' deep channel, n= 0.040 Earth, cobble bottom, clean sides  
Side Slope Z-value= 2.0 ' Top Width= 5.00'  
Length= 427.0' Slope= 0.0749 ' / '  
Inlet Invert= 99.50', Outlet Invert= 67.50'



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Page 113

### Summary for Pond RG-1: Rain Garden-1 - Entrance

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth > 3.18" for 10-Year event  
Inflow = 1.88 cfs @ 12.35 hrs, Volume= 15,447 cf  
Outflow = 1.99 cfs @ 12.35 hrs, Volume= 14,386 cf, Atten= 0%, Lag= 0.0 min  
Primary = 1.99 cfs @ 12.35 hrs, Volume= 14,386 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 2  
Peak Elev= 51.68' @ 12.35 hrs Surf.Area= 1,423 sf Storage= 2,031 cf

Plug-Flow detention time= 71.2 min calculated for 14,386 cf (93% of inflow)  
Center-of-Mass det. time= 32.9 min ( 868.9 - 836.0 )

Volume	Invert	Avail.Storage	Storage Description			
#1	49.00'	2,031 cf	Rain Garden (Irregular) Listed below (Recalc)			
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)	
49.00	425	82.3	0	0	425	
50.00	701	101.5	557	557	720	
51.00	1,034	120.4	862	1,419	1,072	
51.50	1,423	139.2	612	2,031	1,466	

Device	Routing	Invert	Outlet Devices			
#1	Primary	51.00'	24.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 51.00' / 50.50' S= 0.0050 '/ S= 0.0050 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf			

Primary OutFlow Max=1.99 cfs @ 12.35 hrs HW=51.68' (Free Discharge)

1=Culvert (Barrel Controls 1.99 cfs @ 3.14 fps)

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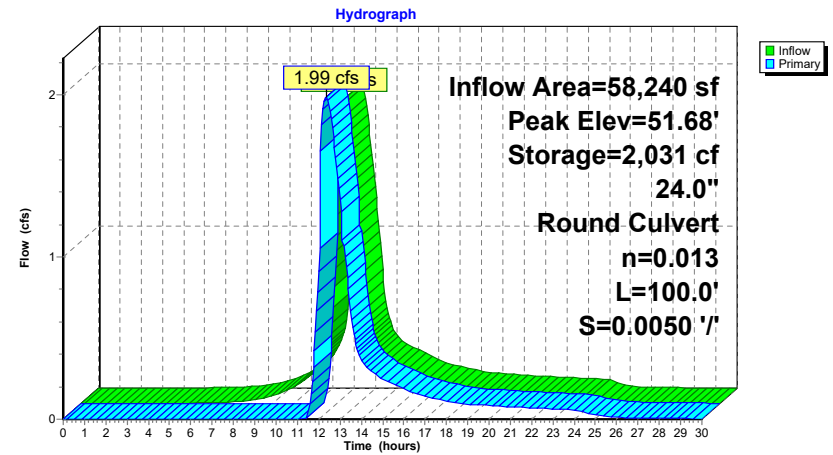
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Page 114

### Pond RG-1: Rain Garden-1 - Entrance





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Page 115

### Summary for Pond RG-2: Rain Garden #2 - Driveway

Inflow Area = 5,160 sf, 100.00% Impervious, Inflow Depth = 4.64" for 10-Year event  
Inflow = 0.55 cfs @ 12.09 hrs, Volume= 1,997 cf  
Outflow = 0.03 cfs @ 13.75 hrs, Volume= 482 cf, Atten= 94%, Lag= 100.1 min  
Primary = 0.03 cfs @ 13.75 hrs, Volume= 482 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 163.51' @ 13.75 hrs Surf.Area= 1,543 sf Storage= 1,529 cf

Plug-Flow detention time= 505.2 min calculated for 481 cf (24% of inflow)  
Center-of-Mass det. time= 275.4 min ( 1,023.9 - 748.4 )

Volume	Invert	Avail.Storage	Storage Description
#1	162.00'	3,504 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
162.00	564	214.6	0	0	564
164.00	1,965	252.4	2,388	2,388	2,044
164.50	2,509	276.8	1,116	3,504	3,080

Device	Routing	Invert	Outlet Devices
#1	Primary	163.50'	10.0' long x 5.0' 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) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.67 2.66 2.68 2.70			
2.74 2.79 2.88			

Primary OutFlow Max=0.02 cfs @ 13.75 hrs HW=163.51' (Free Discharge)

1=Broad-Crested Rectangular Weir (Weir Controls 0.02 cfs @ 0.22 fps)

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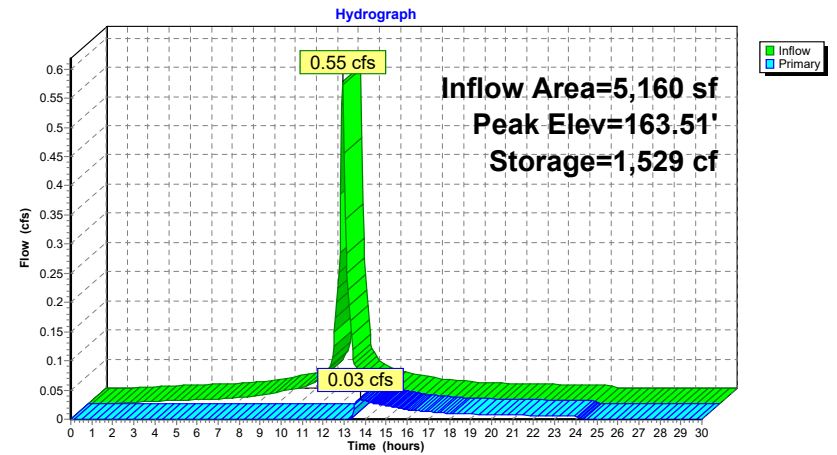
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Page 116

### Pond RG-2: Rain Garden #2 - Driveway



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Page 117

### Summary for Pond SDP-1: Surface Detention Pond-1

Inflow Area = 51,002 sf, 18.01% Impervious, Inflow Depth = 3.10" for 10-Year event  
Inflow = 4.12 cfs @ 12.09 hrs, Volume= 13,181 cf  
Outflow = 3.14 cfs @ 12.17 hrs, Volume= 11,225 cf, Atten= 24%, Lag= 4.5 min  
Primary = 3.14 cfs @ 12.17 hrs, Volume= 11,225 cf  
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 78.92' @ 12.17 hrs Surf.Area= 2,020 sf Storage= 3,538 cf

Plug-Flow detention time= 114.3 min calculated for 11,225 cf (85% of inflow)  
Center-of-Mass det. time= 50.5 min ( 862.0 - 811.6 )

Volume	Invert	Avail.Storage	Storage Description
#1	76.00'	8,088 cf	Surface Detention Pond (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
76.00	531	104.1	0	0	531
78.00	1,488	192.6	1,939	1,939	2,642
80.00	2,756	230.3	4,179	6,118	3,979
80.50	5,256	368.3	1,970	8,088	10,554

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.50'	10.0' long x 10.0' breadth Emergency OverFlow 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
#2	Primary	78.00'	15.0" Round Culvert L= 100.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 78.00' / 77.00' S= 0.0100 '/ S Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=3.09 cfs @ 12.17 hrs HW=78.91' (Free Discharge)  
2=Culvert (Inlet Controls 3.09 cfs @ 3.24 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=76.00' (Free Discharge)  
1=Emergency OverFlow Weir ( Controls 0.00 cfs)

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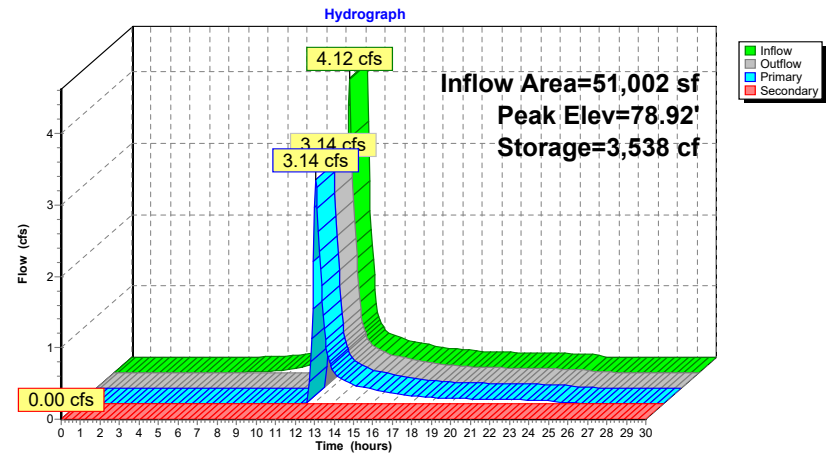
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Page 118

### Pond SDP-1: Surface Detention Pond-1



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Page 119

### Summary for Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth = 3.19" for 10-Year event  
Inflow = 4.65 cfs @ 12.10 hrs, Volume= 15,459 cf  
Outflow = 1.88 cfs @ 12.35 hrs, Volume= 15,447 cf, Atten= 60%, Lag= 15.0 min  
Primary = 1.88 cfs @ 12.35 hrs, Volume= 15,447 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 48.59' @ 12.35 hrs Surf.Area= 3,520 sf Storage= 3,300 cf

Plug-Flow detention time= 29.1 min calculated for 15,447 cf (100% of inflow)  
Center-of-Mass det. time= 28.6 min ( 836.0 - 807.4 )

Volume	Invert	Avail.Storage	Storage Description
#1A	47.00'	3,452 cf	<b>27.50'W x 128.00'L x 4.00'H Field A</b> 14,080 cf Overall - 5,450 cf Embedded = 8,630 cf x 40.0% Voids
#2A	47.50'	5,450 cf	<b>CMP Round 36 x 36</b> Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 36 Chambers in 6 Rows 25.50' Header x 7.07 sf x 2 = 360.5 cf Inside
			8,902 cf Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	47.00'	<b>18.0" Round Culvert</b> L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.00' / 46.00' S= 0.0100 'f' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.77 sf
#2	Device 1	51.00'	<b>5.0' long x 0.5' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Device 1	47.00'	<b>8.0" Vert. 8" Orifice</b> C= 0.600

**Primary OutFlow** Max=1.88 cfs @ 12.35 hrs HW=48.59' (Free Discharge)

- 1=Culvert (Passes 1.88 cfs of 6.14 cfs potential flow)
- 2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)
- 3=8" Orifice (Orifice Controls 1.88 cfs @ 5.39 fps)

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Page 120

### Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP) - Chamber Wizard Field A

**Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)**

Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf

Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

6 Chambers/Row x 20.00' Long +3.00' Header x 2 = 126.00' Row Length +12.0" End Stone x 2 = 128.00' Base Length  
6 Rows x 36.0" Wide + 18.0" Spacing x 5 + 12.0" Side Stone x 2 = 27.50' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

36 Chambers x 141.4 cf + 25.50' Header x 7.07 sf x 2 = 5,449.9 cf Chamber Storage

14,080.0 cf Field - 5,449.9 cf Chambers = 8,630.1 cf Stone x 40.0% Voids = 3,452.0 cf Stone Storage

Chamber Storage + Stone Storage = 8,901.9 cf = 0.204 af

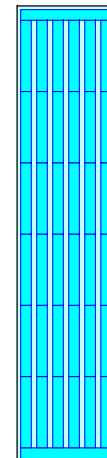
Overall Storage Efficiency = 63.2%

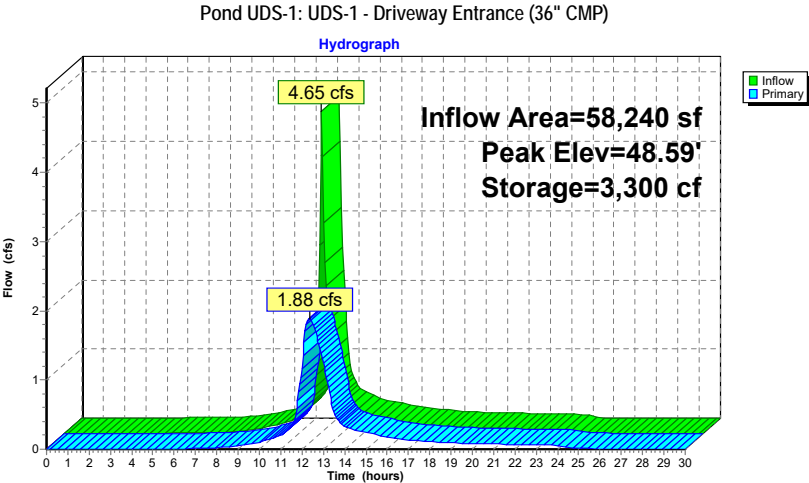
Overall System Size = 128.00' x 27.50' x 4.00'

36 Chambers

521.5 cy Field

319.6 cy Stone





Summary for Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)

Inflow Area = 70,127 sf, 81.35% Impervious, Inflow Depth = 4.28" for 10-Year event  
Inflow = 7.11 cfs @ 12.09 hrs, Volume= 25,031 cf  
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 105.93' @ 24.40 hrs Surf.Area= 7,020 sf Storage= 25,031 cf  
Flood Elev= 109.25' Surf.Area= 7,020 sf Storage= 42,647 cf

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

Volume	Invert	Avail. Storage	Storage Description
#1A	101.00'	12,163 cf	54.00'W x 130.00'L x 9.00'H Field A 63,180 cf Overall - 32,773 cf Embedded = 30,407 cf x 40.0% Voids
#2A	101.50'	32,773 cf	CMP Round 96 x 30 Inside #1 Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 30 Chambers in 5 Rows 52.00' Header x 50.27 sf x 1 = 2,613.8 cf Inside
		44,936 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.00' S= 0.0100 ' S Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	109.25'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=101.00' (Free Discharge)  
1=Culvert ( Controls 0.00 cfs)  
2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96 (Round Corrugated Metal Pipe)  
Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf  
Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

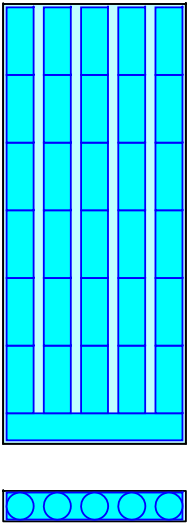
6 Chambers/Row x 20.00' Long +8.00' Header x 1 = 128.00' Row Length +12.0" End Stone x 2 = 130.00' Base Length  
5 Rows x 96.0" Wide + 36.0" Spacing x 4 + 12.0" Side Stone x 2 = 54.00' Base Width  
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

30 Chambers x 1,005.3 cf + 52.00' Header x 50.27 sf = 32,773.1 cf Chamber Storage

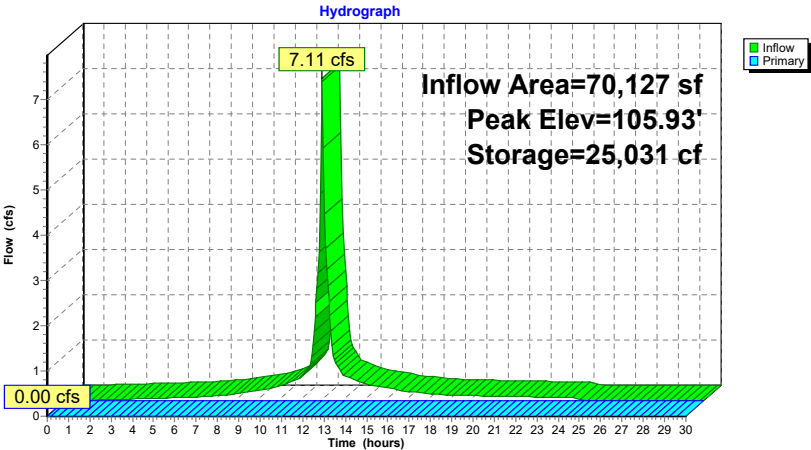
63,180.0 cf Field - 32,773.1 cf Chambers = 30,406.9 cf Stone x 40.0% Voids = 12,162.8 cf Stone Storage

Chamber Storage + Stone Storage = 44,935.9 cf = 1.032 af  
Overall Storage Efficiency = 71.1%  
Overall System Size = 130.00' x 54.00' x 9.00'

30 Chambers  
2,340.0 cy Field  
1,126.2 cy Stone



Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)



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Page 125

### Summary for Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)

Inflow Area = 44,954 sf, 90.58% Impervious, Inflow Depth = 4.46" for 10-Year event  
Inflow = 4.73 cfs @ 12.09 hrs, Volume= 16,726 cf  
Outflow = 0.10 cfs @ 17.37 hrs, Volume= 8,419 cf, Atten= 98%, Lag= 317.1 min  
Discarded = 0.10 cfs @ 17.37 hrs, Volume= 8,419 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 119.55' @ 17.37 hrs Surf.Area= 6,624 sf Storage= 11,197 cf

Plug-Flow detention time= 432.8 min calculated for 8,405 cf (50% of inflow)  
Center-of-Mass det. time= 309.5 min ( 1,067.5 - 757.9 )

Volume	Invert	Avail.Storage	Storage Description
#1A	117.00'	6,521 cf	23.00'W x 288.00'L x 4.00'H Field A 26,496 cf Overall - 10,193 cf Embedded = 16,303 cf x 40.0% Voids
#2A	117.50'	10,193 cf	CMP Round 36 x 70 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 70 Chambers in 5 Rows 21.00' Header x 7.07 sf x 2 = 296.9 cf Inside
		16,714 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	117.00'	15.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 117.00' / 116.00' S= 0.0100 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.23 sf
#2	Discarded	117.00'	0.520 in/hr Exfiltration over Wetted area
#3	Device 1	120.45'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.10 cfs @ 17.37 hrs HW=119.55' (Free Discharge)  
└─2=Exfiltration (Exfiltration Controls 0.10 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=117.00' (Free Discharge)  
└─1=Culvert ( Controls 0.00 cfs)  
└─3=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

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Page 126

### Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)

Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf

Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

14 Chambers/Row x 20.00' Long +3.00' Header x 2 = 286.00' Row Length +12.0" End Stone x 2 = 288.00' Base Length  
5 Rows x 36.0" Wide + 18.0" Spacing x 4 + 12.0" Side Stone x 2 = 23.00' Base Width  
6.0' Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

70 Chambers x 141.4 cf + 21.00' Header x 7.07 sf x 2 = 10,192.9 cf Chamber Storage

26,496.0 cf Field - 10,192.9 cf Chambers = 16,303.1 cf Stone x 40.0% Voids = 6,521.2 cf Stone Storage

Chamber Storage + Stone Storage = 16,714.1 cf = 0.384 af

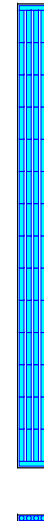
Overall Storage Efficiency = 63.1%

Overall System Size = 288.00' x 23.00' x 4.00'

70 Chambers

981.3 cy Field

603.8 cy Stone



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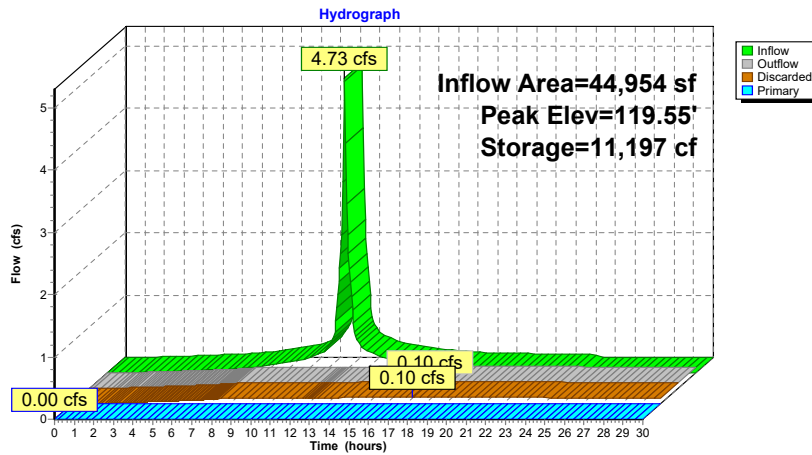
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Page 127

### Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)



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Page 128

### Summary for Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)

Inflow Area = 37,779 sf, 57.72% Impervious, Inflow Depth = 3.79" for 10-Year event  
Inflow = 3.60 cfs @ 12.09 hrs, Volume= 11,919 cf  
Outflow = 0.31 cfs @ 13.06 hrs, Volume= 11,691 cf, Atten= 91%, Lag= 58.1 min  
Discarded = 0.13 cfs @ 13.06 hrs, Volume= 9,743 cf  
Primary = 0.18 cfs @ 13.06 hrs, Volume= 1,948 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 108.85' @ 13.06 hrs Surf.Area= 4,930 sf Storage= 5,679 cf  
Flood Elev= 108.50' Surf.Area= 4,930 sf Storage= 4,321 cf

Plug-Flow detention time= 314.4 min calculated for 11,671 cf (98% of inflow)  
Center-of-Mass det. time= 302.7 min ( 1,091.2 / 788.5 )

Volume	Invert	Avail. Storage	Storage Description
#1A	107.00'	4,775 cf	72.50'W x 68.00'L x 4.00'H Field A 19,720 cf Overall - 7,783 cf Embedded = 11,937 cf x 40.0% Voids
#2A	107.50'	7,783 cf	CMP Round 36 x 48 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 48 Chambers in 16 Rows 70.50' Header x 7.07 sf x 2 = 996.7 cf Inside
		12,558 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	107.00'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 107.00' / 102.00' S= 0.0500'/ft Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	108.50'	4.0" Vert. Orifice/Grate C= 0.600
#3	Discarded	107.00'	1.020 in/hr Exfiltration over Wetted area

Discarded OutFlow Max=0.13 cfs @ 13.06 hrs HW=108.85' (Free Discharge)  
3=Exfiltration (Exfiltration Controls 0.13 cfs)

Primary OutFlow Max=0.18 cfs @ 13.06 hrs HW=108.85' (Free Discharge)  
1=Culvert (Passes 0.18 cfs of 3.47 cfs potential flow)  
2=Orifice/Grate (Orifice Controls 0.18 cfs @ 2.05 fps)

Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)  
Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf  
Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

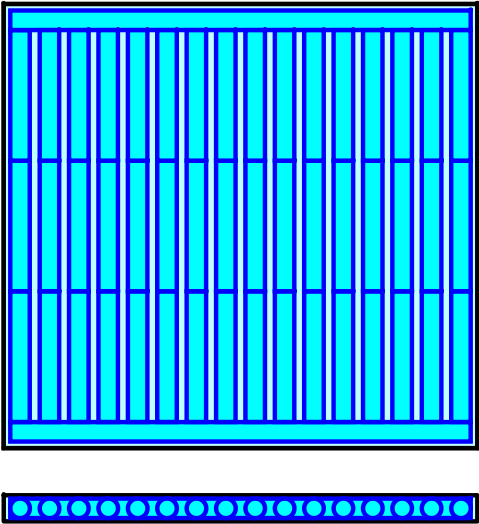
3 Chambers/Row x 20.00' Long +3.00' Header x 2 = 66.00' Row Length +12.0" End Stone x 2 = 68.00' Base Length  
16 Rows x 36.0" Wide + 18.0" Spacing x 15 + 12.0" Side Stone x 2 = 72.50' Base Width  
6.0' Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

48 Chambers x 141.4 cf + 70.50' Header x 7.07 sf x 2 = 7,782.5 cf Chamber Storage

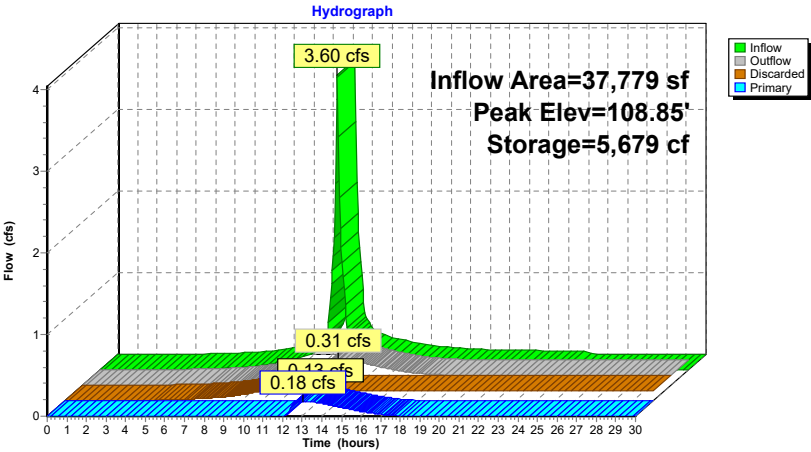
19,720.0 cf Field - 7,782.5 cf Chambers = 11,937.5 cf Stone x 40.0% Voids = 4,775.0 cf Stone Storage

Chamber Storage + Stone Storage = 12,557.5 cf = 0.288 af  
Overall Storage Efficiency = 63.7%  
Overall System Size = 68.00' x 72.50' x 4.00'

48 Chambers  
730.4 cy Field  
442.1 cy Stone



Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)





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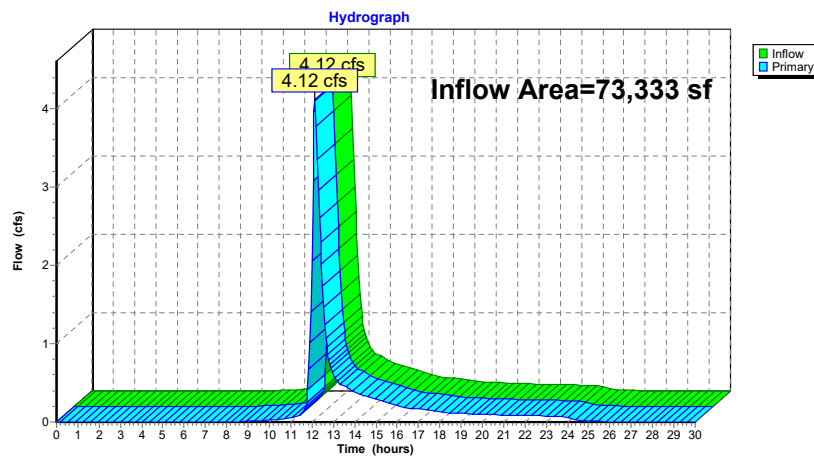
Page 131

### Summary for Link SP-1: Study Point #1

Inflow Area = 73,333 sf, 19.56% Impervious, Inflow Depth > 2.55" for 10-Year event  
Inflow = 4.12 cfs @ 12.14 hrs, Volume= 15,568 cf  
Primary = 4.12 cfs @ 12.14 hrs, Volume= 15,568 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-1: Study Point #1



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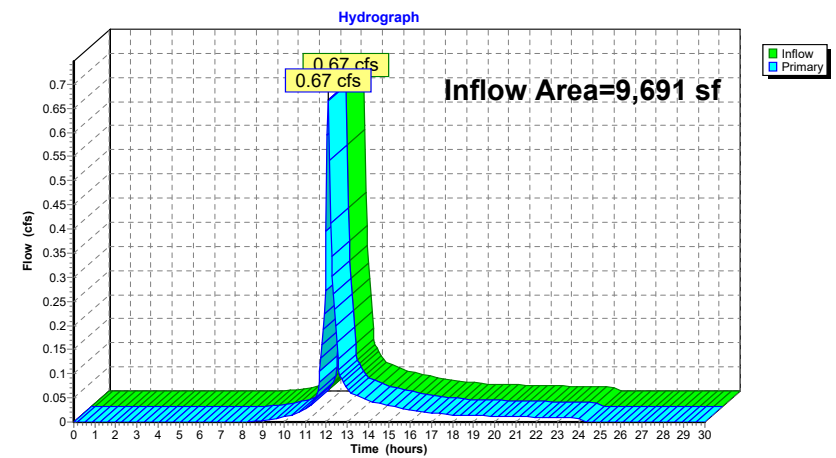
Page 132

### Summary for Link SP-2: Study Point #2

Inflow Area = 9,691 sf, 0.00% Impervious, Inflow Depth = 2.61" for 10-Year event  
Inflow = 0.67 cfs @ 12.09 hrs, Volume= 2,108 cf  
Primary = 0.67 cfs @ 12.09 hrs, Volume= 2,108 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Link SP-2: Study Point #2



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Page 133

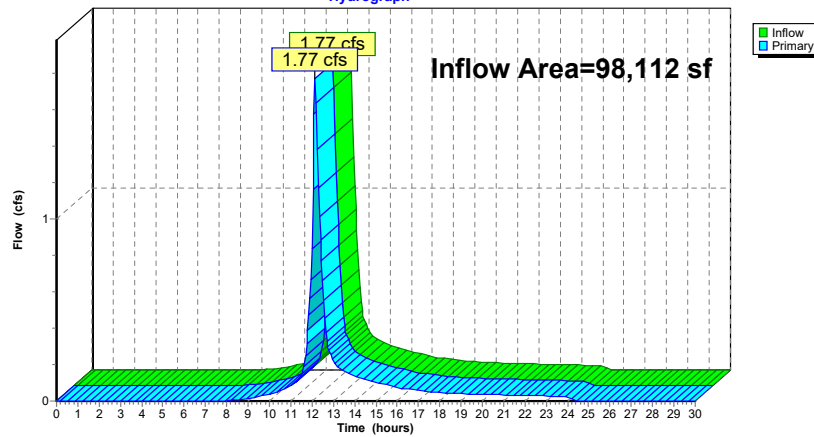
### Summary for Link SP-3: Study Point #3

Inflow Area = 98,112 sf, 58.66% Impervious, Inflow Depth = 0.80" for 10-Year event  
Inflow = 1.77 cfs @ 12.15 hrs, Volume= 6,503 cf  
Primary = 1.77 cfs @ 12.15 hrs, Volume= 6,503 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-3: Study Point #3

Hydrograph



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Page 134

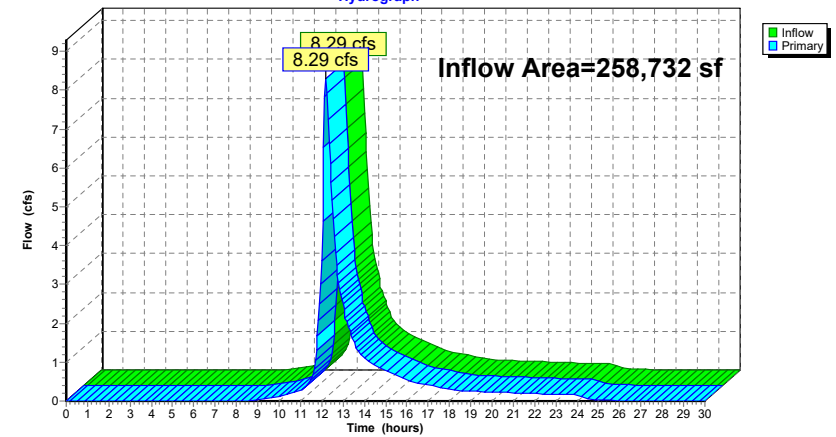
### Summary for Link SP-4: Study Point #4

Inflow Area = 258,732 sf, 29.63% Impervious, Inflow Depth > 1.95" for 10-Year event  
Inflow = 8.29 cfs @ 12.20 hrs, Volume= 41,948 cf  
Primary = 8.29 cfs @ 12.20 hrs, Volume= 41,948 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-4: Study Point #4

Hydrograph



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Page 135

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North	Runoff Area=17,171 sf 0.00% Impervious Runoff Depth=3.83" Tc=6.0 min CN=79 Runoff=1.73 cfs 5,483 cf
Subcatchment P-10: Proposed Building Roof	Runoff Area=30,342 sf 100.00% Impervious Runoff Depth=5.93" Tc=6.0 min CN=98 Runoff=4.11 cfs 14,998 cf
Subcatchment P-11: South Courtyard	Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=5.93" Tc=6.0 min CN=98 Runoff=2.74 cfs 9,975 cf
Subcatchment P-12: Southeast Roof Area	Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=5.93" Tc=6.0 min CN=98 Runoff=3.69 cfs 13,472 cf
Subcatchment P-13: Main Parking Area	Runoff Area=17,700 sf 76.07% Impervious Runoff Depth=5.47" Tc=6.0 min CN=94 Runoff=2.33 cfs 8,061 cf
Subcatchment P-14: WWTF/Driveway	Runoff Area=19,605 sf 33.29% Impervious Runoff Depth=4.57" Tc=6.0 min CN=86 Runoff=2.30 cfs 7,468 cf
Subcatchment P-15: South Lawn/Fire Access Road	Runoff Area=18,445 sf 0.00% Impervious Runoff Depth=3.93" Tc=6.0 min CN=80 Runoff=1.90 cfs 6,048 cf
Subcatchment P-16: Entrance Drive	Runoff Area=20,820 sf 44.13% Impervious Runoff Depth=4.79" Tc=6.0 min CN=88 Runoff=2.53 cfs 8,310 cf
Subcatchment P-17: Detention Pond-1	Runoff Area=11,737 sf 0.00% Impervious Runoff Depth=3.93" Tc=6.0 min CN=80 Runoff=1.21 cfs 3,849 cf
Subcatchment P-18: Entry Driveway	Runoff Area=5,160 sf 100.00% Impervious Runoff Depth=5.93" Tc=6.0 min CN=98 Runoff=0.70 cfs 2,551 cf
Subcatchment P-2: Direct Flow to Wetlands "F"	Runoff Area=9,691 sf 0.00% Impervious Runoff Depth=3.73" Tc=6.0 min CN=78 Runoff=0.95 cfs 3,012 cf
Subcatchment P-3: Flow Southwest Off-Site	Runoff Area=27,985 sf 1.79% Impervious Runoff Depth=3.93" Flow Length=194' Slope=0.0100 'l' Tc=10.9 min CN=80 Runoff=2.49 cfs 9,177 cf
Subcatchment P-4: Flow Southeast to Wetlands "A"	Runoff Area=117,759 sf 0.54% Impervious Runoff Depth=3.73" Flow Length=186' Tc=14.0 min CN=78 Runoff=9.11 cfs 36,598 cf
Subcatchment P-5: Entrance Drive	Runoff Area=14,879 sf 78.94% Impervious Runoff Depth=5.47" Tc=6.0 min CN=94 Runoff=1.96 cfs 6,776 cf
Subcatchment P-6: Landcaped Slope/Walls	Runoff Area=18,477 sf 5.22% Impervious Runoff Depth=3.93" Tc=6.0 min UI Adjusted CN=80 Runoff=1.91 cfs 6,059 cf
Subcatchment P-7: Landscaped Slope	Runoff Area=24,884 sf 3.17% Impervious Runoff Depth=4.04" Tc=6.0 min CN=81 Runoff=2.63 cfs 8,376 cf

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Page 136

Subcatchment P-8: Cul-de-Sac/Garage Turn Around	Runoff Area=22,451 sf 74.60% Impervious Runoff Depth=5.35" Tc=6.0 min CN=93 Runoff=2.93 cfs 10,010 cf
Subcatchment P-9: North Courtyard/Green Roof	Runoff Area=15,328 sf 33.00% Impervious Runoff Depth=4.57" Tc=6.0 min CN=86 Runoff=1.80 cfs 5,839 cf
Reach SWALE: Swale Abutting Entry Driveway	Avg. Flow Depth=0.27' Max Vel=3.65 fps Inflow=2.63 cfs 8,376 cf n=0.040 L=427.0' S=0.0749 'l' Capacity=16.60 cfs Outflow=2.54 cfs 8,376 cf
Pond RG-1: Rain Garden-1 - Entrance	Peak Elev=51.76' Storage=2,031 cf Inflow=2.28 cfs 21,198 cf 24.0" Round Culvert n=0.013 L=100.0' S=0.0050 'l' Outflow=2.43 cfs 20,580 cf
Pond RG-2: Rain Garden #2 - Driveway	Peak Elev=163.54' Storage=1,582 cf Inflow=0.70 cfs 2,551 cf Outflow=0.21 cfs 1,036 cf
Pond SDP-1: Surface Detention Pond-1	Peak Elev=79.15' Storage=4,026 cf Inflow=5.64 cfs 18,207 cf Primary=4.31 cfs 16,251 cf Secondary=0.00 cfs 0 cf Outflow=4.31 cfs 16,251 cf
Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)	Peak Elev=49.17' Storage=4,915 cf Inflow=6.36 cfs 21,211 cf Outflow=2.28 cfs 21,198 cf
Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)	Peak Elev=107.21' Storage=32,442 cf Inflow=9.15 cfs 32,441 cf Outflow=0.00 cfs 0 cf
Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)	Peak Elev=120.44' Storage=15,193 cf Inflow=6.03 cfs 21,533 cf Discarded=0.11 cfs 9,138 cf Primary=0.00 cfs 0 cf Outflow=0.11 cfs 9,138 cf
Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)	Peak Elev=109.32' Storage=7,555 cf Inflow=4.73 cfs 15,849 cf Discarded=0.13 cfs 10,221 cf Primary=0.34 cfs 4,869 cf Outflow=0.47 cfs 15,089 cf
Link SP-1: Study Point #1	Inflow=5.72 cfs 22,769 cf Primary=5.72 cfs 22,769 cf
Link SP-2: Study Point #2	Inflow=0.95 cfs 3,012 cf Primary=0.95 cfs 3,012 cf
Link SP-3: Study Point #3	Inflow=2.49 cfs 9,177 cf Primary=2.49 cfs 9,177 cf
Link SP-4: Study Point #4	Inflow=11.63 cfs 62,047 cf Primary=11.63 cfs 62,047 cf

Total Runoff Area = 439,868 sf Runoff Volume = 166,062 cf Average Runoff Depth = 4.53"  
66.23% Pervious = 291,317 sf 33.77% Impervious = 148,551 sf

Summary for Subcatchment P-1: Flow to Wetlands - North

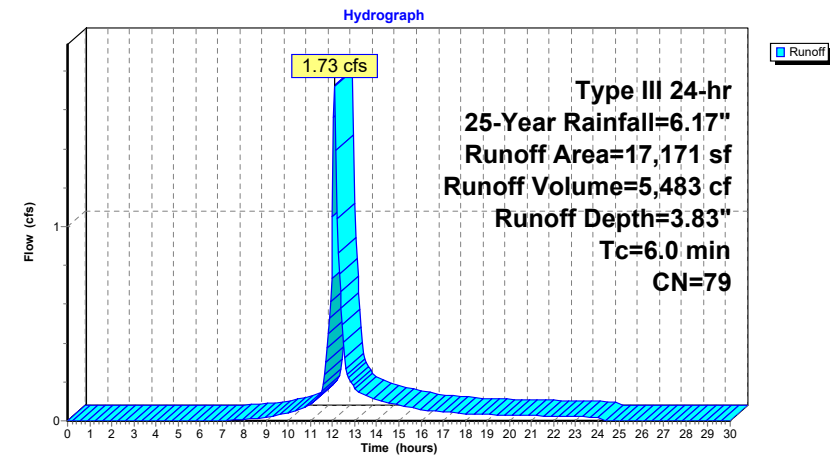
Runoff = 1.73 cfs @ 12.09 hrs, Volume= 5,483 cf, Depth= 3.83"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
12,252	80	>75% Grass cover, Good, HSG D
4,919	77	Woods, Good, HSG D
17,171	79	Weighted Average
17,171		100.00% Pervious Area

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

Subcatchment P-1: Flow to Wetlands - North



Summary for Subcatchment P-10: Proposed Building Roof

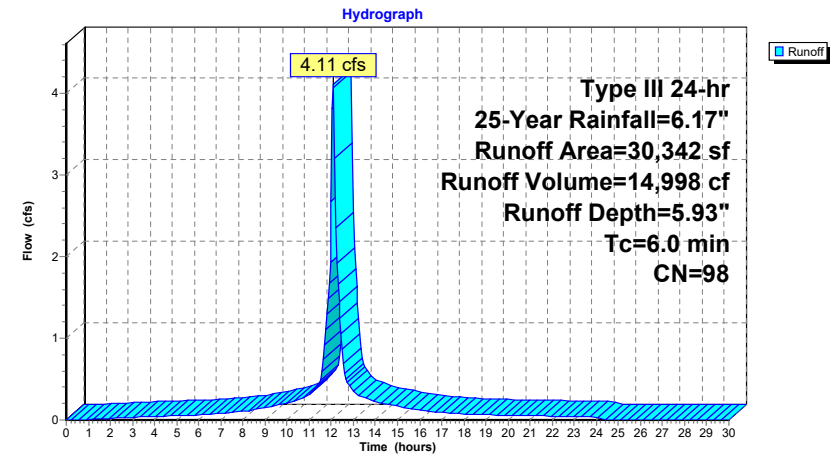
Runoff = 4.11 cfs @ 12.09 hrs, Volume= 14,998 cf, Depth= 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
30,342	98	Unconnected roofs, HSG D
30,342		100.00% Impervious Area
30,342		100.00% Unconnected

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

Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

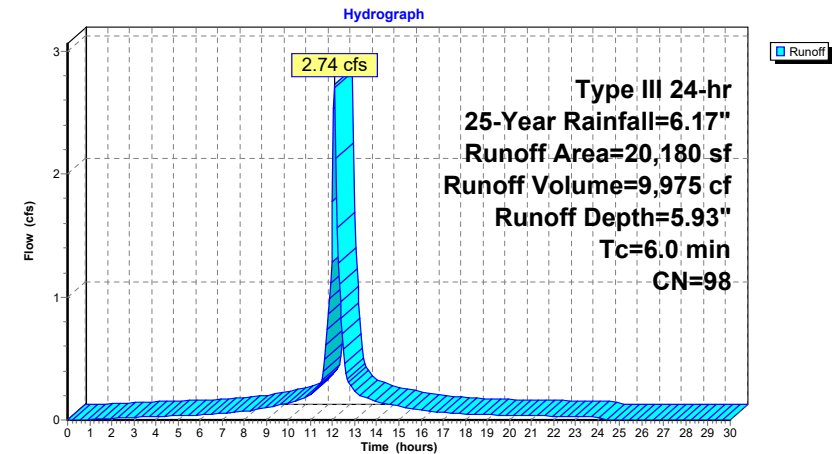
Runoff = 2.74 cfs @ 12.09 hrs, Volume= 9,975 cf, Depth= 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

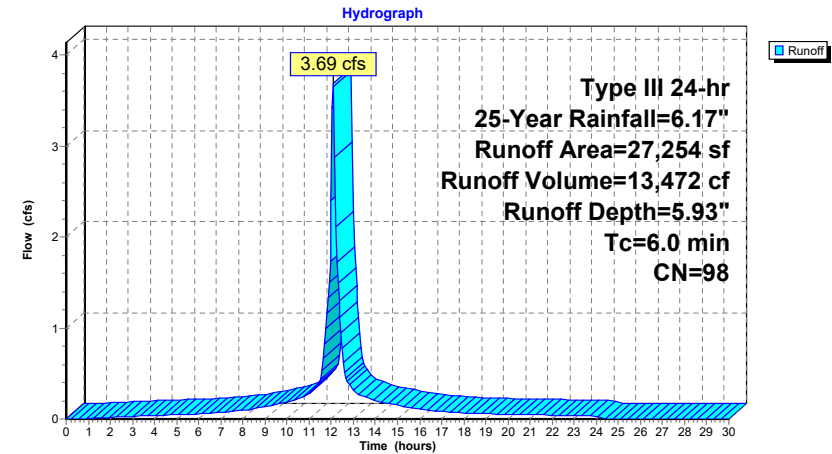
Runoff = 3.69 cfs @ 12.09 hrs, Volume= 13,472 cf, Depth= 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

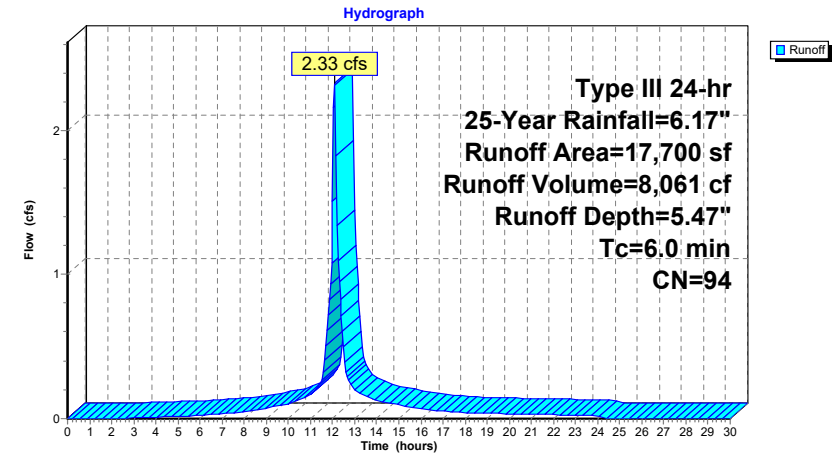
Runoff = 2.33 cfs @ 12.09 hrs, Volume= 8,061 cf, Depth= 5.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
13,464	98	Unconnected pavement, HSG D
4,236	80	>75% Grass cover, Good, HSG D
17,700	94	Weighted Average
4,236		23.93% Pervious Area
13,464		76.07% Impervious Area
13,464		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area



Summary for Subcatchment P-14: WWTF/Driveway

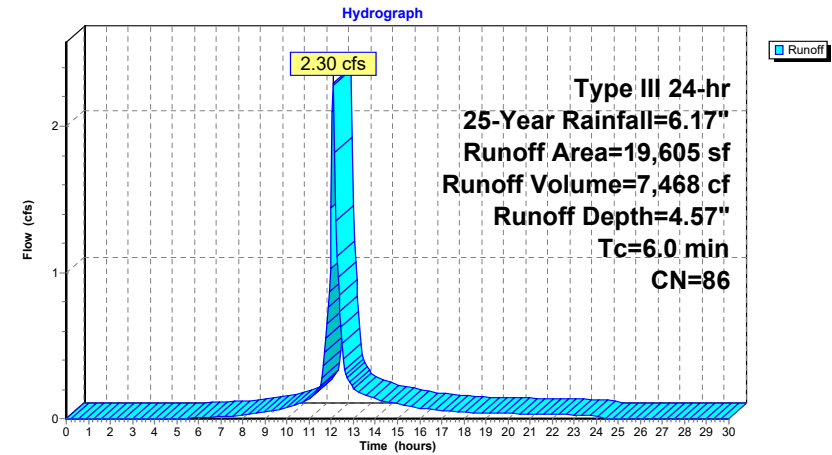
Runoff = 2.30 cfs @ 12.09 hrs, Volume= 7,468 cf, Depth= 4.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
6,526	98	Paved parking, HSG D
9,225	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
19,605	86	Weighted Average
13,079		66.71% Pervious Area
6,526		33.29% Impervious Area

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

Subcatchment P-14: WWTF/Driveway



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Type III 24-hr 25-Year Rainfall=6.17"

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Page 143

### Summary for Subcatchment P-15: South Lawn/Fire Access Road

Runoff = 1.90 cfs @ 12.09 hrs, Volume= 6,048 cf, Depth= 3.93"

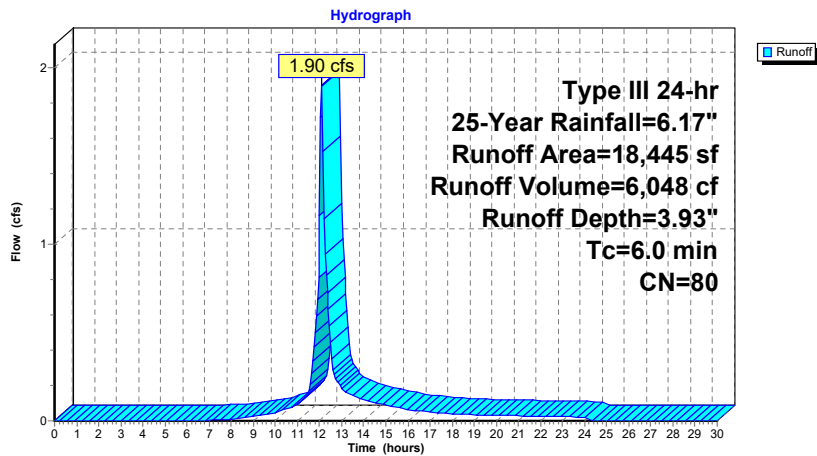
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
14,591	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
18,445	80	Weighted Average
18,445		100.00% Pervious Area

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

### Subcatchment P-15: South Lawn/Fire Access Road



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Page 144

### Summary for Subcatchment P-16: Entrance Drive

Runoff = 2.53 cfs @ 12.09 hrs, Volume= 8,310 cf, Depth= 4.79"

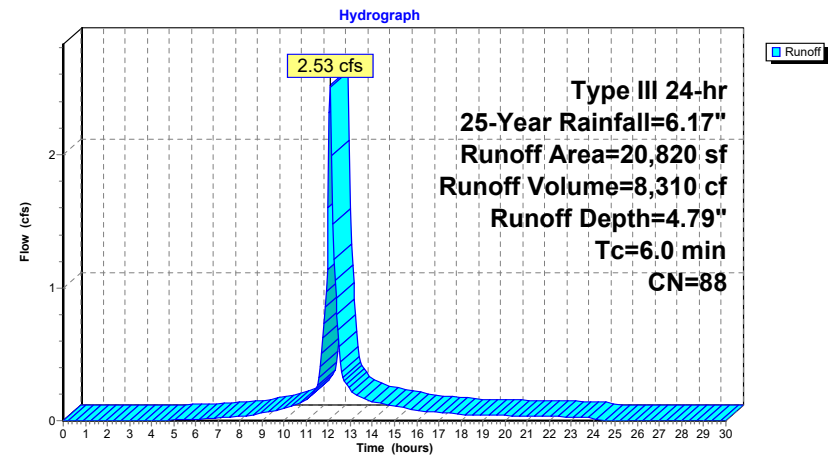
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
9,187	98	Unconnected pavement, HSG D
11,633	80	>75% Grass cover, Good, HSG D
20,820	88	Weighted Average
11,633		55.87% Pervious Area
9,187		44.13% Impervious Area
9,187		100.00% Unconnected

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

### Subcatchment P-16: Entrance Drive



Summary for Subcatchment P-17: Detention Pond-1

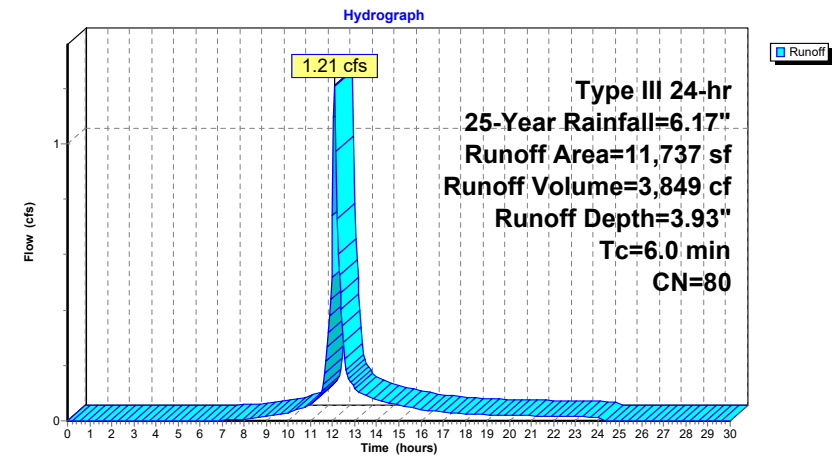
Runoff = 1.21 cfs @ 12.09 hrs, Volume= 3,849 cf, Depth= 3.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
4,872	91	Gravel roads, HSG D
6,865	73	Brush, Good, HSG D
11,737	80	Weighted Average
11,737		100.00% Pervious Area

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

Subcatchment P-17: Detention Pond-1



Summary for Subcatchment P-18: Entry Driveway

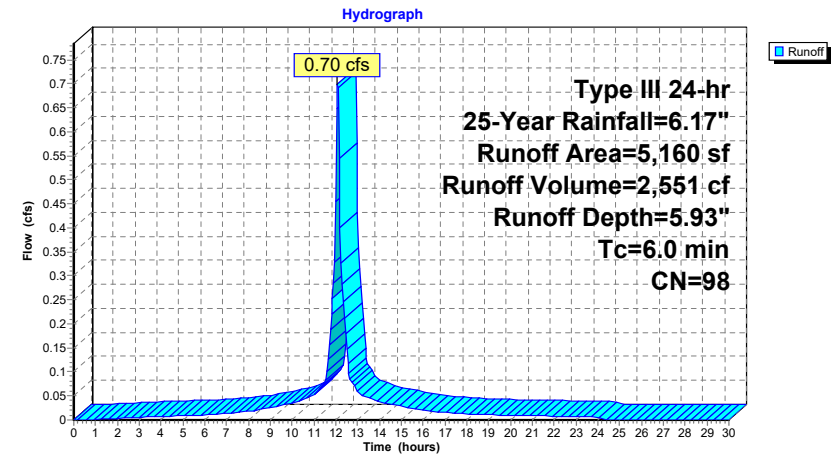
Runoff = 0.70 cfs @ 12.09 hrs, Volume= 2,551 cf, Depth= 5.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
5,160	98	Unconnected pavement, HSG D
5,160		100.00% Impervious Area
5,160		100.00% Unconnected

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

Subcatchment P-18: Entry Driveway





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Page 147

## Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

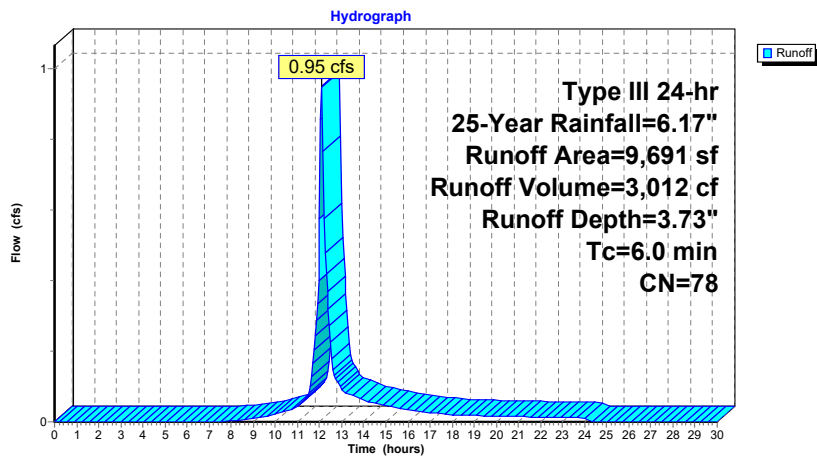
Runoff = 0.95 cfs @ 12.09 hrs, Volume= 3,012 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
1,678	80	>75% Grass cover, Good, HSG D
8,013	77	Woods, Good, HSG D
9,691	78	Weighted Average
9,691		100.00% Pervious Area

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

## Subcatchment P-2: Direct Flow to Wetlands "F"



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Page 148

## Summary for Subcatchment P-3: Flow Southwest Off-Site

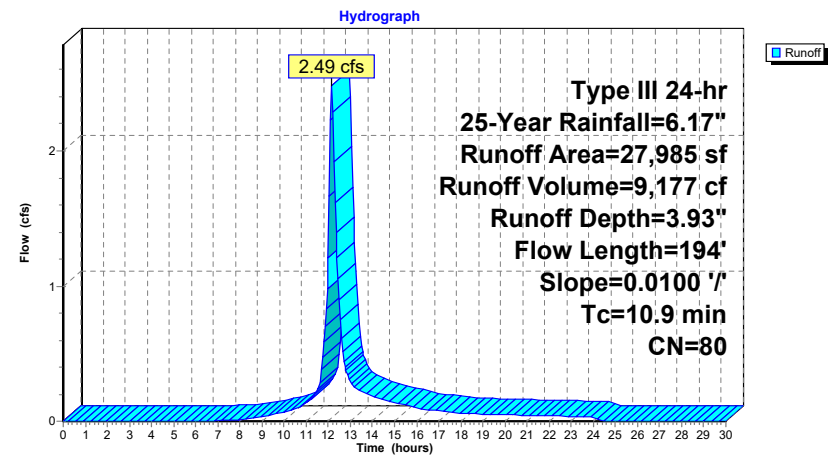
Runoff = 2.49 cfs @ 12.15 hrs, Volume= 9,177 cf, Depth= 3.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
24,995	80	>75% Grass cover, Good, HSG D
2,490	77	Woods, Good, HSG D
500	98	Unconnected pavement, HSG D
27,985	80	Weighted Average
27,485		98.21% Pervious Area
500		1.79% Impervious Area
500		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0100	0.11		Sheet Flow, Grass: Short n= 0.150 P2= 3.16"
3.4	144	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
10.9	194				Total

## Subcatchment P-3: Flow Southwest Off-Site



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Page 149

### Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

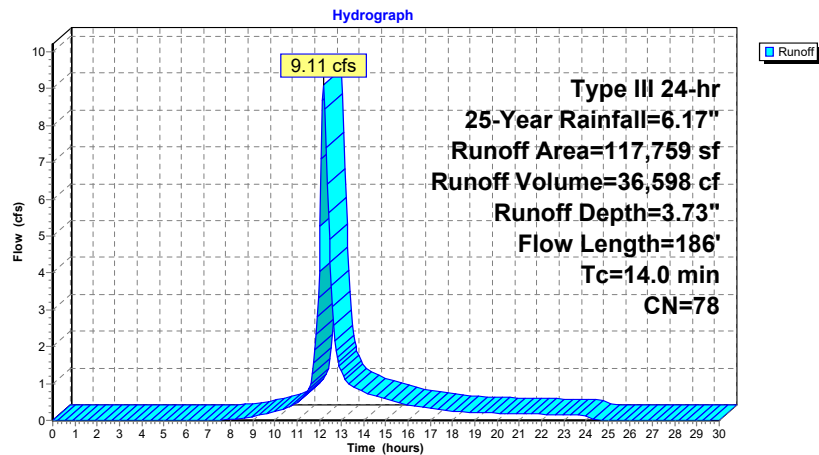
Runoff = 9.11 cfs @ 12.20 hrs, Volume= 36,598 cf, Depth= 3.73"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
92,430	77	Woods, Good, HSG D
24,696	80	>75% Grass cover, Good, HSG D
633	98	Unconnected pavement, HSG D
117,759	78	Weighted Average
117,126		99.46% Pervious Area
633		0.54% Impervious Area
633		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

### Subcatchment P-4: Flow Southeast to Wetlands "A"



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Page 150

### Summary for Subcatchment P-5: Entrance Drive

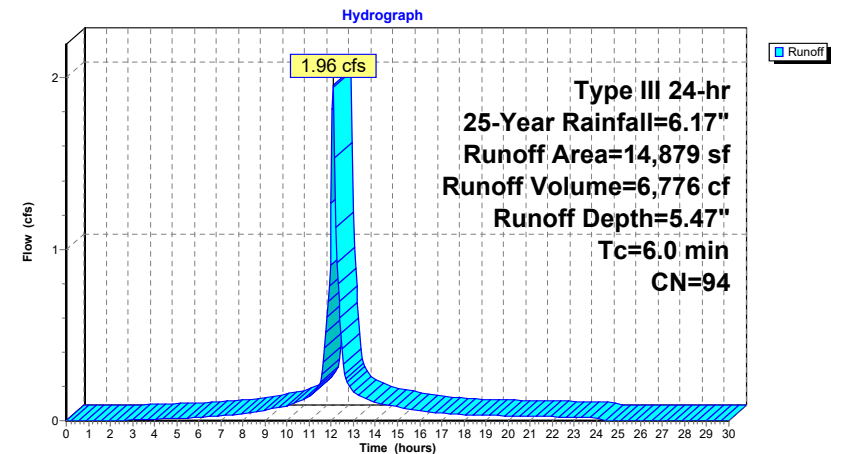
Runoff = 1.96 cfs @ 12.09 hrs, Volume= 6,776 cf, Depth= 5.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
11,745	98	Paved parking, HSG D
3,134	80	>75% Grass cover, Good, HSG D
14,879	94	Weighted Average
3,134		21.06% Pervious Area
11,745		78.94% Impervious Area

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

### Subcatchment P-5: Entrance Drive



Summary for Subcatchment P-6: Landcaped Slope/Walls

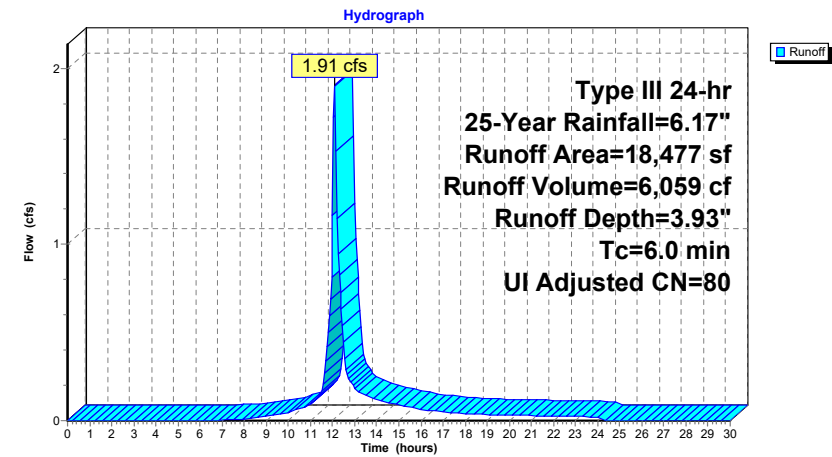
Runoff = 1.91 cfs @ 12.09 hrs, Volume= 6,059 cf, Depth= 3.93"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Adj	Description
17,512	80		>75% Grass cover, Good, HSG D
965	98		Unconnected pavement, HSG D
18,477	81	80	Weighted Average, UI Adjusted
17,512			94.78% Pervious Area
965			5.22% Impervious Area
965			100.00% Unconnected

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

Subcatchment P-6: Landcaped Slope/Walls



Summary for Subcatchment P-7: Landscaped Slope

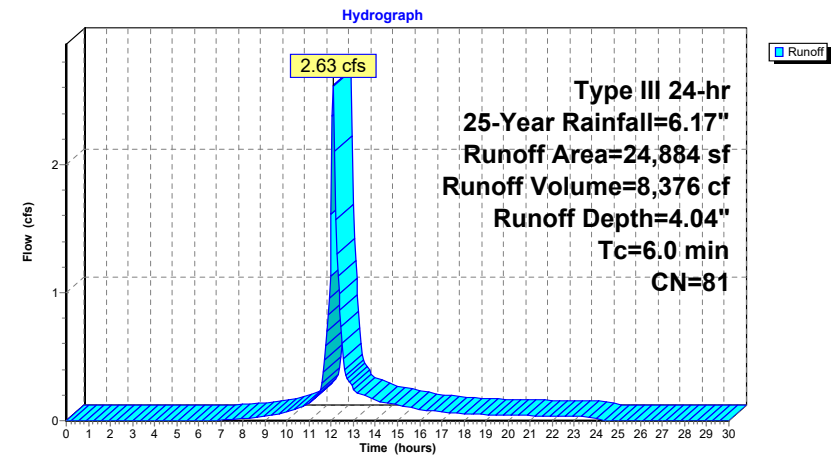
Runoff = 2.63 cfs @ 12.09 hrs, Volume= 8,376 cf, Depth= 4.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
788	98	Paved parking, HSG D
24,096	80	>75% Grass cover, Good, HSG D
24,884	81	Weighted Average
24,096		96.83% Pervious Area
788		3.17% Impervious Area

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

Subcatchment P-7: Landscaped Slope



Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

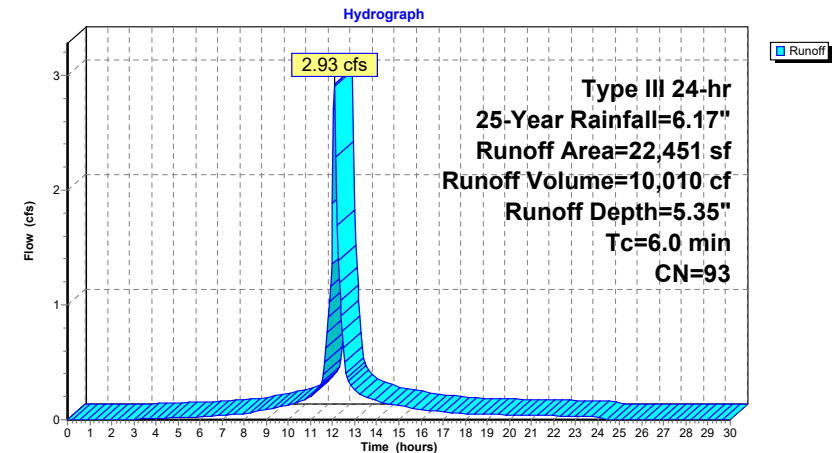
Runoff = 2.93 cfs @ 12.09 hrs, Volume= 10,010 cf, Depth= 5.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
16,749	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,451	93	Weighted Average
5,702		25.40% Pervious Area
16,749		74.60% Impervious Area

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

Subcatchment P-8: Cul-de-Sac/Garage Turn Around



Summary for Subcatchment P-9: North Courtyard/Green Roof

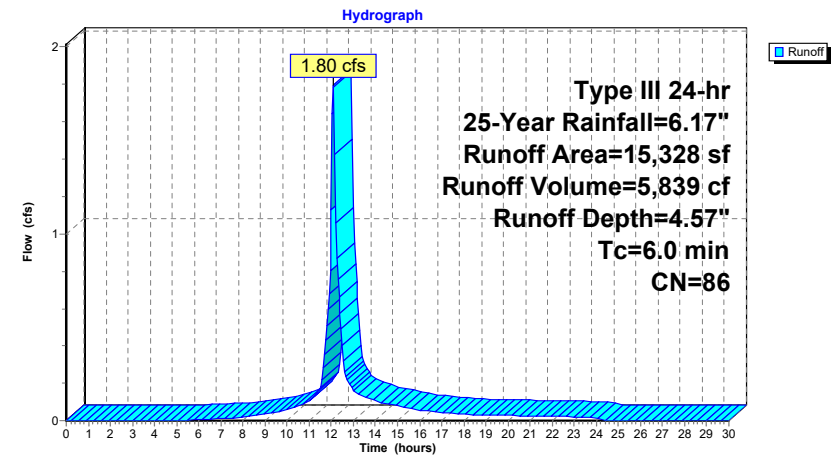
Runoff = 1.80 cfs @ 12.09 hrs, Volume= 5,839 cf, Depth= 4.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 25-Year Rainfall=6.17"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

Subcatchment P-9: North Courtyard/Green Roof



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Page 155

### Summary for Reach SWALE: Swale Abutting Entry Driveway

Inflow Area = 24,884 sf, 3.17% Impervious, Inflow Depth = 4.04" for 25-Year event  
Inflow = 2.63 cfs @ 12.09 hrs, Volume= 8,376 cf  
Outflow = 2.54 cfs @ 12.11 hrs, Volume= 8,376 cf, Atten= 3%, Lag= 1.3 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

Max. Velocity= 3.65 fps, Min. Travel Time= 2.0 min

Avg. Velocity= 1.00 fps, Avg. Travel Time= 7.1 min

Peak Storage= 297 cf @ 12.11 hrs

Average Depth at Peak Storage= 0.27'

Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 16.60 cfs

2.00' x 0.75' deep channel, n= 0.040 Earth, cobble bottom, clean sides

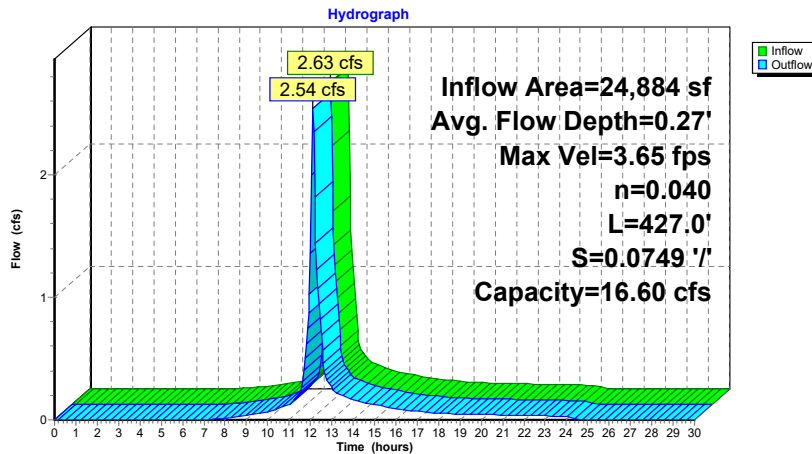
Side Slope Z-value= 2.0 ' Top Width= 5.00'

Length= 427.0' Slope= 0.0749 ' /'

Inlet Invert= 99.50', Outlet Invert= 67.50'



Reach SWALE: Swale Abutting Entry Driveway



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Page 156

### Summary for Pond RG-1: Rain Garden-1 - Entrance

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth > 4.37" for 25-Year event  
Inflow = 2.28 cfs @ 12.39 hrs, Volume= 21,198 cf  
Outflow = 2.43 cfs @ 12.39 hrs, Volume= 20,580 cf, Atten= 0%, Lag= 0.0 min  
Primary = 2.43 cfs @ 12.39 hrs, Volume= 20,580 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 2

Peak Elev= 51.76' @ 12.38 hrs Surf.Area= 1,423 sf Storage= 2,031 cf

Plug-Flow detention time= 45.0 min calculated for 20,580 cf (97% of inflow)

Center-of-Mass det. time= 27.0 min ( 855.5 - 828.5 )

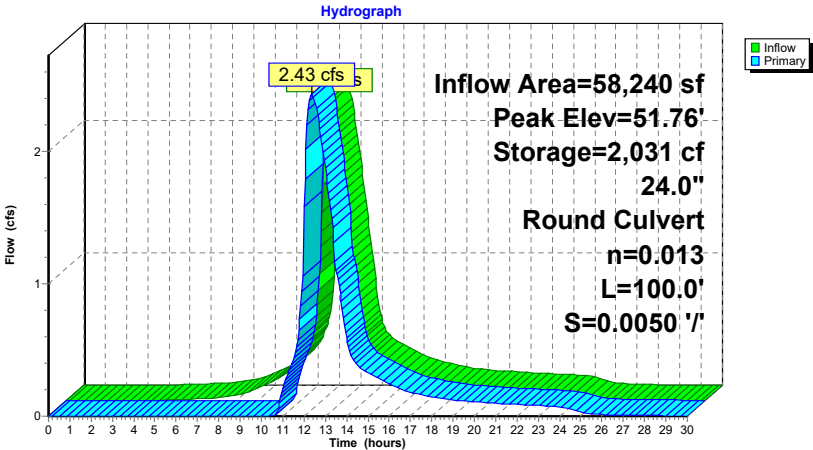
Volume	Invert	Avail.Storage	Storage Description		
#1	49.00'	2,031 cf	Rain Garden (Irregular) Listed below (Recalc)		
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
49.00	425	82.3	0	0	425
50.00	701	101.5	557	557	720
51.00	1,034	120.4	862	1,419	1,072
51.50	1,423	139.2	612	2,031	1,466

Device	Routing	Invert	Outlet Devices		
#1	Primary	51.00'	24.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900		
			Inlet / Outlet Invert= 51.00' / 50.50' S= 0.0050 ' /' Cc= 0.900		
			n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf		

Primary OutFlow Max=2.43 cfs @ 12.39 hrs HW=51.76' (Free Discharge)

1=Culvert (Barrel Controls 2.43 cfs @ 3.30 fps)

Pond RG-1: Rain Garden-1 - Entrance



Summary for Pond RG-2: Rain Garden #2 - Driveway

Inflow Area = 5,160 sf, 100.00% Impervious, Inflow Depth = 5.93" for 25-Year event  
Inflow = 0.70 cfs @ 12.09 hrs, Volume= 2,551 cf  
Outflow = 0.21 cfs @ 12.41 hrs, Volume= 1,036 cf, Atten= 69%, Lag= 19.3 min  
Primary = 0.21 cfs @ 12.41 hrs, Volume= 1,036 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 163.54' @ 12.41 hrs Surf.Area= 1,570 sf Storage= 1,582 cf

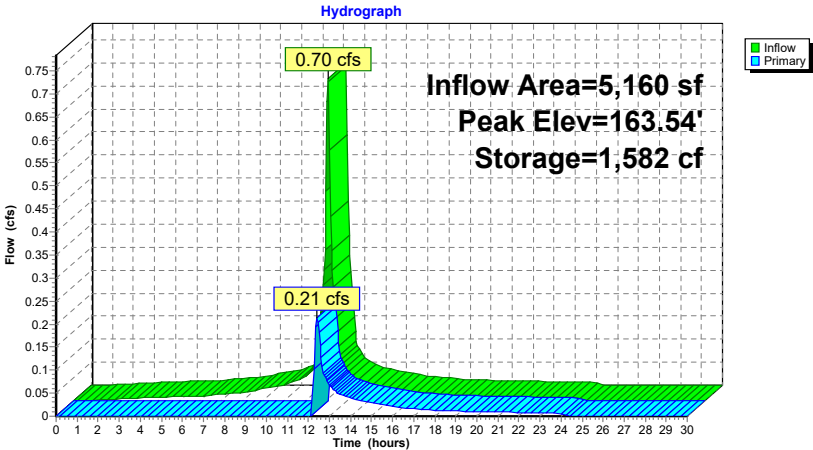
Plug-Flow detention time= 328.1 min calculated for 1,034 cf (41% of inflow)  
Center-of-Mass det. time= 172.1 min ( 916.9 - 744.7 )

Volume	Invert	Avail.Storage	Storage Description		
#1	162.00'	3,504 cf	Custom Stage Data (Irregular) Listed below (Recalc)		
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
162.00	564	214.6	0	0	564
164.00	1,965	252.4	2,388	2,388	2,044
164.50	2,509	276.8	1,116	3,504	3,080

Device	Routing	Invert	Outlet Devices											
#1	Primary	163.50'	10.0' long x 5.0' 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) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70											
			2.74 2.79 2.88											

Primary OutFlow Max=0.21 cfs @ 12.41 hrs HW=163.54' (Free Discharge)  
1=Broad-Crested Rectangular Weir (Weir Controls 0.21 cfs @ 0.48 fps)

Pond RG-2: Rain Garden #2 - Driveway



Summary for Pond SDP-1: Surface Detention Pond-1

Inflow Area = 51,002 sf, 18.01% Impervious, Inflow Depth = 4.28" for 25-Year event  
Inflow = 5.64 cfs @ 12.09 hrs, Volume= 18,207 cf  
Outflow = 4.31 cfs @ 12.16 hrs, Volume= 16,251 cf, Atten= 24%, Lag= 4.4 min  
Primary = 4.31 cfs @ 12.16 hrs, Volume= 16,251 cf  
Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 79.15' @ 12.16 hrs Surf.Area= 2,169 sf Storage= 4,026 cf

Plug-Flow detention time= 93.3 min calculated for 16,224 cf (89% of inflow)  
Center-of-Mass det. time= 43.1 min ( 845.9 - 802.7 )

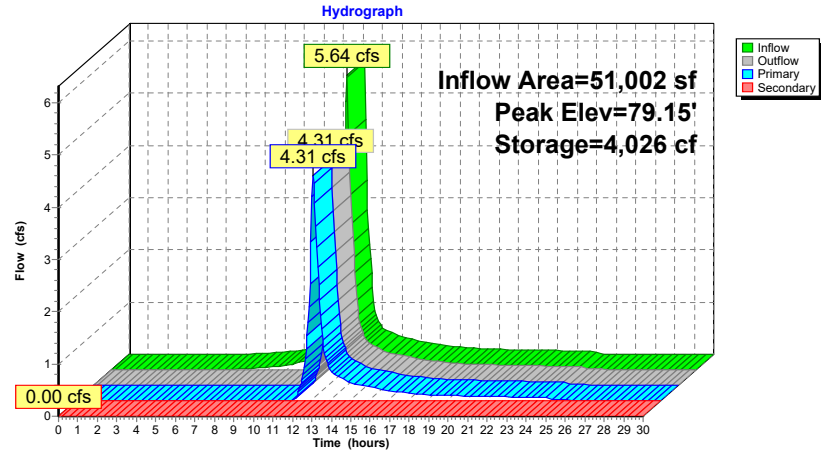
Volume	Invert	Avail.Storage	Storage Description		
#1	76.00'	8,088 cf	Surface Detention Pond (Irregular) Listed below (Recalc)		
Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
76.00	531	104.1	0	0	531
78.00	1,488	192.6	1,939	1,939	2,642
80.00	2,756	230.3	4,179	6,118	3,979
80.50	5,256	368.3	1,970	8,088	10,554

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.50'	10.0' long x 10.0' breadth Emergency OverFlow 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
#2	Primary	78.00'	15.0" Round Culvert L= 100.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 78.00' / 77.00' S= 0.0100 '/ S Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=4.26 cfs @ 12.16 hrs HW=79.14' (Free Discharge)  
2=Culvert (Inlet Controls 4.26 cfs @ 3.63 fps)

Secondary OutFlow Max=0.00 cfs @ 0.00 hrs HW=76.00' (Free Discharge)  
1=Emergency OverFlow Weir ( Controls 0.00 cfs)

Pond SDP-1: Surface Detention Pond-1



Summary for Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth = 4.37" for 25-Year event  
Inflow = 6.36 cfs @ 12.10 hrs, Volume= 21,211 cf  
Outflow = 2.28 cfs @ 12.39 hrs, Volume= 21,198 cf, Atten= 64%, Lag= 17.2 min  
Primary = 2.28 cfs @ 12.39 hrs, Volume= 21,198 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 49.17' @ 12.39 hrs Surf.Area= 3,520 sf Storage= 4,915 cf

Plug-Flow detention time= 29.6 min calculated for 21,198 cf (100% of inflow)  
Center-of-Mass det. time= 29.2 min ( 828.5 - 799.3 )

Volume	Invert	Avail.Storage	Storage Description
#1A	47.00'	3,452 cf	27.50'W x 128.00'L x 4.00'H Field A 14,080 cf Overall - 5,450 cf Embedded = 8,630 cf x 40.0% Voids
#2A	47.50'	5,450 cf	CMP Round 36 x 36 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 36 Chambers in 6 Rows 25.50' Header x 7.07 sf x 2 = 360.5 cf Inside
8,902 cf			Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	47.00'	18.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.00' / 46.00' S= 0.0100 /' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.77 sf
#2	Device 1	51.00'	5.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Device 1	47.00'	8.0" Vert. 8" Orifice C= 0.600

Primary OutFlow Max=2.27 cfs @ 12.39 hrs HW=49.16' (Free Discharge)  
1=Culvert (Passes 2.27 cfs of 7.99 cfs potential flow)  
2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)  
3=8" Orifice (Orifice Controls 2.27 cfs @ 6.52 fps)



Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)  
Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf  
Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

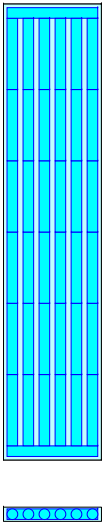
6 Chambers/Row x 20.00' Long +3.00' Header x 2 = 126.00' Row Length +12.0" End Stone x 2 = 128.00' Base Length  
6 Rows x 36.0" Wide + 18.0" Spacing x 5 + 12.0" Side Stone x 2 = 27.50' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

36 Chambers x 141.4 cf + 25.50' Header x 7.07 sf x 2 = 5,449.9 cf Chamber Storage

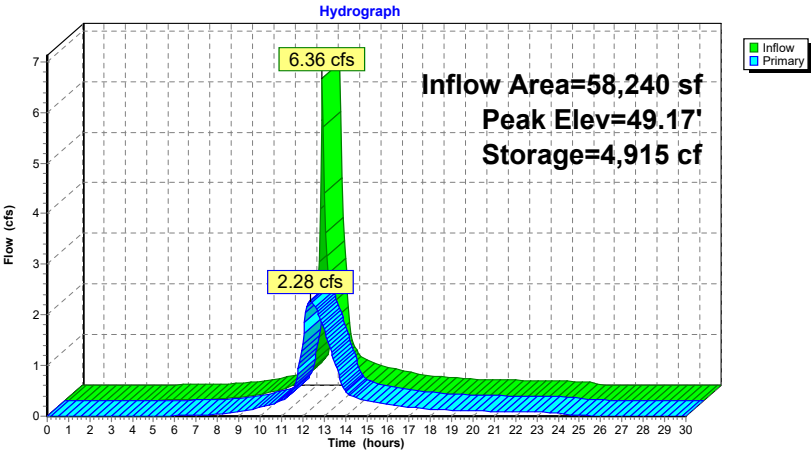
14,080.0 cf Field - 5,449.9 cf Chambers = 8,630.1 cf Stone x 40.0% Voids = 3,452.0 cf Stone Storage

Chamber Storage + Stone Storage = 8,901.9 cf = 0.204 af  
Overall Storage Efficiency = 63.2%  
Overall System Size = 128.00' x 27.50' x 4.00'

36 Chambers  
521.5 cy Field  
319.6 cy Stone



Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)



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Page 165

### Summary for Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)

Inflow Area = 70,127 sf, 81.35% Impervious, Inflow Depth = 5.55" for 25-Year event  
Inflow = 9.15 cfs @ 12.09 hrs, Volume= 32,441 cf  
Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0 cf, Atten= 100%, Lag= 0.0 min  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 107.21' @ 24.40 hrs Surf.Area= 7,020 sf Storage= 32,442 cf  
Flood Elev= 109.25' Surf.Area= 7,020 sf Storage= 42,647 cf

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

Volume	Invert	Avail.Storage	Storage Description
#1A	101.00'	12,163 cf	<b>54.00'W x 130.00'L x 9.00'H Field A</b> 63,180 cf Overall - 32,773 cf Embedded = 30,407 cf x 40.0% Voids
#2A	101.50'	32,773 cf	<b>CMP Round 96" x 30' Inside #1</b> Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 30 Chambers in 5 Rows 52.00' Header x 50.27 sf x 1 = 2,613.8 cf Inside
		44,936 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	<b>12.0" Round Culvert</b> L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.00' S= 0.0100 '/ S= 0.0100 ' n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	109.25'	<b>4.0' long x 0.5' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=101.00' (Free Discharge)

1=Culvert ( Controls 0.00 cfs)

2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

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Page 166

### Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96" (Round Corrugated Metal Pipe)

Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf

Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

6 Chambers/Row x 20.00' Long +8.00' Header x 1 = 128.00' Row Length +12.0" End Stone x 2 = 130.00' Base Length  
5 Rows x 96.0" Wide + 36.0" Spacing x 4 + 12.0" Side Stone x 2 = 54.00' Base Width  
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

30 Chambers x 1,005.3 cf + 52.00' Header x 50.27 sf = 32,773.1 cf Chamber Storage

63,180.0 cf Field - 32,773.1 cf Chambers = 30,406.9 cf Stone x 40.0% Voids = 12,162.8 cf Stone Storage

Chamber Storage + Stone Storage = 44,935.9 cf = 1.032 af

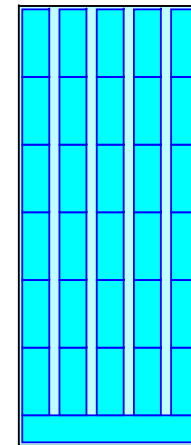
Overall Storage Efficiency = 71.1%

Overall System Size = 130.00' x 54.00' x 9.00'

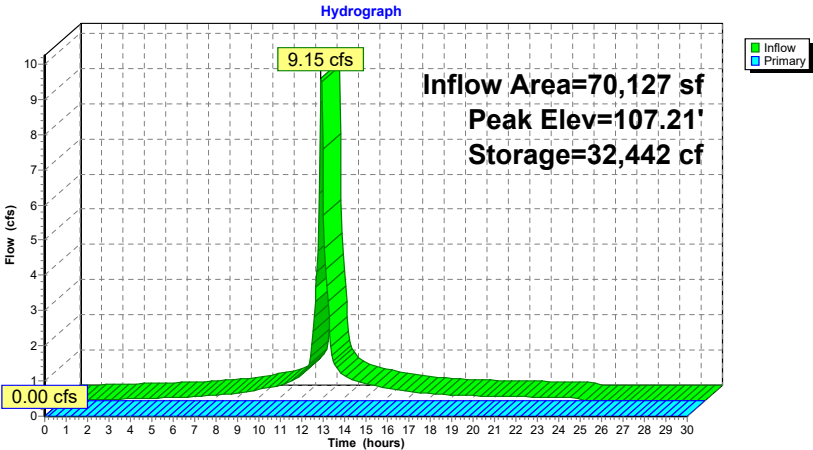
30 Chambers

2,340.0 cy Field

1,126.2 cy Stone



Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)



Summary for Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)

Inflow Area = 44,954 sf, 90.58% Impervious, Inflow Depth = 5.75" for 25-Year event  
Inflow = 6.03 cfs @ 12.09 hrs, Volume= 21,533 cf  
Outflow = 0.11 cfs @ 17.99 hrs, Volume= 9,138 cf, Atten= 98%, Lag= 354.3 min  
Discarded = 0.11 cfs @ 17.99 hrs, Volume= 9,138 cf  
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 120.44' @ 17.99 hrs Surf.Area= 6,624 sf Storage= 15,193 cf

Plug-Flow detention time= 441.0 min calculated for 9,122 cf (42% of inflow)  
Center-of-Mass det. time= 297.2 min ( 1,050.6 - 753.4 )

Volume	Invert	Avail. Storage	Storage Description
#1A	117.00'	6,521 cf	23.00'W x 288.00'L x 4.00'H Field A 26,496 cf Overall - 10,193 cf Embedded = 16,303 cf x 40.0% Voids
#2A	117.50'	10,193 cf	CMP Round 36 x 70 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 70 Chambers in 5 Rows 21.00' Header x 7.07 sf x 2 = 296.9 cf Inside
		16,714 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	117.00'	15.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 117.00' / 116.00' S= 0.0100 ' S= 0.0100 ' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.23 sf
#2	Discarded	117.00'	0.520 in/hr Exfiltration over Wetted area
#3	Device 1	120.45'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.11 cfs @ 17.99 hrs HW=120.44' (Free Discharge)  
2=Exfiltration (Exfiltration Controls 0.11 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=117.00' (Free Discharge)  
1=Culvert ( Controls 0.00 cfs)  
3=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)

Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)  
Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf  
Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

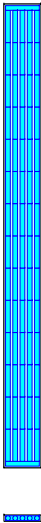
14 Chambers/Row x 20.00' Long +3.00' Header x 2 = 286.00' Row Length +12.0" End Stone x 2 = 288.00' Base Length  
5 Rows x 36.0" Wide + 18.0" Spacing x 4 + 12.0" Side Stone x 2 = 23.00' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

70 Chambers x 141.4 cf + 21.00' Header x 7.07 sf x 2 = 10,192.9 cf Chamber Storage

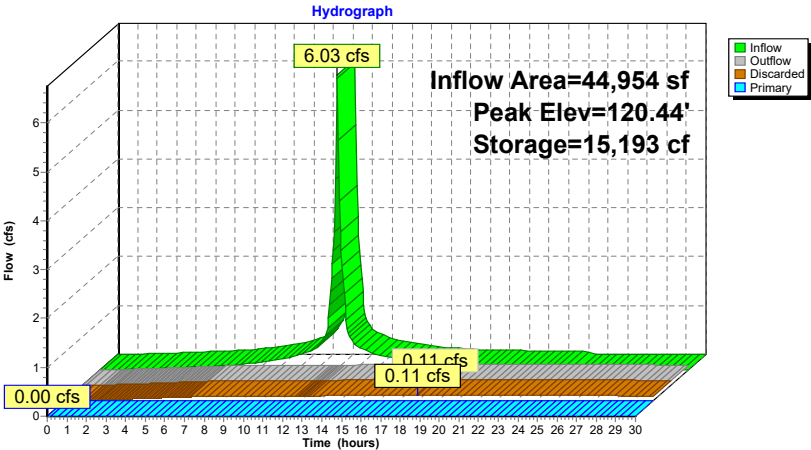
26,496.0 cf Field - 10,192.9 cf Chambers = 16,303.1 cf Stone x 40.0% Voids = 6,521.2 cf Stone Storage

Chamber Storage + Stone Storage = 16,714.1 cf = 0.384 af  
Overall Storage Efficiency = 63.1%  
Overall System Size = 288.00' x 23.00' x 4.00'

70 Chambers  
981.3 cy Field  
603.8 cy Stone



Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)



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Page 171

### Summary for Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)

Inflow Area = 37,779 sf, 57.72% Impervious, Inflow Depth = 5.03" for 25-Year event  
Inflow = 4.73 cfs @ 12.09 hrs, Volume= 15,849 cf  
Outflow = 0.47 cfs @ 12.89 hrs, Volume= 15,089 cf, Atten= 90%, Lag= 48.1 min  
Discarded = 0.13 cfs @ 12.89 hrs, Volume= 10,221 cf  
Primary = 0.34 cfs @ 12.89 hrs, Volume= 4,869 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 109.32' @ 12.89 hrs Surf.Area= 4,930 sf Storage= 7,555 cf  
Flood Elev= 108.50' Surf.Area= 4,930 sf Storage= 4,321 cf

Plug-Flow detention time= 281.2 min calculated for 15,089 cf (95% of inflow)  
Center-of-Mass det. time= 253.9 min (1,035.1 - 781.2)

Volume	Invert	Avail.Storage	Storage Description
#1A	107.00'	4,775 cf	<b>72.50'W x 68.00'L x 4.00'H Field A</b> 19,720 cf Overall - 7,783 cf Embedded = 11,937 cf x 40.0% Voids
#2A	107.50'	7,783 cf	<b>CMP Round 36</b> x 48 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 48 Chambers in 16 Rows 70.50' Header x 7.07 sf x 2 = 996.7 cf Inside
12,558 cf			Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	107.00'	<b>12.0" Round Culvert</b> L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 107.00' / 102.00' S= 0.0500 'ft Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	108.50'	<b>4.0" Vert. Orifice/Grate</b> C= 0.600
#3	Discarded	107.00'	<b>1.020 in/hr Exfiltration over Wetted area</b>

**Discarded OutFlow** Max=0.13 cfs @ 12.89 hrs HW=109.32' (Free Discharge)  
↳ **3=Exfiltration** (Exfiltration Controls 0.13 cfs)

**Primary OutFlow** Max=0.34 cfs @ 12.89 hrs HW=109.32' (Free Discharge)  
↳ **1=Culvert** (Passes 0.34 cfs of 4.03 cfs potential flow)  
↳ **2=Orifice/Grate** (Orifice Controls 0.34 cfs @ 3.90 fps)

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Page 172

### Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP) - Chamber Wizard Field A

**Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)**

Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf

Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

3 Chambers/Row x 20.00' Long +3.00' Header x 2 = 66.00' Row Length +12.0" End Stone x 2 = 68.00' Base Length  
16 Rows x 36.0" Wide + 18.0" Spacing x 15 + 12.0" Side Stone x 2 = 72.50' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

48 Chambers x 141.4 cf + 70.50' Header x 7.07 sf x 2 = 7,782.5 cf Chamber Storage

19,720.0 cf Field - 7,782.5 cf Chambers = 11,937.5 cf Stone x 40.0% Voids = 4,775.0 cf Stone Storage

Chamber Storage + Stone Storage = 12,557.5 cf = 0.288 af

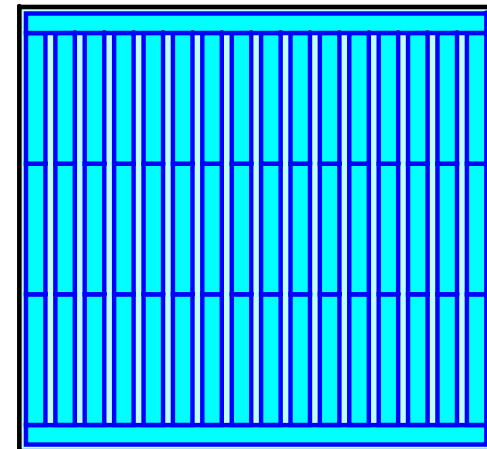
Overall Storage Efficiency = 63.7%

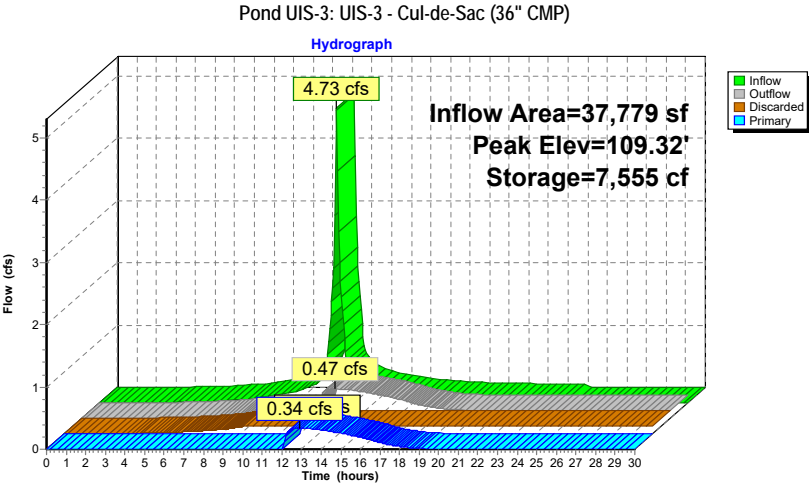
Overall System Size = 68.00' x 72.50' x 4.00'

48 Chambers

730.4 cy Field

442.1 cy Stone





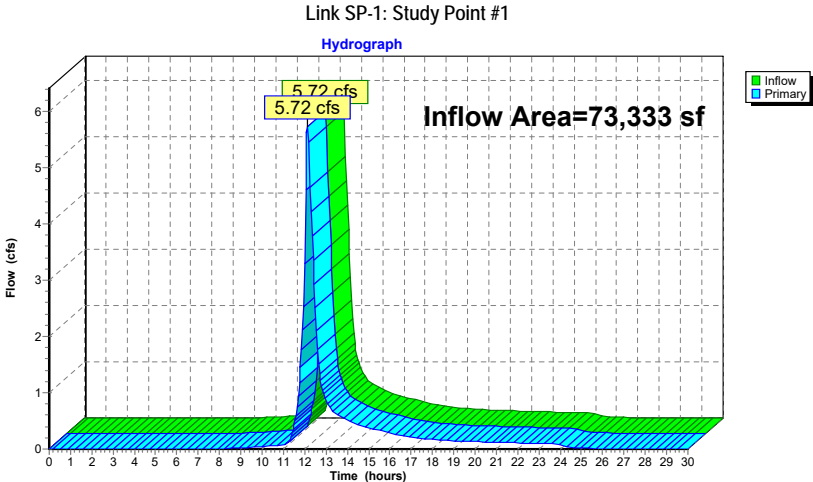
Summary for Link SP-1: Study Point #1

Inflow Area = 73,333 sf, 19.56% Impervious, Inflow Depth > 3.73" for 25-Year event

Inflow = 5.72 cfs @ 12.13 hrs, Volume= 22,769 cf

Primary = 5.72 cfs @ 12.13 hrs, Volume= 22,769 cf, Atten= 0%, Lag= 0.0 min

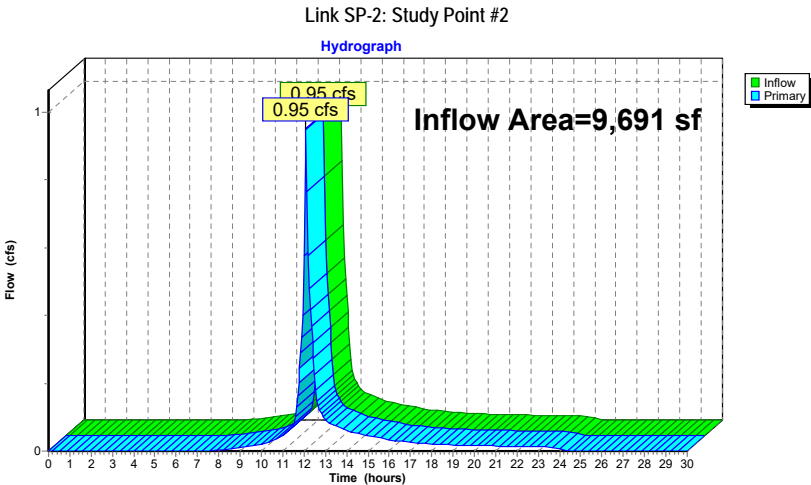
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Summary for Link SP-2: Study Point #2

Inflow Area = 9,691 sf, 0.00% Impervious, Inflow Depth = 3.73" for 25-Year event  
Inflow = 0.95 cfs @ 12.09 hrs, Volume= 3,012 cf  
Primary = 0.95 cfs @ 12.09 hrs, Volume= 3,012 cf, Atten= 0%, Lag= 0.0 min

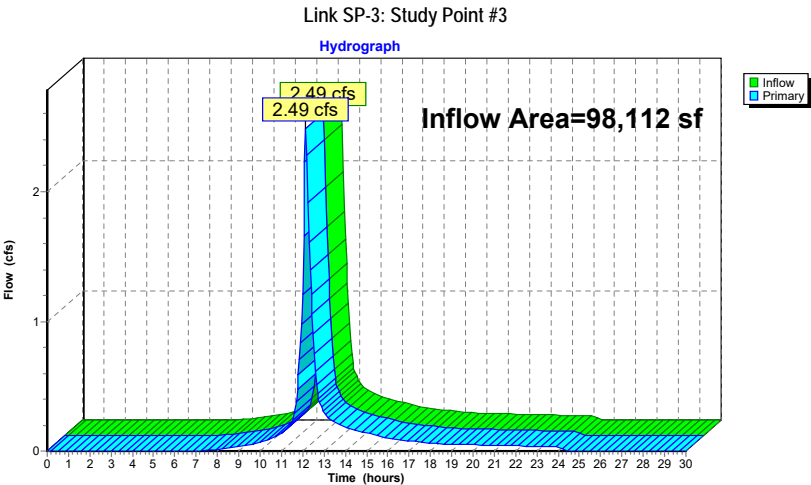
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Summary for Link SP-3: Study Point #3

Inflow Area = 98,112 sf, 58.66% Impervious, Inflow Depth = 1.12" for 25-Year event  
Inflow = 2.49 cfs @ 12.15 hrs, Volume= 9,177 cf  
Primary = 2.49 cfs @ 12.15 hrs, Volume= 9,177 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



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Page 177

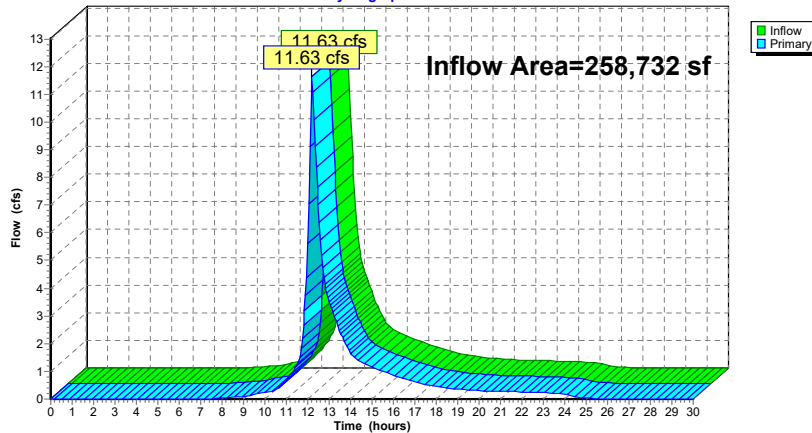
### Summary for Link SP-4: Study Point #4

Inflow Area = 258,732 sf, 29.63% Impervious, Inflow Depth > 2.88" for 25-Year event  
Inflow = 11.63 cfs @ 12.20 hrs, Volume= 62,047 cf  
Primary = 11.63 cfs @ 12.20 hrs, Volume= 62,047 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs

#### Link SP-4: Study Point #4

Hydrograph



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Page 178

Time span=0.00-30.00 hrs, dt=0.05 hrs, 601 points  
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN  
Reach routing by Stor-Ind method - Pond routing by Stor-Ind method

Subcatchment P-1: Flow to Wetlands - North	Runoff Area=17,171 sf 0.00% Impervious Runoff Depth=6.26" Tc=6.0 min CN=79 Runoff=2.78 cfs 8,953 cf
Subcatchment P-10: Proposed Building Roof	Runoff Area=30,342 sf 100.00% Impervious Runoff Depth=8.56" Tc=6.0 min CN=98 Runoff=5.88 cfs 21,643 cf
Subcatchment P-11: South Courtyard	Runoff Area=20,180 sf 100.00% Impervious Runoff Depth=8.56" Tc=6.0 min CN=98 Runoff=3.91 cfs 14,395 cf
Subcatchment P-12: Southeast Roof Area	Runoff Area=27,254 sf 100.00% Impervious Runoff Depth=8.56" Tc=6.0 min CN=98 Runoff=5.28 cfs 19,441 cf
Subcatchment P-13: Main Parking Area	Runoff Area=17,700 sf 76.07% Impervious Runoff Depth=8.08" Tc=6.0 min CN=94 Runoff=3.38 cfs 11,915 cf
Subcatchment P-14: WWTF/Driveway	Runoff Area=19,605 sf 33.29% Impervious Runoff Depth=7.11" Tc=6.0 min CN=86 Runoff=3.49 cfs 11,614 cf
Subcatchment P-15: South Lawn/Fire Access Road	Runoff Area=18,445 sf 0.00% Impervious Runoff Depth=6.38" Tc=6.0 min CN=80 Runoff=3.03 cfs 9,805 cf
Subcatchment P-16: Entrance Drive	Runoff Area=20,820 sf 44.13% Impervious Runoff Depth=7.35" Tc=6.0 min CN=88 Runoff=3.79 cfs 12,755 cf
Subcatchment P-17: Detention Pond-1	Runoff Area=11,737 sf 0.00% Impervious Runoff Depth=6.38" Tc=6.0 min CN=80 Runoff=1.93 cfs 6,239 cf
Subcatchment P-18: Entry Driveway	Runoff Area=5,160 sf 100.00% Impervious Runoff Depth=8.56" Tc=6.0 min CN=98 Runoff=1.00 cfs 3,681 cf
Subcatchment P-2: Direct Flow to Wetlands "F"	Runoff Area=9,691 sf 0.00% Impervious Runoff Depth=6.13" Tc=6.0 min CN=78 Runoff=1.54 cfs 4,954 cf
Subcatchment P-3: Flow Southwest Off-Site	Runoff Area=27,985 sf 1.79% Impervious Runoff Depth=6.38" Flow Length=194' Slope=0.0100 ' /' Tc=10.9 min CN=80 Runoff=3.97 cfs 14,876 cf
Subcatchment P-4: Flow Southeast to Wetlands "A"	Runoff Area=117,759 sf 0.54% Impervious Runoff Depth=6.13" Flow Length=186' Tc=14.0 min CN=78 Runoff=14.83 cfs 60,203 cf
Subcatchment P-5: Entrance Drive	Runoff Area=14,879 sf 78.94% Impervious Runoff Depth=8.08" Tc=6.0 min CN=94 Runoff=2.84 cfs 10,016 cf
Subcatchment P-6: Landcaped Slope/Walls	Runoff Area=18,477 sf 5.22% Impervious Runoff Depth=6.38" Tc=6.0 min UI Adjusted CN=80 Runoff=3.04 cfs 9,822 cf
Subcatchment P-7: Landscaped Slope	Runoff Area=24,884 sf 3.17% Impervious Runoff Depth=6.50" Tc=6.0 min CN=81 Runoff=4.15 cfs 13,480 cf



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Page 179

Subcatchment P-8: Cul-de-Sac/Garage Turn Around	Runoff Area=22,451 sf 74.60% Impervious Runoff Depth=7.96" Tc=6.0 min CN=93 Runoff=4.26 cfs 14,887 cf
Subcatchment P-9: North Courtyard/Green Roof	Runoff Area=15,328 sf 33.00% Impervious Runoff Depth=7.11" Tc=6.0 min CN=86 Runoff=2.73 cfs 9,080 cf
Reach SWALE: Swale Abutting Entry Driveway	Avg. Flow Depth=0.35' Max Vel=4.22 fps Inflow=4.15 cfs 13,480 cf n=0.040 L=427.0' S=0.0749' Capacity=16.60 cfs Outflow=4.05 cfs 13,480 cf
Pond RG-1: Rain Garden-1 - Entrance	Peak Elev=51.87' Storage=2,031 cf Inflow=3.10 cfs 33,304 cf 24.0" Round Culvert n=0.013 L=100.0' S=0.0050' Outflow=3.10 cfs 31,814 cf
Pond RG-2: Rain Garden #2 - Driveway	Peak Elev=163.61' Storage=1,691 cf Inflow=1.00 cfs 3,681 cf Outflow=0.87 cfs 2,166 cf
Pond SDP-1: Surface Detention Pond-1	Peak Elev=79.62' Storage=5,115 cf Inflow=8.75 cfs 28,799 cf Primary=5.89 cfs 26,581 cf Secondary=0.96 cfs 261 cf Outflow=6.84 cfs 26,841 cf
Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)	Peak Elev=50.74' Storage=8,540 cf Inflow=9.87 cfs 33,317 cf Outflow=3.10 cfs 33,304 cf
Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)	Peak Elev=109.33' Storage=42,955 cf Inflow=13.28 cfs 47,652 cf Outflow=0.27 cfs 5,005 cf
Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)	Peak Elev=120.82' Storage=16,227 cf Inflow=8.66 cfs 31,355 cf Discarded=0.11 cfs 9,672 cf Primary=2.58 cfs 8,783 cf Outflow=2.68 cfs 18,455 cf
Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)	Peak Elev=110.67' Storage=11,900 cf Inflow=6.99 cfs 23,967 cf Discarded=0.14 cfs 11,061 cf Primary=0.59 cfs 11,393 cf Outflow=0.73 cfs 22,454 cf
Link SP-1: Study Point #1	Inflow=9.21 cfs 37,699 cf Primary=9.21 cfs 37,699 cf
Link SP-2: Study Point #2	Inflow=2.16 cfs 5,215 cf Primary=2.16 cfs 5,215 cf
Link SP-3: Study Point #3	Inflow=3.97 cfs 19,880 cf Primary=3.97 cfs 19,880 cf
Link SP-4: Study Point #4	Inflow=18.08 cfs 112,194 cf Primary=18.08 cfs 112,194 cf

Total Runoff Area = 439,868 sf Runoff Volume = 257,758 cf Average Runoff Depth = 7.03"  
66.23% Pervious = 291,317 sf 33.77% Impervious = 148,551 sf

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The Sanctuary, Manchester-by-the-Sea, MA  
Type III 24-hr 100-Year Rainfall=8.80"

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Page 180

### Summary for Subcatchment P-1: Flow to Wetlands - North

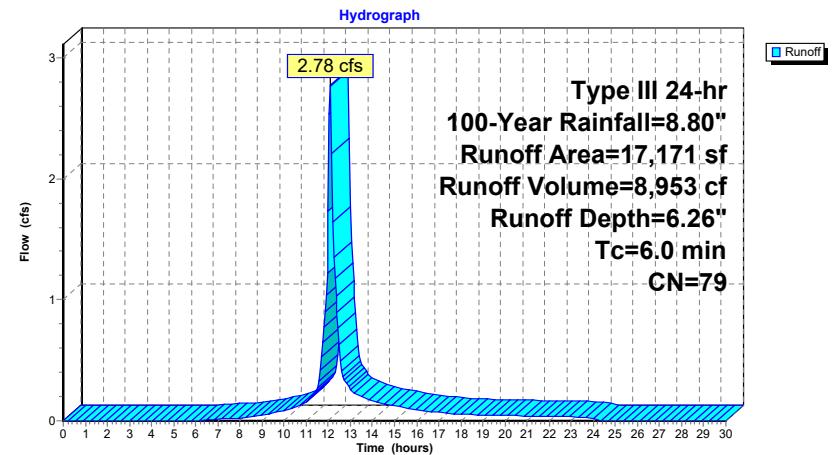
Runoff = 2.78 cfs @ 12.09 hrs, Volume= 8,953 cf, Depth= 6.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
12,252	80	>75% Grass cover, Good, HSG D
4,919	77	Woods, Good, HSG D
17,171	79	Weighted Average
17,171		100.00% Pervious Area

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

### Subcatchment P-1: Flow to Wetlands - North



Summary for Subcatchment P-10: Proposed Building Roof

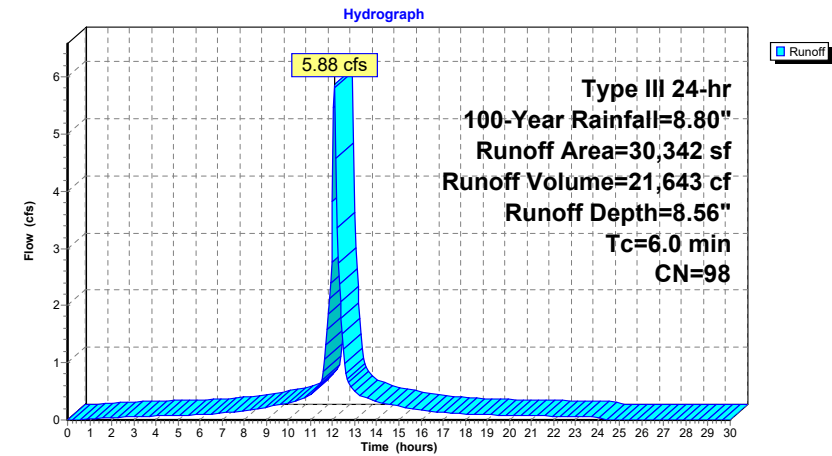
Runoff = 5.88 cfs @ 12.09 hrs, Volume= 21,643 cf, Depth= 8.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
30,342	98	Unconnected roofs, HSG D
30,342		100.00% Impervious Area
30,342		100.00% Unconnected

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

Subcatchment P-10: Proposed Building Roof



Summary for Subcatchment P-11: South Courtyard

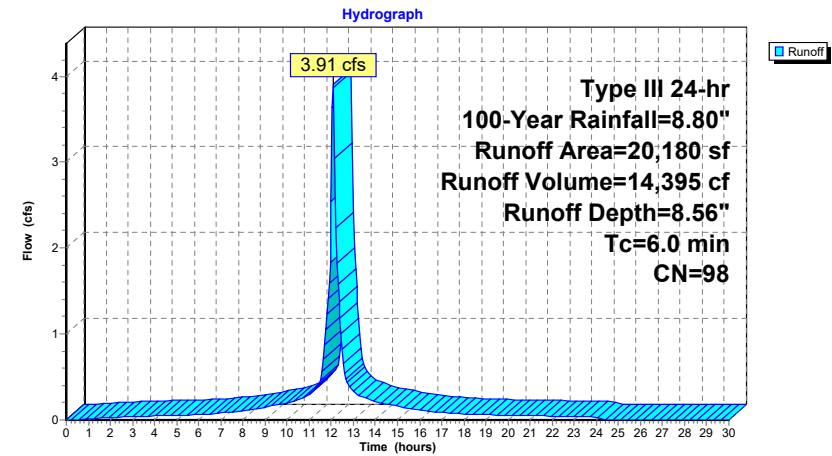
Runoff = 3.91 cfs @ 12.09 hrs, Volume= 14,395 cf, Depth= 8.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
20,180	98	Unconnected pavement, HSG D
20,180		100.00% Impervious Area
20,180		100.00% Unconnected

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

Subcatchment P-11: South Courtyard



Summary for Subcatchment P-12: Southeast Roof Area

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

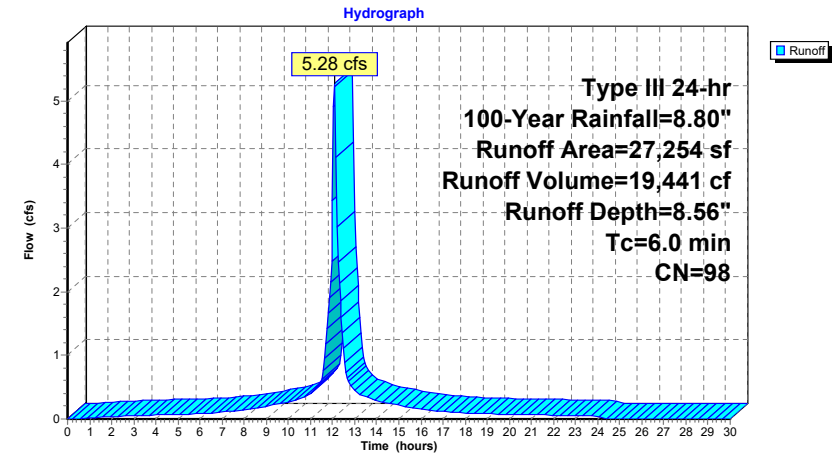
Runoff = 5.28 cfs @ 12.09 hrs, Volume= 19,441 cf, Depth= 8.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
27,254	98	Unconnected roofs, HSG D
27,254		100.00% Impervious Area
27,254		100.00% Unconnected

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

Subcatchment P-12: Southeast Roof Area



Summary for Subcatchment P-13: Main Parking Area

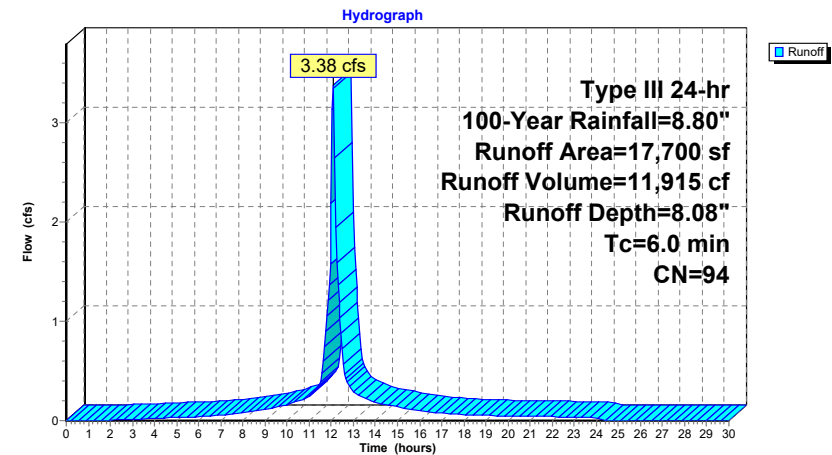
Runoff = 3.38 cfs @ 12.09 hrs, Volume= 11,915 cf, Depth= 8.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
13,464	98	Unconnected pavement, HSG D
4,236	80	>75% Grass cover, Good, HSG D
17,700	94	Weighted Average
4,236		23.93% Pervious Area
13,464		76.07% Impervious Area
13,464		100.00% Unconnected

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

Subcatchment P-13: Main Parking Area



Summary for Subcatchment P-14: WWTF/Driveway

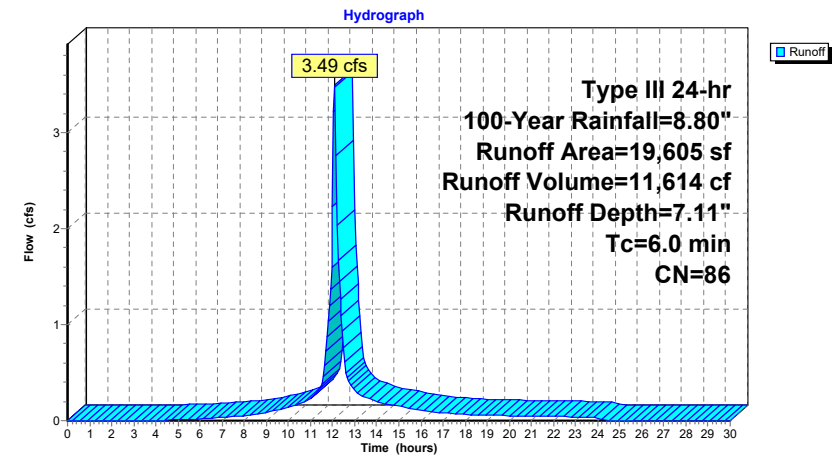
Runoff = 3.49 cfs @ 12.09 hrs, Volume= 11,614 cf, Depth= 7.11"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
6,526	98	Paved parking, HSG D
9,225	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
19,605	86	Weighted Average
13,079		66.71% Pervious Area
6,526		33.29% Impervious Area

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

Subcatchment P-14: WWTF/Driveway



Summary for Subcatchment P-15: South Lawn/Fire Access Road

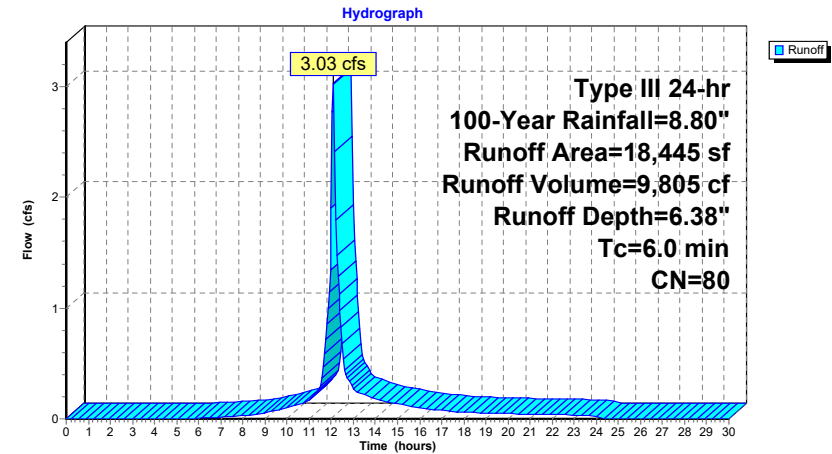
Runoff = 3.03 cfs @ 12.09 hrs, Volume= 9,805 cf, Depth= 6.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
14,591	80	>75% Grass cover, Good, HSG D
3,854	80	GrassPave-2
18,445	80	Weighted Average
18,445		100.00% Pervious Area

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

Subcatchment P-15: South Lawn/Fire Access Road



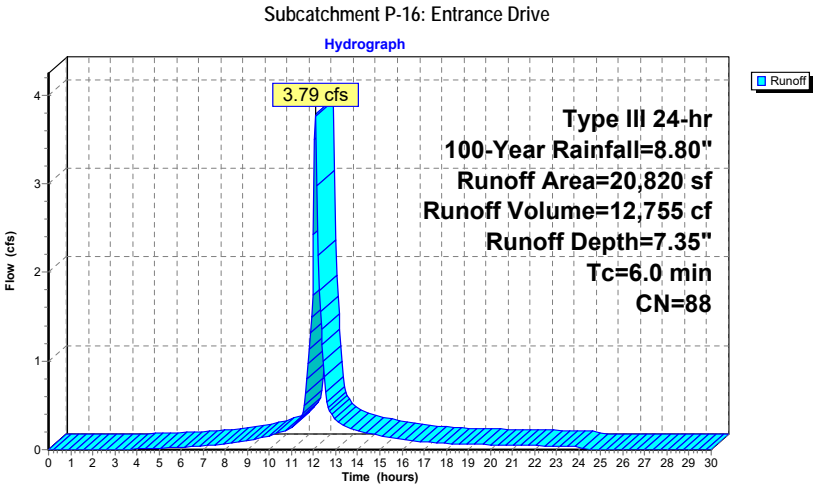
Summary for Subcatchment P-16: Entrance Drive

Runoff = 3.79 cfs @ 12.09 hrs, Volume= 12,755 cf, Depth= 7.35"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
9,187	98	Unconnected pavement, HSG D
11,633	80	>75% Grass cover, Good, HSG D
20,820	88	Weighted Average
11,633		55.87% Pervious Area
9,187		44.13% Impervious Area
9,187		100.00% Unconnected

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



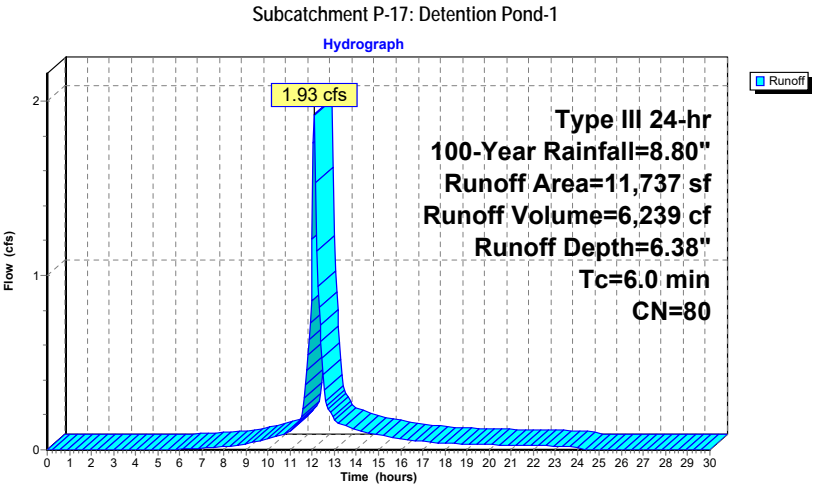
Summary for Subcatchment P-17: Detention Pond-1

Runoff = 1.93 cfs @ 12.09 hrs, Volume= 6,239 cf, Depth= 6.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
4,872	91	Gravel roads, HSG D
6,865	73	Brush, Good, HSG D
11,737	80	Weighted Average
11,737		100.00% Pervious Area

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



Summary for Subcatchment P-18: Entry Driveway

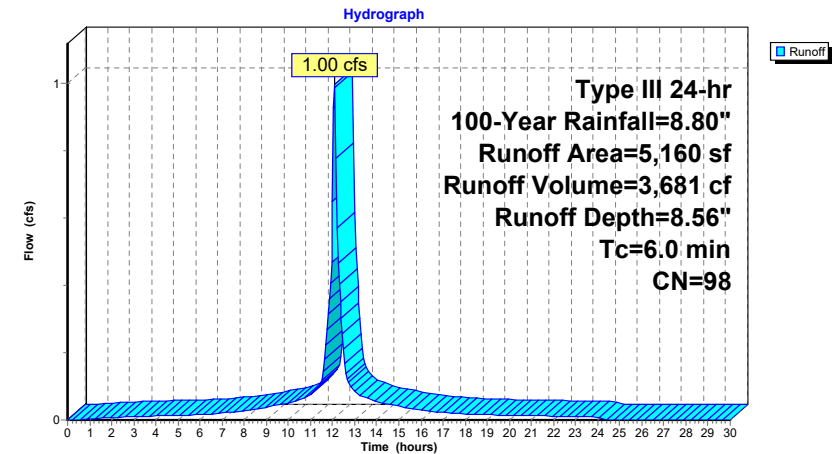
Runoff = 1.00 cfs @ 12.09 hrs, Volume= 3,681 cf, Depth= 8.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
5,160	98	Unconnected pavement, HSG D
5,160		100.00% Impervious Area
5,160		100.00% Unconnected

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

Subcatchment P-18: Entry Driveway



Summary for Subcatchment P-2: Direct Flow to Wetlands "F"

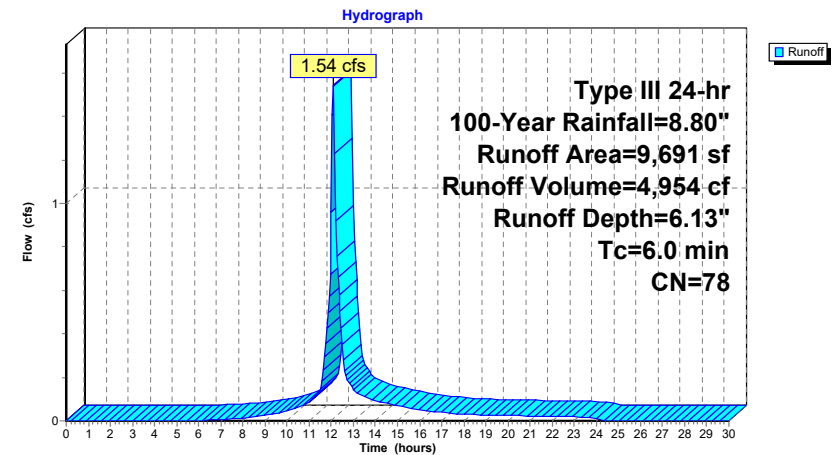
Runoff = 1.54 cfs @ 12.09 hrs, Volume= 4,954 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
1,678	80	>75% Grass cover, Good, HSG D
8,013	77	Woods, Good, HSG D
9,691	78	Weighted Average
9,691		100.00% Pervious Area

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

Subcatchment P-2: Direct Flow to Wetlands "F"



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Type III 24-hr 100-Year Rainfall=8.80"

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Page 191

## Summary for Subcatchment P-3: Flow Southwest Off-Site

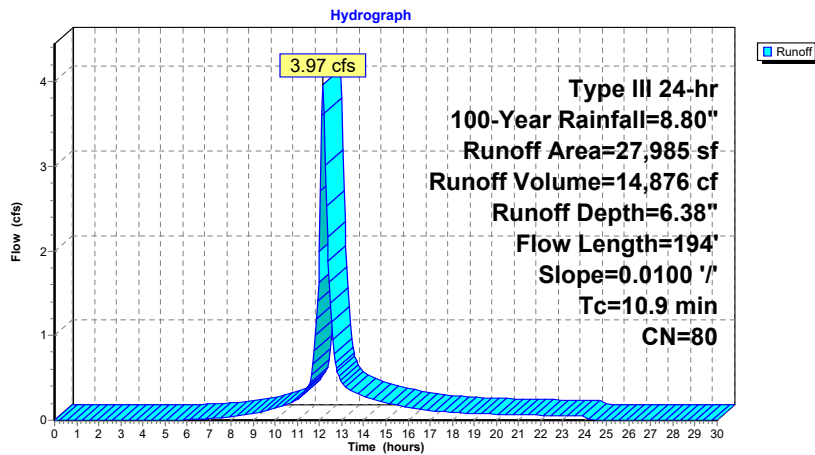
Runoff = 3.97 cfs @ 12.15 hrs, Volume= 14,876 cf, Depth= 6.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
24,995	80	>75% Grass cover, Good, HSG D
2,490	77	Woods, Good, HSG D
500	98	Unconnected pavement, HSG D
27,985	80	Weighted Average
27,485		98.21% Pervious Area
500		1.79% Impervious Area
500		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.5	50	0.0100	0.11		Sheet Flow, Grass: Short n= 0.150 P2= 3.16"
3.4	144	0.0100	0.70		Shallow Concentrated Flow, Short Grass Pasture Kv= 7.0 fps
10.9	194	Total			

## Subcatchment P-3: Flow Southwest Off-Site



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Type III 24-hr 100-Year Rainfall=8.80"

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Page 192

## Summary for Subcatchment P-4: Flow Southeast to Wetlands "A"

Tc of 4.6 rounds to minimum of 5.0. Use Tc = 5.0 minutes for E-2.

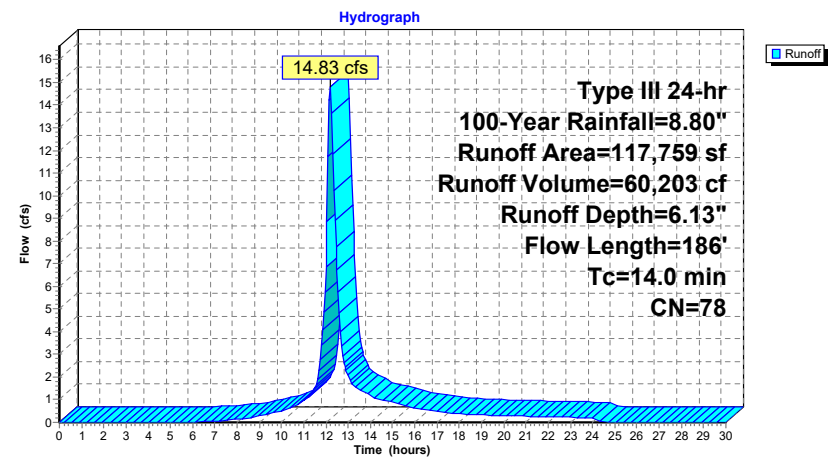
Runoff = 14.83 cfs @ 12.19 hrs, Volume= 60,203 cf, Depth= 6.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
92,430	77	Woods, Good, HSG D
24,696	80	>75% Grass cover, Good, HSG D
633	98	Unconnected pavement, HSG D
117,759	78	Weighted Average
117,126		99.46% Pervious Area
633		0.54% Impervious Area
633		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
11.4	50	0.1000	0.07		Sheet Flow, Woods: Dense underbrush n= 0.800 P2= 3.16"
2.6	136	0.1200	0.87		Shallow Concentrated Flow, Forest w/Heavy Litter Kv= 2.5 fps
14.0	186	Total			

## Subcatchment P-4: Flow Southeast to Wetlands "A"



Summary for Subcatchment P-5: Entrance Drive

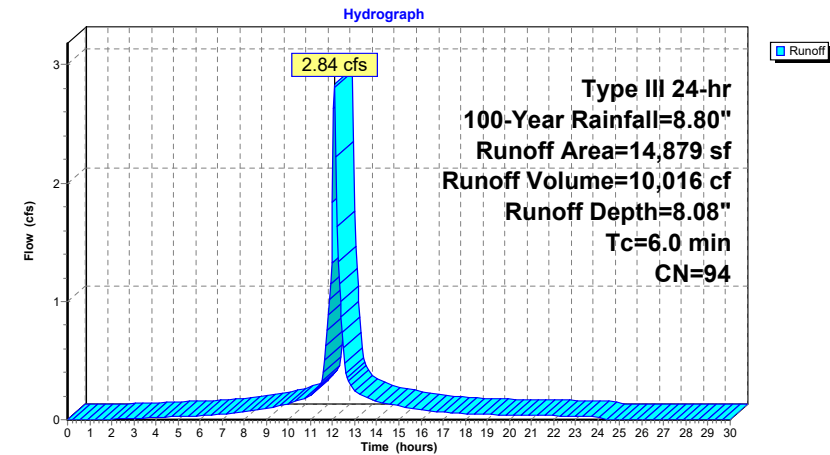
Runoff = 2.84 cfs @ 12.09 hrs, Volume= 10,016 cf, Depth= 8.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
11,745	98	Paved parking, HSG D
3,134	80	>75% Grass cover, Good, HSG D
14,879	94	Weighted Average
3,134		21.06% Pervious Area
11,745		78.94% Impervious Area

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

Subcatchment P-5: Entrance Drive



Summary for Subcatchment P-6: Landcaped Slope/Walls

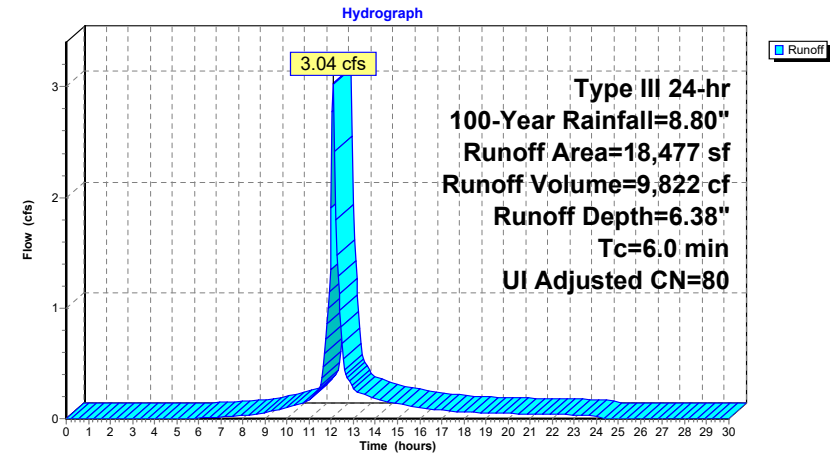
Runoff = 3.04 cfs @ 12.09 hrs, Volume= 9,822 cf, Depth= 6.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Adj	Description
17,512	80		>75% Grass cover, Good, HSG D
965	98		Unconnected pavement, HSG D
18,477	81	80	Weighted Average, UI Adjusted
17,512			94.78% Pervious Area
965			5.22% Impervious Area
965			100.00% Unconnected

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

Subcatchment P-6: Landcaped Slope/Walls





Summary for Subcatchment P-7: Landscaped Slope

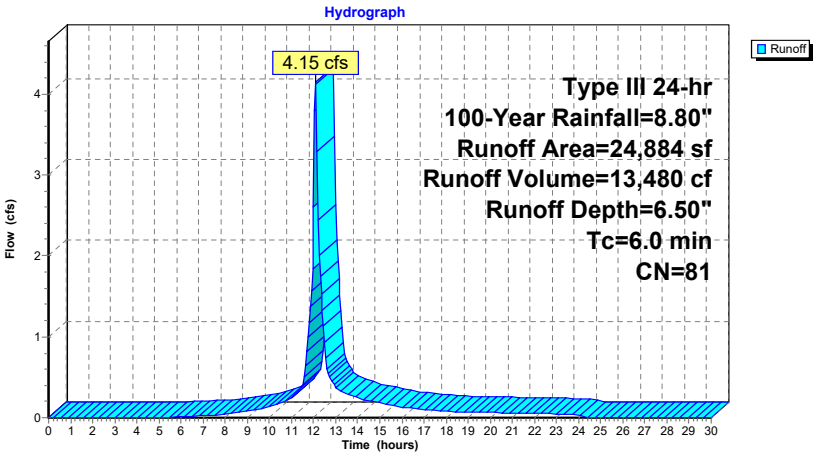
Runoff = 4.15 cfs @ 12.09 hrs, Volume= 13,480 cf, Depth= 6.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
788	98	Paved parking, HSG D
24,096	80	>75% Grass cover, Good, HSG D
24,884	81	Weighted Average
24,096		96.83% Pervious Area
788		3.17% Impervious Area

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

Subcatchment P-7: Landscaped Slope



Summary for Subcatchment P-8: Cul-de-Sac/Garage Turn Around

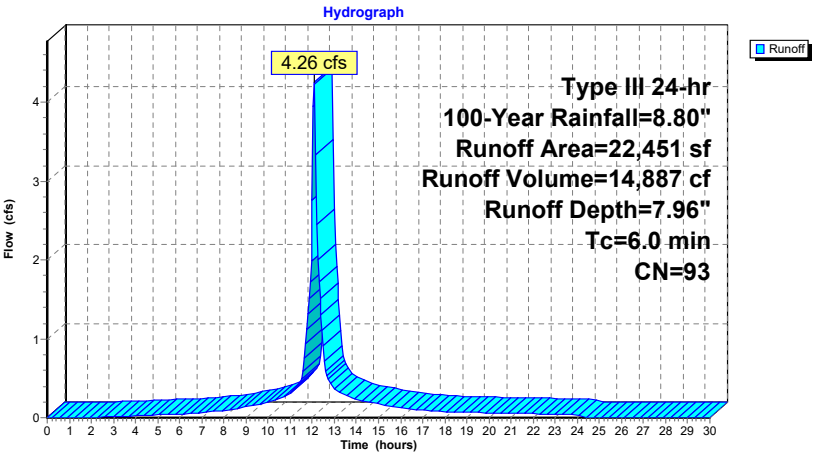
Runoff = 4.26 cfs @ 12.09 hrs, Volume= 14,887 cf, Depth= 7.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
16,749	98	Paved parking, HSG D
5,702	80	>75% Grass cover, Good, HSG D
22,451	93	Weighted Average
5,702		25.40% Pervious Area
16,749		74.60% Impervious Area

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

Subcatchment P-8: Cul-de-Sac/Garage Turn Around



Summary for Subcatchment P-9: North Courtyard/Green Roof

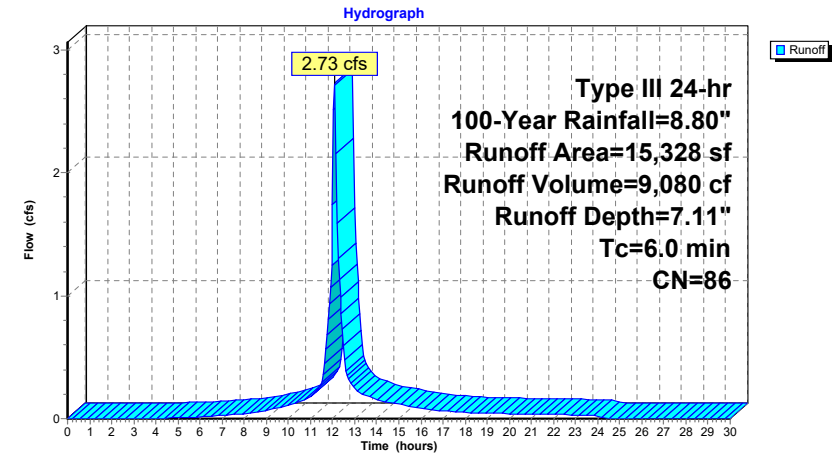
Runoff = 2.73 cfs @ 12.09 hrs, Volume= 9,080 cf, Depth= 7.11"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Type III 24-hr 100-Year Rainfall=8.80"

Area (sf)	CN	Description
5,058	98	Unconnected roofs, HSG D
10,270	80	>75% Grass cover, Good, HSG D
15,328	86	Weighted Average
10,270		67.00% Pervious Area
5,058		33.00% Impervious Area
5,058		100.00% Unconnected

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

Subcatchment P-9: North Courtyard/Green Roof



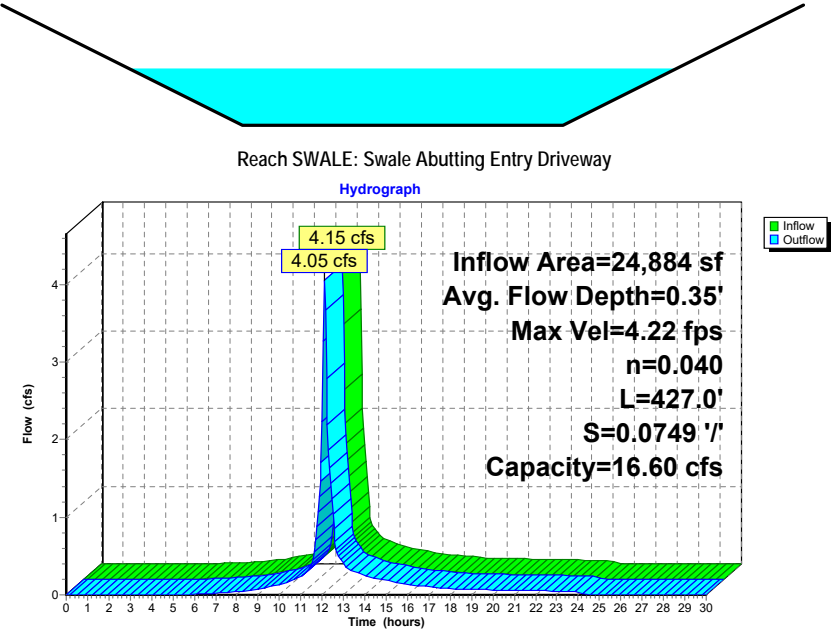
Summary for Reach SWALE: Swale Abutting Entry Driveway

Inflow Area = 24,884 sf, 3.17% Impervious, Inflow Depth = 6.50" for 100-Year event  
Inflow = 4.15 cfs @ 12.09 hrs, Volume= 13,480 cf  
Outflow = 4.05 cfs @ 12.11 hrs, Volume= 13,480 cf, Atten= 2%, Lag= 1.2 min

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Max. Velocity= 4.22 fps, Min. Travel Time= 1.7 min  
Avg. Velocity = 1.14 fps, Avg. Travel Time= 6.2 min

Peak Storage= 410 cf @ 12.11 hrs  
Average Depth at Peak Storage= 0.35'  
Bank-Full Depth= 0.75' Flow Area= 2.6 sf, Capacity= 16.60 cfs

2.00' x 0.75' deep channel, n= 0.040 Earth, cobble bottom, clean sides  
Side Slope Z-value= 2.0 ' Top Width= 5.00'  
Length= 427.0' Slope= 0.0749 ' / '  
Inlet Invert= 99.50', Outlet Invert= 67.50'



Summary for Pond RG-1: Rain Garden-1 - Entrance

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth > 6.86" for 100-Year event  
Inflow = 3.10 cfs @ 12.42 hrs, Volume= 33,304 cf  
Outflow = 3.10 cfs @ 12.42 hrs, Volume= 31,814 cf, Atten= 0%, Lag= 0.0 min  
Primary = 3.10 cfs @ 12.42 hrs, Volume= 31,814 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs / 2  
Peak Elev= 51.87' @ 12.42 hrs Surf.Area= 1,423 sf Storage= 2,031 cf

Plug-Flow detention time= 50.9 min calculated for 31,814 cf (96% of inflow)  
Center-of-Mass det. time= 24.9 min ( 844.6 - 819.7 )

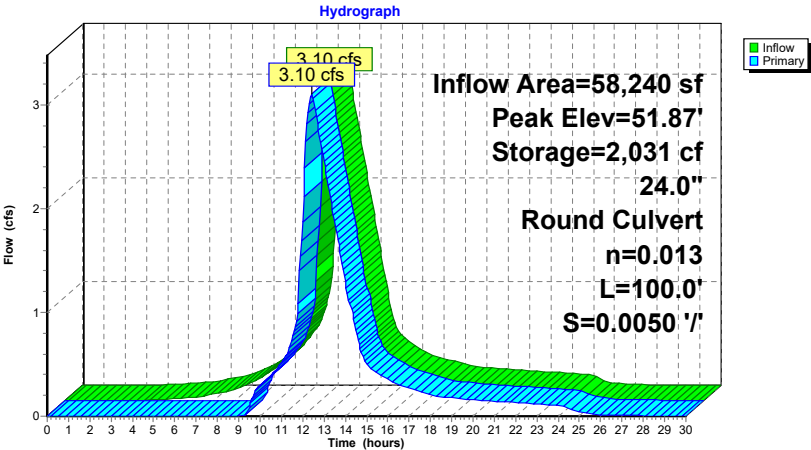
Volume	Invert	Avail.Storage	Storage Description
#1	49.00'	2,031 cf	Rain Garden (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
49.00	425	82.3	0	0	425
50.00	701	101.5	557	557	720
51.00	1,034	120.4	862	1,419	1,072
51.50	1,423	139.2	612	2,031	1,466

Device	Routing	Invert	Outlet Devices
#1	Primary	51.00'	24.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 51.00' / 50.50' S= 0.0050 '/ S= 0.0050 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 3.14 sf

Primary OutFlow Max=3.09 cfs @ 12.42 hrs HW=51.87' (Free Discharge)  
1=Culvert (Barrel Controls 3.09 cfs @ 3.49 fps)

Pond RG-1: Rain Garden-1 - Entrance



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Page 201

Summary for Pond RG-2: Rain Garden #2 - Driveway

Inflow Area = 5,160 sf, 100.00% Impervious, Inflow Depth = 8.56" for 100-Year event  
Inflow = 1.00 cfs @ 12.09 hrs, Volume= 3,681 cf  
Outflow = 0.87 cfs @ 12.14 hrs, Volume= 2,166 cf, Atten= 13%, Lag= 3.2 min  
Primary = 0.87 cfs @ 12.14 hrs, Volume= 2,166 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 163.61' @ 12.14 hrs Surf.Area= 1,626 sf Storage= 1,691 cf

Plug-Flow detention time= 233.1 min calculated for 2,166 cf (59% of inflow)  
Center-of-Mass det. time= 117.5 min ( 857.6 - 740.1 )

Volume	Invert	Avail.Storage	Storage Description
#1	162.00'	3,504 cf	Custom Stage Data (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
162.00	564	214.6	0	0	564
164.00	1,965	252.4	2,388	2,388	2,044
164.50	2,509	276.8	1,116	3,504	3,080

Device	Routing	Invert	Outlet Devices
#1	Primary	163.50'	10.0' long x 5.0' 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) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.67 2.66 2.68 2.70			
2.74 2.79 2.88			

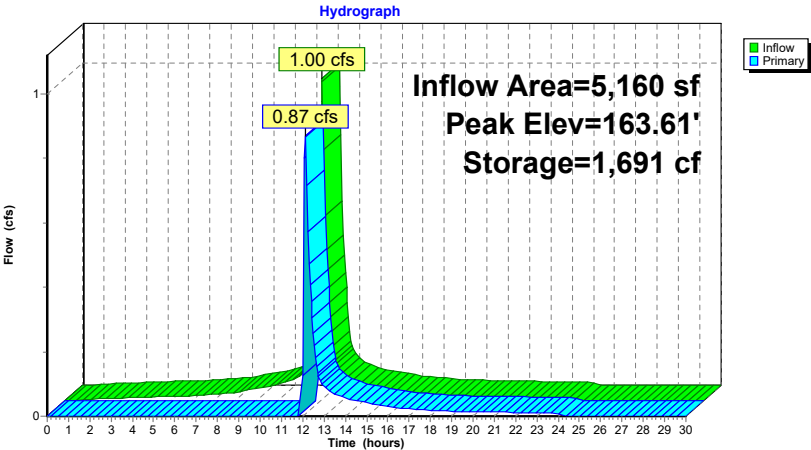
Primary OutFlow Max=0.85 cfs @ 12.14 hrs HW=163.61' (Free Discharge)  
1=Broad-Crested Rectangular Weir (Weir Controls 0.85 cfs @ 0.77 fps)

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Page 202

Pond RG-2: Rain Garden #2 - Driveway



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Page 203

### Summary for Pond SDP-1: Surface Detention Pond-1

Inflow Area = 51,002 sf, 18.01% Impervious, Inflow Depth = 6.78" for 100-Year event  
Inflow = 8.75 cfs @ 12.09 hrs, Volume= 28,799 cf  
Outflow = 6.84 cfs @ 12.16 hrs, Volume= 26,841 cf, Atten= 22%, Lag= 4.3 min  
Primary = 5.89 cfs @ 12.16 hrs, Volume= 26,581 cf  
Secondary = 0.96 cfs @ 12.16 hrs, Volume= 261 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 79.62' @ 12.16 hrs Surf.Area= 2,483 sf Storage= 5,115 cf

Plug-Flow detention time= 71.7 min calculated for 26,841 cf (93% of inflow)  
Center-of-Mass det. time= 35.7 min ( 826.1 - 790.4 )

Volume	Invert	Avail.Storage	Storage Description
#1	76.00'	8,088 cf	Surface Detention Pond (Irregular) Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Perim. (feet)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)	Wet.Area (sq-ft)
76.00	531	104.1	0	0	531
78.00	1,488	192.6	1,939	1,939	2,642
80.00	2,756	230.3	4,179	6,118	3,979
80.50	5,256	368.3	1,970	8,088	10,554

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.50'	10.0' long x 10.0' breadth Emergency OverFlow 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
#2	Primary	78.00'	15.0" Round Culvert L= 100.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 78.00' / 77.00' S= 0.0100 '/ S Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Primary OutFlow Max=5.84 cfs @ 12.16 hrs HW=79.60' (Free Discharge)  
2=Culvert (Inlet Controls 5.84 cfs @ 4.76 fps)

Secondary OutFlow Max=0.84 cfs @ 12.16 hrs HW=79.60' (Free Discharge)  
1=Emergency OverFlow Weir (Weir Controls 0.84 cfs @ 0.80 fps)

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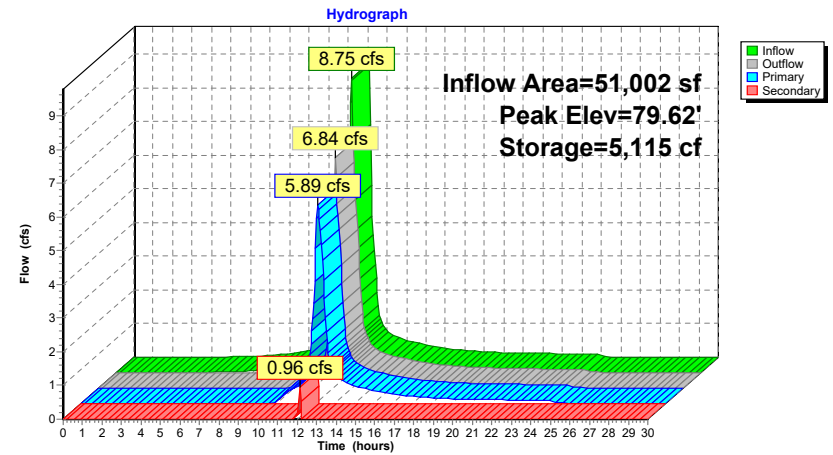
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Page 204

### Pond SDP-1: Surface Detention Pond-1



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Page 205

### Summary for Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)

Inflow Area = 58,240 sf, 23.18% Impervious, Inflow Depth = 6.86" for 100-Year event  
Inflow = 9.87 cfs @ 12.10 hrs, Volume= 33,317 cf  
Outflow = 3.10 cfs @ 12.42 hrs, Volume= 33,304 cf, Atten= 69%, Lag= 19.3 min  
Primary = 3.10 cfs @ 12.42 hrs, Volume= 33,304 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 50.74' @ 12.42 hrs Surf.Area= 3,520 sf Storage= 8,540 cf

Plug-Flow detention time= 32.1 min calculated for 33,304 cf (100% of inflow)  
Center-of-Mass det. time= 31.8 min ( 819.7 - 787.9 )

Volume	Invert	Avail.Storage	Storage Description
#1A	47.00'	3,452 cf	<b>27.50'W x 128.00'L x 4.00'H Field A</b> 14,080 cf Overall - 5,450 cf Embedded = 8,630 cf x 40.0% Voids
#2A	47.50'	5,450 cf	<b>CMP Round 36 x 36 Inside #1</b> Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 36 Chambers in 6 Rows 25.50' Header x 7.07 sf x 2 = 360.5 cf Inside
			8,902 cf Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	47.00'	<b>18.0" Round Culvert</b> L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 47.00' / 46.00' S= 0.0100 'f' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.77 sf
#2	Device 1	51.00'	<b>5.0' long x 0.5' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Device 1	47.00'	<b>8.0" Vert. 8" Orifice</b> C= 0.600

**Primary OutFlow** Max=3.10 cfs @ 12.42 hrs HW=50.74' (Free Discharge)

- 1=Culvert (Passes 3.10 cfs of 11.61 cfs potential flow)
- 2=Broad-Crested Rectangular Weir ( Controls 0.00 cfs)
- 3=8" Orifice (Orifice Controls 3.10 cfs @ 8.88 fps)

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Page 206

### Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP) - Chamber Wizard Field A

**Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)**

Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf

Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

6 Chambers/Row x 20.00' Long +3.00' Header x 2 = 126.00' Row Length +12.0" End Stone x 2 = 128.00' Base Length  
6 Rows x 36.0" Wide + 18.0" Spacing x 5 + 12.0" Side Stone x 2 = 27.50' Base Width  
6.0" Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

36 Chambers x 141.4 cf + 25.50' Header x 7.07 sf x 2 = 5,449.9 cf Chamber Storage

14,080.0 cf Field - 5,449.9 cf Chambers = 8,630.1 cf Stone x 40.0% Voids = 3,452.0 cf Stone Storage

Chamber Storage + Stone Storage = 8,901.9 cf = 0.204 af

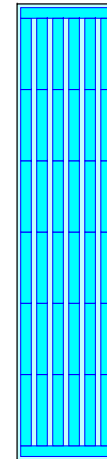
Overall Storage Efficiency = 63.2%

Overall System Size = 128.00' x 27.50' x 4.00'

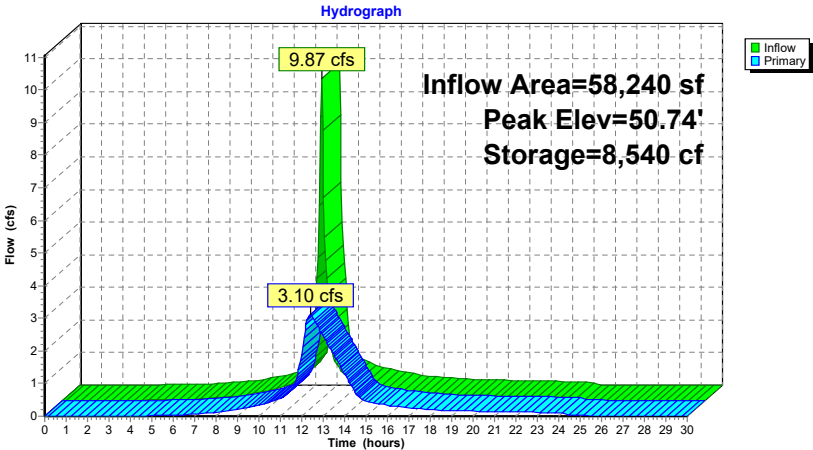
36 Chambers

521.5 cy Field

319.6 cy Stone



Pond UDS-1: UDS-1 - Driveway Entrance (36" CMP)



Summary for Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)

Inflow Area = 70,127 sf, 81.35% Impervious, Inflow Depth = 8.15" for 100-Year event  
Inflow = 13.28 cfs @ 12.09 hrs, Volume= 47,652 cf  
Outflow = 0.27 cfs @ 17.55 hrs, Volume= 5,005 cf, Atten= 98%, Lag= 327.9 min  
Primary = 0.27 cfs @ 17.55 hrs, Volume= 5,005 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 109.33' @ 17.55 hrs Surf.Area= 7,020 sf Storage= 42,955 cf  
Flood Elev= 109.25' Surf.Area= 7,020 sf Storage= 42,647 cf

Plug-Flow detention time= 832.0 min calculated for 4,996 cf (10% of inflow)  
Center-of-Mass det. time= 463.6 min ( 1,214.5 - 750.9 )

Volume	Invert	Avail. Storage	Storage Description
#1A	101.00'	12,163 cf	54.00'W x 130.00'L x 9.00'H Field A 63,180 cf Overall - 32,773 cf Embedded = 30,407 cf x 40.0% Voids
#2A	101.50'	32,773 cf	CMP Round 96 x 30 Inside #1 Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf Overall Size= 96.0"W x 96.0"H x 20.00'L 30 Chambers in 5 Rows 52.00' Header x 50.27 sf x 1 = 2,613.8 cf Inside
		44,936 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 103.00' / 102.00' S= 0.0100 ' /' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	109.25'	4.0' long x 0.5' breadth Broad-Crested Rectangular Weir Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.26 cfs @ 17.55 hrs HW=109.33' (Free Discharge)  
1=Culvert (Passes 0.26 cfs of 7.06 cfs potential flow)  
2=Broad-Crested Rectangular Weir (Weir Controls 0.26 cfs @ 0.80 fps)

Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 96 (Round Corrugated Metal Pipe)  
Effective Size= 96.0"W x 96.0"H => 50.27 sf x 20.00'L = 1,005.3 cf  
Overall Size= 96.0"W x 96.0"H x 20.00'L

96.0" Wide + 36.0" Spacing = 132.0" C-C Row Spacing

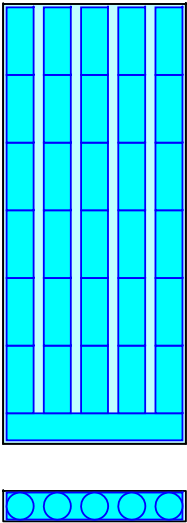
6 Chambers/Row x 20.00' Long +8.00' Header x 1 = 128.00' Row Length +12.0" End Stone x 2 = 130.00' Base Length  
5 Rows x 96.0" Wide + 36.0" Spacing x 4 + 12.0" Side Stone x 2 = 54.00' Base Width  
6.0" Base + 96.0" Chamber Height + 6.0" Cover = 9.00' Field Height

30 Chambers x 1,005.3 cf + 52.00' Header x 50.27 sf = 32,773.1 cf Chamber Storage

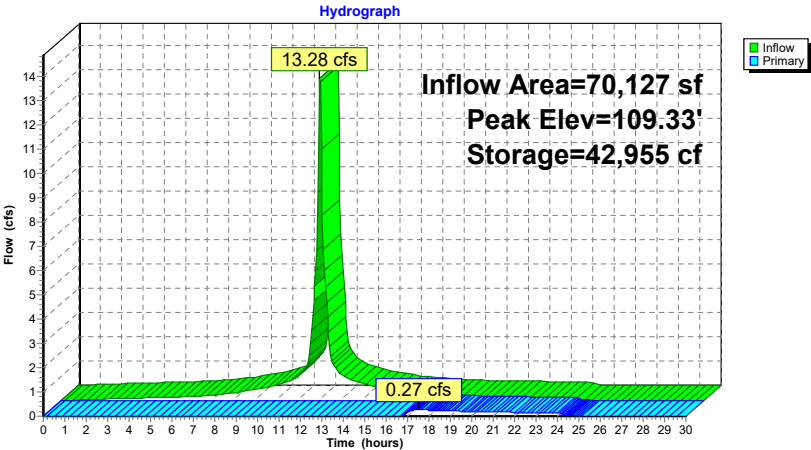
63,180.0 cf Field - 32,773.1 cf Chambers = 30,406.9 cf Stone x 40.0% Voids = 12,162.8 cf Stone Storage

Chamber Storage + Stone Storage = 44,935.9 cf = 1.032 af  
Overall Storage Efficiency = 71.1%  
Overall System Size = 130.00' x 54.00' x 9.00'

30 Chambers  
2,340.0 cy Field  
1,126.2 cy Stone



Pond UIS-1: UIS-1 - Fire Access Road/Lawn (96" CMP)





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Page 211

### Summary for Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)

Inflow Area = 44,954 sf, 90.58% Impervious, Inflow Depth = 8.37" for 100-Year event  
Inflow = 8.66 cfs @ 12.09 hrs, Volume= 31,355 cf  
Outflow = 2.68 cfs @ 12.40 hrs, Volume= 18,455 cf, Atten= 69%, Lag= 19.0 min  
Discarded = 0.11 cfs @ 12.40 hrs, Volume= 9,672 cf  
Primary = 2.58 cfs @ 12.40 hrs, Volume= 8,783 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 120.82' @ 12.40 hrs Surf.Area= 6,624 sf Storage= 16,227 cf

Plug-Flow detention time= 291.8 min calculated for 18,424 cf (59% of inflow)  
Center-of-Mass det. time= 179.8 min ( 927.1 - 747.3 )

Volume	Invert	Avail. Storage	Storage Description
#1A	117.00'	6,521 cf	<b>23.00'W x 288.00'L x 4.00'H Field A</b> 26,496 cf Overall - 10,193 cf Embedded = 16,303 cf x 40.0% Voids
#2A	117.50'	10,193 cf	<b>CMP Round 36" x 70' Inside #1</b> Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 70 Chambers in 5 Rows 21.00' Header x 7.07 sf x 2 = 296.9 cf Inside
		16,714 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	117.00'	<b>15.0" Round Culvert</b> L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 117.00' / 116.00' S= 0.0100 '/' Cc= 0.900 n= 0.012 Corrugated PP, smooth interior, Flow Area= 1.23 sf
#2	Discarded	117.00'	<b>0.520 in/hr Exfiltration over Wetted area</b>
#3	Device 1	120.45'	<b>4.0' long x 0.5' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

**Discarded OutFlow** Max=0.11 cfs @ 12.40 hrs HW=120.82' (Free Discharge)  
↳ **2=Exfiltration** (Exfiltration Controls 0.11 cfs)

**Primary OutFlow** Max=2.56 cfs @ 12.40 hrs HW=120.82' (Free Discharge)  
↳ **1=Culvert** (Passes 2.56 cfs of 8.33 cfs potential flow)  
↳ **3=Broad-Crested Rectangular Weir** (Weir Controls 2.56 cfs @ 1.75 fps)

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Page 212

### Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP) - Chamber Wizard Field A

**Chamber Model = CMP Round 36" (Round Corrugated Metal Pipe)**

Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf

Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

14 Chambers/Row x 20.00' Long +3.00' Header x 2 = 286.00' Row Length +12.0" End Stone x 2 = 288.00' Base Length  
5 Rows x 36.0" Wide + 18.0" Spacing x 4 + 12.0" Side Stone x 2 = 23.00' Base Width  
6.0' Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

70 Chambers x 141.4 cf + 21.00' Header x 7.07 sf x 2 = 10,192.9 cf Chamber Storage

26,496.0 cf Field - 10,192.9 cf Chambers = 16,303.1 cf Stone x 40.0% Voids = 6,521.2 cf Stone Storage

Chamber Storage + Stone Storage = 16,714.1 cf = 0.384 af

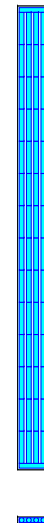
Overall Storage Efficiency = 63.1%

Overall System Size = 288.00' x 23.00' x 4.00'

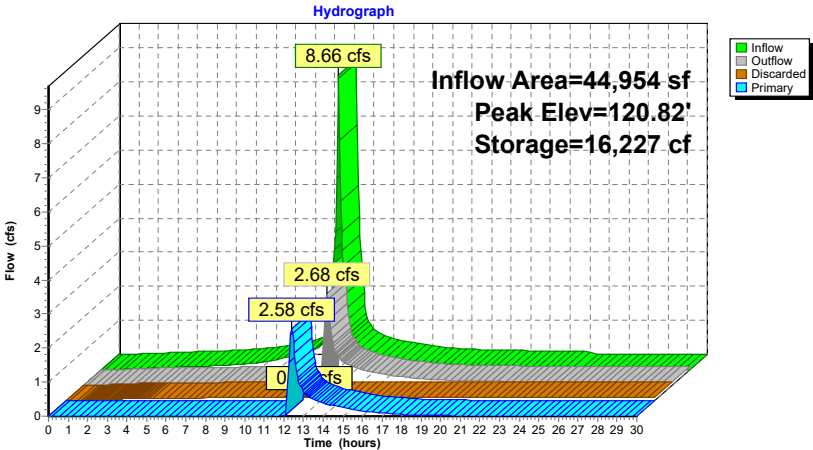
70 Chambers

981.3 cy Field

603.8 cy Stone



Pond UIS-2: UIS-2 - Main Building Entrance (36" CMP)



Summary for Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)

Inflow Area = 37,779 sf, 57.72% Impervious, Inflow Depth = 7.61" for 100-Year event  
Inflow = 6.99 cfs @ 12.09 hrs, Volume= 23,967 cf  
Outflow = 0.73 cfs @ 12.82 hrs, Volume= 22,454 cf, Atten= 89%, Lag= 44.1 min  
Discarded = 0.14 cfs @ 12.82 hrs, Volume= 11,061 cf  
Primary = 0.59 cfs @ 12.82 hrs, Volume= 11,393 cf

Routing by Stor-Ind method, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs  
Peak Elev= 110.67' @ 12.82 hrs Surf.Area= 4,930 sf Storage= 11,900 cf  
Flood Elev= 108.50' Surf.Area= 4,930 sf Storage= 4,321 cf

Plug-Flow detention time= 255.8 min calculated for 22,417 cf (94% of inflow)  
Center-of-Mass det. time= 221.8 min ( 993.0 - 771.2 )

Volume	Invert	Avail.Storage	Storage Description
#1A	107.00'	4,775 cf	72.50'W x 68.00'L x 4.00'H Field A 19,720 cf Overall - 7,783 cf Embedded = 11,937 cf x 40.0% Voids
#2A	107.50'	7,783 cf	CMP Round 36 x 48 Inside #1 Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf Overall Size= 36.0"W x 36.0"H x 20.00'L 48 Chambers in 16 Rows 70.50' Header x 7.07 sf x 2 = 996.7 cf Inside
		12,558 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	107.00'	12.0" Round Culvert L= 100.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 107.00' / 102.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#2	Device 1	108.50'	4.0" Vert. Orifice/Grate C= 0.600
#3	Discarded	107.00'	1.020 in/hr Exfiltration over Wetted area

Discarded OutFlow Max=0.14 cfs @ 12.82 hrs HW=110.67' (Free Discharge)  
3=Exfiltration (Exfiltration Controls 0.14 cfs)

Primary OutFlow Max=0.59 cfs @ 12.82 hrs HW=110.67' (Free Discharge)  
1=Culvert (Passes 0.59 cfs of 5.31 cfs potential flow)  
2=Orifice/Grate (Orifice Controls 0.59 cfs @ 6.81 fps)

Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP) - Chamber Wizard Field A

Chamber Model = CMP Round 36 (Round Corrugated Metal Pipe)  
Effective Size= 36.0"W x 36.0"H => 7.07 sf x 20.00'L = 141.4 cf  
Overall Size= 36.0"W x 36.0"H x 20.00'L

36.0" Wide + 18.0" Spacing = 54.0" C-C Row Spacing

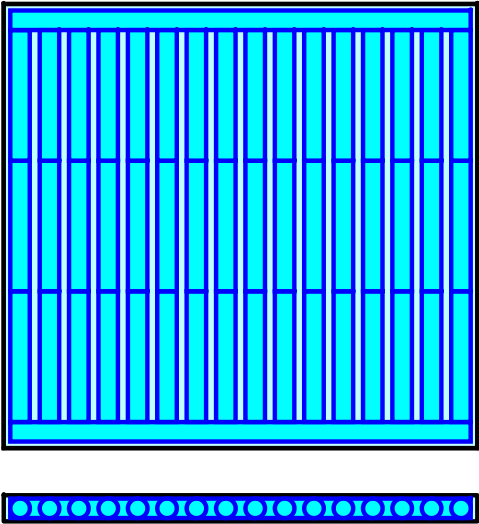
3 Chambers/Row x 20.00' Long +3.00' Header x 2 = 66.00' Row Length +12.0" End Stone x 2 = 68.00' Base Length  
16 Rows x 36.0" Wide + 18.0" Spacing x 15 + 12.0" Side Stone x 2 = 72.50' Base Width  
6.0' Base + 36.0" Chamber Height + 6.0" Cover = 4.00' Field Height

48 Chambers x 141.4 cf + 70.50' Header x 7.07 sf x 2 = 7,782.5 cf Chamber Storage

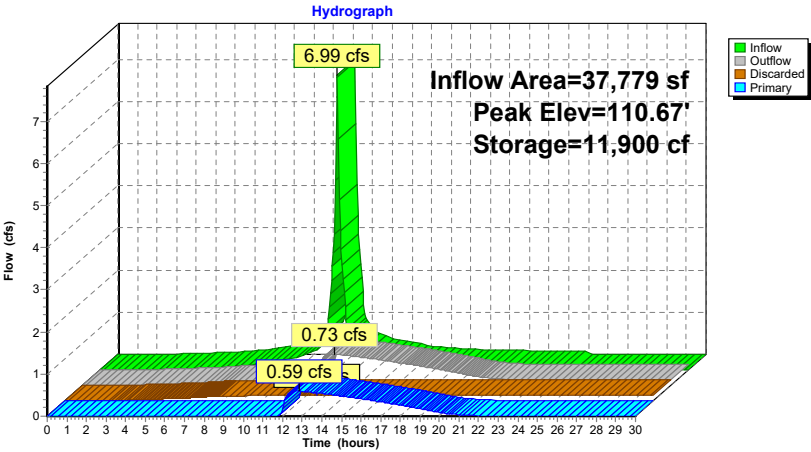
19,720.0 cf Field - 7,782.5 cf Chambers = 11,937.5 cf Stone x 40.0% Voids = 4,775.0 cf Stone Storage

Chamber Storage + Stone Storage = 12,557.5 cf = 0.288 af  
Overall Storage Efficiency = 63.7%  
Overall System Size = 68.00' x 72.50' x 4.00'

48 Chambers  
730.4 cy Field  
442.1 cy Stone

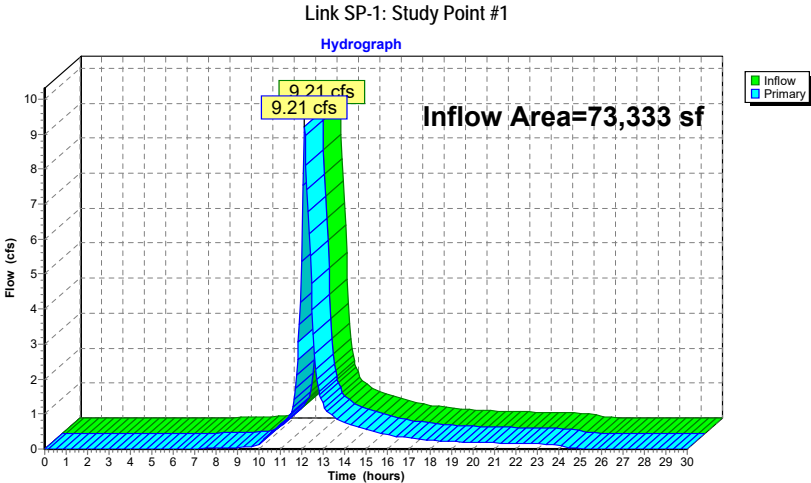


Pond UIS-3: UIS-3 - Cul-de-Sac (36" CMP)



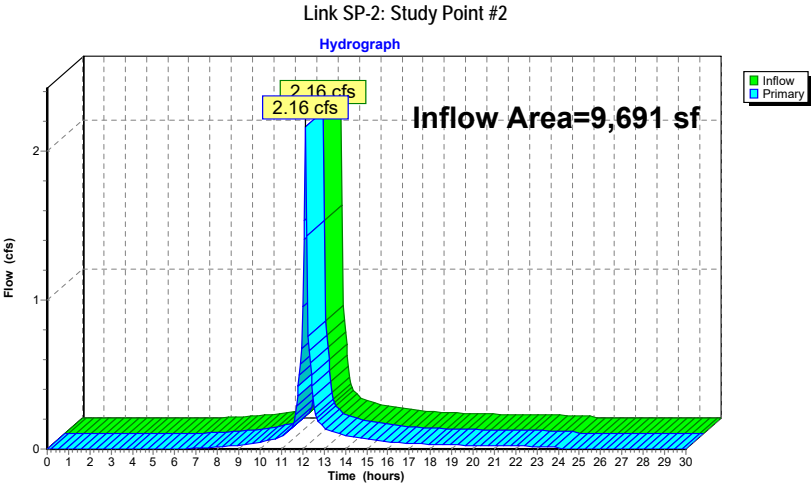
Summary for Link SP-1: Study Point #1

Inflow Area = 73,333 sf, 19.56% Impervious, Inflow Depth > 6.17" for 100-Year event  
Inflow = 9.21 cfs @ 12.12 hrs, Volume= 37,699 cf  
Primary = 9.21 cfs @ 12.12 hrs, Volume= 37,699 cf, Atten= 0%, Lag= 0.0 min  
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



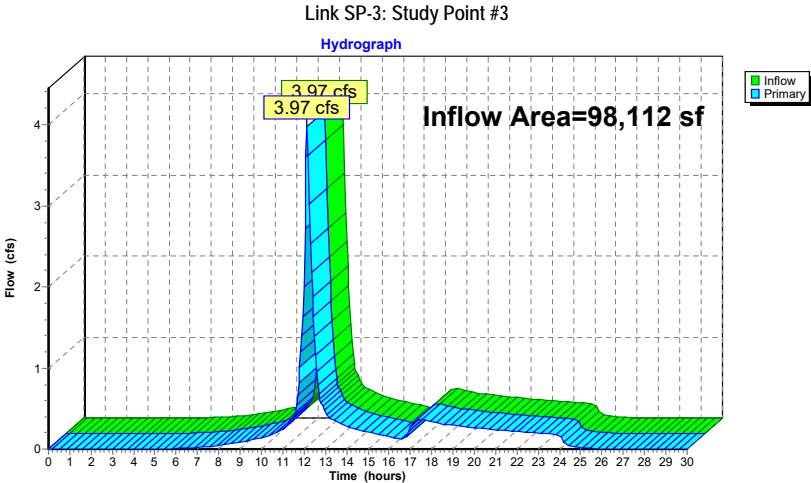
Summary for Link SP-2: Study Point #2

Inflow Area = 9,691 sf, 0.00% Impervious, Inflow Depth = 6.46" for 100-Year event  
Inflow = 2.16 cfs @ 12.15 hrs, Volume= 5,215 cf  
Primary = 2.16 cfs @ 12.15 hrs, Volume= 5,215 cf, Atten= 0%, Lag= 0.0 min  
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



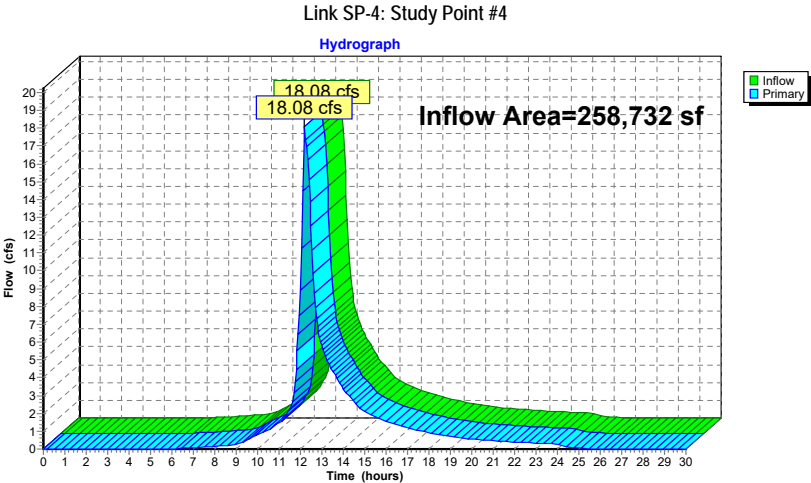
Summary for Link SP-3: Study Point #3

Inflow Area = 98,112 sf, 58.66% Impervious, Inflow Depth = 2.43" for 100-Year event  
Inflow = 3.97 cfs @ 12.15 hrs, Volume= 19,880 cf  
Primary = 3.97 cfs @ 12.15 hrs, Volume= 19,880 cf, Atten= 0%, Lag= 0.0 min  
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs



Summary for Link SP-4: Study Point #4

Inflow Area = 258,732 sf, 29.63% Impervious, Inflow Depth > 5.20" for 100-Year event  
Inflow = 18.08 cfs @ 12.20 hrs, Volume= 112,194 cf  
Primary = 18.08 cfs @ 12.20 hrs, Volume= 112,194 cf, Atten= 0%, Lag= 0.0 min  
Primary outflow = Inflow, Time Span= 0.00-30.00 hrs, dt= 0.05 hrs





## SECTION 5.0 – PLANS





STUDY POINT 2 FLOW WEST TO WETLANDS "F"			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	0.55 CFS	1,788 CF	
10YR STORM	1.15 CFS	3,636 CF	
25YR STORM	1.65 CFS	5,228 CF	
100YR STORM	2.71 CFS	8,665 CF	

STUDY POINT 1 FLOW NORTH TO WETLANDS "D"			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	3.37 CFS	13,306 CF	
10YR STORM	6.94 CFS	26,659 CF	
25YR STORM	9.92 CFS	38,091 CF	
100YR STORM	16.14 CFS	62,659 CF	

STUDY POINT 5 ON-SITE DEPRESSION TO WEST			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	0.01 CFS	8,931 CF	
10YR STORM	0.02 CFS	18,188 CF	
25YR STORM	0.02 CFS	26,139 CF	
100YR STORM	0.03 CFS	43,273 CF	

STUDY POINT 3 FLOWS SOUTHWEST			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	0.94 CFS	3,013 CF	
10YR STORM	1.91 CFS	6,037 CF	
25YR STORM	2.72 CFS	8,626 CF	
100YR STORM	4.42 CFS	14,190 CF	

STUDY POINT 4 FLOW SOUTHEAST TO WETLANDS "A"			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	4.02 CFS	19,162 CF	
10YR STORM	8.40 CFS	38,972 CF	
25YR STORM	12.10 CFS	56,042 CF	
100YR STORM	19.94 CFS	92,883 CF	

**E-2**  
FLOW WEST TO WETLANDS "F"  
TOTAL=17,293± S.F.  
WOODED (HSG D)=17,293± S.F.  
CN=77  
TC=6.0 MIN.

**E-5**  
ON-SITE DEPRESSION  
TOTAL=86,899± S.F.  
WOODED (HSG D)=75,357± S.F.  
WETLAND (HSG D)=8,144± S.F.  
GRAVEL PATH (HSG D)=3,378± S.F.  
CN=78  
TC=9.8 MIN.

**E-4**  
FLOW SOUTH TO WETLANDS "A"  
TOTAL=185,366± S.F.  
WOODED (HSG D)=185,366± S.F.  
CN=77  
TC=20.2 MIN.

**E-1**  
FLOW NORTH TO WETLANDS "D"  
TOTAL=122,563± S.F.  
GRAVEL PATH (HSG D)=4,563± S.F.  
WOODED (HSG D)=118,000± S.F.  
CN=78  
TC=12.4 MIN.

**E-3**  
FLOW SOUTHWEST OFF-SITE  
TOTAL=27,755± S.F.  
GRAVEL PATH (HSG D)=1,087± S.F.  
WOODED (HSG D)=26,668± S.F.  
CN=78  
TC=6.0 MIN.

TOTAL WATERSHED AREA  
= 439,876± S.F.

LEGEND

EXISTING WATERSHED

SCS SOILS BOUNDARY

Tc FLOW PATH

SUBCATCHMENT LABEL

SUBCATCHMENT BOUNDARY

FLOW DIRECTION

- NOTES:
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  - ALL EXISTING AND PROPOSED COVER TYPES SHALL BE CONSIDERED "GOOD" FOR MODELING PURPOSES UNLESS OTHERWISE NOTED.
  - TOTAL SITE WATERSHED AREA IS 439,876± S.F.

ISSUED FOR  
DRAINAGE REPORT  
JULY 16, 2021

PROFESSIONAL ENGINEER FOR  
ALLEN & MAJOR ASSOCIATES, INC.

REV DATE DESCRIPTION

APPLICANT/OWNER:

SLV SCHOOL STREET, LLC  
257 HILLSIDE AVENUE  
NEEDHAM, MA 02494

PROJECT:

THE SANCTUARY AT  
MANCHESTER BY THE SEA  
0 SCHOOL STREET  
MANCHESTER-BY-THE-SEA, MA

PROJECT NO. 2725-01 DATE: 07-16-2021

SCALE: 1"=40' DWG. NAME: C-2725-01

DESIGNED BY: CMQ/SIL CHECKED BY: CMQ

PREPARED BY:

ALLEN & MAJOR ASSOCIATES, INC.

civil engineering • land surveying  
environmental consulting • landscape architecture  
www.allenmajor.com  
100 COMMERCE WAY, SUITE 5  
WOBURN MA 01801-8501  
TEL: (781) 953-6889  
FAX: (781) 953-2856

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DRAWING TITLE: EXISTING WATERSHED PLAN SHEET No. EWS-1

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STUDY POINT 1 FLOW NORTH TO WETLANDS "D"			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	1.28 CFS	7,131	CF
10YR STORM	4.12 CFS	15,568	CF
25YR STORM	5.72 CFS	22,769	CF
100YR STORM	9.21 CFS	37,699	CF

STUDY POINT 2 FLOW WEST TO WETLANDS "F"			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	0.33 CFS	1,052	CF
10YR STORM	0.67 CFS	2,108	CF
25YR STORM	0.95 CFS	3,012	CF
100YR STORM	2.16 CFS	5,215	CF

STUDY POINT 5 ON-SITE DEPRESSION TO WEST (NO PROPOSED FLOWS TO SP-5)			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	0.00 CFS	0	CF
10YR STORM	0.00 CFS	0	CF
25YR STORM	0.00 CFS	0	CF
100YR STORM	0.00 CFS	0	CF

STUDY POINT 3 FLOWS SOUTHWEST			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	0.90 CFS	3,341	CF
10YR STORM	1.77 CFS	6,503	CF
25YR STORM	2.49 CFS	9,177	CF
100YR STORM	3.37 CFS	18,996	CF

STUDY POINT 4 FLOW SOUTHEAST TO WETLANDS "A"			
STORM EVENT	PEAK RATE	VOLUME	
2YR STORM	3.68 CFS	19,816	CF
10YR STORM	8.29 CFS	41,948	CF
25YR STORM	11.63 CFS	62,047	CF
100YR STORM	18.08 CFS	112,194	CF

LEGEND

EXISTING WATERSHED

PROPOSED WATERSHED

SCS SOILS BOUNDARY

Tc FLOW PATH

SUBCATCHMENT LABEL

SUBCATCHMENT BOUNDARY

FLOW DIRECTION

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ISSUED FOR  
DRAINAGE REPORT  
JULY 16, 2021

PROFESSIONAL ENGINEER FOR  
ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION
-----	------	-------------

APPLICANT/OWNER:  
SLV SCHOOL STREET, LLC  
257 HILLSIDE AVENUE  
NEEDHAM, MA 02494

PROJECT:  
THE SANCTUARY  
SCHOOL STREET  
MANCHESTER-BY-THE-SEA, MA

PROJECT NO. 2725-01 DATE: 07-16-2021  
SCALE: 1"=40' DWG. NAME: C-2725-01  
DESIGNED BY: CMQ/SIL CHECKED BY: CMQ

PREPARED BY:

ALLEN & MAJOR ASSOCIATES, INC.

civil engineering • land surveying

environmental consulting • landscape architecture

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DRAWING TITLE: PROPOSED WATERSHED PLAN SHEET No. PWS-1

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GRAPHIC SCALE

0 20 40 60 80 100

( IN FEET )

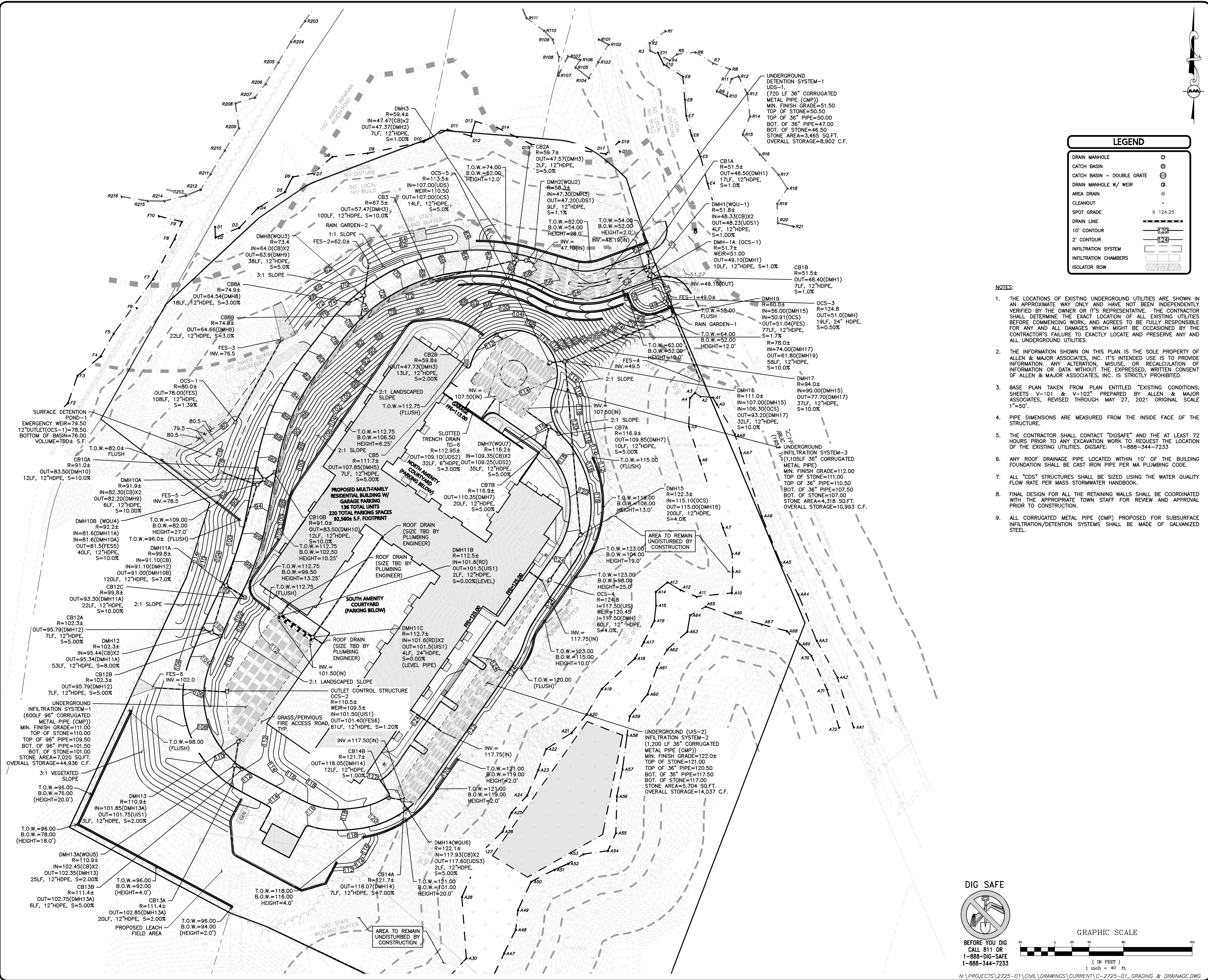
1 inch = 40 ft

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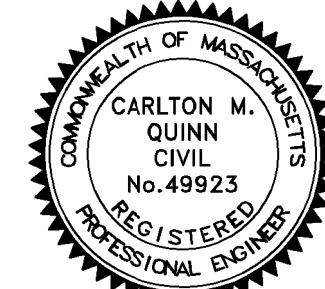




**LEGEND**

DRAIN MANHOLE ○  
CATCH BASIN ●  
CATCH BASIN - DOUBLE GRATE ●  
DRAIN MANHOLE W/ WEIR ○  
AREA DRAIN ○  
CLEANOUT ○  
SPOT GRADE X 124.25  
DRAIN LINE —  
10' CONTOUR — 120 —  
2' CONTOUR — 124 —  
INFILTRATION SYSTEM —  
INFILTRATION CHAMBERS —  
ISOLATOR ROW —

- NOTES:**
1. THE LOCATIONS OF EXISTING UNDERGROUND UTILITIES ARE SHOWN IN AN APPROXIMATE WAY ONLY AND HAVE NOT BEEN INDEPENDENTLY VERIFIED BY THE OWNER OR ITS REPRESENTATIVE. THE CONTRACTOR SHALL DETERMINE THE EXACT LOCATION OF ALL EXISTING UTILITIES BEFORE COMMENCING WORK, AND AGREES TO BE FULLY RESPONSIBLE FOR ANY AND ALL DAMAGES WHICH MIGHT BE OCCASIONED BY THE CONTRACTOR'S FAILURE TO EXACTLY LOCATE AND PRESERVE ANY AND ALL UNDERGROUND UTILITIES.
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  4. PIPE DIMENSIONS ARE MEASURED FROM THE INSIDE FACE OF THE STRUCTURE.
  5. THE CONTRACTOR SHALL CONTACT "DIGSAFE" AND THE AT LEAST 72 HOURS PRIOR TO ANY EXCAVATION WORK TO REQUEST THE LOCATION OF THE EXISTING UTILITIES. DIGSAFE: 1-888-344-7233
  6. ANY ROOF DRAINAGE PIPE LOCATED WITHIN 10' OF THE BUILDING FOUNDATION SHALL BE CAST IRON PIPE PER MA PLUMBING CODE.
  7. ALL "CDS" STRUCTURES SHALL BE SIZED USING THE WATER QUALITY FLOW RATE PER MASS STORMWATER HANDBOOK.
  8. FINAL DESIGN FOR ALL THE RETAINING WALLS SHALL BE COORDINATED WITH THE APPROPRIATE TOWN STAFF FOR REVIEW AND APPROVAL PRIOR TO CONSTRUCTION.
  9. ALL CORRUGATED METAL PIPE (CMP) PROPOSED FOR SUBSURFACE INFILTRATION/RETENTION SYSTEMS SHALL BE MADE OF GALVANIZED STEEL.



PROFESSIONAL ENGINEER FOR  
ALLEN & MAJOR ASSOCIATES, INC.

REV	DATE	DESCRIPTION
-----	------	-------------

APPLICANT/OWNER:  
**SLV SCHOOL STREET, LLC**  
257 HILLSIDE AVENUE  
NEEDHAM, MA 02494

PROJECT:  
**THE SANCTUARY**  
**SCHOOL STREET**  
**MANCHESTER-BY-THE-SEA, MA**

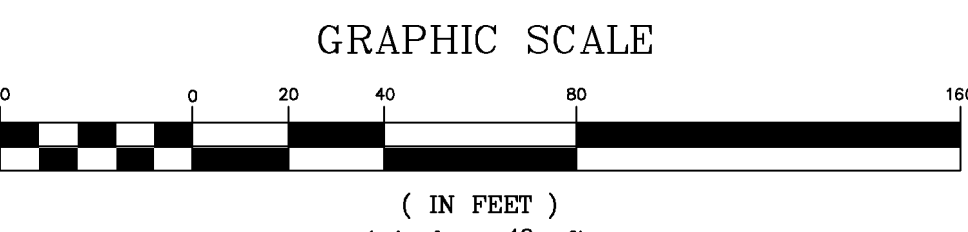
PROJECT NO.	2725-01	DATE:	07-16-2021
SCALE:	1"=40'	DWG. NAME:	C-2725-01
DESIGNED BY:	CMQ/SIL	CHECKED BY:	CMQ

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SHEET No. **C-103**

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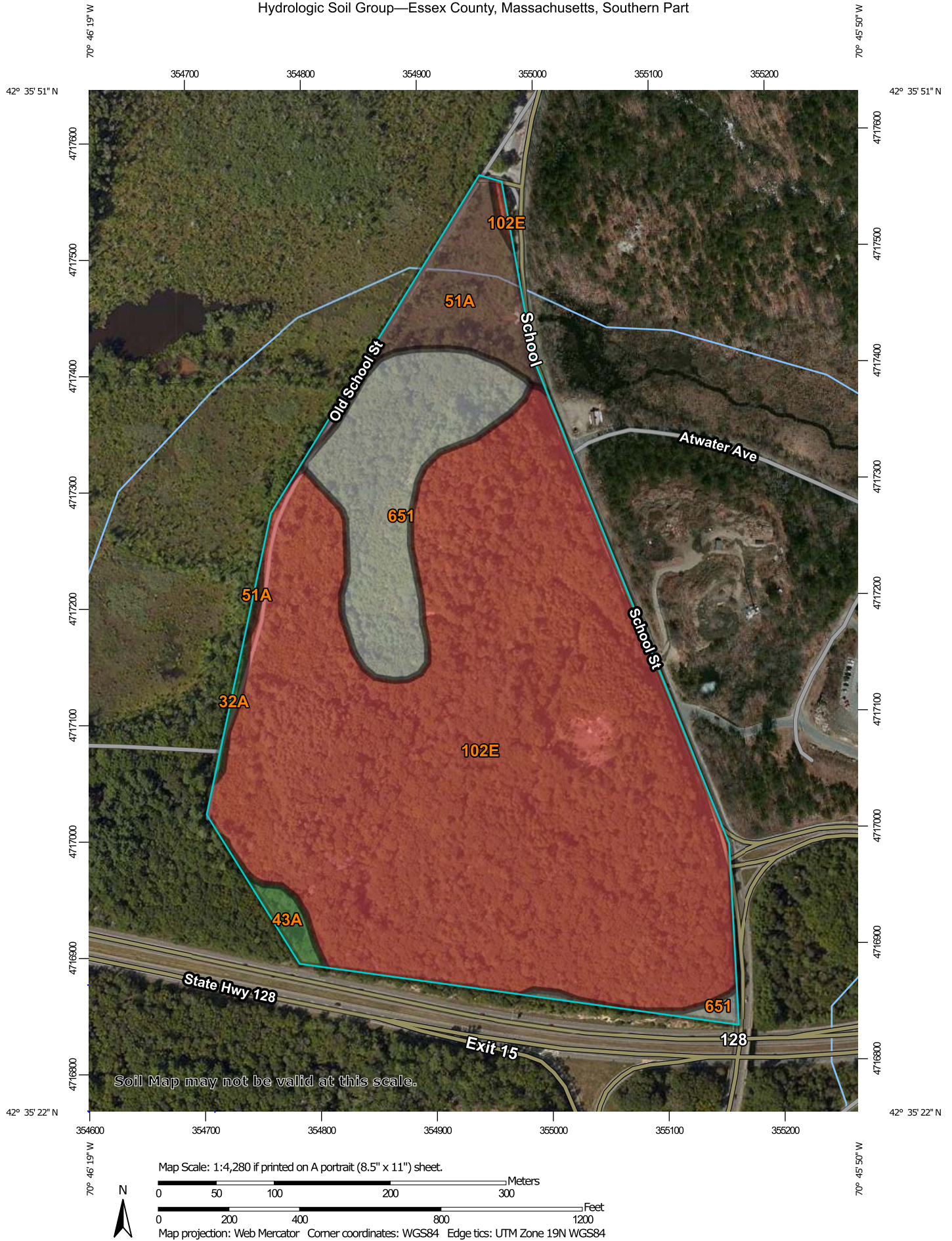




## SECTION 6.0 - APPENDIX



# Hydrologic Soil Group—Essex County, Massachusetts, Southern Part



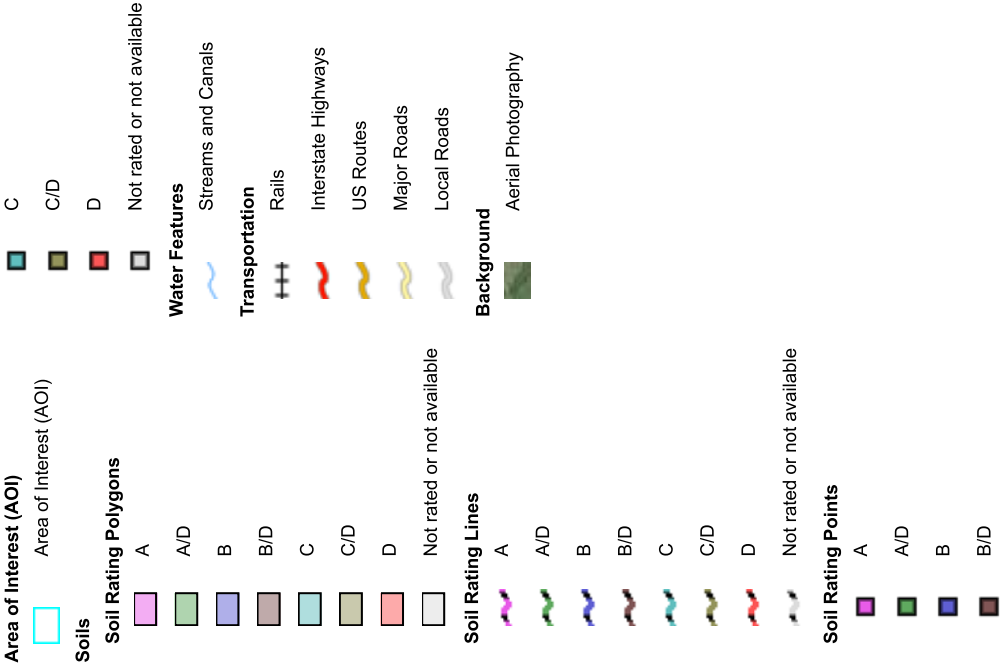
**Natural Resources  
Conservation Service**

Web Soil Survey  
National Cooperative Soil Survey

7/29/2020  
Page 1 of 4



MAP LEGEND



MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:15,800.

**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: Essex County, Massachusetts, Southern Part  
Survey Area Data: Version 17, Jun 9, 2020

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

Date(s) aerial images were photographed: Mar 30, 2011—Sep 19, 2014

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

## Hydrologic Soil Group

Map unit symbol	Map unit name	Rating	Acres in AOI	Percent of AOI
32A	Wareham loamy sand, 0 to 3 percent slopes	A/D	0.2	0.3%
43A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	A/D	0.5	1.0%
51A	Swansea muck, 0 to 1 percent slopes	B/D	3.3	6.7%
102E	Chatfield-Hollis-Rock outcrop complex, 15 to 35 percent slopes	D	38.5	78.8%
651	Udorthents, smoothed		6.4	13.1%
<b>Totals for Area of Interest</b>			<b>48.9</b>	<b>100.0%</b>

## Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

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

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

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

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

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

## Rating Options

*Aggregation Method:* Dominant Condition

*Component Percent Cutoff:* None Specified

*Tie-break Rule:* Higher

# Extreme Precipitation Tables

## Northeast Regional Climate Center

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

Smoothing	Yes
State	Massachusetts
Location	
Longitude	70.767 degrees West
Latitude	42.595 degrees North
Elevation	0 feet
Date/Time	Wed, 29 Jul 2020 13:03:32 -0400

## Extreme Precipitation Estimates

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.27	0.41	0.51	0.67	0.84	1.06	1yr	0.72	0.98	1.24	1.60	2.07	2.71	2.99	1yr	2.40	2.87	3.30	4.01	4.69	1yr
2yr	0.33	0.51	0.64	0.84	1.05	1.34	2yr	0.91	1.24	1.56	1.98	2.53	3.24	3.60	2yr	2.86	3.46	3.97	4.74	5.38	2yr
5yr	0.39	0.61	0.76	1.02	1.31	1.68	5yr	1.13	1.56	1.96	2.51	3.20	4.09	4.60	5yr	3.62	4.42	5.07	6.00	6.76	5yr
10yr	0.44	0.69	0.87	1.19	1.54	2.00	10yr	1.33	1.85	2.34	3.00	3.83	4.88	5.55	10yr	4.32	5.33	6.10	7.18	8.05	10yr
25yr	0.52	0.82	1.05	1.44	1.91	2.50	25yr	1.65	2.33	2.94	3.79	4.84	6.17	7.10	25yr	5.46	6.83	7.79	9.12	10.14	25yr
50yr	0.58	0.93	1.19	1.67	2.26	2.98	50yr	1.95	2.78	3.53	4.55	5.81	7.37	8.57	50yr	6.52	8.24	9.38	10.92	12.08	50yr
100yr	0.66	1.07	1.38	1.95	2.66	3.54	100yr	2.30	3.31	4.20	5.43	6.93	8.80	10.34	100yr	7.79	9.95	11.29	13.09	14.40	100yr
200yr	0.75	1.22	1.58	2.27	3.15	4.22	200yr	2.71	3.94	5.02	6.50	8.30	10.52	12.49	200yr	9.31	12.01	13.60	15.69	17.17	200yr
500yr	0.90	1.48	1.93	2.80	3.92	5.29	500yr	3.39	4.96	6.32	8.21	10.51	13.34	16.03	500yr	11.81	15.41	17.41	19.95	21.67	500yr

## Lower Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.23	0.35	0.43	0.58	0.71	0.84	1yr	0.61	0.82	1.03	1.41	1.81	2.42	2.67	1yr	2.14	2.57	2.95	3.49	4.15	1yr
2yr	0.32	0.49	0.60	0.82	1.01	1.23	2yr	0.87	1.20	1.41	1.84	2.37	3.13	3.47	2yr	2.77	3.34	3.85	4.59	5.21	2yr
5yr	0.36	0.56	0.70	0.96	1.22	1.46	5yr	1.05	1.43	1.66	2.15	2.75	3.74	4.20	5yr	3.31	4.04	4.65	5.55	6.24	5yr
10yr	0.40	0.62	0.77	1.08	1.39	1.67	10yr	1.20	1.64	1.88	2.41	3.08	4.30	4.85	10yr	3.80	4.66	5.37	6.36	7.12	10yr
25yr	0.46	0.70	0.87	1.25	1.64	1.98	25yr	1.42	1.94	2.20	2.79	3.57	5.17	5.84	25yr	4.57	5.62	6.48	7.62	8.41	25yr
50yr	0.51	0.77	0.96	1.38	1.86	2.26	50yr	1.60	2.21	2.48	3.12	3.98	5.96	6.71	50yr	5.27	6.45	7.46	8.73	9.72	50yr
100yr	0.57	0.85	1.07	1.55	2.12	2.57	100yr	1.83	2.51	2.80	3.49	4.43	6.87	7.71	100yr	6.08	7.41	8.60	10.04	11.03	100yr
200yr	0.63	0.94	1.20	1.73	2.41	2.93	200yr	2.08	2.86	3.17	3.88	4.91	7.95	8.88	200yr	7.03	8.54	9.92	11.52	12.50	200yr
500yr	0.73	1.08	1.39	2.02	2.87	3.49	500yr	2.48	3.41	3.73	4.47	5.64	9.66	10.72	500yr	8.55	10.30	12.00	13.87	14.73	500yr

## Upper Confidence Limits

	5min	10min	15min	30min	60min	120min		1hr	2hr	3hr	6hr	12hr	24hr	48hr		1day	2day	4day	7day	10day	
1yr	0.30	0.46	0.56	0.75	0.92	1.08	1yr	0.80	1.05	1.34	1.72	2.20	2.96	3.30	1yr	2.62	3.18	3.67	4.33	5.13	1yr
2yr	0.35	0.54	0.66	0.90	1.11	1.33	2yr	0.96	1.30	1.52	2.01	2.57	3.37	3.75	2yr	2.99	3.61	4.14	4.96	5.61	2yr
5yr	0.42	0.65	0.81	1.11	1.41	1.73	5yr	1.22	1.69	1.99	2.64	3.38	4.45	5.00	5yr	3.94	4.81	5.49	6.49	7.28	5yr
10yr	0.50	0.77	0.96	1.34	1.73	2.13	10yr	1.50	2.09	2.44	3.26	4.14	5.49	6.25	10yr	4.86	6.01	6.84	8.01	8.93	10yr
25yr	0.64	0.97	1.21	1.73	2.27	2.81	25yr	1.96	2.75	3.20	4.31	5.46	7.25	8.40	25yr	6.41	8.08	9.14	10.57	11.72	25yr
50yr	0.76	1.16	1.44	2.08	2.79	3.47	50yr	2.41	3.40	3.94	5.35	6.76	8.93	10.52	50yr	7.91	10.12	11.39	13.04	14.20	50yr
100yr	0.92	1.39	1.74	2.51	3.44	4.28	100yr	2.97	4.19	4.83	6.63	8.35	11.00	13.19	100yr	9.74	12.68	14.20	16.13	17.44	100yr
200yr	1.10	1.65	2.10	3.04	4.23	5.29	200yr	3.65	5.17	5.95	8.22	10.33	13.54	16.53	200yr	11.98	15.89	17.72	19.95	21.42	200yr
500yr	1.41	2.09	2.69	3.91	5.56	6.99	500yr	4.80	6.83	7.84	10.96	13.72	17.83	22.21	500yr	15.78	21.36	23.68	26.40	28.17	500yr

### Manning's Roughness Coefficients ("n")

Conduit	Manning's Coefficients
<b>Closed Conduits</b>	
Asbestos-Cement Pipe	0.011 to 0.015
Brick	0.013 to 0.017
Cast Iron Pipe	
Cement-lined and seal-coated	0.011 to 0.015
Concrete (Monolithic)	
Smooth forms	0.012 to 0.014
Rough forms	0.015 to 0.017
Concrete Pipe	0.011 to 0.015
Corrugated-Metal Pipe (1/2 - STUL 34470 2 1/2-inch corrgrtn.)	
Plain	0.022 to 0.026
Paved invert	0.018 to 0.022
Spun asphalt-lined	0.011 to 0.015
Plastic Pipe (Smooth)	0.011 to 0.015
Vitrified Clay	
Pipes	0.011 to 0.015
Liner channels	0.013 to 0.017
<b>Open Channels</b>	
Lined Channels	
Asphalt	0.013 to 0.017
Brick	0.012 to 0.018
Concrete	0.011 to 0.020
Rubble or riprap	0.020 to 0.035
Vegetal	0.030 to 0.040
Excavated or Dredged	
Earth, straight and uniform	0.020 to 0.030
Earth, winding, fairly uniform	0.025 to 0.040
Rock	0.030 to 0.045
Unmaintained	0.050 to 0.140
Natural Channels (minor streams, top width at flood state < 100 feet)	
Fairly regular section	0.030 to 0.070
Irregular section with pools	0.040 to 0.100

Source: Design and Construction of Sanitary and Storm Sewers, American Society of Civil Engineers and the Water Pollution Control Federation, 1969.

**Title** MA DEP Standard Calculations  
**Project** School Street, Manchester-by-the-Sea, MA  
**Date** July 16, 2021  
**Revised**

By DMR/SJL  
 Chk'd CMQ  
 Apprv'd CMQ

$R_v = F * \text{Impervious Area}$

$R_v$  = Required Recharge Volume, expressed in  $\text{ft}^3$ , cubic yards or acre-feet

$F$  = Target Depth Factor associated with each Hydraulic Soil Group

**Impervious Area** = pavement & rooftop area on site

$V_{wQ}$  = Required Water Quality Treatment Volume ( $\text{ft}^3$ )

$D_{wQ}$  = Water Quality Depth (in)

$A_{IMP}$  = Impervious Area (excluding non-metal roofs)

			IMPERVIOUS AREA (S.F.) BY HSG		Recharge Required			Water Quality Volume Required	
W'SHED	Area (Sq. Ft)	Landscaped		HSG D (F=.1)	F Avg. (Inches)	Impervious Area (Sq. Ft)	$R_v$ ( $\text{ft}^3$ )	$D_{wQ}$ (Inch)	$V_{wQ}$
P-1	17,171	17,171		0	0.100	0	0	1.0	0
P-2	9,691	9,691		0	0.100	0	0	1.0	0
P-3	27,985	27,985		0	0.100	0	0	1.0	0
P-4	117,759	117,126		633	0.100	633	5	1.0	53
P-5	14,879	3,134		11,745	0.100	11,745	98	1.0	979
P-6	18,477	17,512		965	0.100	965	8	1.0	80
P-7	24,884	24,096		788	0.100	788	0	1.0	66
P-8	22,451	5,972		16,479	0.100	16,479	137	1.0	1,373
P-9	15,326	10,268		5,058	0.100	5,058	42	1.0	422
P-10	30,342	0		30,342	0.100	30,342	253	1.0	2,529
P-11	20,180	0		20,180	0.100	20,180	168	1.0	1,682
P-12	27,254	0		27,254	0.100	27,254	227	1.0	2,271
P-13	17,700	4,236		13,464	0.100	13,464	112	1.0	1,122
P-14	19,605	13,079		6,526	0.100	6,526	54	1.0	544
P-15	18,455	18,455		0	0.100	0	0	1.0	0
P-16	20,820	11,633		9,187	0.100	9,187	77	1.0	766
P-17	11,737	11,737		0	0.100	0	0	1.0	0
P-18	5,160	0		5,160	0.100	5,160	43	1.0	430
Total	439,876	292,095		147,781		13,343	1,225		12,315

### STORMWATER RECHARGE SUMMARY CALCULATIONS

$R_v = F * \text{Impervious Area}$

$R_v$  = Required Recharge Volume, expressed in  $\text{ft}^3$ , cubic yards or acre-feet

$F$  = Target Depth Factor associated with each Hydraulic Soil Group

	Required (cf)	Provided (cf)	
$R_v =$	475	42,647	96" CMP Underground Infiltration System - 1 (P-10, P-11, P-14)
$R_v =$	179	4,321	36" CMP Underground Infiltration System - 3 (P-8 & P-9)
$R_v =$	339	15,235	36" CMP Underground Infiltration System - 2 (P-12 & P-13)
$R_v =$	106	0	36" CMP Underground Detention System - 4 (P-5, P-6, P-7)
$R_v =$	77	1,939	Surface Detention Pond - 1 (P-15, P-16, P-17)
$R_v =$	0	1,419	Rain Garden - 1 (Flows from UDS-4)
$R_v =$	43	1,515	Rain Garden - 2 (P-18)
$R_v =$	5	0	Deminimus Unmitigated Area (P-1, P-2, P-3, P-4)
$R_v =$	1,225	67,076	

**Title** MA DEP Standard Calculations  
**Project** School Street, Manchester-by-the-Sea, MA  
**Date** July 16, 2021  
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 Apprv'd CMQ

### STORMWATER QUALITY VOLUME CALCULATIONS

$V_{WQ}$  = Required Water Quality Treatment Volume, expressed in  $ft^3$

$D_{WQ}$  = Water Quality Depth

$A_{IMP}$  = Impervious Area (pavement & rooftop area excluding non-metal roofs)

	Required (cf)	Provided (cf)	
$V_{WQ}$ =	4,754	42,647	96" CMP Underground Infiltration System - 1 (P-10, P-11, P-14)
$V_{WQ}$ =	1,795	4,321	36" CMP Underground Infiltration System - 3 (P-8 & P-9)
$V_{WQ}$ =	3,393	15,235	36" CMP Underground Infiltration System - 2 (P-12 & P-13)
$V_{WQ}$ =	1,125	0	36" CMP Underground Detention System - 1 (P-5, P-6, P-7)
$V_{WQ}$ =	766	1,939	Surface Detention Pond - 1 (P-15, P-16, P-17)
$V_{WQ}$ =	0	1,419	Rain Garden - 1 (Flows from UDS-4)
$V_{WQ}$ =	430	1,515	Rain Garden - 2 (P-18)
$V_{WQ}$ =	53	0	Deminimus Unmitigated Area (P-1, P-2, P-3, P-4)
$V_{WQ}$ =	12,315	67,076	

### DRAWDOWN CALCULATIONS (72 HOURS MAX)

$Time_{drawdown} = (R_v) (1/Design \text{ Infiltration Rate in inches per hour}) (Conversion \text{ for inches to feet}) (1/bottom \text{ area in feet})$

Underground Infiltration System-1	
Infiltration Rate (in/Hr)=	1.02
Bottom Area ( $ft^2$ ) =	7,020
Infiltration Volume ( $ft^3$ ) =	42,647
$Time_{drawdown}$ (Hours)=	71.47

Underground Infiltration System-2	
Infiltration Rate (in/Hr)=	1.02
Bottom Area ( $ft^2$ ) =	5,704
Infiltration Volume ( $ft^3$ ) =	4,321
$Time_{drawdown}$ (Hours)=	8.91

Underground Infiltration System-3	
Infiltration Rate (in/Hr)=	1.02
Bottom Area ( $ft^2$ ) =	4,318
Infiltration Volume ( $ft^3$ ) =	15,235
$Time_{drawdown}$ (Hours)=	41.51

Underground Detention System-1	
Infiltration Rate (in/Hr)=	0
Bottom Area ( $ft^2$ ) =	0
Infiltration Volume ( $ft^3$ ) =	0
$Time_{drawdown}$ (Hours)=	0.00

Rain Garden-2	
Infiltration Rate (in/Hr)=	1.02
Bottom Area ( $ft^2$ ) =	2,509
Infiltration Volume ( $ft^3$ ) =	1,515
$Time_{drawdown}$ (Hours)=	7.10

Rain Garden-1	
Infiltration Rate (in/Hr)=	1.02
Bottom Area ( $ft^2$ ) =	1,423
Infiltration Volume ( $ft^3$ ) =	1,419
$Time_{drawdown}$ (Hours)=	11.73



Computation Sheet									
<b>Title</b> <i>MA DEP Standard Calculations</i> <b>Project</b> <i>School Street, Manchester-by-the-Sea, MA</i> <b>Date</b> July 16, 2021 <b>Revised</b>					<b>By</b> DMR/SJL <b>Chk'd</b> CMQ <b>Apprv'd</b> CMQ				
TSS REMOVAL CALCULATIONS WORKSHEET									
B BMP <sup>1</sup>	C TSS Removal Rate <sup>1</sup>	D Starting TSS Load*	E Amount Removed (C*D)	Remaining Load (D-E)	B BMP <sup>1</sup>	C TSS Removal Rate <sup>1</sup>	D Starting TSS Load*	E Amount Removed (C*D)	Remaining Load (D-E)
Deep Sump Catch Basins	0.25	1.00	0.25	0.75	Deep Sump Catch Basins	0.25	1.00	0.25	0.75
Sediment Removal Proprietary Device	0.50	0.75	0.38	0.38	Sediment Removal Proprietary Device	0.50	0.75	0.38	0.38
Surface Infiltration System w/ Outlet Control	0.80	0.38	0.30	0.08	Rain Garden	0.80	0.38	0.30	0.08
Total TSS Removal =			93%		Total TSS Removal =			93%	
B BMP <sup>1</sup>	C TSS Removal Rate <sup>1</sup>	D Starting TSS Load*	E Amount Removed (C*D)	Remaining Load (D-E)	B BMP <sup>1</sup>	C TSS Removal Rate <sup>1</sup>	D Starting TSS Load*	E Amount Removed (C*D)	Remaining Load (D-E)
Deep Sump Catch Basins	0.25	1.00	0.25	0.75	Deep Sump Catch Basins	0.25	1.00	0.25	0.75
Sediment Removal Proprietary Device	0.50	0.75	0.38	0.38	Sediment Removal Proprietary Device	0.50	0.75	0.38	0.38
Surface Detention Pond	0.80	0.38	0.30	0.08	Sub-surface Infiltration System	0.80	0.38	0.30	0.08
Total TSS Removal =			93%		Total TSS Removal =			93%	

**Title** *MA DEP Standard Calculations*  
**Project** *School Street, Manchester-by-the-Sea, MA*  
**Date** July 16, 2021  
**Revised**

By DMR/SJL  
 Chk'd CMQ  
 Apprv'd CMQ

### STORMWATER QUALITY FLOW RATE CALCULATIONS FOR WATER QUALITY UNITS

Structure Name	Total Area (Acres)	Imp. Area (Acres)	A <sup>IMP</sup> (Sq. Miles)	Tc (min.)	Tc (hrs.)	WQV (inches)	qu (csm/in)
WQU-1	0.34	0.27	0.00042	6.0	0.10	1	774
WQU-2	0.34	0.27	0.00042	6.0	0.10	1	774
WQU-3	0.12	0.12	0.00019	6.0	0.10	1	774
WQU-4	0.48	0.21	0.00033	6.0	0.10	1	774
WQU-5	0.45	0.15	0.00023	6.0	0.10	1	774
WQU-6	0.41	0.31	0.00048	6.0	0.10	1	774
WQU-7	0.22	0.23	0.00037	6.0	0.10	1	774
WQU-8	0.30	0.15	0.00023	6.0	0.10	1	774

Water Quality Flow Rate = Q1 = (qu) (A) (WQV)

Structure Name	Q1 (cfs)
CDS #1	0.33
CDS #2	0.33
CDS #3	0.14
CDS #4	0.26
CDS #5	0.18
CDS #6	0.37
CDS #7	0.28
CDS #8	0.18

Use Contech CDS Model 2015-4 (or approved equal)

## Computation Sheet

Title **Pipe Sizing Table**

Project The Sanctuary - School Street - Manchester By the Sea - Comprehensive Permit

Date July 16, 2021

Revised TBD

A&amp;M Project Number: 2725-01

Minimum Slope: 0.50%

Minimum Pipe Size: 12.00

Rainfall Intensity (in/hr): 6.17 (25 year storm)

Manning's n: 0.013 HDPE/PVC

Minimum Pipe Cover: 2.51

By DMR

Chk'd SJL

Apprv'd CMQ

## Hayes Memorial Drive - Parcel L

Line						Req'd. Capac.	Pipe Size	Slope	Design Capacity		Drop	Invert Elevation		Rim Elev.	
From	To	Length	Area	wgt. C	CA	Qd	D	s	Q <sub>full</sub>	V <sub>full</sub>		Upper	Lower	Upper	Cover
Upper	Lower	(feet)	(acres)			(cfs)	(in)	(%)	(cfs)	(fps)	(feet)	(ft)	(ft)	(ft)	(ft)
CB-1A	DMH1 (WQU1)	17	0.085	0.84	0.072	0.44	12	1.00%	3.6	4.54	0.17	48.50	48.33	51.50	1.88
CB-1B	DMH1 (WQU1)	7	0.085	0.84	0.072	0.44	12	2.43%	5.6	7.07	0.17	48.50	48.33	51.50	1.88
DMH-1	UDS	4				0.89	12	1.00%	3.6	4.54	0.04	48.23	48.19	51.80	2.45
CB-2A	DMH-3	17	0.085	0.84	0.072	0.44	12	1.00%	3.6	4.54	0.17	48.50	48.33	51.50	1.88
CB-2B	DMH-3	7	0.085	0.84	0.072	0.44	12	2.43%	5.6	7.07	0.17	48.50	48.33	51.50	1.88
CB-3	DMH-3	100	0.571	0.35	0.200	1.23	12	10.00%	11.3	14.35	10.00	57.47	47.47	67.50	8.91
DMH-3	DMH-2(WQU)	7				2.12	12	1.00%	3.6	4.54	0.07	47.37	47.30	59.40	10.91
CB-8A	DMH-8	18	0.059	0.95	0.056	2.47	12	3.00%	6.2	7.86	0.54	64.54	64.00	74.90	9.24
CB-8B	DMH-8	22	0.059	0.95	0.056	2.82	12	3.00%	6.2	7.86	0.66	64.66	64.00	74.90	9.12
DMH-8	FES-2	38				5.29	12	5.00%	8.0	10.14	1.90	63.90	62.00	73.40	8.38
CB-12A	DMH-12	7	0.119	0.61	0.073	0.45	12	5.00%	8.0	10.14	0.35	95.79	95.44	102.30	5.38
CB-12B	DMH-12	7	0.119	0.61	0.073	0.45	12	5.00%	8.0	10.14	0.35	95.79	95.44	102.30	5.38
DMH-12	DMH-11A	53				0.91	12	8.00%	10.1	12.83	4.24	95.34	91.10	102.30	5.83
CB-12C	DMH-11A	22	0.423	0.35	0.148	0.91	12	10.00%	11.3	14.35	2.20	93.30	91.10	99.80	5.38
DMH-11A	DMH-10B	120				1.82	12	7.00%	9.4	12.00	8.40	91.00	82.60	99.80	7.68
CB-10A	DMH-10A	12	0.119	0.61	0.073	1.36	12	10.00%	11.3	14.35	1.20	83.50	82.30	91.00	6.38
CB-10B	DMH-10A	12	0.119	0.61	0.073	1.81	12	10.00%	11.3	14.35	1.20	83.50	82.30	91.00	6.38
DMH-10A	DMH-10B	6				3.17	12	10.00%	11.3	14.35	0.60	82.20	81.60	91.90	8.58
DMH-10B	FES-5	40				4.99	15	1.50%	7.9	6.45	0.60	82.20	81.60	92.20	8.63
CB-13A	DMH-13A	20	0.225	0.70	0.157	0.97	12	2.00%	5.0	6.42	0.40	102.85	102.45	111.40	7.43
CB-13B	DMH-13A	6	0.225	0.70	0.157	0.97	12	5.00%	8.0	10.14	0.30	102.75	102.45	111.40	7.53
DMH-1	DMH-2(WQU)	25				1.94	12	2.00%	5.0	6.42	0.50	102.35	101.85	110.90	7.43
CB-14A	DMH-14	7	0.259	0.80	0.206	1.27	12	2.00%	5.0	6.42	0.14	118.07	117.93	121.70	2.51
CB-14B	DMH-14	12	0.259	0.80	0.206	1.27	12	1.00%	3.6	4.54	0.12	118.05	117.93	121.70	2.53
DMH-14	UIS2	2				2.54	12	5.00%	8.0	10.14	0.10	117.60	117.50	122.10	3.38
CB-7A	DMH-7	10	0.487	0.95	0.462	2.85	12	5.00%	8.0	10.14	0.50	109.85	109.35	121.70	10.73
CB-7B	DMH-7	20	0.487	0.95	0.462	2.85	12	5.00%	8.0	10.14	1.00	110.35	109.35	121.70	10.23
DMH-7	UIS-3	35				5.70	12	5.00%	8.0	10.14	1.75	109.25	107.50	122.10	11.73
OCS-4	DMH-15	60	From Hydro-CAD: 25-Year Storm			0.11	12	4.00%	7.1	9.07	2.40	117.50	115.10	124.80	6.18
DMH-15	DMH-16	200				0.11	12	4.00%	7.1	9.07	8.00	115.00	107.00	122.30	6.18
OCS-5	DMH-16	14	From Hydro-CAD: 25-Year Storm			0.34	12	5.00%	8.0	10.14	0.70	107.00	106.30	113.50	5.38
DMH-16	DMH-17	32				0.34	12	10.00%	11.3	14.35	3.20	93.20	90.00	111.00	16.68
DMH-17	DMH-18	37				0.34	12	10.00%	11.3	14.35	3.70	77.70	74.00	94.00	15.18
DMH-18	DMH-19	58				0.34	12	10.00%	11.3	14.35	5.80	61.80	56.00	78.00	15.08
DMH-19	FES-4	77				0.34	12	10.39%	11.5	14.62	8.00	115.00	107.00	122.30	6.18

# The Sanctuary - Manchester-by-the-Sea

## Computation Sheet

Title: **RipRap Sizing Spreadsheet**  
 Project: The Sanctuary - Manchester-by-the-Sea  
 Date: July 16, 2021  
 Revised:  
 A&M Project Number: 2725-01

By: SJL  
 Chk'd: CMQ  
 Apprv'd: CMQ

OUTLET	Do (ft.)	Q25 (cfs)***	Tw (ft.)	La (ft.)	Wup (ft.)	Wdn (ft.)**	d50 (ft.)*
FES-1	2.00	2.28	0.5	15.5	6.0	21.5	0.06
FES-2	1.00	0.21	0.5	7.4	3.0	10.4	0.01
FES-3	1.00	4.31	0.5	14.8	3.0	17.8	0.27
FES-4	2.00	2.43	0.5	15.5	6.0	21.5	0.06
FES-5	1.00	4.43	0.5	15.0	3.0	18.0	0.28
FES-6	1.00	0.00	0.5	7.0	3.0	10.0	0.00

### Notes:

Assume 6" Tw at Outfall

Use MHD M2.02.2 Stone

Depth of Stone to be 6" or 1.5 times d50 - which ever is larger

**\*6" Minimum Stone Diameter**

**\*\*Apron width shall meet defined downstream channel**

**\*\*See pipe sizing spreadsheet for Q25 flows**

### When Tw < 0.5Do at pipe outlet:

$$La = 1.8Q/Do^{1.5} + 7Do$$

$$Wup = 3Do$$

$$Wdn = 3Do + La$$

$$d50 = (0.02Q^{1.3})/(TwDo)$$

### When Tw > or = 0.5Do at pipe outlet:

$$La = 3Q/Do^{1.5} + 7Do$$

$$Wup = 3Do$$

$$Wdn = 3Do + 0.4La$$

$$d50 = (0.02Q^{1.3})/(TwDo)$$

### Where:

Tw = the tailwater depth at the outlet of the pipe or channel

Do = the diameter of the pipe or the width of channel

Q = the discharge from the pipe of channel (25 year Storm)

La = the length of apron

Wup = the upstream width of apron

Wdn = the downstream width of apron

d50 = the median stone diameter

# **NJCAT TECHNOLOGY VERIFICATION**

## **VortSentry<sup>®</sup> Stormwater Treatment System**

**December 2005**

## TABLE OF CONTENTS

1.	Introduction.....	1
1.1	New Jersey Corporation for Advanced Technology (NJCAT) Program.....	1
1.2	Technology Verification Report.....	2
1.3	Technology Description.....	2
1.3.1	Technology Status.....	2
1.3.2	Specific Applicability.....	4
1.3.3	Range of Contaminant Characteristics.....	4
1.3.4	Range of Site Characteristics.....	5
1.3.5	Material Overview, Handling and Safety.....	7
1.4	Project Description.....	7
1.5	Key Contacts.....	7
2.	Evaluation of the Applicant.....	8
2.1	Corporate History.....	8
2.2	Organization and Management.....	8
2.3	Operating Experience with the Proposed Technology.....	8
2.4	Patents.....	9
2.5	Technical Resources, Staff and Capital Equipment.....	9
3.	Treatment System Description.....	10
4.	Technical Performance Claim.....	10
5.	Treatment System Performance.....	11
5.1	NJDEP Recommended TSS Laboratory Testing Procedure.....	11
5.2	Laboratory Studies.....	13
5.2.1	Performance Testing Procedure.....	14
5.2.2	Washout Testing Procedure.....	14
5.2.3	Sample Analysis.....	15
5.2.4	Description of Laboratory Testing Facility.....	15
5.2.5	Laboratory Testing Results.....	15
5.2.6	Washout Testing Results.....	17
5.3	Verification Procedures.....	18
5.3.1	Verified Treatment Flow.....	19
5.4	Inspection and Maintenance.....	19
5.4.1	Inspection.....	19
5.4.2	Maintenance.....	20
5.4.3	Solids Disposal.....	20
5.4.4	Damage Due to Lack of Maintenance.....	21

## TABLE OF CONTENTS (Continued)

6.	Technical Evaluation Analysis.....	21
6.1	Verification of Performance Claim.....	21
6.2	Limitations.....	21
6.2.1	Factors Causing Under-Performance.....	21
6.2.2	Pollutant Transformation and Release.....	21
6.2.3	Sensitivity to Heavy or Fine Sediment Loading.....	21
6.2.4	Bypass Flow.....	22
6.2.5	Mosquitoes.....	22
7.	Net Environmental Benefit.....	22
8.	References.....	22

### **List of Figures**

Figure 1.	VortSentry® Features.....	3
Figure 2.	Routine VortSentry® Operation.....	5
Figure 3.	Moderate Intensity VortSentry® Operation.....	6
Figure 4.	US Silica F-95 Particle Size Distribution.....	11
Figure 5.	Laboratory Testing Facility for the VortSentry® System.....	16

### **List of Tables**

Table 1.	Standard VortSentry® Model Sizes and Dimensions.....	4
Table 2.	Particle Size Distribution.....	12
Table 3.	Treatment Operating Rates and Weight Factors.....	13
Table 4.	Summary of VortSentry® Laboratory Testing Results with F-95 Grade Silica.....	16
Table 5.	Results of Washout Testing at 50% and 100% of the VortSentry® Sediment Storage Capacity.....	17
Table 6.	Weighted Removal Efficiency for the VortSentry® System.....	18
Table 7.	VortSentry Treatment Flows Assuming Volumetric Scaling.....	19



## **1. Introduction**

### **1.1 New Jersey Corporation for Advanced Technology (NJCAT) Program**

NJCAT is a not-for-profit corporation to promote in New Jersey the retention and growth of technology-based businesses in emerging fields such as environmental and energy technologies. NJCAT provides innovators with the regulatory, commercial, technological and financial assistance required to bring their ideas to market successfully. Specifically, NJCAT functions to:

- Advance policy strategies and regulatory mechanisms to promote technology commercialization;
- Identify, evaluate, and recommend specific technologies for which the regulatory and commercialization process should be facilitated;
- Facilitate funding and commercial relationships/alliances to bring new technologies to market and new business to the state; and
- Assist in the identification of markets and applications for commercialized technologies.

The technology verification program specifically encourages collaboration between vendors and users of technology. Through this program, teams of academic and business professionals are formed to implement a comprehensive evaluation of vendor specific performance claims. Thus, suppliers have the competitive edge of an independent third party confirmation of claims.

Pursuant to N.J.S.A. 13:1D-134 et seq. (Energy and Environmental Technology Verification Program), the New Jersey Department of Environmental Protection (NJDEP) and NJCAT have established a Performance Partnership Agreement (PPA) whereby NJCAT performs the technology verification review and NJDEP certifies the net beneficial environmental effect of the technology. In addition, NJDEP/NJCAT work in conjunction to develop expedited or more efficient timeframes for review and decision-making of permits or approvals associated with the verified/certified technology.

The PPA also requires that:

- The NJDEP shall enter into reciprocal environmental technology agreements concerning the evaluation and verification protocols with the United States Environmental Protection Agency (USEPA), other local required or national environmental agencies, entities or groups in other states and New Jersey for the purpose of encouraging and permitting the reciprocal acceptance of technology data and information concerning the evaluation and verification of energy and environmental technologies; and
- The NJDEP shall work closely with the State Treasurer to include in State bid specifications, as deemed appropriate by the State Treasurer, any technology verified under the Energy and Environment Technology Verification Program.

## **1.2 Technology Verification Report**

In October 2005, Stormwater360<sup>TM</sup>, Inc., 200 Enterprise Drive, Scarborough, Maine, 04074, submitted a formal request for participation in the NJCAT Technology Verification Program. The technology proposed, The VortSentry<sup>®</sup> Stormwater Treatment System, is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows. The system was developed in Scarborough, Maine and is described in greater detail later in this report. Through research and field application, the technology has been refined to capture total suspended solids (TSS), sediments, oil and grease, and trash and debris (including floatables and negatively buoyant debris). The request (after pre-screening by NJCAT staff personnel in accordance with the technology assessment guidelines) was accepted into the verification program. This verification report covers the evaluation based upon the performance claim of the vendor, Stormwater360<sup>TM</sup>, Inc. (see Section 4). The verification report differs from typical NJCAT verification reports in that final verification of the VortSentry<sup>®</sup> System (and subsequent NJDEP certification of the technology) awaits completed field testing that meets the full requirements of the Technology Acceptance and Reciprocity Partnership (TARP) – Stormwater Best Management Practice Tier II Protocol for Interstate Reciprocity for stormwater treatment technology. This verification report is intended to evaluate the Stormwater360<sup>TM</sup>, Inc. initial performance claim for the technology based primarily on carefully conducted laboratory studies. This claim is expected to be modified and expanded following completion of the TARP required field-testing.

This project included the evaluation of assembled reports, company manuals, and laboratory testing reports to verify that the VortSentry<sup>®</sup> System meets the performance claim of Stormwater360<sup>TM</sup>, Inc.

## **1.3 Technology Description**

### **1.3.1 Technology Status**

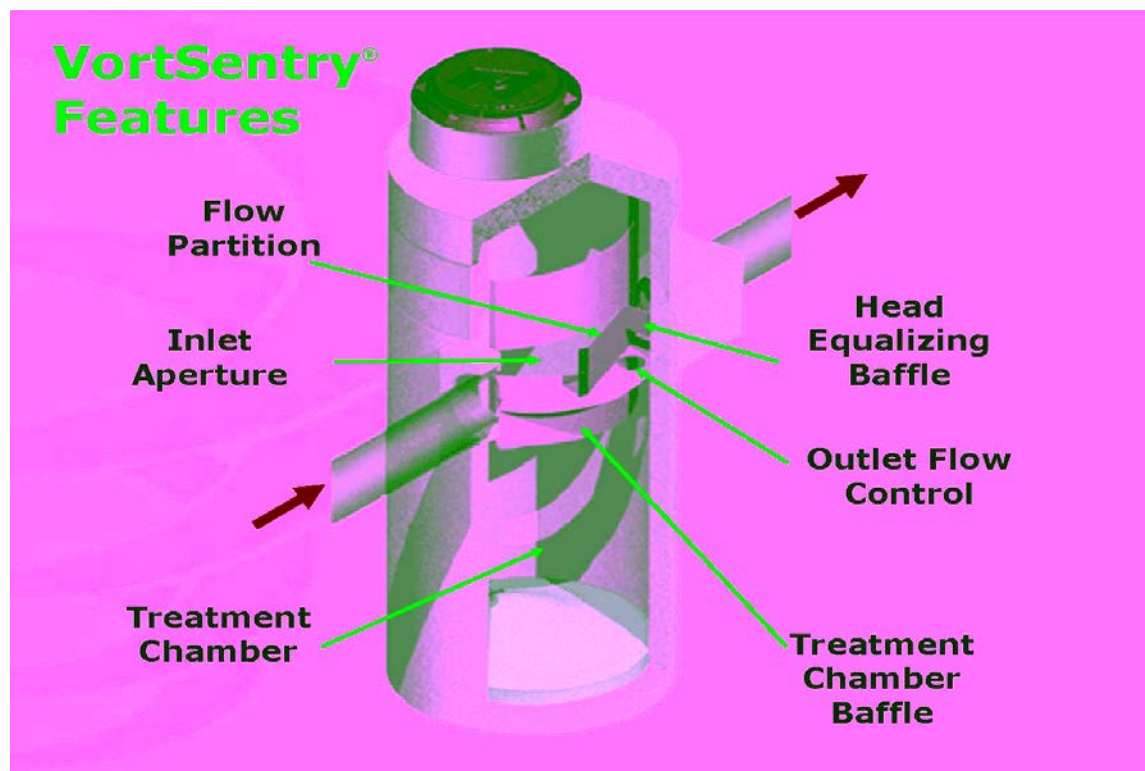
In 1990 Congress established deadlines and priorities for USEPA to require permits for discharges of stormwater that are not mixed or contaminated with household or industrial wastewater. Phase I regulations established that a NPDES (National Pollutant Discharge Elimination System) permit is required for stormwater discharge from municipalities with a separate storm sewer system that serves a population greater than 100,000 and certain defined industrial activities. To receive a NPDES permit, the municipality or specific industry has to develop a stormwater management plan and identify best management practices for stormwater treatment and discharge. Best management practices (BMPs) are measures, systems, processes or controls that reduce pollutants at the source to prevent the pollution of stormwater runoff discharge from the site. Phase II stormwater discharges include all discharges composed entirely of stormwater, except those specifically classified as Phase I discharge.

The nature of pollutants emanating from differing land uses are very diverse. Stormwater360<sup>TM</sup>, Inc. has developed a technology for separating and retaining floating and sinking pollutants including sediment, hydrocarbons and debris under rapid flow conditions using a hydrodynamic separator. The system is designed with a circular treatment chamber that promotes a gentle

swirling motion to encourage settling pollutants to migrate to the center of the chamber where they are deposited. Floating pollutants are elevated above the bottom of the baffle wall where they collect over time. Between maintenance events, pollutants accumulate within the system and are therefore removed from the natural environment. These pollutants may otherwise become a human health hazard, an aesthetic issue or may be cycled within the food chain or water table even if trapped in a land based treatment system. Maintenance is performed from above by a vacuum truck and without interference from internal components.

### *General*

The VortSentry® Stormwater Treatment System is a hydrodynamic separator designed to enhance gravitational separation of floating and settling materials from stormwater flows (See Figure 1). Stormwater flows enter the unit tangentially to the treatment chamber, which promotes a gentle swirling motion. As stormwater circles the treatment chamber, pollutants migrate toward the center of the unit where velocities are the lowest. Over time a conical pile tends to accumulate in the bottom of the treatment chamber containing sediment and associated metals, nutrients, hydrocarbons and other pollutants. Floating debris, oil and grease form a floating layer trapped in front of the treatment chamber baffle. These accumulated pollutants can be easily accessed through manholes conveniently located over the treatment chamber. Maintenance is typically performed through the manhole over the treatment chamber.



**Figure 1. VortSentry® Features**

### 1.3.2 Specific Applicability

The VortSentry® System is well suited to urban stormwater applications due to the following features:

- Laboratory testing has demonstrated that the system is capable of meeting stormwater treatment requirements;
- Below grade installation allows multiple land uses;
- Each system is custom designed to meet the hydraulic demands of site;
- Spill storage and sediment storage volumes can be increased as necessary;
- Technical support is available at no cost before and after the sale;
- There are no expendable or moving parts and a low cleanout volume minimizes operating costs.

The VortSentry® System is a compact, below grade system that is fabricated near the jobsite from concrete and marine grade aluminum. There are six standard precast models available, ranging from three to eight feet in diameter. In some regions VortSentry® systems are available in diameters up to 12 feet, but this is dependant on the capabilities of local precasters. Standard VortSentry® model sizes and dimensions are provided in Table 1.

**Table 1. Standard VortSentry® Model Sizes and Dimensions**

VortSentry® Model	Treatment Chamber Diameter		Depth (below invert)		Recommended Maximum Inlet / Outlet Pipe Size	
	(ft)	(m)	(ft)	(m)	(in)	(mm)
VS30	3	0.9	5.4	1.7	12	300
VS40	4	1.2	6.5	2.0	18	450
VS50	5	1.5	7.4	2.3	18	450
VS60	6	1.8	8.3	2.5	24	600
VS70	7	2.1	9.1	2.8	30	762
VS80	8	2.4	10.1	3.0	30	762

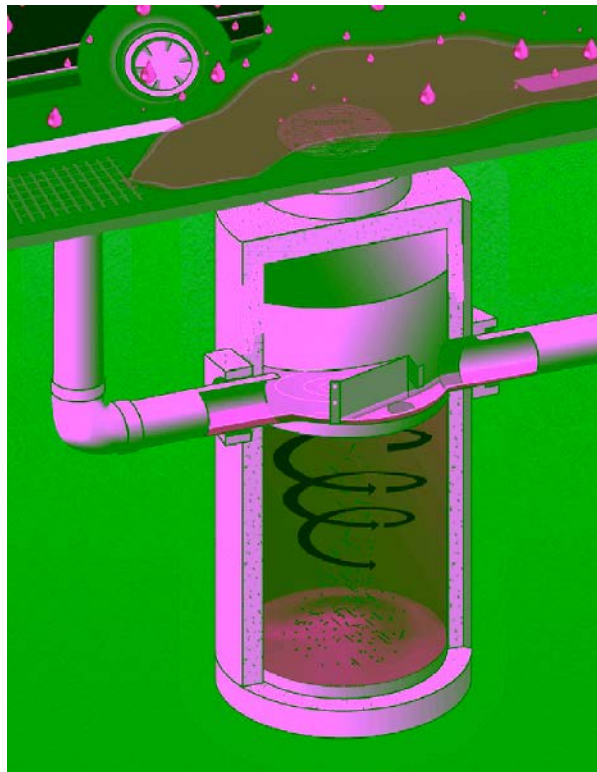
### 1.3.3 Range of Contaminant Characteristics

VortSentry® Systems have been shown to capture a wide range of pollutants of concern. These include: trash and debris (including floatables and negatively buoyant debris); total suspended solids; sediments; and oil and grease.

### 1.3.4 Range of Site Characteristics

#### *Routine operation*

Runoff from low intensity precipitation makes up the vast majority of the total annual flow volume from all sites. During low intensity precipitation events, all flow is diverted into the treatment chamber by the flow partition. The flow partition is designed to work in combination with the outlet flow control orifice to submerge the inlet pipe during the water quality design storm. The effect of submerging the inlet pipe is to reduce inlet velocity and turbulence by increasing the cross sectional area of the flow path. Removal rates of sediment and floating pollutants are very high during routine operation since turbulence and internal velocities are very low, and residence times are relatively high. See Figure 2 for an illustration of routine VortSentry® operation.

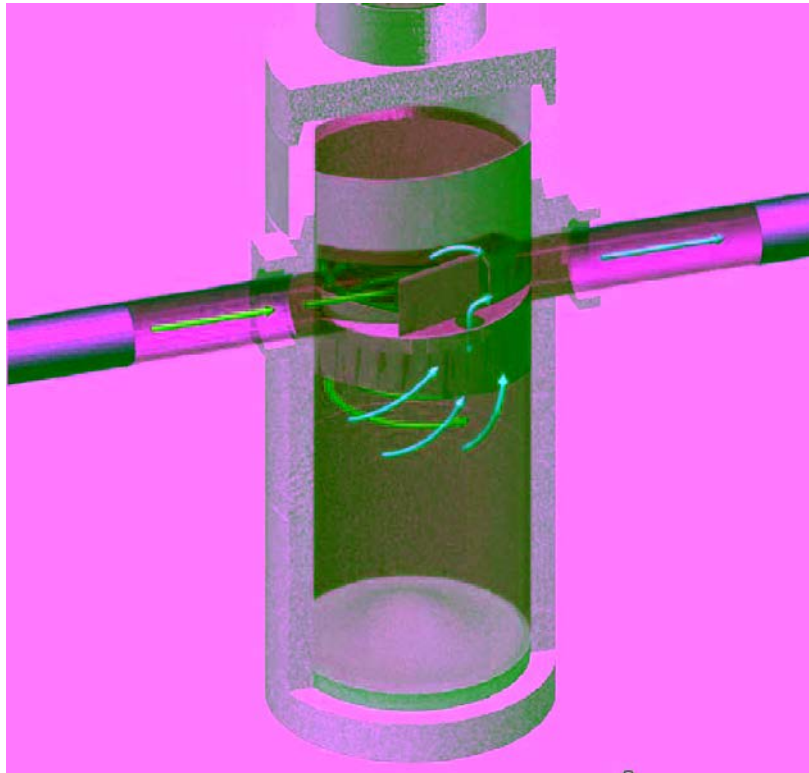


**Figure 2. Routine VortSentry® Operation**

#### *Moderate intensity operation*

As storm intensities and flow rates increase, the operating rate (gpm/ft<sup>3</sup>) in the VortSentry® also increases proportionally. At flow rates typical of moderate intensity storm events, a portion of flow begins to spill over the flow partition. Partitioning a portion of flow around the treatment chamber keeps velocities low in the treatment chamber. This allows the VortSentry® to continue to remove a high percentage of the pollutants from the runoff flowing through the treatment chamber. Maintaining low velocities in the treatment chamber also prevents scour of previously captured pollutants. The rising water surface elevation within the treatment chamber carries

floating contaminants such as trash and oil and grease away from the inlet and above the bottom of the baffle wall. This effectively prevents re-entrainment by separating contaminants from the higher velocity zones within the system. The swirling action increases, which promotes the migration of particles toward the center of the treatment chamber where the particles then form a stable conical pile. See Figure 3 for an illustration of moderate intensity VortSentry® operation.



**Figure 3. Moderate Intensity VortSentry® Operation**

#### *High Intensity Operation*

At peak hydraulic capacity, the water surface elevation within the VortSentry® System increases and a substantial portion of the total flow passes over the flow partition submerging the head equalizing baffle. VortSentry® Systems are designed so that peak conveyance rates are representative of storm events such as the 5-yr or 10-yr rain event. Sediment and hydrocarbon removal rates are low, but previously captured materials remain trapped. This is accomplished by increasing the water surface elevation in the treatment chamber to isolate previously captured floatables and by maintaining low flow velocities in the treatment chamber. To accommodate large, infrequent storms, Stormwater360™, Inc. can also assist with the design of an external bypass to route peak-flows around the treatment unit.

#### *Storm subsidence*

As a storm subsides, treated runoff continues to flow out of the VortSentry® System through the outlet orifice until the water level returns to the dry-weather volume. This process typically takes several minutes after runoff has ceased.

### 1.3.5 Material Overview, Handling and Safety

Accumulated pollutants can easily be accessed through the manhole located above the treatment chamber. To clean out the VortSentry® System with a vacuum truck, it is generally most convenient and efficient to clean all captured pollutants including sediment, oil and grease, and floating debris through the manhole over the treatment chamber. Access to the treatment chamber is unrestricted making the vacuum operation a simple task. Once the treatment chamber and captured pollutants have been vacuumed from the unit, the manhole cover is simply replaced to complete the maintenance event.

Solids recovered from the VortSentry® System can typically be land filled or disposed of at a wastewater treatment plant. It is possible that there may be some specific land use activities that create contaminated solids, which will be captured in the system. Such material would have to be handled and disposed of in accordance with hazardous waste management requirements.

### 1.4 Project Description

This project included the evaluation of assembled reports, company manuals, and laboratory testing reports to verify that VortSentry® Systems meet the performance claim of Stormwater360™, Inc.

### 1.5 Key Contacts

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## **2. Evaluation of the Applicant**

### **2.1 Corporate History**

Stormwater Management, Inc. and Vortechtechnics, Inc. united as Stormwater360<sup>TM</sup>, Inc. in April 2005. The two companies share over 25 years of experience in the stormwater industry. As a combined entity, their goal continues to be preserving and protecting water resources worldwide.

The joint company treats stormwater runoff from commercial, municipal and industrial sites, applying various technologies to address regulatory and customer requirements. Founded in 1988 and based in Scarborough, Maine, Vortechtechnics built their business on the development of hydrodynamic separation technology. Based in Portland Oregon, Stormwater Management led in the development of filtration technology, introducing a horizontal bed configuration with CSF leaf compost media in 1995.

In state-of-the-art laboratories at both locations, engineers and scientists continue to conduct research to further the understanding of nonpoint source pollution and develop practical product solutions. The parent company of Stormwater360<sup>TM</sup>, Inc. is Contech Construction Products, Inc., a leading civil engineering site solutions products and services company involved in highway, drainage, sewage, and site-improvement. In 2004, Vortechtechnics was purchased by Contech; and in April 2005, Contech purchased Stormwater Management.

### **2.2 Organization and Management**

The company Stormwater360<sup>TM</sup>, Inc. is jointly headquartered in Scarborough, Maine, and Portland, Oregon with 19 regional sales offices throughout the United States and Canada. The management team consists of: David Miley, president and CEO; David Pollock, COO and VP of Sales; Jim Lenhart, Chief Technology Officer; Eric Roach, Chief Financial Officer; Fran Tighe, VP of Marketing; and Tom Gorrivan, National Sales Manager. The company has 23 regional sales managers, who report to Tom Gorrivan and work out of regional offices based in Maine, Maryland, Georgia, Texas, Ohio, California, Washington, Oregon, Wisconsin, Pennsylvania, Massachusetts, Nova Scotia, and Ontario.

### **2.3 Operating Experience with the Proposed Technology**

Stormwater360<sup>TM</sup>, Inc. has more than 15 years of experience with stormwater technology, and after several years of research and development the VortSentry® was released in 2003. Currently there are more than 300 installations throughout the United States and Canada. Most importantly, the technology is backed by years of full scale laboratory testing and rigorous field testing is ongoing, including third party studies from several universities and organizations.

## **2.4 Patents**

Stormwater360™ has filed for patent protection for the VortSentry® System with the US Patent Office, and a patent is currently pending.

## **2.5 Technical Resources, Staff and Capital Equipment**

Stormwater360™ completes all design work at its corporate headquarters in Scarborough, Maine and Portland, Oregon. Once a system design is complete, shop drawings are issued to a precast concrete contractor local to the installation site. Representatives from each precast company are trained in VortSentry® construction to ensure the details of construction are properly executed. Different contractors may elect to cast the system differently depending on their equipment and construction capabilities. For example, a precaster would have input regarding the details of construction such as how many pieces per system. They would also determine how the joints are formed and what type of lifting equipment is cast in. Stormwater360™, Inc. ultimately reviews all construction and installation decisions made by the precaster.

The VortSentry® System is delivered to the site by the precaster on the day of installation. VortSentry® systems typically arrive on site in three or more pieces and require some assembly. VortSentry® models VS30-VS50 typically do not require the use of a crane for installation. Once delivered to the site by the precaster the contractor is responsible for assembling and sealing the VortSentry® sections. VortSentry® models VS60 and larger typically require a crane for installation and additional sealing of the aluminum components onsite. The site contractor is responsible for making arrangements to have a crane on site, completing excavation prior to delivery and setting the system into the ground. The contractor is also responsible for grouting the inlet and outlet pipe into the VortSentry® System, backfilling around the system and bringing the manhole frames and covers up to grade. Any work required on components inside the system is typically the responsibility of the Stormwater360™ precast contractor. Installation for all model sizes can typically be completed in two to four hours. Heaviest pick weight will be confirmed by Stormwater360™ staff and communicated to the contractor prior to delivery.

Specific installation instructions and requirements are provided. Stormwater360™ tries to have a representative onsite during installation, but occasionally this is not possible. However, support representatives are always available to address questions that may arise during installation.

When the system arrives on site, it is inspected by the contractor. Any damage due to shipping and handling up to that point must be corrected by the precaster. Once the contractor takes delivery of the unit, it is their responsibility to lift it from the truck, place it in the ground, and connect the inlet and outlet pipes and backfill around it. The contractor will perform a final check against the VortSentry® Specification and the site plan before backfilling is initiated. If there are any installation errors at that point, the contractor will fix them and the system will be back filled.

Adjustments for buoyancy issues, calculation of pick weights, and other custom design items are confirmed before delivery. The inlet and outlet are clearly marked to avoid improper

installation. It is especially important that the system be set in such a way that the inlet pipe is at a 90 degree angle to the side of the tank to encourage proper treatment chamber flow dynamics. This orientation is checked prior to backfilling the unit since a significantly different influent pipe angle may increase inlet turbulence or cause short-circuiting of the treatment chamber.

VortSentry® Systems are typically available within four to six weeks of shop drawing approval.

### **3. Treatment System Description**

The VortSentry® Stormwater Treatment System was designed to capture a wide range of pollutants from stormwater including: trash and debris (including floatables and negatively buoyant debris); total suspended solids; sediments; and oil and grease. Figure 1 displays a simple schematic of the VortSentry® System. The VortSentry® is a compact, below grade stormwater treatment system that employs vortex technology to enhance gravitational separation of floating and settling pollutants from stormwater flows. The device has no moving parts and is fabricated from concrete and marine grade aluminum. The main components of the system are a flow partition, inlet aperture, head equalizing baffle, treatment chamber, outlet flow control orifice, and treatment chamber baffle. The system is also equipped with a manhole for easy inspection and maintenance access.

During operation, stormwater runoff enters the unit tangentially to promote a gentle swirling motion in the treatment chamber. As polluted water circles within the chamber, settleable solids fall into the sump and are retained. Buoyant debris and oil and grease rise to the surface and are separated from the water as it flows under the baffle wall. Finally, treated water exits the treatment chamber through a flow control orifice located behind the baffle wall.

During low-flow conditions, all runoff is diverted into the treatment chamber by the flow partition. At higher flow rates, a portion of the runoff spills over the flow partition and is diverted around the treatment chamber to prevent re-suspension and washout of previously trapped pollutants. Water that spills over the partition flows into the head equalization chamber above the treatment chamber outlet. As the head equalization chamber fills, the head differential driving flow through the treatment chamber collapses. The result is that flow rates in the treatment chamber remain relatively constant even as total flow rates increase substantially. This configuration further reduces the potential for re-suspension or washout.

There are typically six (6) precast VortSentry® System models available to meet the hydraulic and water quality needs of large and small projects (See Table 1). The VortSentry® Systems have the ability to treat a wide range of flows. In certain regions, larger systems are available to accommodate higher flow rates.

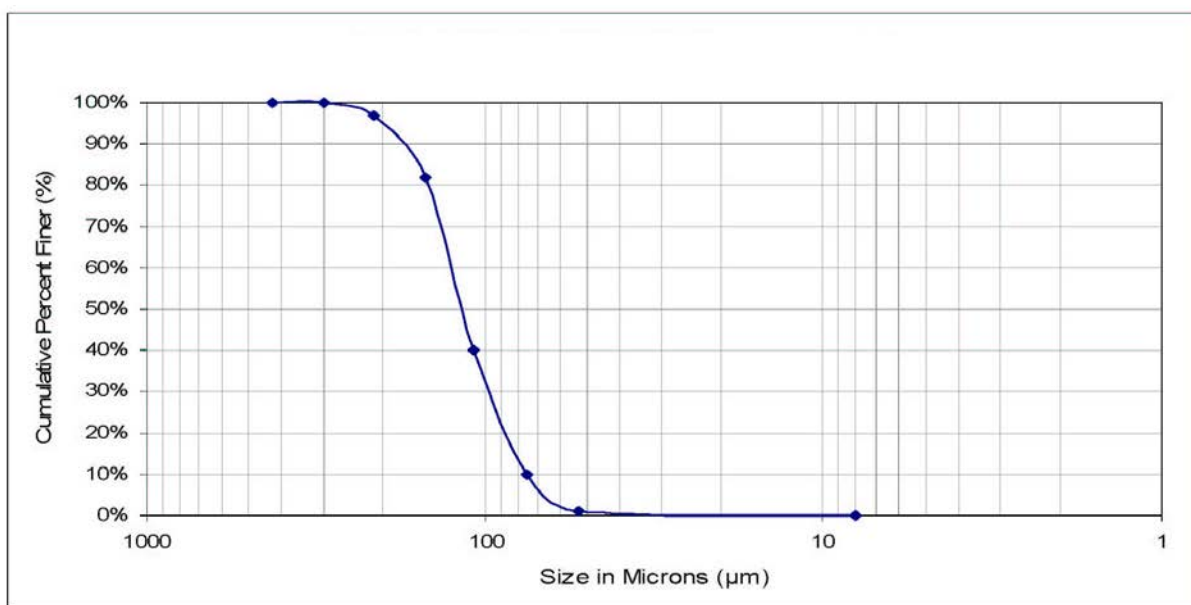
### **4. Technical Performance Claim**

**Claim** - The VortSentry® Stormwater Treatment System, Model VS40, sized at a loading rate of 9.8 gpm/ft<sup>3</sup> (0.022cfs/ft<sup>3</sup>) of treatment volume, has been shown to have a 69% total suspended solids (TSS) removal efficiency, as measured as suspended solids concentration (SSC) (as per the NJDEP methodology for calculation of treatment efficiency) for F-95 silica sand with an

average  $d_{50}$  particle size of 120 microns, an average influent concentration of 209 mg/L and 50% initial sediment loading in laboratory studies using simulated stormwater.

## 5. Treatment System Performance

The VortSentry® System has been tested at the Stormwater360™, Inc. full-scale hydraulic laboratory. The laboratory tests were completed using F-95, a commercially available silica sand gradation. The particle size distribution is shown in Figure 4. Tests were performed with sediment influent concentrations ranging from 88 to 521 mg/l at operating rates from 0.27 to 1.35 cfs. In addition to specific testing, Stormwater360™, Inc. has developed the Rational Rainfall Method™, a model that estimates long term field performance based on site information, local precipitation patterns and laboratory performance data. The VortSentry® System is currently being tested in the field by Stormwater360™, Inc. staff as well as by independent researchers.



**Figure 4. US Silica F-95 Particle Size Distribution**

### 5.1 NJDEP Recommended TSS Laboratory Testing Procedure

Stormwater360™, Inc. designed their laboratory testing to comply with NJDEP's recommended TSS Laboratory Testing Procedure; the NJDEP testing procedure is presented herein. The NJDEP has prepared a Total Suspended Solids Laboratory Testing Procedure to help guide vendors as they prepare to test their stormwater treatment systems prior to applying for NJCAT verification.

The Testing Procedure has three components:

1. Particle size distribution

2. Full scale laboratory testing requirements
3. Measuring treatment efficiency

1. Particle size distribution:

The following particle size distribution was utilized to evaluate a manufactured treatment system (See Table 2). A natural/commercial soil representing the USDA definition of a sandy loam material was used. This hypothetical distribution was selected as it represents the various particles that would be associated with typical stormwater runoff from a post construction site.

Specifically, the following distribution can be utilized:

**Table 2. Particle Size Distribution**

<b>Particle Size (microns)</b>	<b>Sandy loam (percent by mass)</b>
500-1000 (coarse sand)	5.0
250-500 (medium sand)	5.0
100-250 (fine sand)	30.0
50-100 (very fine sand)	15.0
2-50 (silt)	(8-50 um, 25%) (2-8 um, 15%)*
1-2 (clay)	5.0

Notes:

1. Recommended density of particles  $\leq 2.65$  g/cm<sup>3</sup>

\*The 8 um diameter is the boundary between very fine silt and fine silt according to the definition of American Geophysical Union. The reference for this division/classification is: Lane, E. W., et al. (1947), "Report of the Subcommittee on Sediment Terminology," Transactions of the American Geophysical Union, Vol. 28, No. 6, pp. 936-938.

2. Full scale lab test requirements

- A. At a minimum, complete a total of 15 test runs including three (3) tests each at a constant flow rate of 25, 50, 75, 100, and 125 percent of the treatment flow rate. These tests should be operated with initial sediment loading of 50% of the unit's capture capacity.
- B. The three tests for each treatment flow rate will be conducted for influent concentrations of 100, 200, and 300 mg/L.
- C. For an online system, complete two tests at the maximum hydraulic operating rate. Utilizing clean water, the tests will be operated with initial sediment loading at 50% and 100% of the unit's capture capacity. These tests will be utilized to check the potential for TSS resuspension and washout.
- D. The test runs should be conducted at a temperature between 73-79 degrees Fahrenheit or colder.

3. Measuring treatment efficiency

- A. Calculate the individual removal efficiency for the 15 test runs.
- B. Average the three test runs for each operating rate.

- C. The average percent removal efficiency will then be multiplied by a specified weight factor (see Table 3) for that particular operating rate.
- D. The results of the five numbers will then be summed to obtain the theoretical annual TSS load removal efficiency of the system.

**Table 3. Treatment Operating Rates and Weight Factors**

<b>Treatment operating rate</b>	<b>Weight factor</b>
25%	.25
50%	.30
75%	.20
100%	.15
125%	.10

Notes:

Weight factors were based upon the average annual distribution of runoff volumes in New Jersey and the assumed similarity with the distribution of runoff peaks. This runoff volume distribution was based upon accepted computation methods for small storm hydrology and a statistical analysis of 52 years of daily rainfall data at 92 rainfall gages.

## **5.2 Laboratory Studies**

In June of 2005, Stormwater360<sup>TM</sup> initiated a VortSentry<sup>®</sup> laboratory testing program in accordance with the New Jersey Department of Environmental Protection's (NJDEP) Total Suspended Solids Laboratory Test Procedure. All testing was conducted in the Stormwater360<sup>TM</sup> laboratory in Scarborough, ME on a full scale 4-ft diameter VortSentry<sup>®</sup> model VS40. The ultimate objective of the testing program was to provide a sufficient body of performance data to warrant an interim certification from the NJDEP. In order to comply with the requirements of the NJDEP testing protocol and to provide a data set that is comparable to the data sets of other stormwater treatment technologies that have completed the Tier I testing program, Stormwater360<sup>TM</sup> modeled its VortSentry<sup>®</sup> test plan to be consistent with the test plans for other technologies that have participated in the Tier I testing program.

All testing was conducted using F-95, a commercially available silica sand gradation (See Figure 4). Sediment was mixed with tap water in a 55-gallon recirculating slurry bin. A peristaltic pump was utilized to meter the slurry mixture into the influent line upstream of the test apparatus at a known rate.

Influent samples were collected at a 6-inch gate valve located upstream of the VortSentry<sup>®</sup> System. Effluent samples were collected by sweeping a sample bottle through the free discharge of a down-turned 90° PVC elbow, which discharges into a catch tank downstream of the VortSentry<sup>®</sup> System. All samples were collected in 500 ml HDPE sample bottles. Once the system was stabilized at the desired flow rate the metering pump was activated, starting the delivery of sediment to the VortSentry<sup>®</sup> System. Once sediment introduction was initiated, the

system was run for a period of time equal to three times the detention time of the system before the first samples were collected. This allows the system to reach equilibrium. After three detention times have passed, a series of ten paired influent and effluent samples were taken at one minute intervals. Effluent samples were staggered from influent samples by the detention time of the test unit. Once ten influent and effluent samples were collected, the system was shut down. Sediment was not removed from the test system after each test effectively allowing additional sediment to accumulate within the treatment chamber sump.

To reduce recirculation of material within the test system, a silt fence was constructed in the catch tank to filter the effluent before it was pumped back to the water supply tank. Background samples were drawn from the water supply tank using a GLI Automatic Vacuum Sampler to monitor the sediment concentration in the source water. If the mean sediment concentration in the source water exceeded 10 mg/l during a test, the water supply tank was drained and cleaned, and the test was then repeated.

### **5.2.1 Performance Testing Procedure**

1. Prior to the start of each test, the VortSentry<sup>®</sup> System was filled to 50% of its sediment capture depth (1.5ft) with F-95 sediment.
2. A sediment/water slurry was prepared in a ratio of 1.25 lb of sediment/gallon of water in the slurry mixer.
3. Adequate mixing was ensured by starting the slurry mixture at least five minutes before the start of the sediment metering pump.
4. The inlet flow control valve was opened and the flow rate through the VortSentry<sup>®</sup> System was stabilized at the target flow rate. The system was considered stable when the flow rate remained stable for approximately one minute.
5. The metering pump was started at the target rpm rate (rate required to produce target influent concentration). This was time 0:00.
6. After three detention times, the first background sample was collected. Background samples were collected at a one minute interval for the duration of the test.
7. One minute after the first background sample was taken, the first influent sample was collected. Influent samples were collected at one minute intervals until ten samples are taken.  
Note: Immediately before each influent sample was taken, the gate valve was flushed by quickly opening and closing it. This cleared any settled material from the mouth of the valve.
8. One detention time after the first influent sample was taken, the first effluent sample was collected.
9. Effluent samples were collected at a one minute interval until ten samples were taken.
10. After ten influent and effluent samples were collected, the metering pump and slurry tank mixer were stopped.
11. The background sampler was then stopped.
12. The VortSentry<sup>®</sup> System was shut down.

### **5.2.2 Washout Testing Procedure**

Upon completion of the required performance testing, two washout trials were conducted to determine the potential for material to be scoured from the VortSentry<sup>®</sup> System. The first trial



was conducted with the VortSentry® model VS40 filled to 50% (19 ft<sup>3</sup>) of its sediment capture volume with F-95. The second trial was conducted with the VortSentry® System filled to 100% (38 ft<sup>3</sup>) of its sediment capture volume. Both of these trials were conducted at the system's peak hydraulic capacity. Both trials were conducted with clean water. No sediment was injected into the influent stream. Upon start up, the system was brought to its peak operating capacity. Effluent sampling was started as soon as flow was introduced to the unit and continued in 30-second intervals until the conclusion of the test. Sampling before the unit had reached its hydraulic capacity was allowed for documentation of any material that was scoured before the VortSentry® System reaches hydraulic capacity. Once the system had reached hydraulic capacity, sampling continued in 30 second intervals for five minutes. Given the relatively short detention time of the unit under peak operating conditions, this was ample time to determine the unit's scour potential.

### **5.2.3 Sample Analysis**

Sample analysis was conducted at the Stormwater360™, Inc. laboratory by trained laboratory technicians. Samples were analyzed in compliance with ASTM D 3977-97 a whole sample variation of the TSS method, also referred to as the suspended sediment concentration (SSC) method.

### **5.2.4 Description of Laboratory Testing Facility**

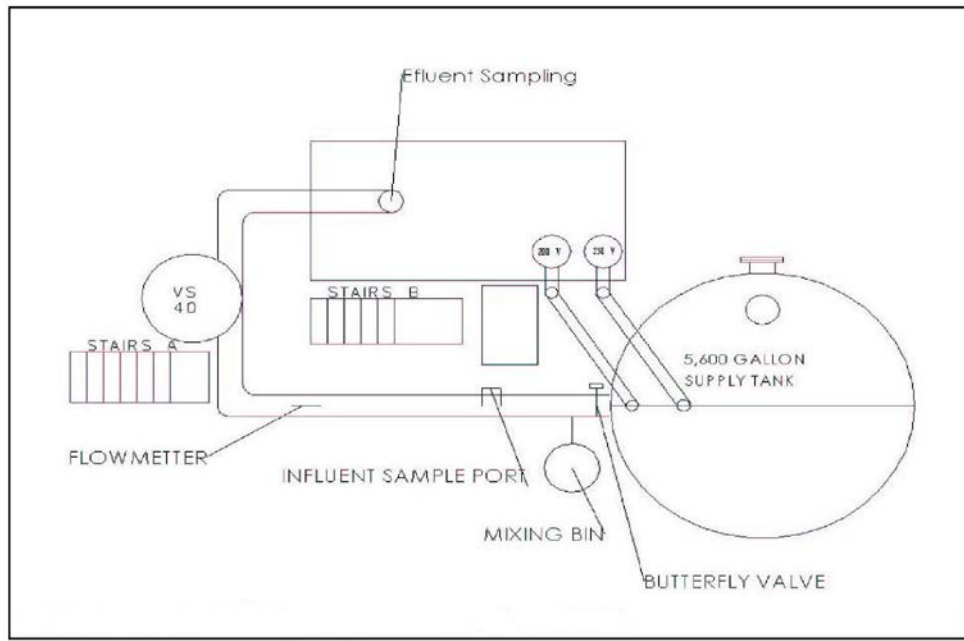
All VortSentry® System performance testing was conducted at the Stormwater360™, Inc. research laboratory in Scarborough, Maine. Water was stored in a 5,600 gallon supply tank and delivered to the VortSentry® System through a gravity fed 12-inch diameter PVC pipe. Flow through the pipe was regulated by a 12 inch butterfly valve located upstream of the VortSentry® System. A 1/3 horse power Dayton split phase motor was used to mix sediment and water into a slurry in a 55 gallon conical bottom mixing bin. The slurry was then metered into the 12 inch PVC pipe just downstream of the butterfly valve with a Watson Marlow peristaltic pump. The conical bottom slurry tank was equipped with an under drain which remained open during the test to allow the slurry to be continuously recirculated within the bin with a Randolph Model 750 peristaltic pump. Influent samples were collected through a 6 inch PVC gate valve located directly downstream of the sediment metering port. Flow was monitored with an ISCO 4250 Area Velocity flow meter that was installed in the influent pipe. Effluent discharged from a down turned 12 inch PVC elbow into an aluminum catch tank. A silt fence, consisting of standard landscaping fabric mounted to a frame, was installed in the catch tank to filter effluent before it was recirculated to the water supply tank. Two ten horsepower Zoeller sewage pumps returned flow from the catch tank to the supply tank. The layout of the VortSentry® System test setup is shown in Figure 5.

### **5.2.5 Laboratory Testing Results**

Results of the 15 individual tests conducted in accordance with the NJDEP laboratory testing protocol are summarized in Table 4. The target flow rate for each test was determined assuming the target treatment flow rate was 1.1 cfs. The target treatment flow rate was identified through preliminary testing to gauge system performance. The actual flow rate as reported in Table 4

represents the mean flow rate measured during each test. The removal efficiency reported for each test represents the mean suspended solids load reduction for that test and is calculated using the following equation:

$$\text{Removal Efficiency} = (\text{Influent Conc.} - \text{Effluent Conc.}) / \text{Influent Conc.}$$



**Figure 5. Laboratory Testing Facility for the VortSentry® System**

**Table 4. Summary of VortSentry® Laboratory Testing Results with F-95 Grade Silica**

Test Number	Percent of Treatment Flow (%)	Target Flow Rate (cfs)	Target Conc. (mg/l)	Actual Flow Rate (cfs)	Influent Conc. (mg/l)	Effluent Conc. (mg/l)	Removal Efficiency (%)
1	25	0.27	100	0.27	88	6	93
2	25	0.27	200	0.27	200	12	94
3	25	0.27	300	0.26	266	13	95
4	50	0.55	100	0.56	92	23	75
5	50	0.55	200	0.54	219	60	73
6	50	0.55	300	0.54	521	121	77
7	75	0.82	100	0.84	130	44	66
8	75	0.82	200	0.83	142	53	63
9	75	0.82	300	0.81	304	122	60
10	100	1.10	100	1.11	95	49	48
11	100	1.10	200	1.10	167	80	52
12	100	1.10	300	1.09	277	164	41
13	125	1.35	100	1.35	137	102	26
14	125	1.35	200	1.24	233	163	30
15	125	1.35	300	1.35	263	179	32

### 5.2.6 Washout Testing Results

As required by the NJDEP laboratory testing protocol, a washout analysis was conducted at both 50 and 100 percent of the VortSentry® System sediment storage capacity. The protocol required each trial to be conducted at the maximum hydraulic operating rate of the unit. Due to the driving head limitations of the water supply tank in the laboratory, the maximum hydraulic operating rate for the model VS40 VortSentry® System was approximately 1.8 cfs. A VortSentry® model VS40 can be configured with additional hydraulic capacity, but this additional flow was directed over the flow partition and did not significantly impact the flow rate or velocity of flow through the treatment chamber. By limiting the flow rate and velocity through the treatment chamber, resuspension of previously captured material is unlikely.

The mean flow rate for the washout tests at both 50 and 100 percent of sediment storage capacity was 1.77 cfs. Results for both tests are shown in Table 5. During both tests the sediment concentration in the source water was monitored and subtracted from the VortSentry® System effluent concentration. Solids in the source water are typically attributable to recirculation of material during previous tests. With the sump filled to 50 percent of the VortSentry® System sediment storage capacity (1.5 feet), no washout was observed. The mean effluent concentration for suspended solids was less than the mean background concentration indicating a net removal of solids from the source water as it passed through the VortSentry® System. With the sump filled to 100 percent of the VortSentry® System sediment storage capacity (three feet), minimal washout was observed. The mean effluent concentration for suspended solids was slightly higher than the mean background concentration indicating a small amount of material was exported from the system. The mean effluent solids concentration after accounting for background solids was 8 mg/l, which is quite low; fine particles were present in the F-95 stock as a result of manufacture and handling. Most of the sediment was manually loaded into the VortSentry® System for this testing as opposed to being captured by the unit, so it is likely that residual fine material that would not typically be present in the sump was subsequently lost from the unit.

**Table 5. Results of Washout Testing at 50% and 100% of the VortSentry® Sediment Storage Capacity**

	<b>Average Background Concentration (mg/l)</b>	<b>Average Effluent Concentration (mg/l)</b>	<b>Mean Adjusted Effluent Concentration (mg/l)</b>
50% of sediment storage capacity (1.5 ft)	8	5	-3
100% of sediment storage capacity (3 ft)	5	14	8

### 5.3 Verification Procedures

All the data provided to NJCAT were reviewed to fully understand the capabilities of the VortSentry® System. To verify the Stormwater360™, Inc. claim, the laboratory data were reviewed and compared to the NJDEP Laboratory Testing Protocol. Although Stormwater360™, Inc. attempted to design their laboratory experiment to satisfy the NJDEP TSS laboratory testing protocol, there are two distinct differences between Stormwater360™, Inc. laboratory testing and the NJDEP protocol. The NJDEP protocol is for total suspended solids (TSS) laboratory testing, while Stormwater360™, Inc. analyzed their samples as suspended sediment concentration (SSC). Also, the  $d_{50}$  of the NJDEP recommended sediment is approximately 67 microns, while the  $d_{50}$  of the F-95 silica used in the Stormwater360™, Inc. laboratory testing was 120 microns.

The NJDEP weighting factors were used with the laboratory data that were presented in Table 4. The resulting overall removal efficiency based upon the NJDEP methodology is presented below in Table 6.

Since the treatment volume of the VS40 system is 50 ft<sup>3</sup>, the tested flow rate of 1.1 cfs can be converted to 9.8 gpm/ft<sup>3</sup>(0.022 cfs/ft<sup>3</sup>). Based upon the data presented in Table 6, the removal efficiency of the system is 69%, thereby verifying the Stormwater360™, Inc. claim.

Based upon the wash out laboratory data presented by Stormwater360™, Inc., there is virtually no potential of re-suspension and wash out of sediment contained in the VortSentry® System.

**Table 6. Weighted Removal Efficiency for the VortSentry® System**

<b>Percent of Treatment Flow Rate (%)</b>	<b>Target VS40 Flow Rate (cfs)</b>	<b>Removal Efficiency (%)</b>	<b>Weight factor</b>	<b>Weighted Removal Efficiency (%)</b>
25	0.27	94	0.25	24
50	0.55	75	0.30	22
75	0.82	63	0.20	13
100	1.10	47	0.15	7
125	1.35	29	0.10	3
<b>Weighted Removal Efficiency =</b>				<b>69</b>

### 5.3.1 Verified Treatment Flow

In order to appropriately scale any hydraulic structure, there must be similitude between the proposed model and the tested laboratory prototype. Geometric similitude is achieved by maintaining a constant aspect ratio of 0.9 for all models. For modeling purposes, the treatment depth is considered to be the distance from the top of the flow partition to the top of the 3' deep storage sump.

It has been shown in the laboratory that VortSentry® removal rates are dependent on the volumetric operating rate. Therefore, treatment flow rates for models other than the tested unit have been calculated which provide the same volumetric operating rate of 9.8 gpm/ft<sup>3</sup> (0.022 cfs/ft<sup>3</sup>). Table 7 shows these peak treatment flow rate for each VortSentry® model.

**Table 7. VortSentry Treatment Flows Assuming Volumetric Scaling**

Model Number	Diameter (ft)	Treatment Volume (ft <sup>3</sup> )	Treatment Flow Rate		Operating Rate	
			(cfs)	(gpm)	(cfs/ft <sup>3</sup> )	(gpm/ft <sup>3</sup> )
VS30	3	21	0.46	207	0.022	9.8
VS40	4	50	1.1	494	0.022	9.8
VS50	5	98	2.15	965	0.022	9.8
VS60	6	170	3.71	1,665	0.022	9.8
VS70	7	269	5.90	2,648	0.022	9.8
VS80	8	402	8.80	3,950	0.022	9.8
VS100*	10*	785	17.19	7,715	0.022	9.8
VS120*	12*	1,357	29.70	13,330	0.022	9.8

\* 10 and 12 ft. diameter units are not available in all markets.

### 5.4 Inspection and Maintenance

The VortSentry® System requires minimal routine maintenance. However, it is important that the system be inspected at regular intervals and cleaned when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more on site activities than the size of the unit (i.e., heavy winter sanding will cause the treatment chamber to fill more quickly but regular sweeping will slow accumulation).

#### 5.4.1 Inspection

Inspection is the key to effective maintenance, and it is easily performed. Stormwater360™, Inc. recommends ongoing quarterly inspections of accumulated pollutants. Sediment accumulation may be especially variable during the first year after installation as catch basin sumps are filled and as construction disturbances and landscaping stabilize. Quarterly inspections are typically sufficient to ensure that systems are cleaned out at the appropriate time. Inspections may need to be performed more often in the winter months in climates where sanding operations may lead to

rapid accumulations or in other areas with heavy sediment loading. It is very useful to keep a record of each inspection.

The VortSentry® System should be cleaned when inspection reveals that the sediment depth has accumulated to three feet in the treatment chamber sump. This determination can be made by taking two measurements with a stadia rod or similar measuring device. One measurement should be taken from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. The system should be cleaned out if the difference between the two measurements is three feet or more.

Note: To avoid underestimating the volume of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile may offer less resistance to the end of the rod than larger particles toward the bottom of the pile.

#### **5.4.2 Maintenance**

Maintaining the VortSentry® System is easiest when there is no flow entering the system. For this reason it is a good idea to schedule the cleanout during dry weather. Cleanout of the VortSentry® System with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. If such a truck is not available, a “clamshell” grab may be used, but it is difficult to remove all accumulated pollutants with these devices.

Accumulated sediment is typically evacuated through the manhole over the treatment chamber. Simply remove the cover and insert the vacuum hose into the treatment chamber. All contents of the treatment chamber should be removed with the vacuum hose. The treatment chamber will contain a combination of liquid, sediment, floating debris, and oil and grease.

Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually cheaper to dispose of than the oil water emulsion that may be created by vacuuming the oily layer. In VortSentry® System installations where there is little risk of petroleum spills, liquid contaminants may not accumulate as quickly as sediment. However, any oil or gasoline spill should be cleaned out immediately. Trash can be netted out if it needs to be separated from the other pollutants.

Manhole covers should be securely seated following cleaning activities, to ensure that surface runoff does not leak into the unit from above.

#### **5.4.3 Solids Disposal**

Solids recovered from the VortSentry® System can typically be land filled or disposed of at a wastewater treatment plant, but local regulations will ultimately govern disposal procedures.

#### **5.4.4 Damage Due to Lack of Maintenance**

It is unlikely that the VortSentry® System will become damaged due to lack of maintenance since there are no fragile internal parts. However, adhering to a regular maintenance plan ensures optimal performance of the system.

### **6. Technical Evaluation Analysis**

#### **6.1 Verification of Performance Claim**

Based on the evaluation of the results from laboratory studies, sufficient data is available to support the Stormwater360™, Inc. claim: The VortSentry® Stormwater Treatment System, Model VS40, sized at a loading rate of 9.8 gpm/ft<sup>3</sup> (0.022cfs/ft<sup>3</sup>) of treatment volume, has been shown to have a 69% total suspended solids (TSS) removal efficiency, as measured as suspended solids concentration (SSC) (as per the NJDEP methodology for calculation of treatment efficiency) for F-95 silica sand with an average d<sub>50</sub> particle size of 120 microns, an average influent concentration of 209 mg/L and 50% initial sediment loading in laboratory studies using simulated stormwater.

#### **6.2 Limitations**

##### **6.2.1 Factors Causing Under-Performance**

If the VortSentry® System is designed and installed correctly, there is minimal possibility of failure. There are no moving parts to bind or break, nor are there parts that are particularly susceptible to wear or corrosion. Lack of maintenance may cause the system to operate at a reduced efficiency, and it is possible that eventually the system will become totally plugged with sediment.

##### **6.2.2 Pollutant Transformation and Release**

The VortSentry® System will not increase the net pollutant load to the downstream environment. However, pollutants may be transformed within the unit. For example, organic matter may decompose and release nitrogen in the form of nitrogen gas or nitrate. These processes are similar to those in wetlands but probably occur at slower rates in the VortSentry® System due to the absence of light and mixing by wind, thermal inputs and biological activity. Accumulated sediment will not be lost from the system under normal operating conditions.

##### **6.2.3 Sensitivity to Heavy or Fine Sediment Loading**

The VortSentry® System requires no pretreatment. Heavy loads of sediment will increase the needed maintenance frequency but will not negatively affect overall performance.

#### **6.2.4 Bypass Flow**

The VortSentry® System is typically designed such that a portion of the total conveyance flow through the system is bypassed around the treatment chamber. Flow rates exceeding the treatment capacity of the system are typically routed around the treatment chamber over the flow partition.

#### **6.2.5 Mosquitoes**

The VortSentry® System design incorporates standing water in the treatment chamber sump, which can be a breeding site for mosquitoes. To address this potential problem Stormwater360™ sells an optional manhole cover insert that allows outgassing but will prevent mosquitoes from entering the system through the manhole covers. A flap valve can be installed at the terminal end of the outlet pipe to prevent mosquitoes from entering the unit from the downstream side.

### **7. Net Environmental Benefit**

The NJDEP encourages the development of innovative environmental technologies (IET) and has established a performance partnership between their verification/certification process and NJCAT's third party independent technology verification program. The NJDEP, in the IET data and technology verification/certification process, will work with any company that can demonstrate a net beneficial effect (NBE) irrespective of the operational status, class or stage of an IET. The NBE is calculated as a mass balance of the IET in terms of its inputs of raw materials, water and energy use and its outputs of air emissions, wastewater discharges, and solid waste residues. Overall the IET should demonstrate a significant reduction of the impacts to the environment when compared to baseline conditions for the same or equivalent inputs and outputs.

Once VortSentry® Systems have been certified for interim use within New Jersey, Stormwater360™, Inc. will then proceed to install and monitor systems in the field for the purpose of achieving goals set by the Tier II Protocol and final certification. At that time, a net environmental benefit evaluation will be completed. However, it should be noted that the Stormwater360™, Inc. technology requires no input of raw material, has no moving parts, and therefore, uses no water or energy.

### **8. References**

Patel, M. 2003, *Draft Total Suspended Solids Laboratory Testing Procedures*, December 23, 2003, New Jersey Department of Environmental Protection, Office of Innovative Technology and Market Development.

Stormwater360™, Inc., October 2005, VortSentry® Stormwater Treatment System Technology Report, *Prepared for: New Jersey Corporation for Advanced Technology*.

Stormwater360™, Inc., October 2005, VortSentry® Technical Design Manual.





## State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION

Bureau of Nonpoint Pollution Control

Division of Water Quality

Post Office Box 029

Trenton, New Jersey 08625-029

609-633-7021 Fax: 609-984-2147

[http://www.state.nj.us/dep/dwq/bnpc\\_home.htm](http://www.state.nj.us/dep/dwq/bnpc_home.htm)

CHRIS CHRISTIE  
*Governor*

KIM GUADAGNO  
*Lt. Governor*

BOB MARTIN  
*Acting Commissioner*

Derek Berg  
Regulatory Manager – Stormwater  
CONTECH Engineered Solutions  
200 Enterprise Drive  
Scarborough, ME 04074

Re: Final Certification  
Continuous Deflective Separator (CDS) by CONTECH Engineered Solutions LLC

**Expiration Date: December 1, 2016**

**TSS Removal Rate: 50%**

Dear Mr. Berg:

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7(c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). CONTECH Engineered Solutions LLC has requested a Final Certification for the Continuous Deflective Separator (CDS) Stormwater Treatment System.

This project falls under the July 15, 2011 “Transition for Manufactured Treatment Devices,” under *C. Manufactured Treatment Devices Seeking Final Certification – In Process* which are MTDs that have commenced field testing on or before August 1, 2011.

NJDEP received the required information and signed statements by the NJCAT Technical Director and the manufacturer indicating that the requirements of the Field Testing Protocols in place at the initiation of testing have been met or exceeded. The NJCAT letter also includes a recommended certified TSS removal rate and the required maintenance plan.

**The NJDEP certifies the use of the CONTECH Engineered Solutions LLC CDS Stormwater Treatment System at a TSS removal rate of 50%, subject to the following conditions:**

1. The various models and associated water quality flow capacities shall be sized for the peak flow of the New Jersey Water Quality Design Storm per N.J.A.C. 7:8-5, as shown in Table 1 below.

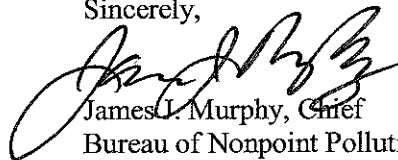
New Jersey Treatment Rates for CDS Models Based on a Surface Area Specific Loading Rate of 25.16gpm/ft <sup>2</sup>		
CDS Model	Manhole Diameter (ft)	Treatment Flow Rate (cfs)
CDS-4	4	0.7
CDS-5	5	1.1
CDS-6	6	1.6
CDS-8	8	2.8
CDS-10	10	4.4
CDS-12	12	6.3

2. The CDS Stormwater Treatment System can be used on-line or off-line.
3. A hydrodynamic separator, such as the CDS Stormwater Treatment System, cannot be used in series with another hydrodynamic separator to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.
4. The maintenance plan for the sites using this device shall incorporate at a minimum, the maintenance requirements for the CDS Stormwater Treatment System shown attached.

In addition to the attached, the detailed maintenance plan must include all of the items identified in Chapter 8: Maintenance of the New Jersey Stormwater Best Management Manual. Such items include, but are not limited to, the list of inspection and maintenance equipment and tools, specific corrective and preventative maintenance tasks, indication of problems in the system, and training of maintenance personnel.

Additional information regarding the implementation of the Stormwater Management rules N.J.A.C. 7:8 are available at [www.njstormwater.org](http://www.njstormwater.org). Please contact Sandra Blick of my office at (609) 633-7021 if you have any questions.

Sincerely,



James L. Murphy, Chief  
Bureau of Nonpoint Pollution Control

c: Chron File  
Richard Magee, NJCAT  
Mark Pedersen, DLUR  
Elizabeth Dragon, BNPC

# CDS Maintenance

The CDS system must be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit, e.g., unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping will slow accumulation.

## Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant deposition and transport may vary from year to year and regular inspections will help insure that the system is cleaned out at the appropriate time. At a minimum, inspections must be performed twice per year (i.e. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid pollutant accumulations, or in equipment washdown areas. Additionally, installations where excessive amounts of trash are expected should be inspected more frequently.

The visual inspection must ascertain that the system components are in working order and that there are no blockages or obstructions to the inlet and/or separation screen. The inspection must also identify accumulations of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick such as a stadia rod, tape measure or other measuring instrument. If sorbent material is used for enhanced removal of hydrocarbons then the level of discoloration of the sorbent material should also be identified during inspection. Sorbent material must be replaced when it is predominantly dark in color (similar to oil). It is useful and often required as part of a permit to keep a record of each inspection.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (screen/cylinder) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained behind the screen. For units possessing a sizable depth below grade (depth to pipe), a single access point allows for both sump cleanout and access behind the screen.

The CDS system must be cleaned when the level of sediment in the sump has reached a depth of 12 inches or more to avoid exceeding the maximum 24 inch sediment depth and/or when an appreciable level of hydrocarbons and trash has accumulated. If sorbent material is used, it must be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Finer, silty particles at the top of the pile typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine if the height of the sediment pile off the bottom of the sump floor exceeds 75% (18 inches) of the total height of isolated sump.

## **Cleaning**

Cleaning of the CDS systems should be done during dry weather conditions when no flow is entering the system. Cleanout of the CDS with a vacuum truck is generally the most effective and convenient method of excavating pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be pumped out if pollutant build-up exists in this area.

In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, an oil or gasoline spill should be cleaned out immediately. Motor oil and other hydrocarbons that accumulate on a more routine basis must be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use adsorbent pads since they are usually less expensive to dispose of than the oil/water emulsion that may be created by vacuuming the oily layer. Trash can be netted out if you wish to separate it from the other pollutants. The screen should be power washed to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure proper safety precautions. Confined Space Entry procedures need to be followed.

Disposal of all material removed from the CDS system must be done in accordance with local regulations. In many locations, disposal of evacuated sediments may be handled in the same manner as disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

## **Illicit Discharge Compliance Statement**

### **Responsibility:**

The Owner is responsible for ultimate compliance with all provisions of the Massachusetts Stormwater Management Policy, the USEPA NPDES Construction General Permit and responsible for identifying and eliminating illicit discharges (as defined by the USEPA).

**OWNER NAME:** SLV School Street, LLC.

**ADDRESS:** 257 Hillside Avenue

Needham, MA 02494

**TEL. NUMBER:** (617) 276-7261

### **Engineer's Compliance Statement:**

To the best of my knowledge, the attached plans, computations and specifications meet the requirements of Standard 10 of the Massachusetts Stormwater Handbook regarding illicit discharges to the stormwater management system and that no detectable illicit discharges exist on the site. All documents and attachments were prepared under my direction and qualified personnel properly gathered and evaluated the information submitted, to the best of my knowledge.

Included with this statement are site plans, drawn to scale, that identify the location of systems for conveying stormwater on the site and show that these systems do not allow the entry of any illicit discharges into the stormwater management system. The plans also show any systems for conveying wastewater and/or groundwater on the site and show that there are no connections between the stormwater and wastewater systems.

For a redevelopment project (if applicable), all actions taken to identify and remove illicit discharges, including without limitation, visual screening, dye or smoke testing, and the removal of any sources of illicit discharges to the stormwater management system are documented and included with this statement.

Notwithstanding the foregoing, an illicit discharge does not include discharges from the following activities or facilities: firefighting, water line flushing, landscape irrigation, uncontaminated groundwater, potable water sources, foundation drains, air conditioning condensation, footing drains, individual resident car washing, flows from riparian habitats and wetlands, dechlorinated water from swimming pools, water used for street washing, and water used to clean residential buildings without detergents.