Stormwater Management Report

LACKEY DAM LOGISTICS CENTER

Lackey Dam Road
Sutton and Uxbridge, Massachusetts

Prepared for:
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9/6/2022

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LIST OF ATTACHMENTS

1.0 INTRODUCTION

The proposed Lackey Dam Logistics Center development consists of an approximately 179,122 square feet warehouse building including associated improvements (the Project). The proposed Project includes a stormwater management system designed to mitigate potential impacts the proposed Project could have on the existing watershed. Stormwater controls have been proposed to control peak runoff rates, provide water quality treatment and sediment removal, and promote groundwater recharge. The proposed system has been designed to comply with:

- The 2008 Massachusetts Department of Environmental Protection (DEP) Stormwater Management Handbook,
- The Massachusetts Wetland Protection Act (310 CMR 10.00), and
- Local Wetland Regulations

The pre- and post-development hydrologic conditions were modeled using HydroCAD™ version 10.20-2d to demonstrate that post-development stormwater runoff rates will be less than or equal to the pre-development rates. Watershed maps with soil types as well as a detailed analysis of the model results are also included. The following table summarizes the peak runoff rates for the pre- and post-development conditions.

Table 1: Pre- & Post-development Peak Runoff Rate Comparison, units are in cubic feet per second (cfs).

Storm Event	2 Year		10 Year		100 Year	
	Pre	Post	*Pre*	Post	*Pre*	Post
Design Point 1	*0.28*	0.76	*3.80*	3.54	*24.00*	23.82
Design Point 2	*0.94*	0.50	*7.08*	3.11	*29.99*	14.70
Design Point 3	*0.00*	0.00	*0.01*	0.00	*0.37*	0.01

2.0 PRE-DEVELOPMENT CONDITIONS

2.1 Site Conditions

The proposed development is located off Lackey Dam Road in the towns of Sutton and Uxbridge, Massachusetts. The site is largely undeveloped and contains wooded areas interspersed with forested wetlands. The Project site is bounded by Lackey Dam Road to the south and east, Oakhurst Road to the north, wetlands to the east and southwest, and abutting residential and industrial properties to the northwest. The existing #100 Lackey Dam Road single-family residence is located at the south end of the proposed development. The southern portion of the site slopes toward Lackey Dam Road and toward the wetland system located along the southwestern perimeter of the site. There is a high point located along the northwestern perimeter of site. The northern portion of the site slopes toward the eastern wetland system with a minor, northern area first draining directly to Oakhurst Road. The southwestern and eastern wetland systems drain to the eastern side of Lackey Dam Road via existing culvert pipes.

Runoff from the site currently drains to three primary locations:

DP-1: Wetland system located along the southwestern portion of the site.
DP-2: Wetland system located along the northeastern portion of the site.
DP-3: Oakhurst Road along the northern portion of the site.

These design points have been named correspondingly in the hydrologic analyses.

2.1.1 Critical Areas

Critical Areas as defined by Standard 6 of the 2008 MassDEP Stormwater Management Handbook are areas where high levels of stormwater treatment is required; typically the first inch of runoff is treated using specific best management practices (BMPs) and pre-treatment methods. Specific source control and pollution prevention measures are also required.

The site does not contain, nor is it tributary to any Critical Areas.

2.1.2 Total Maximum Daily Loads (TMDL)

A TMDL is the greatest amount of a pollutant that a waterbody can accept and still meet water quality standards for protecting public health and maintaining the designated beneficial uses of those waters for drinking, swimming, recreation, and fishing. A TMDL is implemented by specifying how much of that pollutant can come from point, nonpoint, and natural sources.

The site is not within a watershed with a TMDL or draft TMDL.

2.2 Soil Description

The Natural Resources Conservation Service (NRCS) lists the on-site soils as Hydrologic Soil Group (HSG) A & B. The NRCS Soil Survey mapped one area as “Not Rated/Not Available”. For design purposes, this area was assumed to be HSG D.

A representative from McArdle Gannon Associates, Inc. (MGA), the project geotechnical engineer, conducted site wide soil testing that verify the NRCS classification. This testing informed elevations of estimated seasonal high groundwater and refusal.

Refer to Attachment 1: Soil Data for additional information.

2.3 Hydrologic Analysis

Sub-catchment areas were delineated based on existing runoff patterns and topographic information. This information is shown on the *Pre-Development Conditions Watershed Map* included in Attachment 2. Summaries of each area with respect to Curve Number and Time of Concentration calculations can be found in the model results also in Attachment 2.

3.0 POST-DEVELOPMENT CONDITIONS

3.1 Design Strategy

The proposed development includes a 179,122 square foot warehouse building with associated loading bays, parking areas and access drives. Significant earthwork will be required for the project. During the preliminary design phase of the site layout, consideration was given to conserving environmentally sensitive features and minimizing impacts on the existing hydrology.

Stormwater runoff from the proposed parking areas and roadways will be collected in deep sump hooded catch basins and subsequently conveyed through a drain pipe network and proprietary stormwater quality treatment units prior to discharging to three infiltration basins located throughout the site for peak rate attenuation and recharge to groundwater. Runoff from the proposed rooftop will be collected in a subsurface roof drain network and will also discharge to two of the three infiltration basins. The basins will discharge upland of the on-site wetland systems, consistent with the existing hydrology of the site.

All stormwater BMPs were designed to treat a minimum of the first 0.5 inch of runoff generated by the on-site impervious areas. Stormwater BMP sizing worksheets and water quality sizing calculations are included in Attachment 5 of this report.

Infiltration basins were selected as the primary best management practices for peak rate attenuation due to the mapped NRCS soils onsite as well as the depths to groundwater as confirmed by the soil testing.

3.2 Hydrologic Analysis

The design points established for the pre-development conditions analysis were used in the post-development analysis for direct comparison. The tributary areas and flow paths were modified to reflect post-development conditions. See Attachment 3 for the *Post-Development Conditions Watershed Map*. Summaries of each area with respect to Curve Number and Time of Concentration calculations can be found in the model results in Attachment 3.

3.3 Stormwater Management Controls Sizing

Infiltration Basins

The three infiltration basins have been designed to reduce post-development peak rates of runoff up to the 100-year storm event. In order to reduce sediment and meet treatment requirements, runoff will be conveyed to proprietary treatment structures prior to discharging into each of the three infiltration basins. The outlet control structures have been designed as a multi-stage outlet with low-flow orifices proposed above the bottom of the basin to infiltrate retained runoff and control the discharge rates for a variety of storm events. The outlets consist of precast structures with circular orifices and/or rectangular weirs routed to pipe outfalls with flared ends and riprap pads at the discharge points to direct stormwater towards the bordering vegetated wetlands (BVW). To prevent overtopping, an emergency spillway has been provided (in addition to open grates at the top of the outlet control structures) to direct the excess flow towards the BVW, consistent with the existing drainage pattern. The basins have been designed so that they will provide the required offset to groundwater.

The infiltration basins were sized using the static method, as described in Chapter 3 of the Massachusetts Stormwater Handbook, using a Rawls exfiltration rate of 0.52 inches per hour (for HSG B soils). The system has been designed to meet the required recharge volume and will fully dewater within 72 hours.

3.4 Hydraulic Calculations

In compliance with local requirements, the proposed stormwater collection and conveyance system will be designed to convey the 25-year rational storm event as well as to not surcharge structure grates and covers during the 100-year rational storm event. A watershed map and detailed hydraulic analysis are provided in Attachment 4.

3.5 Compliance with DEP Stormwater Management Standards

The proposed stormwater management system was designed in compliance with the ten (10) DEP Stormwater Management Standards. The following summary provides key information related to the proposed stormwater management system, its design elements, and mitigation measures for potential impacts.

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

There will be no direct discharge of untreated stormwater to nearby wetlands or waters of the Commonwealth. Runoff from impervious areas of the site will be conveyed to stormwater management controls for water quality treatment, runoff rate attenuation and groundwater recharge prior to discharge to adjacent wetlands.

STANDARD 2: **Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates.**

The stormwater management design will generally control post-development peak discharge rates for the 2, 10, & 100-year, 24-hour storms so as to maintain pre-development peak discharge rates. There is a de minimis increase in the peak rate of runoff at DP-1 during the 2-year storm. This is due to elevation constraints (not being able to route all of the post-development subcatchments adjacent to Lackey Dam Road to Basin #1, given the proposed bottom elevation). Refer to Section 1.0 Introduction for a summary of the peak rates of runoff.

STANDARD 3: **Loss of annual recharge to groundwater shall be eliminated or minimized through the use of environmentally sensitive site design, low impact development techniques, stormwater 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 types. 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 stormwater management system includes three infiltration basins that will effectively recharge groundwater on-site. The infiltration basins were sized using the static method based on the required recharge volume for the post-development site. As a result, annual recharge from the post-development site is designed to exceed the annual recharge from the site under pre-development conditions. See Attachment 4 for the Groundwater Recharge Calculation.

STANDARD 4: **Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS).**

The proposed project will meet the water quality requirements of Standard 4 using on-site treatment trains that achieve 80% TSS removal. Structural BMPs include deep sump hooded catch basins and proprietary water quality structures for treatment of stormwater runoff prior to infiltration in the basins. All BMPs designed for water quality treatment will be sized to capture and treat the flow rate associated with the first 0.5-inch of runoff from proposed impervious surfaces. All proposed stormwater management BMPs will be operated and maintained to ensure continued water quality treatment of runoff. The Site Owner's Manual complies with the Long-Term Pollution Prevention Plan (Standard 4) and the Long-Term Operation and Maintenance Plan (Standard 9) requirements of the 2008 Massachusetts Department of Environmental Protection (MassDEP) Stormwater Management Standards. The Manual outlines source control and pollution prevention measures and maintenance requirements of stormwater best management practices (BMPs) associated with the proposed development.

STANDARD 5: **For land uses with higher potential pollutant loads (LUHPPLs), 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.**

The proposed project is not associated with stormwater discharges from land uses with higher potential pollutant loads.

STANDARD 6: **Stormwater discharges to critical areas must utilize certain stormwater management BMPs approved for critical areas. Critical areas are Outstanding Resource Waters, shellfish beds, swimming beaches, coldwater fisheries and recharge areas for public water supplies.**

There are no stormwater discharges to critical areas associated with this project. The proposed site improvements will drain to Lackey Pond, which is not identified as a critical area.

STANDARD 7: **Redevelopment of previously developed sites must meet the Stormwater Management Standards to the maximum extent practicable. However, if it is not practicable to meet all the Standards,**

new (retrofitted or expanded) stormwater management systems must be designed to improve existing conditions.

The proposed project is new development, and therefore this standard does not apply.

STANDARD 8: **A plan to control construction-related impacts during 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 Stormwater Pollution Prevention Plan (SWPPP) will be developed prior to construction to comply with Section 3 of the NPDES Construction General Permit for Stormwater Discharges; therefore the requirements of Standard 8 are fulfilled.

STANDARD 9: **A Long-Term Operation and Maintenance (O&M) Plan shall be developed and implemented to ensure that stormwater management systems function as designed.**

The Site Owner's Manual complies with the Long-Term Pollution Prevention Plan (Standard 4) and the Long-Term Operation and Maintenance Plan (Standard 9) requirements of the 2008 Massachusetts Department of Environmental Protection (MassDEP) Stormwater Management Standards. The Manual outlines source control and pollution prevention measures and maintenance requirements of the stormwater best management practices (BMPs) associated with the proposed development. See Attachment 5 for the Site Owner's Manual.

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

There will be no illicit discharges to the proposed stormwater management system associated with the proposed project. An Illicit Discharge Compliance Statement is provided on the following page.

3.6 Illicit Discharge Compliance Statement

An illicit discharge is any discharge to a stormwater management system that is not comprised entirely of stormwater, discharges from fire-fighting activities, and certain non-designated non-stormwater discharges.

To the best of my knowledge, no detectable illicit discharge exists on site. The site plans included with this report detail the storm sewers that convey stormwater on the site and demonstrate that these systems do not include the entry of an illicit discharge. A Site Owner's Manual is also included, which contains the Long Term Pollution Plan that outlines measures to prevent future illicit discharges. As the Site Owner, I will ultimately be responsible for implementing the Long Term Pollution Prevention Plan.

Signature: ____

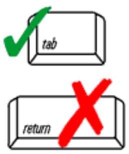
Owner

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

Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

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

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

As noted in the Checklist, the Stormwater Management Report shall document compliance with each of the Stormwater Management Standards as provided in the Massachusetts Stormwater Handbook. The soils evaluation and calculations shall be done using the methodologies set forth in Volume 3 of the Massachusetts Stormwater Handbook.

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

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

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

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature

COMMONWEALTH OF MASSACHUSETTS
Daniel M. Feeney
CIVIL ENGINEER
NO. 41422
REGISTERED PROFESSIONAL ENGINEER

9/6/2022
Signature and Date

Checklist

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

☒ New development

☐ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

☐ No disturbance to any Wetland Resource Areas

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

☐ Reduced Impervious Area (Redevelopment Only)

☐ Minimizing disturbance to existing trees and shrubs

☐ LID Site Design Credit Requested:

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

☐ Use of “country drainage” versus curb and gutter conveyance and pipe

☐ Bioretention Cells (includes Rain Gardens)

☐ Constructed Stormwater Wetlands (includes Gravel Wetlands designs)

☐ Treebox Filter

☐ Water Quality Swale

☐ Grass Channel

☐ Green Roof

☐ Other (describe): ______________________________

Standard 1: No New Untreated Discharges

☒ No new untreated discharges

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

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

Checklist (continued)

Standard 2: Peak Rate Attenuation

☐ Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
☐ Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

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

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

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist (continued)

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

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

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

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

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

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

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

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

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

Checklist (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.

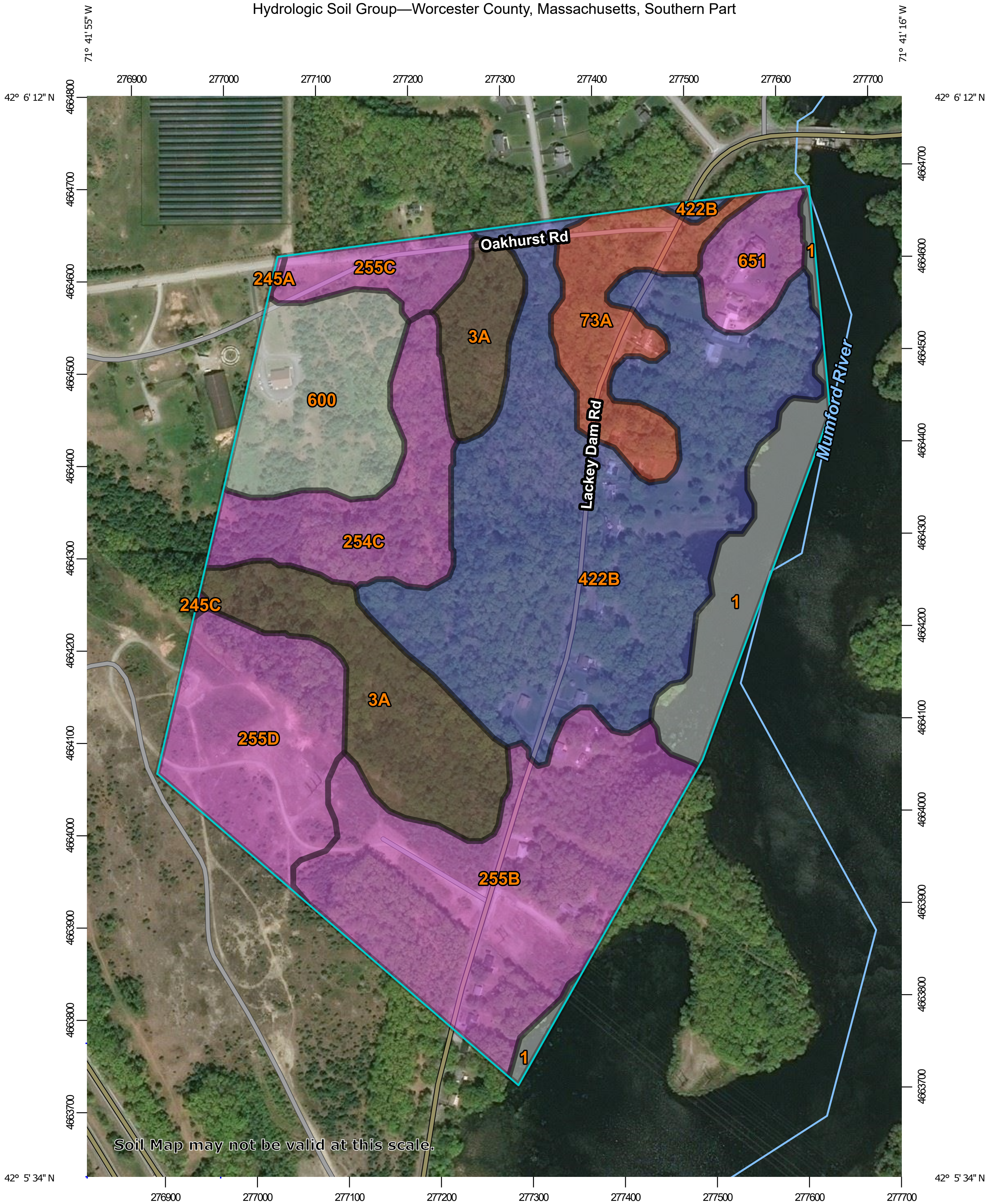
Standard 9: Operation and Maintenance Plan

- ☒ 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.

Attachment 1
Soil Data



Map Scale: 1:5,710 if printed on A portrait (8.5" x 11") sheet.

Meters: 0, 50, 100, 200, 300

Feet: 0, 250, 500, 1000, 1500

N

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

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Rating Polygons

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Lines

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Soil Rating Points

A

A/D

B

B/D

C

C/D

D

Not rated or not available

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

MAP INFORMATION

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

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

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 13, Jun 11, 2020

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

Date(s) aerial images were photographed: May 18, 2019—Jul 9, 2019

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
1	Water		6.6	5.7%
3A	Scarboro and Walpole soils, 0 to 3 percent slopes	B/D	13.0	11.3%
73A	Whitman fine sandy loam, 0 to 3 percent slopes, extremely stony	D	6.9	6.0%
245A	Hinckley loamy sand, 0 to 3 percent slopes	A	0.1	0.1%
245C	Hinckley loamy sand, 8 to 15 percent slopes	A	0.0	0.0%
254C	Merrimac fine sandy loam, 8 to 15 percent slopes	A	8.2	7.1%
255B	Windsor loamy sand, 3 to 8 percent slopes	A	20.9	18.1%
255C	Windsor loamy sand, 8 to 15 percent slopes	A	3.1	2.7%
255D	Windsor loamy sand, 15 to 25 percent slopes	A	10.4	9.0%
422B	Canton fine sandy loam, 0 to 8 percent slopes, extremely stony	B	34.1	29.6%
600	Pits, gravel		8.8	7.7%
651	Udorthents, smoothed	A	3.2	2.8%
Totals for Area of Interest			**115.2**	**100.0%**

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.

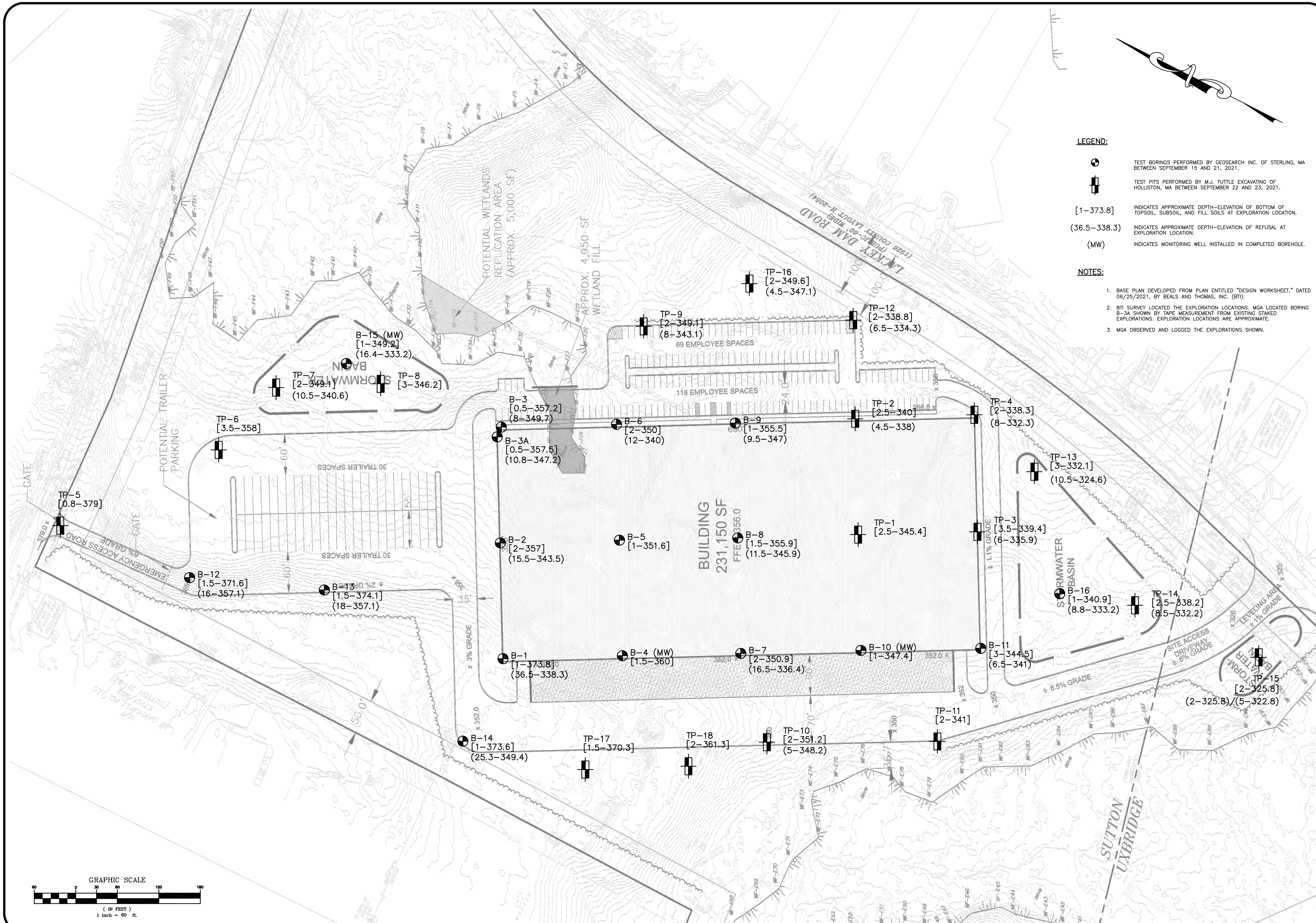
If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: None Specified

Tie-break Rule: Higher



REVISIONS

DRAWN BY: RED

DESIGNED BY: RED

CHECKED BY: JJG

MGA McArdle Gannon Associates, Inc.
Engineers & Consultants
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EXPLORATION LOCATION PLAN
PROPOSED BLACKSTONE LOGISTICS CENTER
LOT 2 - LACKEY DAM ROAD
UXBRIDGE AND SUTTON, MASSACHUSETTS

NOVEMBER 2021

SCALE: 1" = 60'

JOB No. G0875

FIG No. 2

SHEET 1 OF 1

REDUCED COPY

McArdle Gannon Associates, Inc.
Engineers & Consultants

TABLE 1
SUBSURFACE EXPLORATION SUMMARY
Page 1 of 2

Project: Proposed Blackstone Logistics Center - Lot 2
Location: Lackey Dam Rd, Uxbridge and Sutton, MA
MGA Job No.: G0875

Exploration No.	Ground Surface Elevation (feet) (1)	Thickness of Existing Fill (feet)	Thickness of Topsoil /Subsoil (feet)	Depth to Top of Natural (feet)	Elevation of Top of Natural (feet)	Depth to Refusal (feet)	Elevation of Refusal (feet)	Depth to Groundwater (feet)	Elevation of Groundwater (feet)
B-1	374.8	0.0	1.0	1.0	373.8	36.5	338.3	20.0	354.8
B-2	359.0	0.0	2.0	2.0	357.0	15.9	343.1	12.0	347.0
B-3	357.7	0.0	0.5	0.5	357.2	8.0	349.7	NE	NE
B-3A	358.0	0.0	0.5	0.5	357.5	10.8	347.3	NE	NE
B-4 (MW)	361.5	0.0	1.5	1.5	360.0	NE	NE	11.7	349.8
B-5	352.6	0.0	1.0	1.0	351.6	NE	NE	7.6	345.0
B-6	352.0	0.0	2.0	2.0	350.0	NE	NE	4.5	347.5
B-7	352.9	0.0	2.0	2.0	350.9	16.5	336.4	8.5	344.4
B-8	357.4	0.0	1.5	1.5	355.9	11.5	345.9	NE	NE
B-9	356.5	0.0	1.0	1.0	355.5	9.5	347.0	NE	NE
B-10 (MW)	348.4	1.0	0.0	1.0	347.4	NE	NE	9.1	339.3
B-11	347.5	0.0	1.0	1.0	346.5	6.5	341.0	NE	NE
B-12	373.1	0.0	1.5	1.5	371.6	16.0	357.1	15.0	358.1
B-13	375.1	0.0	1.0	1.0	374.1	18.0	357.1	NE	NE
B-14	374.6	0.0	1.0	1.0	373.6	25.3	349.4	20.0	354.6
B-15 (MW)	350.2	0.0	1.0	1.0	349.2	16.4	333.8	5.5	344.7
B-16	341.9	0.0	1.0	1.0	340.9	8.8	333.2	NE	NE

Notes:
(1) Ground surface elevations for the explorations were determined by survey performed by Beals and Thomas, Inc. Elevations should be considered approximate.
NE = Not Encountered
NA = Not Available

TABLE 1
SUBSURFACE EXPLORATION SUMMARY

Project: Proposed Blackstone Logistics Center - Lot 2
Location: Lackey Dam Rd, Uxbridge and Sutton, MA
MGA Job No.: G0875

Exploration No.	Ground Surface Elevation (feet) (1)	Thickness of Existing Fill (feet)	Thickness of Topsoil /Subsoil (feet)	Depth to Top of Natural (feet)	Elevation of Top of Natural (feet)	Depth to Refusal (feet)	Elevation of Refusal (feet)	Depth to Groundwater (feet)	Elevation of Groundwater (feet)
TP-1	347.9	0.0	2.5	2.5	345.4	NE	NE	NE	NE
TP-2	342.5	0.0	2.5	2.5	340.0	4.5	338.0	NE	NE
TP-3	341.9	0.0	2.5	2.5	339.4	6.0	335.9	NE	NE
TP-4	340.3	0.0	2.0	2.0	338.3	8.0	332.3	NE	NE
TP-5	379.7	0.0	0.8	0.8	378.9	NE	NE	NE	NE
TP-6	361.5	2.0	1.5	3.5	358.0	NE	NE	NE	NE
TP-7	351.1	0.0	2.0	2.0	349.1	10.5	340.6	8.0	343.1
TP-8	349.2	0.0	3.0	3.0	346.2	NE	NE	7.0	342.2
TP-9	351.1	0.0	2.0	2.0	349.1	8.0	343.1	NE	NE
TP-10	353.2	0.0	2.0	2.0	351.2	NE	NE	NE	NE
TP-11	343.0	0.0	2.0	2.0	341.0	NE	NE	NE	NE
TP-12	340.8	0.0	2.0	2.0	338.8	6.5	334.3	NE	NE
TP-13	335.1	0.0	3.0	3.0	332.1	10.5	324.6	NE	NE
TP-14	340.7	0.0	2.5	2.5	338.2	8.5	332.2	NE	NE
TP-15	327.8	0.0	2.0	2.0	325.8	5.0	322.8	NE	NE
TP-16	351.6	0.0	2.0	2.0	349.6	4.5	347.1	NE	NE
TP-17	371.8	1.5	0.0	1.5	370.3	NE	NE	7.0	364.8
TP-18	363.3	0.0	2.0	2.0	361.3	NE	NE	NE	NE

Notes:
(1) Ground surface elevations for the explorations were determined by survey performed by Beals and Thomas, Inc. Elevations should be considered approximate.
NE = Not Encountered
NA = Not Available

McArdle Gannon Associates, Inc.
Engineers & Consultants

TEST BORING LOG

BORING B-15 (MW)

PROJECT: Blackstone Logistics Center - Lot 2, Sutton & Uxbridge, MA
CLIENT: Scannell Properties
CONTRACTOR: Geosearch, Inc.

MGA NO. : G0875
SHEET NO. : 1 of 1
LOCATION N : See Plan
E :
ELEVATION : 350.2'±
DATE START : 9/16/21
END : 9/16/21
DRILLER : Sean Preston
ENGINEER : Robert Bosselman

GROUNDWATER		DEPTH (ft) OF:		
Date	Time	Water	Casing	Hole
9/16/21	12:00	6'	10'	12'
9/23/21	12:40	5.5'	MW	OUT

EQUIPMENT	CASING	SAMPLER	CORE
Type	HSA	Split Spoon	---
Size I.D.	4-1/4"	1-3/8"	---
Hammer Wt.	---	140#	- - - -
Hammer Fall	---	30"	- - - -

Depth in Feet	Strata Change	Case BPF (Drill) (min/ft)	Sampler Blows Per 6" (RQD%)	Sample Number/ Type	Sample Depth Range (ft)	Sample Recov-ery (in)	Elev-ation/ Depth (ft)	FIELD CLASSIFICATION AND REMARKS
0			2	S-1	0.0 0.5	4	349.7 0.5	Dark brown, fine to medium SAND, some Silt, trace fine Gravel. -TOPSOIL-
			4	S-1A	0.5 1.0	4	349.2 1.0	Orange-brown, fine to coarse SAND, some fine to coarse Gravel, litte (+) Silt. -SUBSOIL-
			15 70/3"	S-1B	1.0 2.0	8		Gray to olive, fine to coarse SAND, some fine to coarse Gravel, little (+) Silt. (possible Cobble/Boulder Fragments)
4			11 19 34 37	S-2	5.0 7.0	22		Very dense, Light brown, fine to coarse SAND, some fine Gravel, little (-) Silt.
8								-SAND AND GRAVEL-
12			15 20 15 14	S-3	10.0 12.0	20		Dense, Gray to beige, fine to coarse SAND, some fine to coarse Gravel, little (+) Silt.
16			11 17	S-4	15.0 16.0	8	335.2 15.0	Light Brown, fine to coarse SAND, little fine Gravel, trace (-) Silt. -SAND-
			80/5"	S-4A	16.0 16.4	5 -	334.2 16.0 333.2 17.0	Light Brown, fine to medium SAND and SILT. -SAND AND SILT-
								Bottom of Boring, Split Spoon Refusal at 16.4 Feet
20								

Well Schematic

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY
0 - 4	Very Loose	0 - 2	Very Soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium Dense	4 - 8	Medium Stiff
30 - 50	Dense	8 - 15	Stiff
50 +	Very Dense	15 - 30	Very Stiff
		30+	Hard

SAMPLE IDENTIFICATION
- S - Split Spoon
- T - Thin Wall Tube
- U - Undisturbed Piston
- C - Diamond Core
- W - Wash Sample

SUMMARY
Overburden:
Rock:
Samples:

BORING B-15 (MW)

McArdle Gannon Associates, Inc.
Engineers & Consultants

TEST BORING LOG

BORING B-16

PROJECT: Blackstone Logistics Center - Lot 2, Sutton & Uxbridge, MA
CLIENT: Scannell Properties
CONTRACTOR: Geosearch, Inc.

MGA NO. : G0875
SHEET NO. : 1 of 1
LOCATION N : See Plan
E :
ELEVATION : 341.9'±
DATE START : 9/20/21
END : 9/20/21
DRILLER : Sean Preston
ENGINEER : Robert Drown

GROUNDWATER		DEPTH (ft) OF:		
Date	Time	Water	Casing	Hole
9/20/21	12:50	NE	8.75'	8.75'

EQUIPMENT	CASING	SAMPLER	CORE
Type	HSA	Split Spoon	---
Size I.D.	4-1/4"	1-3/8"	---
Hammer Wt.	---	140#	- - - -
Hammer Fall	---	30"	- - - -

Depth in Feet	Strata Change	Case BPF (Drill) (min/ft)	Sampler Blows Per 6" (RQD%)	Sample Number/ Type	Sample Depth Range (ft)	Sample Recovery (in)	Elevation/ Depth (ft)	FIELD CLASSIFICATION AND REMARKS
0			1	S-1	0.0 - 0.5	6	341.4 / 0.5	Dark brown, fine to medium SAND, some Silt, little Roots. -TOPSOIL-
			1	S-1A	0.5 - 1.0	6	340.9 / 1.0	Orange-brown, fine to medium SAND, some (-) Silt, trace (-) Roots. -SUBSOIL-
			1, 1	S-1B	1.0 - 2.0	12		Olive-brown, fine to medium SAND, trace (+) Silt.
4							336.9 / 5.0	-SAND-
			5, 5, 6, 5	S-2	5.0 - 7.0	24		Moist, Medium Dense, Olive/Brown, SILT and fine SAND.
8							333.2 / 8.8	-SAND AND SILT-
						-		Bottom of Boring, Auger Refusal at 8.75 Feet.
12								
16								
20								

BLOWS/FT.	DENSITY	BLOWS/FT.	CONSISTENCY
0 - 4	Very Loose	0 - 2	Very Soft
4 - 10	Loose	2 - 4	Soft
10 - 30	Medium Dense	4 - 8	Medium Stiff
30 - 50	Dense	8 - 15	Stiff
50 +	Very Dense	15 - 30	Very Stiff
		30+	Hard

SAMPLE IDENTIFICATION
- S - Split Spoon
- T - Thin Wall Tube
- U - Undisturbed Piston
- C - Diamond Core
- B - Bulk/Grab Sample

SUMMARY
Station:
Rock:
Samples:

BORING B-16

KEY TO SYMBOLS

Symbol Description

Strata symbols

- Topsoil
- Sand
- Sand and Silt
- Silt
- Glacial Till
- Subsoil
- Sand and Gravel
- Weathered Rock
- Fill
- Granite

Soil Samplers

- Split Spoon

Monitor Well Details

- assorted cuttings
- bentonite pellets
- silica sand, blank PVC
- slotted pipe w/ sand
- endcap on pipe packed in sand
- no pipe, filler material

Notes:

1. Geosearch, Inc. performed the test borings with a all terrain vehicle mounted drill rig equipped with an automatic safety hammer on September 15 through 21, 2021.

2. Beals and Thomas, Inc. (BTI) survey located the test borings and provided ground surface elevations indicated on the logs. MGA located boring B-3A by tape measurement from surveyed locations by BTI. MGA estimated the ground surface elevation for B-3A based on contours on the referanced plans. Elevations are approximate.

3. MGA observed and logged the borings.

4. 'NE' = Not Encountered

5. It should be noted that groundwater level at the site will fluctuate due to varying climatic, surface, and subsurface conditions. Therefore, groundwater levels encountered during construction and thereafter may differ from those reported herein.

Commonwealth of Massachusetts
City/Town of Sutton

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-7 (Hole #) 09/22/21 (Date) 10:30 (Time) Sunny (Weather) 42.099361 (Latitude) -71.693624 (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Young growth Forest (Vegetation) Few Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 5 (Slope (%))

   Description of Location: Wooded Area in undeveloped area.

2. Soil Parent Material: Glaciofluvial Deposits Outwash (Landform) Toe Slope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >200 feet Drainage Way >50 feet Wetlands >50 feet
   Property Line >50 feet Drinking Water Well >50 feet Other >50 feet

4. Unsuitable Materials Present: ☒ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☒ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: 96 Depth Weeping from Pit 96 Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-12	Ap	Loamy Sand	10YR 4/1				0-5	0	Massive	Very Friable	
12-24	Bw	Loamy Sand	10YR 6/8				0-5	0	Massive	Very Friable	
24-48	C1	Loamy Sand	10YR 6/1				5-10	0	Massive	Very Friable	
48-126	C2	Loamy Sand	10YR 5/1	84	7.5YR 6/8	30	25-30	5-10	Massive	Friable	
126	R										

Additional Notes:

Commonwealth of Massachusetts
City/Town of Sutton

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-8 (Hole #) 09/22/21 (Date) 11:15 (Time) Sunny (Weather) 42.099361 (Latitude) -71.693624 (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Young growth Forest (Vegetation) Few Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 5 (Slope (%))

   Description of Location: Wooded Area in undeveloped area.

2. Soil Parent Material: Glaciofluvial Deposits Outwash (Landform) Toe Slope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >200 feet Drainage Way >50 feet Wetlands >50 feet
   Property Line >50 feet Drinking Water Well >50 feet Other >50 feet

4. Unsuitable Materials Present: ☐ Yes ☒ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☐ Bedrock

5. Groundwater Observed: ☒ Yes ☐ No If yes: 84 Depth Weeping from Pit 84 Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-18	Ap	Loamy Sand	10YR 3/1				0-5	0	Massive	Very Friable	
18-36	Bw	Loamy Sand	10YR 6/8				0-5	0	Massive	Very Friable	
36-120	C1	Loamy Sand	10YR 5/1	72	7.5YR 6/8	50	10-15	0-5	Massive	Very Friable	

Additional Notes:

Commonwealth of Massachusetts
City/Town of Sutton

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-13 (Hole #) 09/23/21 (Date) 8:55 (Time) Sunny (Weather) 42.099361 (Latitude) -71.693624 (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Young growth Forest (Vegetation) Few Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 5 (Slope (%))

   Description of Location: Wooded Area in undeveloped area.

2. Soil Parent Material: Glaciofluvial Deposits Outwash (Landform) Toe Slope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >200 feet Drainage Way >50 feet Wetlands >50 feet
   Property Line >50 feet Drinking Water Well >50 feet Other >50 feet

4. Unsuitable Materials Present: ☒ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☒ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-24	Ap	Sandy Loam	10YR 4/3				0	0	Massive	Very Friable	
24-36	Bw	Sandy Loam	10YR 6/8				0-5	0	Massive	Very Friable	
36-126	C1	Sandy Loam	10YR 5/1				25-30	10-15	Massive	(1)	
126	R										

Additional Notes:
(1) Firm in Place, Very Friable in hand.

Commonwealth of Massachusetts
City/Town of Sutton

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-14 (Hole #) 09/22/21 (Date) 3:00 (Time) Sunny (Weather) 42.099361 (Latitude) -71.693624 (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Young growth Forest (Vegetation) Few Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 5 (Slope (%))

   Description of Location: Wooded Area in undeveloped area.

2. Soil Parent Material: Glaciofluvial Deposits Outwash (Landform) Toe Slope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >200 feet Drainage Way >50 feet Wetlands >50 feet
   Property Line >50 feet Drinking Water Well >50 feet Other >50 feet

4. Unsuitable Materials Present: ☒ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☒ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-12	Ap	Sandy Loam	10YR 3/1				0	0	Massive	Very Friable	
12-30	Bw	Sandy Loam	10YR 6/8				0-5	0	Massive	Very Friable	
30-60	C1	Loamy Sand	10YR 6/1				5-15	5	Massive	Very Friable	
60-102	C2	Sandy Loam	10YR 5/1				20-30	10	Massive	(1)	
102	R										

Additional Notes:
(1) Firm in Place, Very Friable in hand.

Commonwealth of Massachusetts
City/Town of Sutton

Form 11 - Soil Suitability Assessment for On-Site Sewage Disposal

C. On-Site Review *(minimum of two holes required at every proposed primary and reserve disposal area)*

Deep Observation Hole Number: TP-15 (Hole #) 09/22/21 (Date) 3:10 (Time) Sunny (Weather) 42.099361 (Latitude) -71.693624 (Longitude:)

1. Land Use: Woodland (e.g., woodland, agricultural field, vacant lot, etc.) Young growth Forest (Vegetation) Few Boulders (Surface Stones (e.g., cobbles, stones, boulders, etc.)) 5 (Slope (%))

   Description of Location: Wooded Area in undeveloped area.

2. Soil Parent Material: Glaciofluvial Deposits Outwash (Landform) Toe Slope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances from: Open Water Body >200 feet Drainage Way >50 feet Wetlands >50 feet
   Property Line >50 feet Drinking Water Well >50 feet Other >50 feet

4. Unsuitable Materials Present: ☒ Yes ☐ No If Yes: ☐ Disturbed Soil ☐ Fill Material ☐ Weathered/Fractured Rock ☒ Bedrock

5. Groundwater Observed: ☐ Yes ☒ No If yes: ______ Depth Weeping from Pit ______ Depth Standing Water in Hole

Soil Log

Depth (in)	Soil Horizon /Layer	Soil Texture (USDA)	Soil Matrix: Color-Moist (Munsell)	Redoximorphic Features			Coarse Fragments % by Volume		Soil Structure	Soil Consistence (Moist)	Other
				Depth	Color	Percent	Gravel	Cobbles & Stones			
0-6	Ap	Sandy Loam	10YR 3/4				0-5	0	Massive	Very Friable	
6-24	Bw	Sandy Loam	10YR 6/8				5-10	10	Massive	Very Friable	
24-60	C1	Sandy Loam	10YR 5/1				15-20	5-10	Massive	(1)	
24	R										Refusal North side of TP
60	R										Refusal South side of TP

Additional Notes:
(1) Firm in Place, Very Friable in hand.

Attachment 2
Pre-Development Hydrologic Analysis

PRE-DEVELOPMENT HYDROLOGIC ANALYSIS

OBJECTIVE

To determine the pre-development peak runoff rates for the site for the 2-, 10-, and 100-year storm events.

CONCLUSION(S)

Peak Runoff Rates

The following numbers represent the peak rates of runoff from the site under pre-development conditions:

Storm Event	Design Point 1 (cfs)	Design Point 2 (cfs)	Design Point 3 (cfs)
2-year	0.28	0.94	0.00
10-year	3.80	7.08	0.01
100-year	24.00	29.99	0.37

CALCULATION METHODS

1. CN and Tc determined based on TR-55 methodology.
2. Runoff rates and volumes were computed using HydroCAD version 10.20-2d.
3. Area take-offs performed using Civil 3D.

ASSUMPTIONS

1. Hydrologic group of on-site soils was determined based on the United States Department of Agriculture, NRCS Soil Survey information.
2. The area shown on the NRCS Soil Survey as “Not Rated/Not Available” was modeled as Hydrologic Soil Group (HSG) D.
3. Per TR-55, a minimum time of concentration of 6 minutes was used.
4. Surface cover types and boundaries have been estimated based upon B+T Topographic Plan information.
5. The area of analysis is limited to the area affected by the proposed development.

SOURCES OF DATA/ EQUATIONS

1. Pre-Development Conditions Watershed Map, dated 09/01/2022, prepared by Beals and Thomas, Inc. (307706P037C-001).
2. TR-55 Urban Hydrology for Small Watersheds, SCS, 1986.
3. NRCS Soil Survey for Worcester County, downloaded from Web Soil Survey 2.0 on 3/4/2021.
4. B+T Topographic Plans, B+T File No. 307706P069B.
5. Massachusetts DEP Stormwater Handbook, February 2008.

REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	M. Bruckman	3/4/2021	N/A	N/A	N/A	N/A
1	M. Bruckman	7/22/2021	N/A	N/A	N/A	N/A
2	T. Michalak	5/9/2022	DMF	5/16/2022	DMF	5/16/2022
3	R. Kennedy	9/1/2022	JRM	9/2/2022	DMF	9/6/2022

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LIST OF ATTACHMENTS

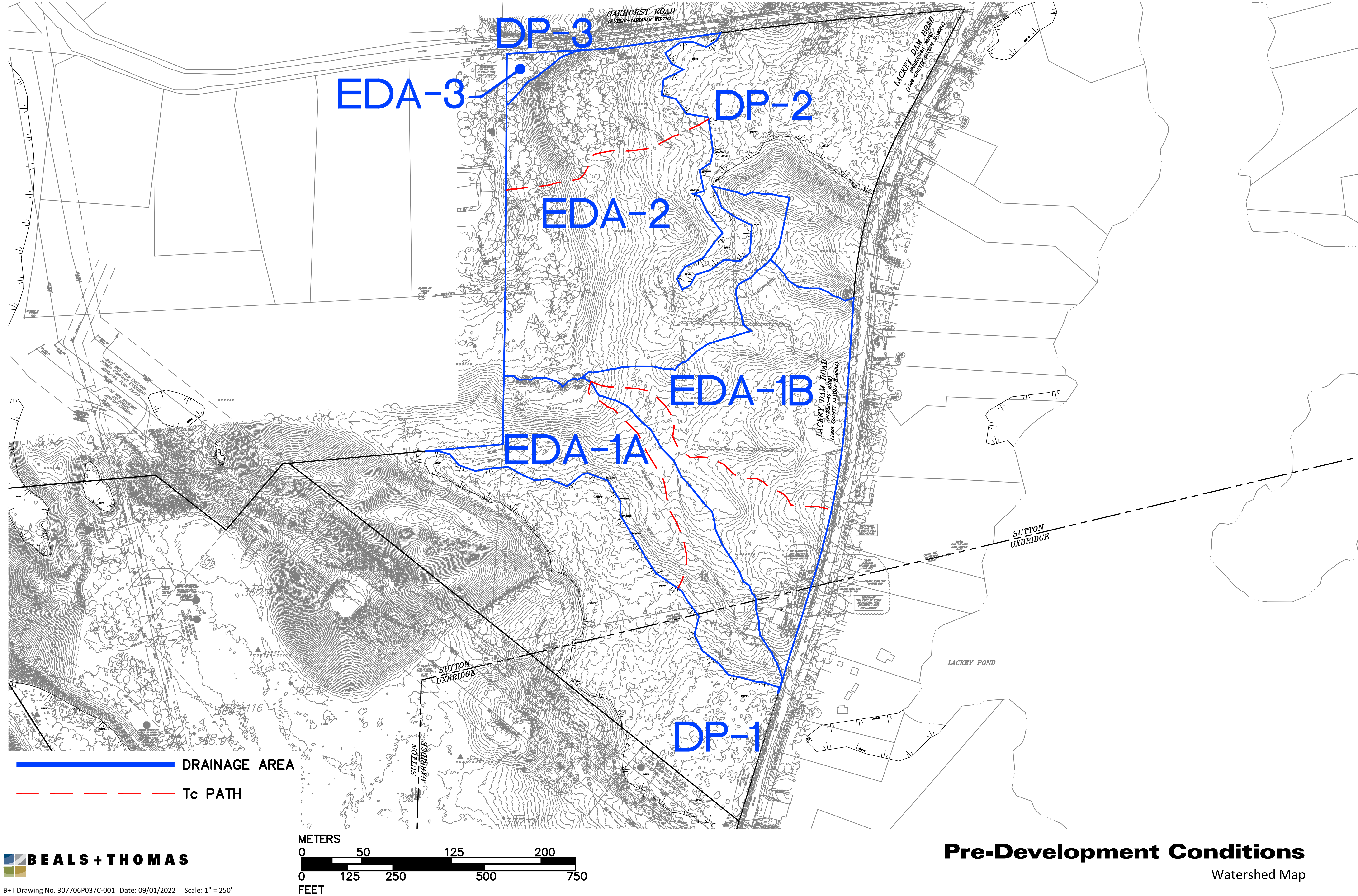
1. Pre-Development Conditions Watershed Map, dated 09/01/2022, prepared by Beals and Thomas, Inc.
2. Pre-Development Conditions Hydrology Report from HydroCAD file 307706HC001C, dated 09/01/2022.

REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	M. Bruckman	3/4/2021	N/A	N/A	N/A	N/A
1	M. Bruckman	7/22/2021	N/A	N/A	N/A	N/A
2	T. Michalak	5/9/2022	DMF	5/16/2022	DMF	5/16/2022
3	R. Kennedy	9/1/2022	JRM	9/2/2022	DMF	9/6/2022

307706CS001D

Lackey Dam Logistics Center

Sutton/Uxbridge, Massachusetts



BEALS + THOMAS

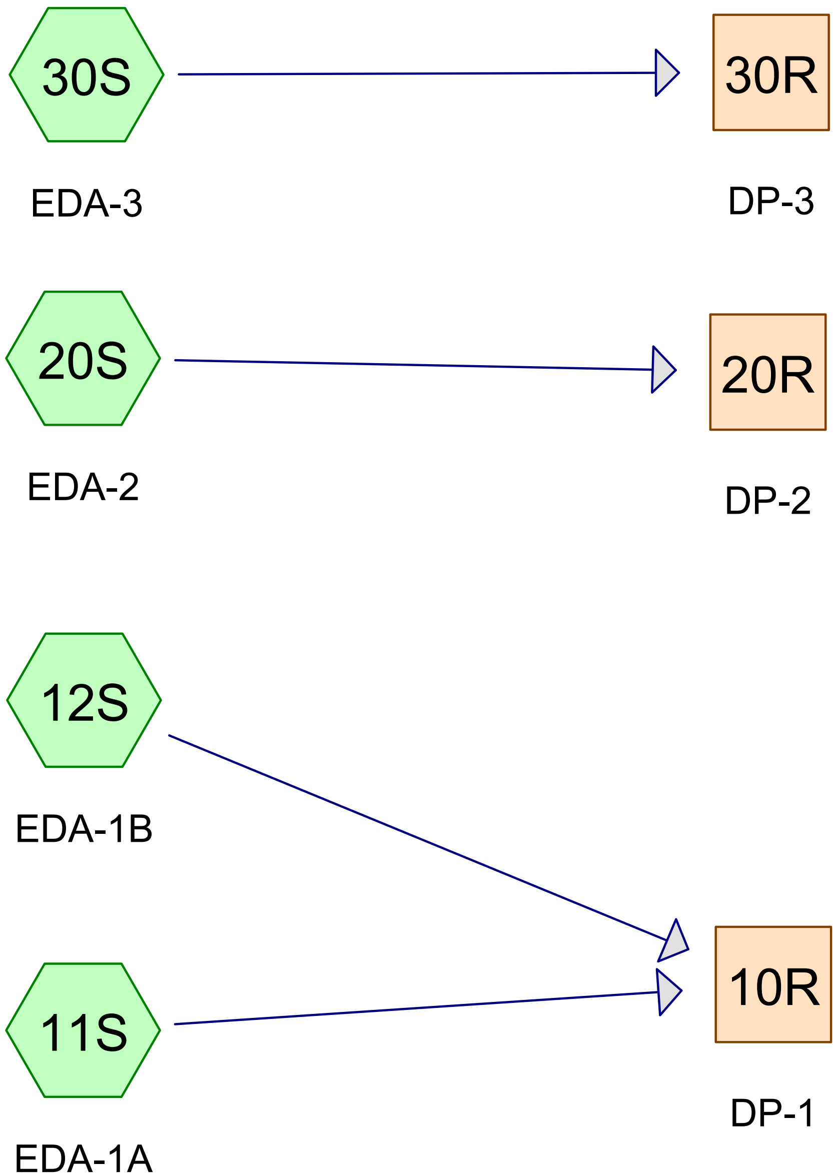
B+T Drawing No. 307706P037C-001 Date: 09/01/2022 Scale: 1" = 250'

Pre-Development Conditions

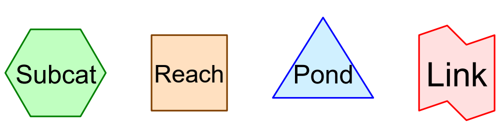
Watershed Map

Figure

1



PRE-DEVELOPMENT CONDITIONS



Routing Diagram for 307706HC001C
Prepared by Beals & Thomas Inc, Printed 9/1/2022
HydroCAD® 10.20-2d s/n 04493 © 2021 HydroCAD Software Solutions LLC

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	NRCC 24-hr	D	Default	24.00	1	3.23	2
2	10-Year	NRCC 24-hr	D	Default	24.00	1	4.85	2
3	100-Year	NRCC 24-hr	D	Default	24.00	1	8.71	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.954	39	>75% Grass cover, Good, HSG A (11S, 12S, 20S, 30S)
0.473	61	>75% Grass cover, Good, HSG B (11S, 12S)
1.976	80	>75% Grass cover, Good, HSG D (20S, 30S)
0.094	98	Paved parking, HSG B (11S, 12S)
0.030	98	Roofs, HSG B (12S)
6.576	30	Woods, Good, HSG A (11S, 12S, 20S, 30S)
12.191	55	Woods, Good, HSG B (11S, 12S, 20S)
3.043	77	Woods, Good, HSG D (20S, 30S)
25.337	**53**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
7.530	HSG A	11S, 12S, 20S, 30S
12.788	HSG B	11S, 12S, 20S
0.000	HSG C	
5.019	HSG D	20S, 30S
0.000	Other	
25.337		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.954	0.473	0.000	1.976	0.000	3.403	>75% Grass cover, Good	11S, 12S, 20S, 30S
0.000	0.094	0.000	0.000	0.000	0.094	Paved parking	11S, 12S
0.000	0.030	0.000	0.000	0.000	0.030	Roofs	12S
6.576	12.191	0.000	3.043	0.000	21.810	Woods, Good	11S, 12S, 20S, 30S
7.530	**12.788**	**0.000**	**5.019**	**0.000**	**25.337**	**TOTAL AREA**	

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 11S: EDA-1A Runoff Area=5.162 ac 0.85% Impervious Runoff Depth=0.06"
Flow Length=669' Tc=20.4 min CN=46 Runoff=0.03 cfs 0.027 af

Subcatchment 12S: EDA-1B Runoff Area=8.351 ac 0.96% Impervious Runoff Depth=0.21"
Flow Length=815' Tc=20.9 min CN=53 Runoff=0.28 cfs 0.143 af

Subcatchment 20S: EDA-2 Runoff Area=11.560 ac 0.00% Impervious Runoff Depth=0.29"
Flow Length=620' Tc=15.9 min CN=56 Runoff=0.94 cfs 0.278 af

Subcatchment 30S: EDA-3 Runoff Area=0.264 ac 0.00% Impervious Runoff Depth=0.00"
Tc=6.0 min CN=40 Runoff=0.00 cfs 0.000 af

Reach 10R: DP-1 Inflow=0.28 cfs 0.170 af
Outflow=0.28 cfs 0.170 af

Reach 20R: DP-2 Inflow=0.94 cfs 0.278 af
Outflow=0.94 cfs 0.278 af

Reach 30R: DP-3 Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Total Runoff Area = 25.337 ac Runoff Volume = 0.448 af Average Runoff Depth = 0.21"
99.51% Pervious = 25.213 ac 0.49% Impervious = 0.124 ac

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 11S: EDA-1A Runoff Area=5.162 ac 0.85% Impervious Runoff Depth=0.44"
Flow Length=669' Tc=20.4 min CN=46 Runoff=0.59 cfs 0.189 af

Subcatchment 12S: EDA-1B Runoff Area=8.351 ac 0.96% Impervious Runoff Depth=0.79"
Flow Length=815' Tc=20.9 min CN=53 Runoff=3.25 cfs 0.551 af

Subcatchment 20S: EDA-2 Runoff Area=11.560 ac 0.00% Impervious Runoff Depth=0.97"
Flow Length=620' Tc=15.9 min CN=56 Runoff=7.08 cfs 0.930 af

Subcatchment 30S: EDA-3 Runoff Area=0.264 ac 0.00% Impervious Runoff Depth=0.20"
Tc=6.0 min CN=40 Runoff=0.01 cfs 0.004 af

Reach 10R: DP-1 Inflow=3.80 cfs 0.741 af
Outflow=3.80 cfs 0.741 af

Reach 20R: DP-2 Inflow=7.08 cfs 0.930 af
Outflow=7.08 cfs 0.930 af

Reach 30R: DP-3 Inflow=0.01 cfs 0.004 af
Outflow=0.01 cfs 0.004 af

Total Runoff Area = 25.337 ac Runoff Volume = 1.675 af Average Runoff Depth = 0.79"
99.51% Pervious = 25.213 ac 0.49% Impervious = 0.124 ac

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 11S: EDA-1A	Runoff Area=5.162 ac 0.85% Impervious Runoff Depth=2.24" Flow Length=669' Tc=20.4 min CN=46 Runoff=7.19 cfs 0.962 af
Subcatchment 12S: EDA-1B	Runoff Area=8.351 ac 0.96% Impervious Runoff Depth=3.04" Flow Length=815' Tc=20.9 min CN=53 Runoff=16.81 cfs 2.119 af
Subcatchment 20S: EDA-2	Runoff Area=11.560 ac 0.00% Impervious Runoff Depth=3.40" Flow Length=620' Tc=15.9 min CN=56 Runoff=29.99 cfs 3.274 af
Subcatchment 30S: EDA-3	Runoff Area=0.264 ac 0.00% Impervious Runoff Depth=1.57" Tc=6.0 min CN=40 Runoff=0.37 cfs 0.035 af
Reach 10R: DP-1	Inflow=24.00 cfs 3.081 af Outflow=24.00 cfs 3.081 af
Reach 20R: DP-2	Inflow=29.99 cfs 3.274 af Outflow=29.99 cfs 3.274 af
Reach 30R: DP-3	Inflow=0.37 cfs 0.035 af Outflow=0.37 cfs 0.035 af

Total Runoff Area = 25.337 ac Runoff Volume = 6.389 af Average Runoff Depth = 3.03"
99.51% Pervious = 25.213 ac 0.49% Impervious = 0.124 ac

Summary for Subcatchment 11S: EDA-1A

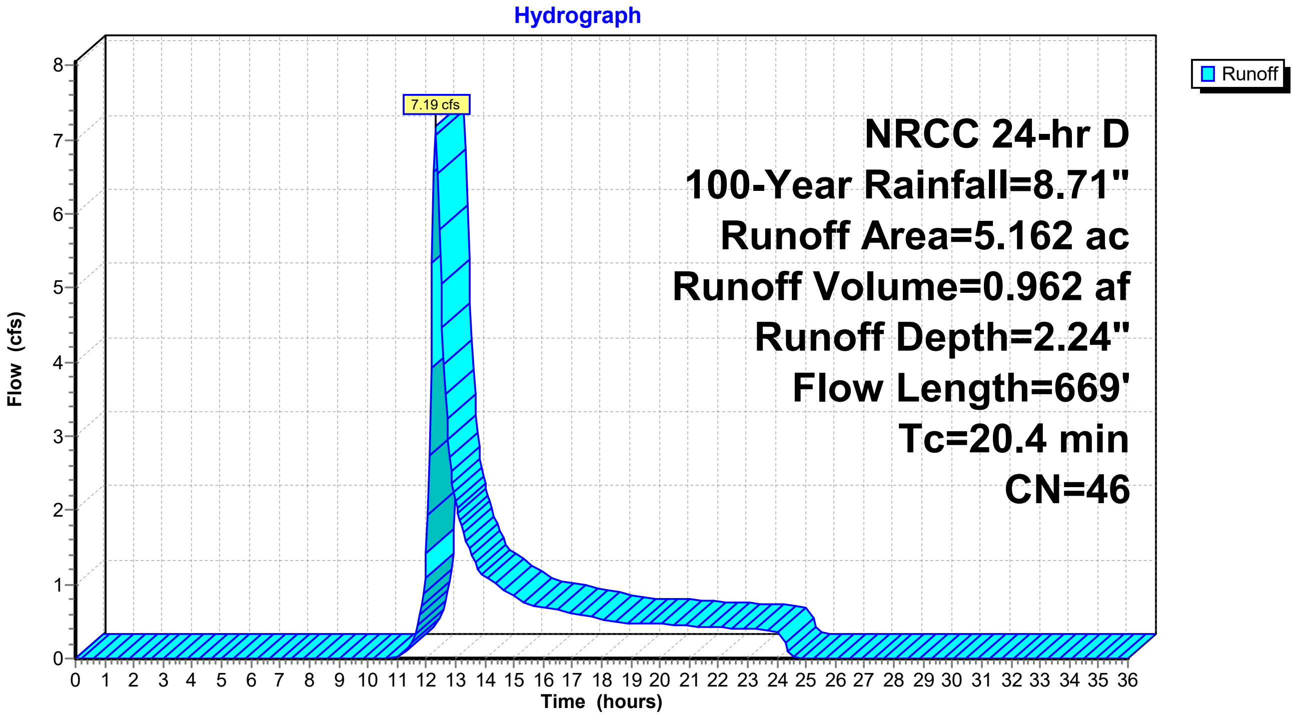
Runoff = 7.19 cfs @ 12.32 hrs, Volume= 0.962 af, Depth= 2.24"
Routed to Reach 10R : DP-1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
1.945	30	Woods, Good, HSG A
3.072	55	Woods, Good, HSG B
0.003	39	>75% Grass cover, Good, HSG A
0.098	61	>75% Grass cover, Good, HSG B
0.044	98	Paved parking, HSG B
5.162	46	Weighted Average
5.118		99.15% Pervious Area
0.044		0.85% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.3	50	0.0300	0.08		**Sheet Flow, SHT** Woods: Light underbrush n= 0.400 P2= 3.32"
1.3	114	0.0833	1.44		**Shallow Concentrated Flow, SCF-1** Woodland Kv= 5.0 fps
0.9	101	0.1485	1.93		**Shallow Concentrated Flow, SCF-2** Woodland Kv= 5.0 fps
3.3	99	0.0101	0.50		**Shallow Concentrated Flow, SCF-3** Woodland Kv= 5.0 fps
4.1	248	0.0403	1.00		**Shallow Concentrated Flow, SCF-4** Woodland Kv= 5.0 fps
0.5	57	0.1316	1.81		**Shallow Concentrated Flow, SCF-5** Woodland Kv= 5.0 fps
20.4	669	Total			

Subcatchment 11S: EDA-1A



Summary for Subcatchment 12S: EDA-1B

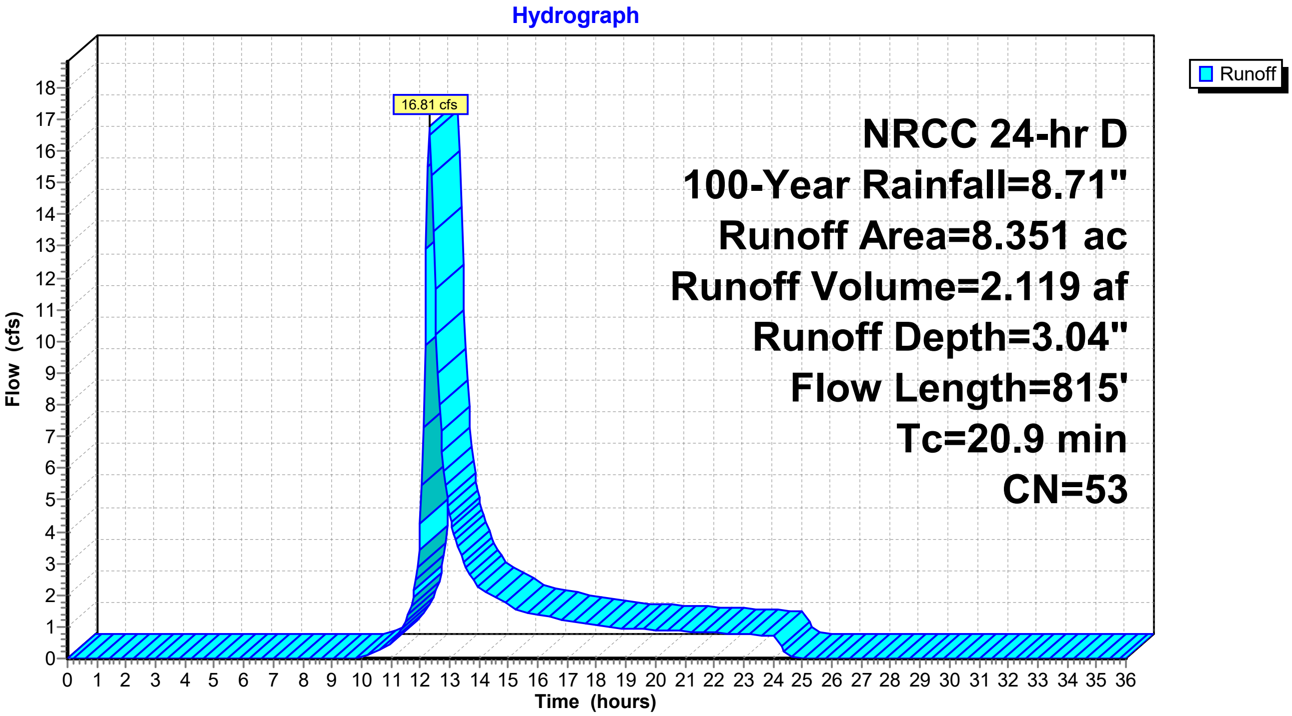
Runoff = 16.81 cfs @ 12.32 hrs, Volume= 2.119 af, Depth= 3.04"
Routed to Reach 10R : DP-1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.914	30	Woods, Good, HSG A
6.981	55	Woods, Good, HSG B
0.001	39	>75% Grass cover, Good, HSG A
0.375	61	>75% Grass cover, Good, HSG B
0.030	98	Roofs, HSG B
0.050	98	Paved parking, HSG B
8.351	53	Weighted Average
8.271		99.04% Pervious Area
0.080		0.96% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.0600	0.11		**Sheet Flow, SHT** Woods: Light underbrush n= 0.400 P2= 3.32"
0.7	65	0.0923	1.52		**Shallow Concentrated Flow, SCF-1** Woodland Kv= 5.0 fps
3.5	198	0.0354	0.94		**Shallow Concentrated Flow, SCF-2** Woodland Kv= 5.0 fps
6.0	297	0.0269	0.82		**Shallow Concentrated Flow, SCF-3** Woodland Kv= 5.0 fps
2.9	205	0.0561	1.18		**Shallow Concentrated Flow, SCF-4** Woodland Kv= 5.0 fps
20.9	815	Total			

Subcatchment 12S: EDA-1B



Summary for Subcatchment 20S: EDA-2

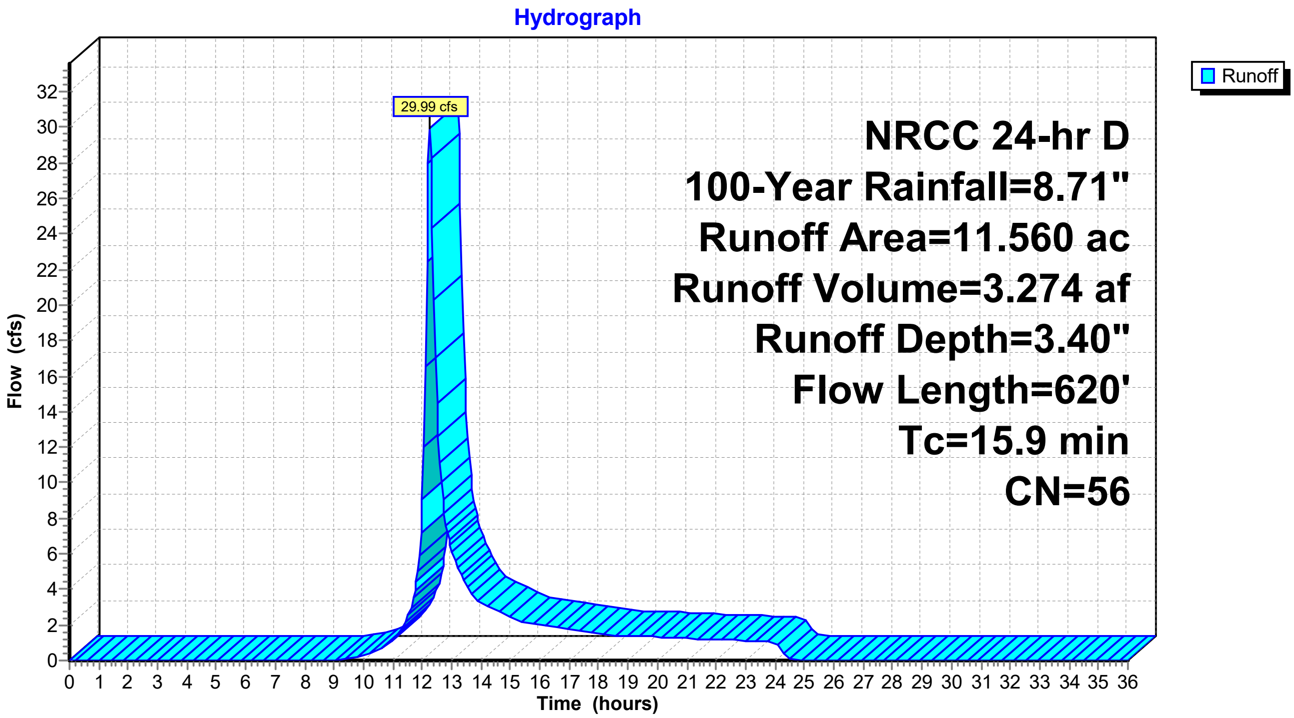
Runoff = 29.99 cfs @ 12.25 hrs, Volume= 3.274 af, Depth= 3.40"
Routed to Reach 20R : DP-2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
3.703	30	Woods, Good, HSG A
2.138	55	Woods, Good, HSG B
3.037	77	Woods, Good, HSG D
0.709	39	>75% Grass cover, Good, HSG A
1.973	80	>75% Grass cover, Good, HSG D
11.560	56	Weighted Average
11.560		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.0600	0.11		**Sheet Flow, SHT** Woods: Light underbrush n= 0.400 P2= 3.32"
1.5	74	0.0270	0.82		**Shallow Concentrated Flow, SCF-1** Woodland Kv= 5.0 fps
0.9	101	0.1485	1.93		**Shallow Concentrated Flow, SCF-2** Woodland Kv= 5.0 fps
5.7	395	0.0532	1.15		**Shallow Concentrated Flow, SCF-3** Woodland Kv= 5.0 fps
15.9	620	Total			

Subcatchment 20S: EDA-2



Summary for Subcatchment 30S: EDA-3

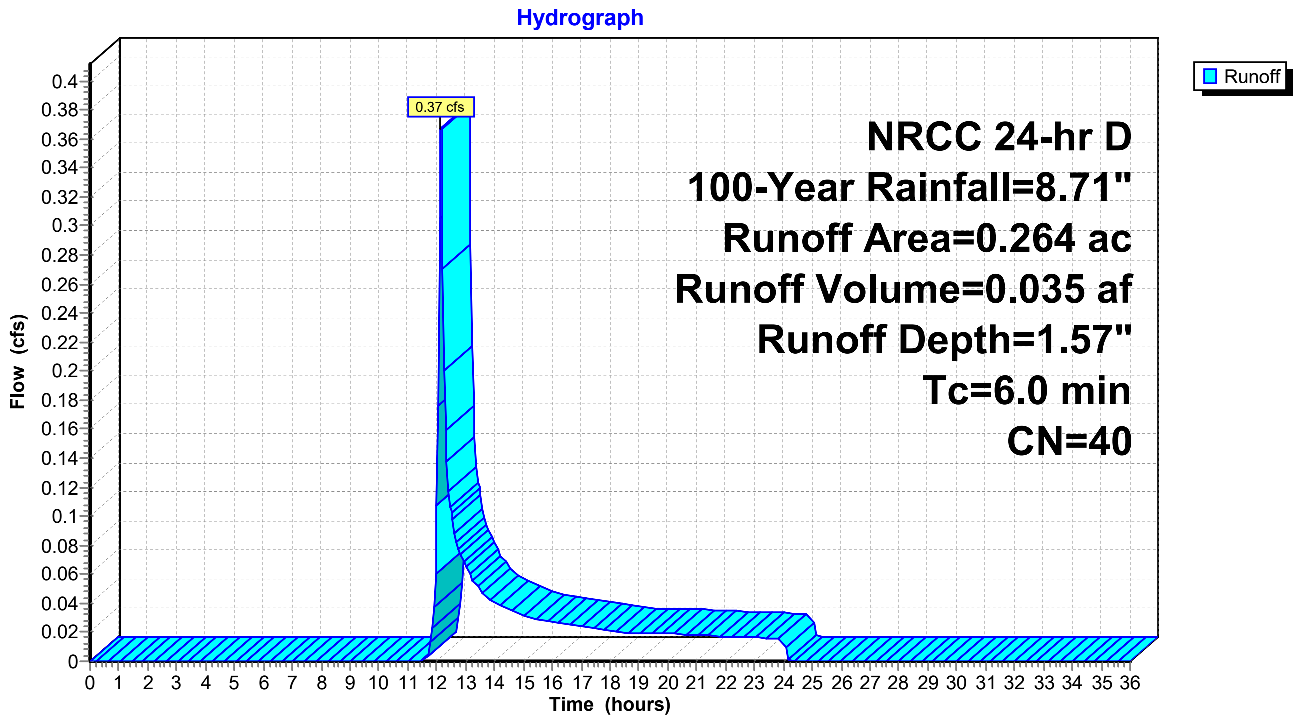
Runoff = 0.37 cfs @ 12.14 hrs, Volume= 0.035 af, Depth= 1.57"
Routed to Reach 30R : DP-3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.241	39	>75% Grass cover, Good, HSG A
0.003	80	>75% Grass cover, Good, HSG D
0.014	30	Woods, Good, HSG A
0.006	77	Woods, Good, HSG D
0.264	40	Weighted Average
0.264		100.00% Pervious Area

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

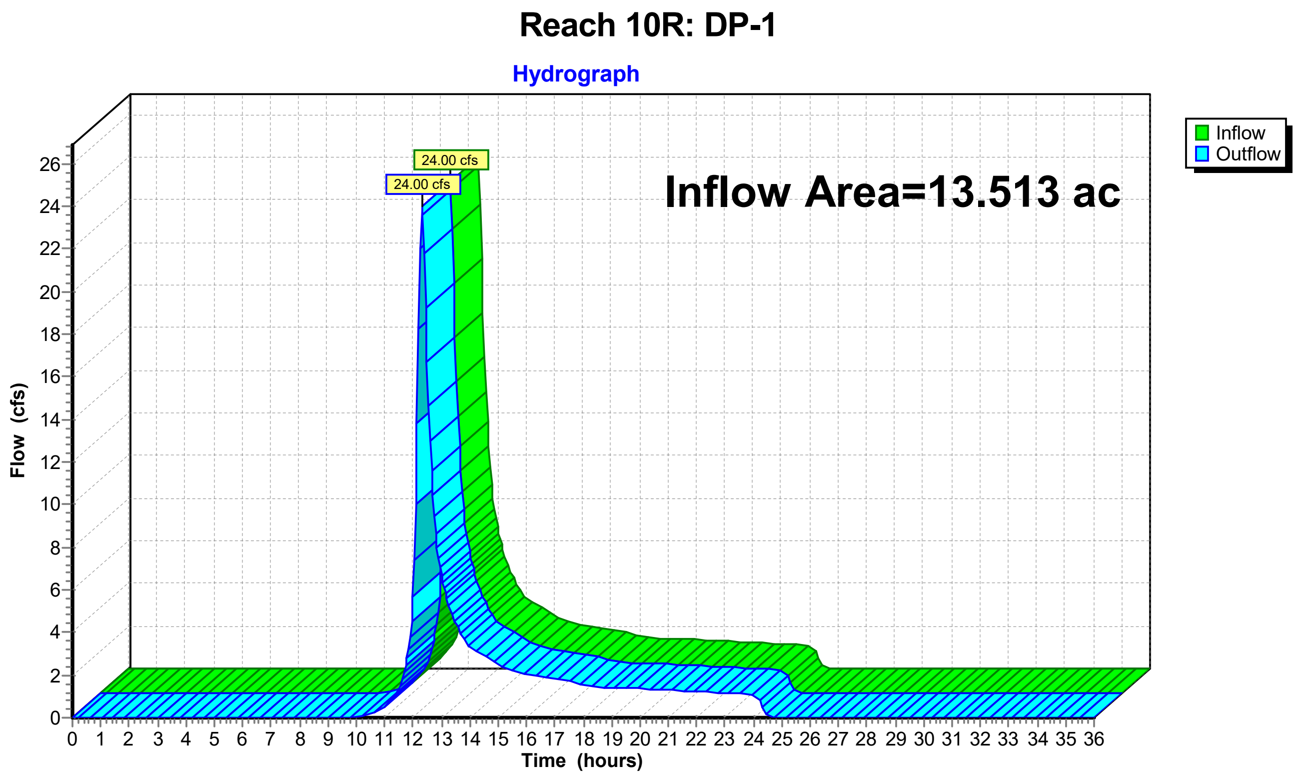
Subcatchment 30S: EDA-3



Summary for Reach 10R: DP-1

Inflow Area =	13.513 ac,	0.92% Impervious,	Inflow Depth = 2.74"	for 100-Year event	
Inflow =	24.00 cfs @	12.32 hrs,	Volume=	3.081 af	
Outflow =	24.00 cfs @	12.32 hrs,	Volume=	3.081 af,	Atten= 0%, Lag= 0.0 min

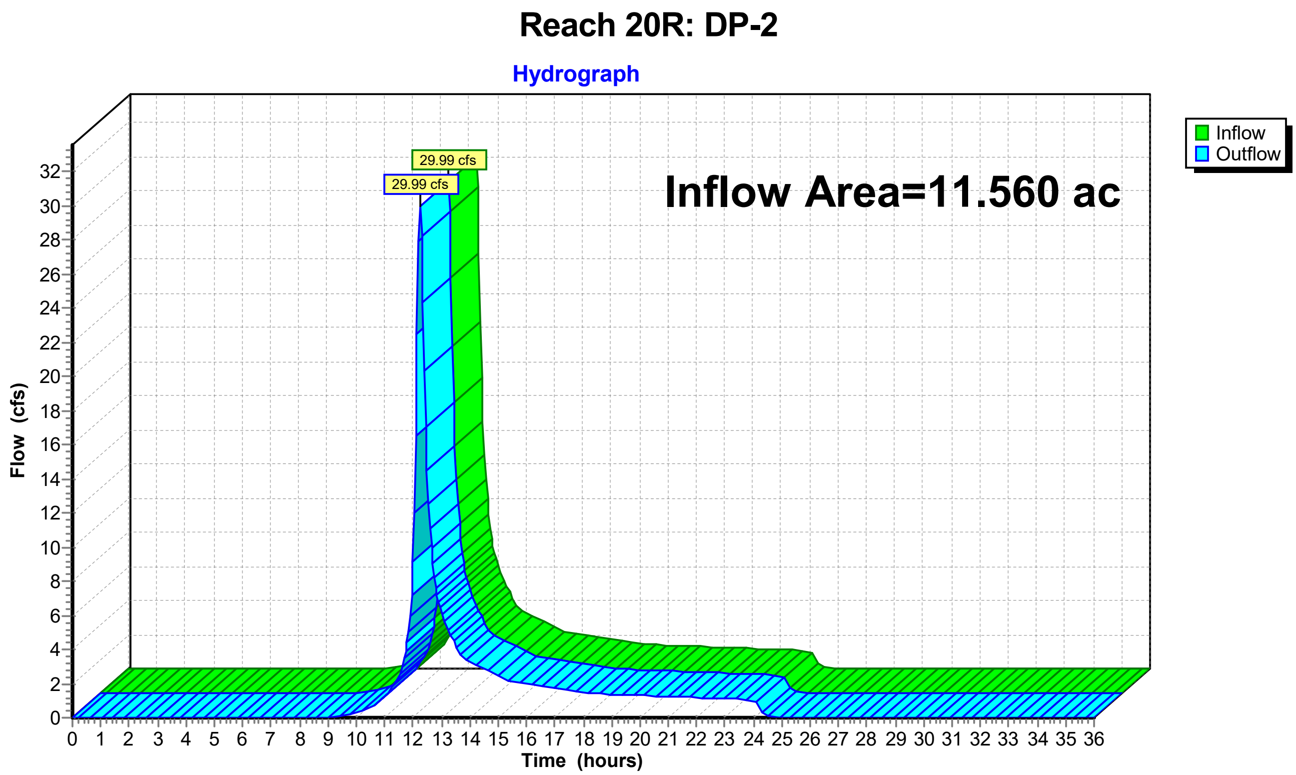
Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs



Summary for Reach 20R: DP-2

Inflow Area =	11.560 ac,	0.00% Impervious,	Inflow Depth = 3.40"	for 100-Year event	
Inflow =	29.99 cfs @	12.25 hrs,	Volume=	3.274 af	
Outflow =	29.99 cfs @	12.25 hrs,	Volume=	3.274 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

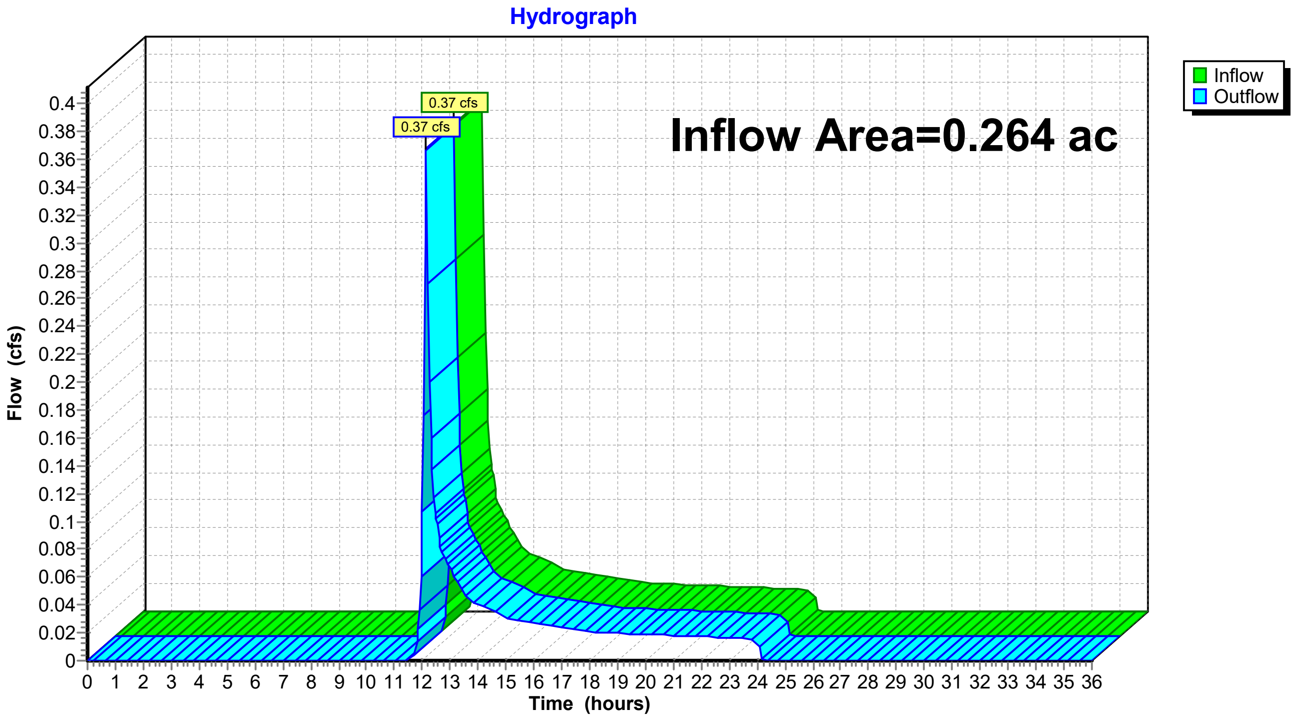


Summary for Reach 30R: DP-3

Inflow Area =	0.264 ac,	0.00% Impervious, Inflow Depth = 1.57"		for 100-Year event
Inflow =	0.37 cfs @	12.14 hrs, Volume=	0.035 af	
Outflow =	0.37 cfs @	12.14 hrs, Volume=	0.035 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs

Reach 30R: DP-3



Attachment 3
Post-Development Hydrologic Analysis

POST-DEVELOPMENT HYDROLOGIC CALCULATIONS

OBJECTIVE
To determine the post-development peak runoff rates for the site for the 2-, 10-, and 100-year storm events.

CONCLUSION(S)
Peak Runoff Rates
The following numbers represent the peak rates of runoff from the site under post-development conditions:

Storm Event	Design Point 1 (cfs)	Design Point 2 (cfs)	Design Point 3 (cfs)
2-year	0.76	0.50	0.00
10-year	3.54	3.11	0.00
100-year	23.82	14.70	0.01

CALCULATION METHODS
1. CN and Tc determined based on TR-55 methodology.
2. Runoff rates and volumes were computed using HydroCAD version 10.20-2d.
3. Area take-offs performed using Civil 3D.

ASSUMPTIONS
1. Hydrologic group of on-site soils was determined based on the United States Department of Agriculture, NRCS Soil Survey information.
2. The area shown on the NRCS Soil Survey as “Not Rated/Not Available” was modeled as Hydrologic Soil Group (HSG) D.
3. Per TR-55, a minimum time of concentration of 6 minutes was used.
4. Surface cover types and boundaries have been estimated based upon B+T Topographic Plan information and the proposed site design.
5. The area of analysis is limited to the area affected by the proposed development.

SOURCES OF DATA/ EQUATIONS
1. Post-Development Conditions Watershed Map, dated 09/01/2022, prepared by Beals and Thomas, Inc. (307706P037C-002).
2. TR-55 Urban Hydrology for Small Watersheds, SCS, 1986.
3. NRCS Soil Survey for Worcester County downloaded from Web Soil Survey 2.0 on 3/4/2021.
4. B+T Topographic Plans, B+T File No. 307706P069B.
5. Proposed site design, B+T Design File No. 307706D017C.
6. Massachusetts DEP Stormwater Handbook, February 2008.

REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	T. Michalak	5/13/2022	DMF	5/16/2022	DMF	5/16/2022
1	R. Kennedy	9/1/2022	JRM	9/2/2022	DMF	9/6/2022

307706CS002B

LIST OF ATTACHMENTS

1. Post-Development Conditions Watershed Map, dated 09/01/2022, prepared by Beals and Thomas, Inc.
2. Post-Development Conditions Hydrology Report from HydroCAD file 307706HC002B, dated 09/01/2022.

REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	T. Michalak	5/13/2022	DMF	5/16/2022	DMF	5/16/2022
1	R. Kennedy	9/1/2022	JRM	9/2/2022	DMF	9/6/2022

307706CS002B

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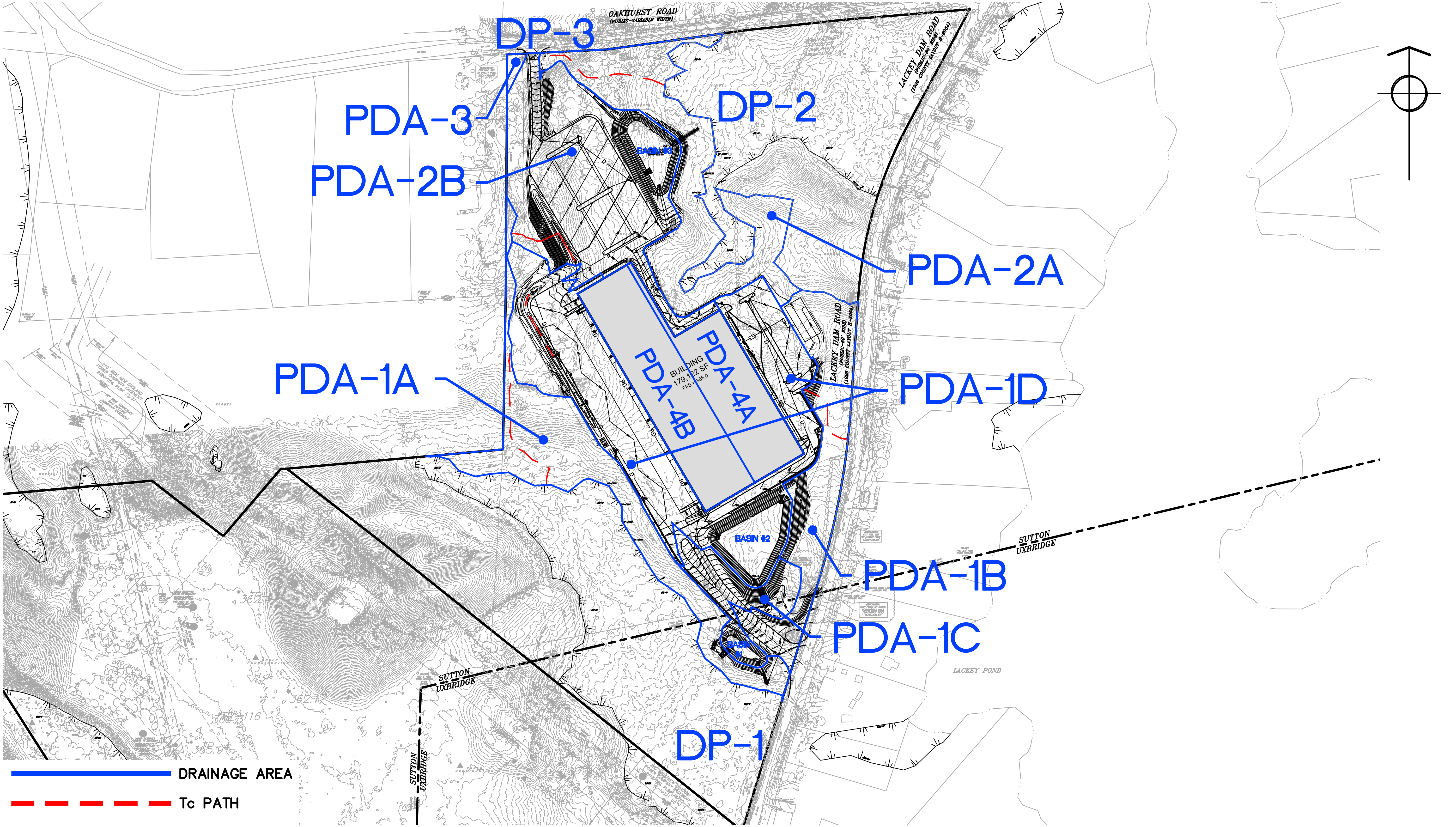
Sutton/Uxbridge, Massachusetts



METERS 0 50 125 200
0 125 250 500 750 FEET

BEALS + THOMAS

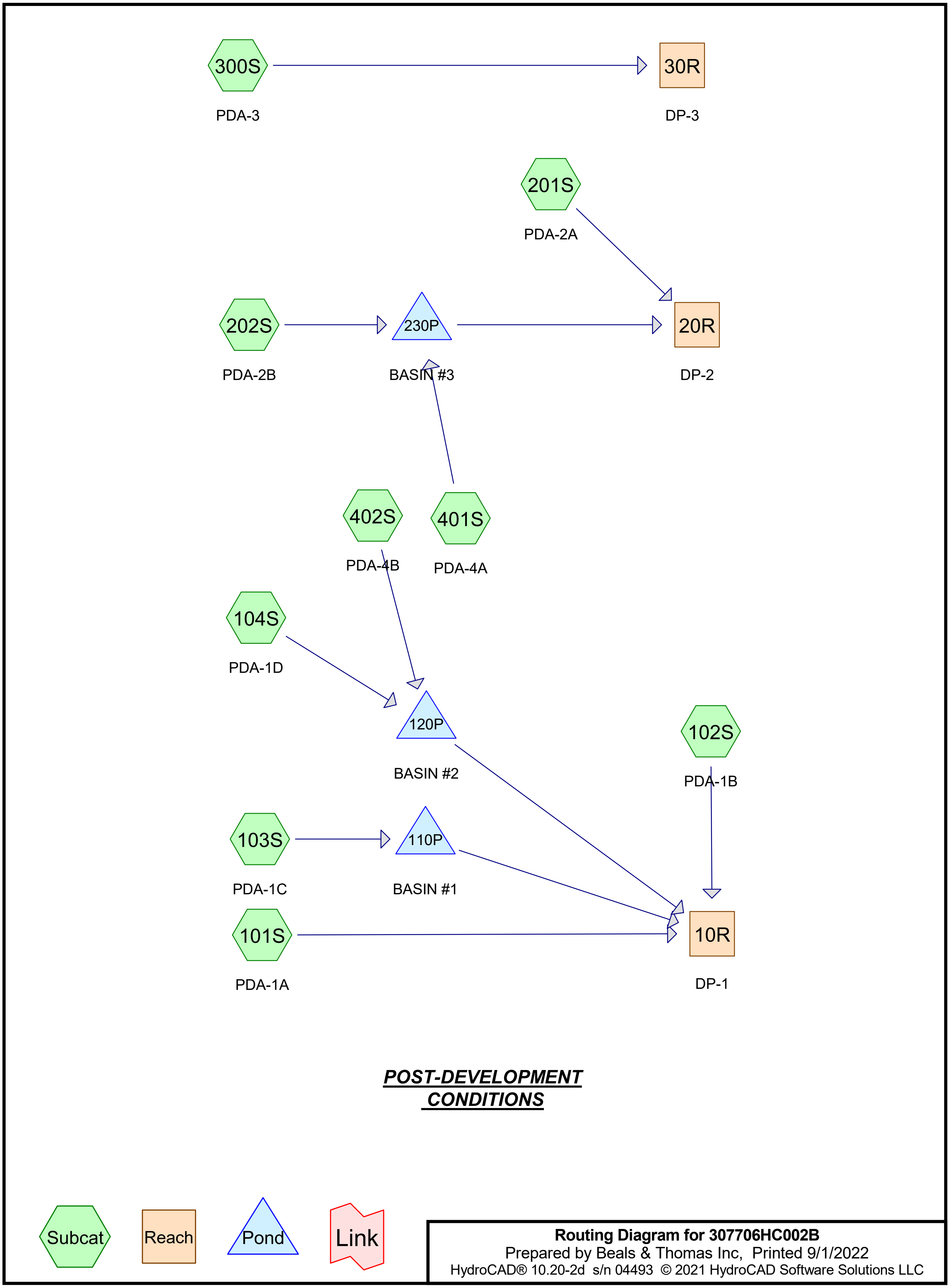
B+T Drawing No. 307706P037C-002 Date: 09/01/2022 Scale: 1" = 250'

Post-Development Conditions

Watershed Map

Figure

2



Routing Diagram for 307706HC002B
Prepared by Beals & Thomas Inc, Printed 9/1/2022
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Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year	NRCC 24-hr	D	Default	24.00	1	3.23	2
2	10-Year	NRCC 24-hr	D	Default	24.00	1	4.85	2
3	100-Year	NRCC 24-hr	D	Default	24.00	1	8.71	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
1.906	39	>75% Grass cover, Good, HSG A (101S, 104S, 201S, 202S, 300S)
3.117	61	>75% Grass cover, Good, HSG B (101S, 102S, 103S, 104S, 201S, 202S)
1.550	80	>75% Grass cover, Good, HSG D (104S, 201S, 202S)
1.930	98	Paved parking, HSG A (104S, 202S)
2.773	98	Paved parking, HSG B (102S, 103S, 104S, 202S)
2.311	98	Paved parking, HSG D (104S, 202S)
1.428	98	Roofs, HSG A (401S, 402S)
2.351	98	Roofs, HSG B (401S, 402S)
0.332	98	Roofs, HSG D (402S)
2.266	30	Woods, Good, HSG A (101S, 104S, 201S, 202S, 300S)
4.547	55	Woods, Good, HSG B (101S, 102S, 103S, 201S)
0.825	77	Woods, Good, HSG D (101S, 104S, 202S)
25.337	**73**	**TOTAL AREA**

Soil Listing (all nodes)

Area (acres)	Soil Group	Subcatchment Numbers
7.530	HSG A	101S, 104S, 201S, 202S, 300S, 401S, 402S
12.788	HSG B	101S, 102S, 103S, 104S, 201S, 202S, 401S, 402S
0.000	HSG C	
5.019	HSG D	101S, 104S, 201S, 202S, 402S
0.000	Other	
25.337		**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
1.906	3.117	0.000	1.550	0.000	6.573	>75% Grass cover, Good	101S, 102S, 103S, 104S, 201S, 202S, 300S
1.930	2.773	0.000	2.311	0.000	7.014	Paved parking	102S, 103S, 104S, 202S
1.428	2.351	0.000	0.332	0.000	4.112	Roofs	401S, 402S
2.266	4.547	0.000	0.825	0.000	7.638	Woods, Good	101S, 102S, 103S, 104S, 201S, 202S, 300S
7.530	**12.788**	**0.000**	**5.019**	**0.000**	**25.337**	**TOTAL AREA**	

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 101S: PDA-1A Runoff Area=2.987 ac 0.00% Impervious Runoff Depth=0.08"
Flow Length=415' Tc=14.1 min CN=47 Runoff=0.02 cfs 0.019 af

Subcatchment 102S: PDA-1B Runoff Area=2.612 ac 8.70% Impervious Runoff Depth=0.46"
Flow Length=218' Tc=9.3 min CN=61 Runoff=0.76 cfs 0.099 af

Subcatchment 103S: PDA-1C Runoff Area=1.053 ac 30.22% Impervious Runoff Depth=0.95"
Tc=6.0 min CN=72 Runoff=1.03 cfs 0.083 af

Subcatchment 104S: PDA-1D Runoff Area=6.093 ac 64.33% Impervious Runoff Depth=1.71"
Flow Length=191' Slope=0.0200 '/' Tc=7.9 min CN=84 Runoff=10.56 cfs 0.867 af

Subcatchment 201S: PDA-2A Runoff Area=3.404 ac 0.00% Impervious Runoff Depth=0.08"
Flow Length=344' Tc=11.1 min CN=47 Runoff=0.03 cfs 0.022 af

Subcatchment 202S: PDA-2B Runoff Area=5.005 ac 50.93% Impervious Runoff Depth=1.49"
Flow Length=254' Tc=10.1 min CN=81 Runoff=6.91 cfs 0.623 af

Subcatchment 300S: PDA-3 Runoff Area=0.071 ac 0.00% Impervious Runoff Depth=0.00"
Tc=6.0 min CN=31 Runoff=0.00 cfs 0.000 af

Subcatchment 401S: PDA-4A Runoff Area=1.675 ac 100.00% Impervious Runoff Depth=3.00"
Tc=6.0 min CN=98 Runoff=4.70 cfs 0.418 af

Subcatchment 402S: PDA-4B Runoff Area=2.437 ac 100.00% Impervious Runoff Depth=3.00"
Tc=6.0 min CN=98 Runoff=6.84 cfs 0.609 af

Reach 10R: DP-1 Inflow=0.76 cfs 0.708 af
Outflow=0.76 cfs 0.708 af

Reach 20R: DP-2 Inflow=0.50 cfs 0.756 af
Outflow=0.50 cfs 0.756 af

Reach 30R: DP-3 Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Pond 110P: BASIN #1 Peak Elev=326.10' Storage=3,461 cf Inflow=1.03 cfs 0.083 af
Outflow=0.02 cfs 0.010 af

Pond 120P: BASIN #2 Peak Elev=342.28' Storage=50,927 cf Inflow=17.24 cfs 1.476 af
Outflow=0.36 cfs 0.579 af

Pond 230P: BASIN #3 Peak Elev=348.66' Storage=29,177 cf Inflow=11.22 cfs 1.041 af
Outflow=0.47 cfs 0.734 af

Total Runoff Area = 25.337 ac Runoff Volume = 2.740 af Average Runoff Depth = 1.30"
56.09% Pervious = 14.211 ac 43.91% Impervious = 11.126 ac

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 101S: PDA-1A Runoff Area=2.987 ac 0.00% Impervious Runoff Depth=0.49"
Flow Length=415' Tc=14.1 min CN=47 Runoff=0.51 cfs 0.121 af

Subcatchment 102S: PDA-1B Runoff Area=2.612 ac 8.70% Impervious Runoff Depth=1.28"
Flow Length=218' Tc=9.3 min CN=61 Runoff=2.91 cfs 0.279 af

Subcatchment 103S: PDA-1C Runoff Area=1.053 ac 30.22% Impervious Runoff Depth=2.08"
Tc=6.0 min CN=72 Runoff=2.36 cfs 0.183 af

Subcatchment 104S: PDA-1D Runoff Area=6.093 ac 64.33% Impervious Runoff Depth=3.13"
Flow Length=191' Slope=0.0200 '/' Tc=7.9 min CN=84 Runoff=19.13 cfs 1.591 af

Subcatchment 201S: PDA-2A Runoff Area=3.404 ac 0.00% Impervious Runoff Depth=0.49"
Flow Length=344' Tc=11.1 min CN=47 Runoff=0.63 cfs 0.138 af

Subcatchment 202S: PDA-2B Runoff Area=5.005 ac 50.93% Impervious Runoff Depth=2.85"
Flow Length=254' Tc=10.1 min CN=81 Runoff=13.22 cfs 1.190 af

Subcatchment 300S: PDA-3 Runoff Area=0.071 ac 0.00% Impervious Runoff Depth=0.01"
Tc=6.0 min CN=31 Runoff=0.00 cfs 0.000 af

Subcatchment 401S: PDA-4A Runoff Area=1.675 ac 100.00% Impervious Runoff Depth=4.61"
Tc=6.0 min CN=98 Runoff=7.10 cfs 0.644 af

Subcatchment 402S: PDA-4B Runoff Area=2.437 ac 100.00% Impervious Runoff Depth=4.61"
Tc=6.0 min CN=98 Runoff=10.34 cfs 0.937 af

Reach 10R: DP-1 Inflow=3.54 cfs 1.901 af
Outflow=3.54 cfs 1.901 af

Reach 20R: DP-2 Inflow=3.11 cfs 1.617 af
Outflow=3.11 cfs 1.617 af

Reach 30R: DP-3 Inflow=0.00 cfs 0.000 af
Outflow=0.00 cfs 0.000 af

Pond 110P: BASIN #1 Peak Elev=326.39' Storage=4,520 cf Inflow=2.36 cfs 0.183 af
Outflow=0.12 cfs 0.109 af

Pond 120P: BASIN #2 Peak Elev=343.20' Storage=74,305 cf Inflow=29.24 cfs 2.528 af
Outflow=1.32 cfs 1.392 af

Pond 230P: BASIN #3 Peak Elev=349.44' Storage=41,372 cf Inflow=19.72 cfs 1.834 af
Outflow=2.81 cfs 1.479 af

Total Runoff Area = 25.337 ac Runoff Volume = 5.082 af Average Runoff Depth = 2.41"
56.09% Pervious = 14.211 ac 43.91% Impervious = 11.126 ac

Time span=0.00-36.00 hrs, dt=0.05 hrs, 721 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 101S: PDA-1A Runoff Area=2.987 ac 0.00% Impervious Runoff Depth=2.35"
Flow Length=415' Tc=14.1 min CN=47 Runoff=5.26 cfs 0.585 af

Subcatchment 102S: PDA-1B Runoff Area=2.612 ac 8.70% Impervious Runoff Depth=3.99"
Flow Length=218' Tc=9.3 min CN=61 Runoff=9.95 cfs 0.869 af

Subcatchment 103S: PDA-1C Runoff Area=1.053 ac 30.22% Impervious Runoff Depth=5.32"
Tc=6.0 min CN=72 Runoff=5.98 cfs 0.467 af

Subcatchment 104S: PDA-1D Runoff Area=6.093 ac 64.33% Impervious Runoff Depth=6.78"
Flow Length=191' Slope=0.0200 '/' Tc=7.9 min CN=84 Runoff=39.85 cfs 3.442 af

Subcatchment 201S: PDA-2A Runoff Area=3.404 ac 0.00% Impervious Runoff Depth=2.35"
Flow Length=344' Tc=11.1 min CN=47 Runoff=6.64 cfs 0.667 af

Subcatchment 202S: PDA-2B Runoff Area=5.005 ac 50.93% Impervious Runoff Depth=6.41"
Flow Length=254' Tc=10.1 min CN=81 Runoff=28.88 cfs 2.675 af

Subcatchment 300S: PDA-3 Runoff Area=0.071 ac 0.00% Impervious Runoff Depth=0.68"
Tc=6.0 min CN=31 Runoff=0.01 cfs 0.004 af

Subcatchment 401S: PDA-4A Runoff Area=1.675 ac 100.00% Impervious Runoff Depth=8.47"
Tc=6.0 min CN=98 Runoff=12.81 cfs 1.182 af

Subcatchment 402S: PDA-4B Runoff Area=2.437 ac 100.00% Impervious Runoff Depth=8.47"
Tc=6.0 min CN=98 Runoff=18.64 cfs 1.720 af

Reach 10R: DP-1 Inflow=23.82 cfs 5.824 af
Outflow=23.82 cfs 5.824 af

Reach 20R: DP-2 Inflow=14.70 cfs 4.144 af
Outflow=14.70 cfs 4.144 af

Reach 30R: DP-3 Inflow=0.01 cfs 0.004 af
Outflow=0.01 cfs 0.004 af

Pond 110P: BASIN #1 Peak Elev=327.43' Storage=8,924 cf Inflow=5.98 cfs 0.467 af
Outflow=1.05 cfs 0.393 af

Pond 120P: BASIN #2 Peak Elev=344.73' Storage=116,610 cf Inflow=58.11 cfs 5.162 af
Outflow=11.74 cfs 3.977 af

Pond 230P: BASIN #3 Peak Elev=351.34' Storage=75,369 cf Inflow=40.64 cfs 3.857 af
Outflow=9.23 cfs 3.477 af

Total Runoff Area = 25.337 ac Runoff Volume = 11.612 af Average Runoff Depth = 5.50"
56.09% Pervious = 14.211 ac 43.91% Impervious = 11.126 ac

Summary for Subcatchment 101S: PDA-1A

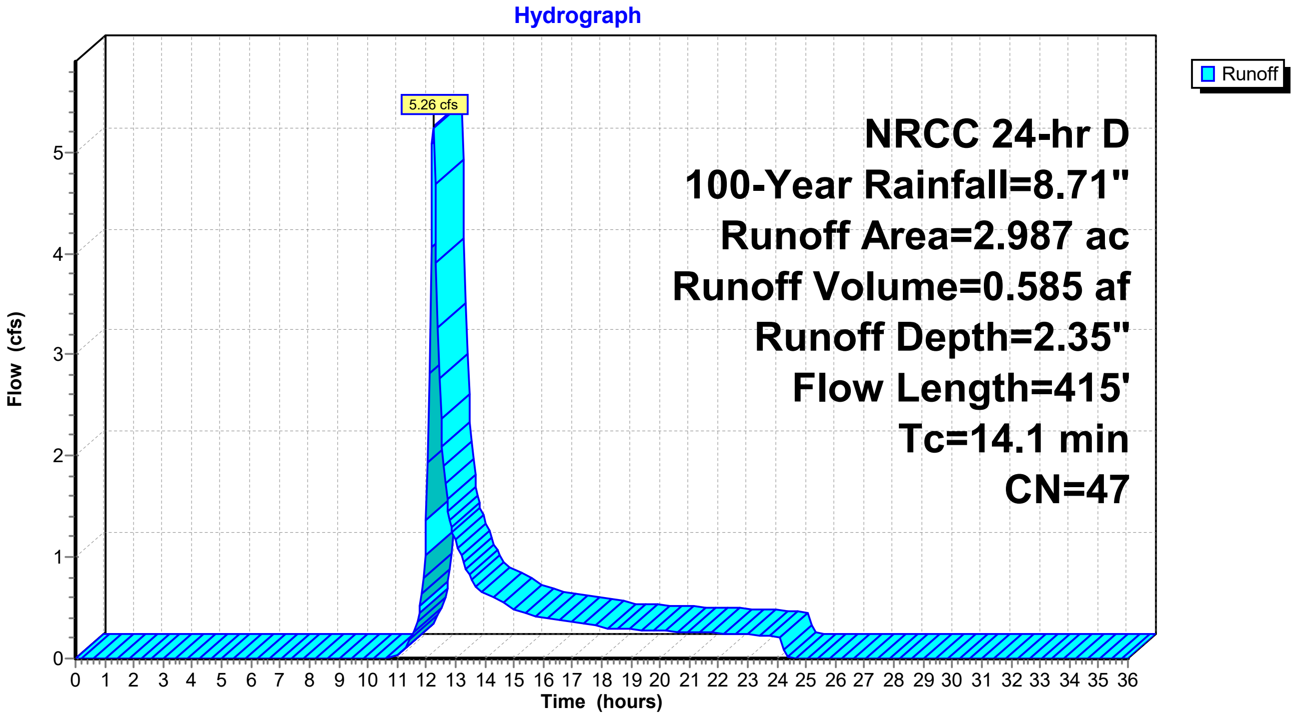
Runoff = 5.26 cfs @ 12.24 hrs, Volume= 0.585 af, Depth= 2.35"
Routed to Reach 10R : DP-1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.060	39	>75% Grass cover, Good, HSG A
0.258	61	>75% Grass cover, Good, HSG B
1.154	30	Woods, Good, HSG A
1.364	55	Woods, Good, HSG B
0.151	77	Woods, Good, HSG D
2.987	47	Weighted Average
2.987		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
9.2	50	0.0400	0.09		**Sheet Flow, SHT** Woods: Light underbrush n= 0.400 P2= 3.32"
2.1	214	0.1168	1.71		**Shallow Concentrated Flow, SCF-1** Woodland Kv= 5.0 fps
2.8	151	0.0331	0.91		**Shallow Concentrated Flow, SCF-2** Woodland Kv= 5.0 fps
14.1	415	Total			

Subcatchment 101S: PDA-1A



Summary for Subcatchment 102S: PDA-1B

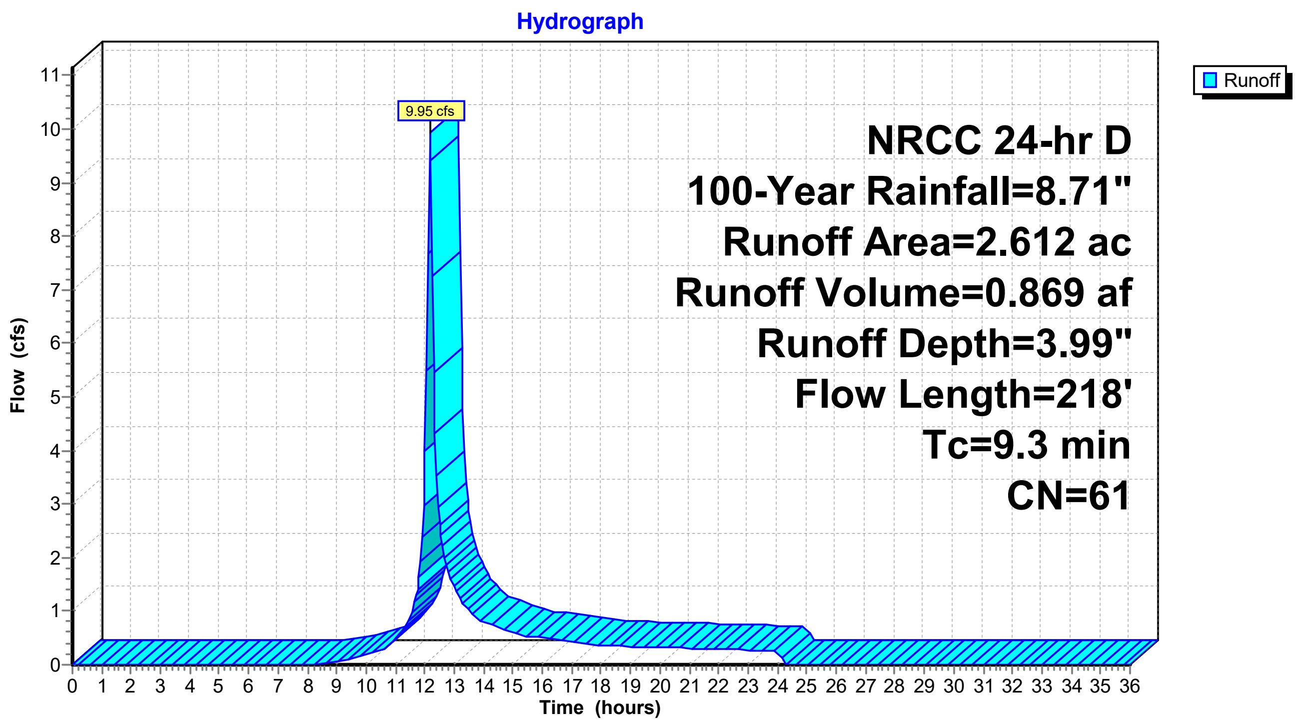
Runoff = 9.95 cfs @ 12.17 hrs, Volume= 0.869 af, Depth= 3.99"
Routed to Reach 10R : DP-1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.881	61	>75% Grass cover, Good, HSG B
0.227	98	Paved parking, HSG B
1.503	55	Woods, Good, HSG B
2.612	61	Weighted Average
2.385		91.30% Pervious Area
0.227		8.70% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
4.9	50	0.0265	0.17		**Sheet Flow, SHT** Grass: Short n= 0.150 P2= 3.32"
4.4	168	0.0164	0.64		**Shallow Concentrated Flow, SCF-1** Woodland Kv= 5.0 fps
9.3	218	Total			

Subcatchment 102S: PDA-1B



Summary for Subcatchment 103S: PDA-1C

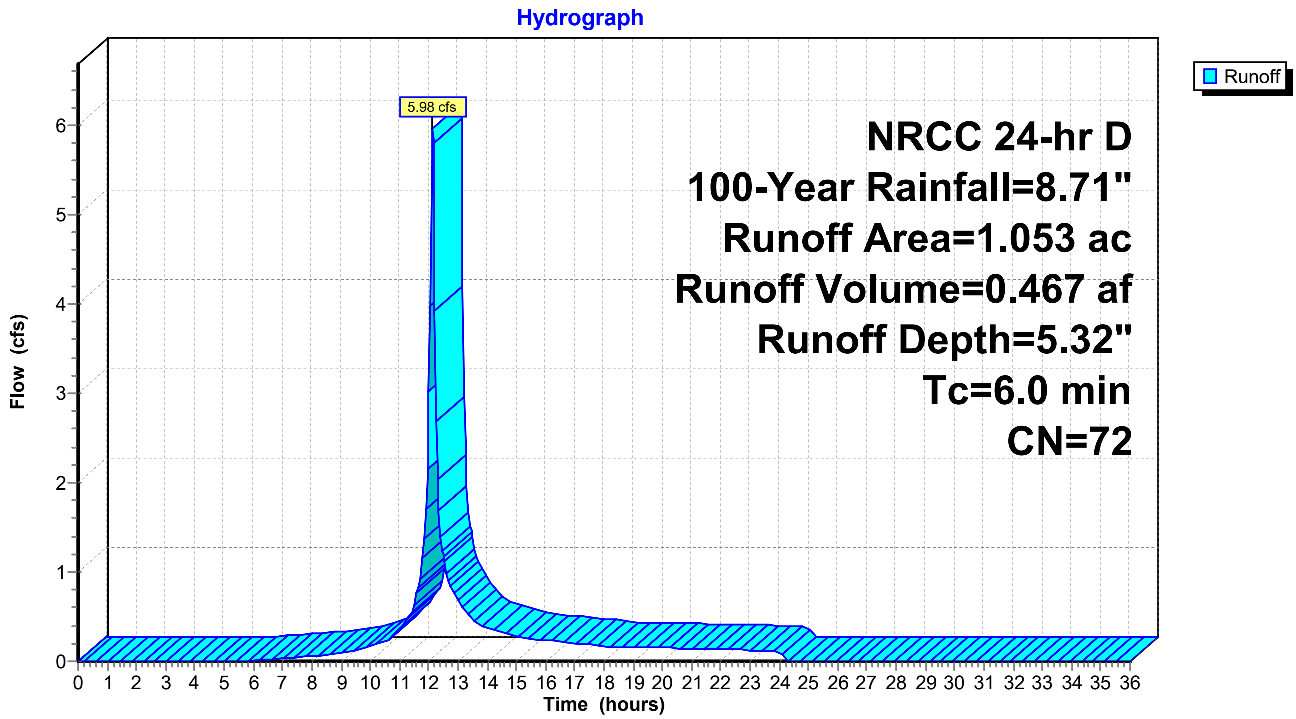
Runoff = 5.98 cfs @ 12.13 hrs, Volume= 0.467 af, Depth= 5.32"
Routed to Pond 110P : BASIN #1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.679	61	>75% Grass cover, Good, HSG B
0.318	98	Paved parking, HSG B
0.056	55	Woods, Good, HSG B
1.053	72	Weighted Average
0.735		69.78% Pervious Area
0.318		30.22% Impervious Area

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

Subcatchment 103S: PDA-1C



Summary for Subcatchment 104S: PDA-1D

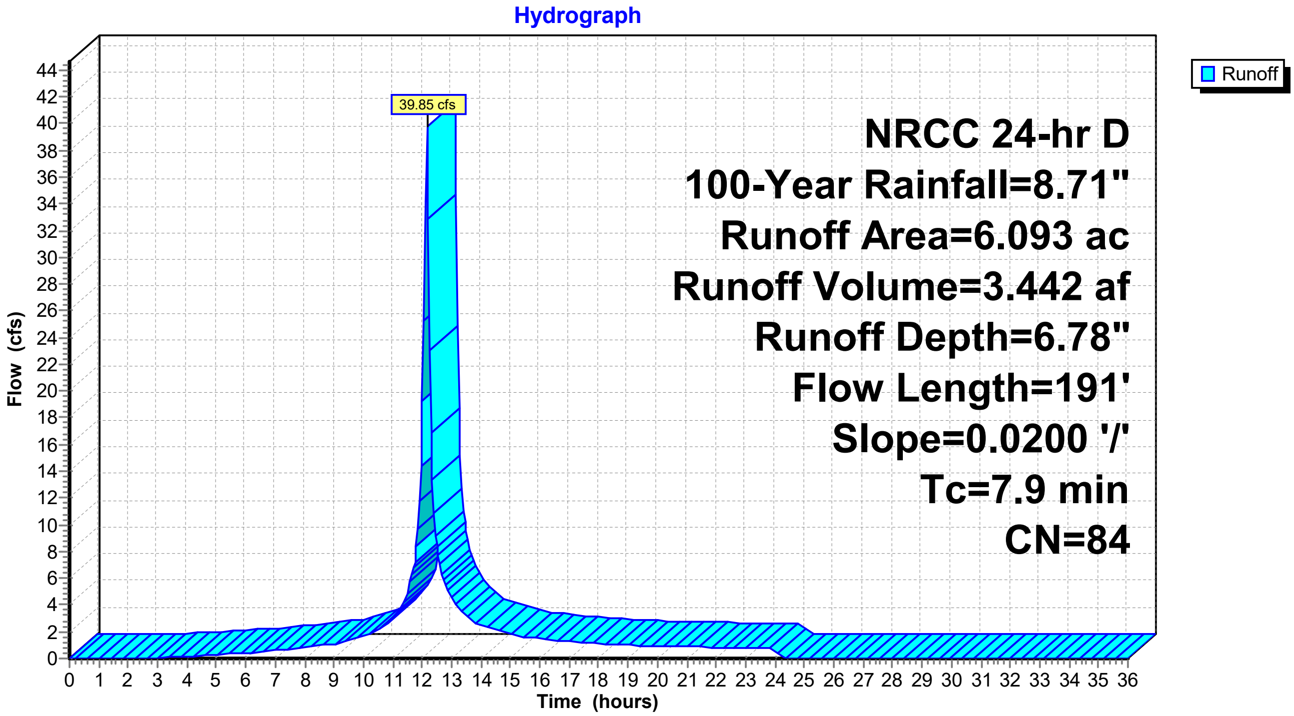
Runoff = 39.85 cfs @ 12.15 hrs, Volume= 3.442 af, Depth= 6.78"
Routed to Pond 120P : BASIN #2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.233	39	>75% Grass cover, Good, HSG A
1.087	61	>75% Grass cover, Good, HSG B
0.356	80	>75% Grass cover, Good, HSG D
1.120	98	Paved parking, HSG A
2.164	98	Paved parking, HSG B
0.636	98	Paved parking, HSG D
0.246	30	Woods, Good, HSG A
0.252	77	Woods, Good, HSG D
6.093	84	Weighted Average
2.173		35.67% Pervious Area
3.920		64.33% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.5	50	0.0200	0.15		**Sheet Flow, SHT** Grass: Short n= 0.150 P2= 3.32"
2.4	141	0.0200	0.99		**Shallow Concentrated Flow, SCF-1** Short Grass Pasture Kv= 7.0 fps
7.9	191	Total			

Subcatchment 104S: PDA-1D



Summary for Subcatchment 201S: PDA-2A

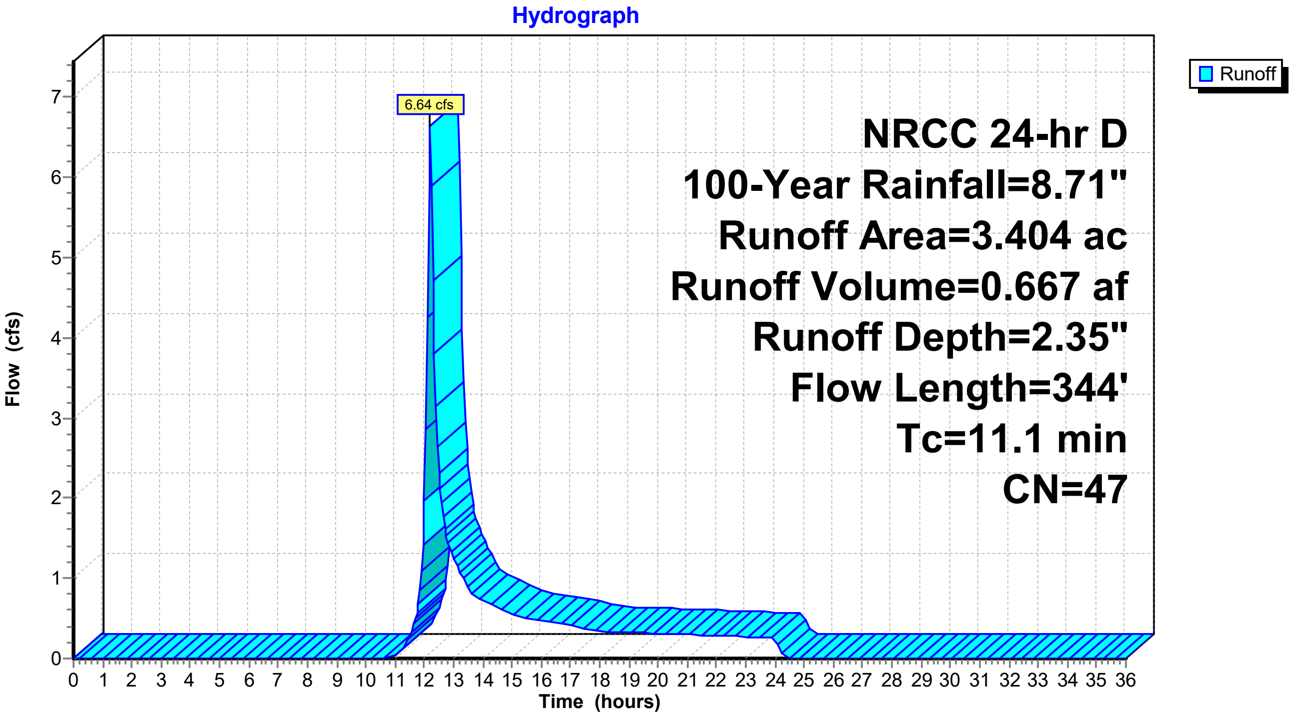
Runoff = 6.64 cfs @ 12.20 hrs, Volume= 0.667 af, Depth= 2.35"
Routed to Reach 20R : DP-2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.768	39	>75% Grass cover, Good, HSG A
0.178	61	>75% Grass cover, Good, HSG B
0.078	80	>75% Grass cover, Good, HSG D
0.756	30	Woods, Good, HSG A
1.624	55	Woods, Good, HSG B
3.404	47	Weighted Average
3.404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.3	50	0.0700	0.11		**Sheet Flow, SHT** Woods: Light underbrush n= 0.400 P2= 3.32"
0.3	43	0.3023	2.75		**Shallow Concentrated Flow, SCF-1** Woodland Kv= 5.0 fps
3.5	251	0.0558	1.18		**Shallow Concentrated Flow, SCF-2** Woodland Kv= 5.0 fps
11.1	344	Total			

Subcatchment 201S: PDA-2A



Summary for Subcatchment 202S: PDA-2B

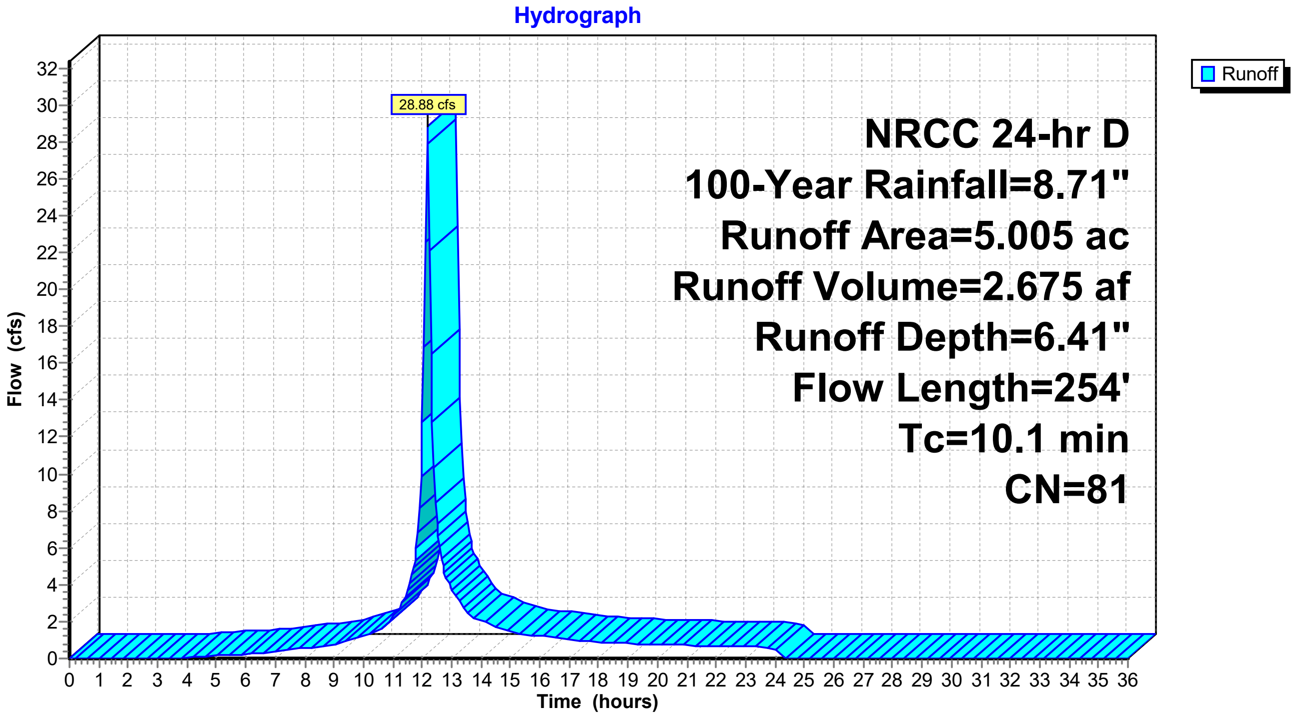
Runoff = 28.88 cfs @ 12.17 hrs, Volume= 2.675 af, Depth= 6.41"
Routed to Pond 230P : BASIN #3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.840	39	>75% Grass cover, Good, HSG A
0.034	61	>75% Grass cover, Good, HSG B
1.116	80	>75% Grass cover, Good, HSG D
0.810	98	Paved parking, HSG A
0.064	98	Paved parking, HSG B
1.675	98	Paved parking, HSG D
0.044	30	Woods, Good, HSG A
0.423	77	Woods, Good, HSG D
5.005	81	Weighted Average
2.456		49.07% Pervious Area
2.549		50.93% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.8	50	0.0600	0.11		**Sheet Flow, SHT** Woods: Light underbrush n= 0.400 P2= 3.32"
0.2	16	0.0870	1.47		**Shallow Concentrated Flow, SCF-1** Woodland Kv= 5.0 fps
0.5	50	0.0680	1.83		**Shallow Concentrated Flow, SCF-2** Short Grass Pasture Kv= 7.0 fps
0.2	49	0.5000	4.95		**Shallow Concentrated Flow, SCF-3** Short Grass Pasture Kv= 7.0 fps
1.4	89	0.0225	1.05		**Shallow Concentrated Flow, SCF-4** Short Grass Pasture Kv= 7.0 fps
10.1	254	Total			

Subcatchment 202S: PDA-2B



Summary for Subcatchment 300S: PDA-3

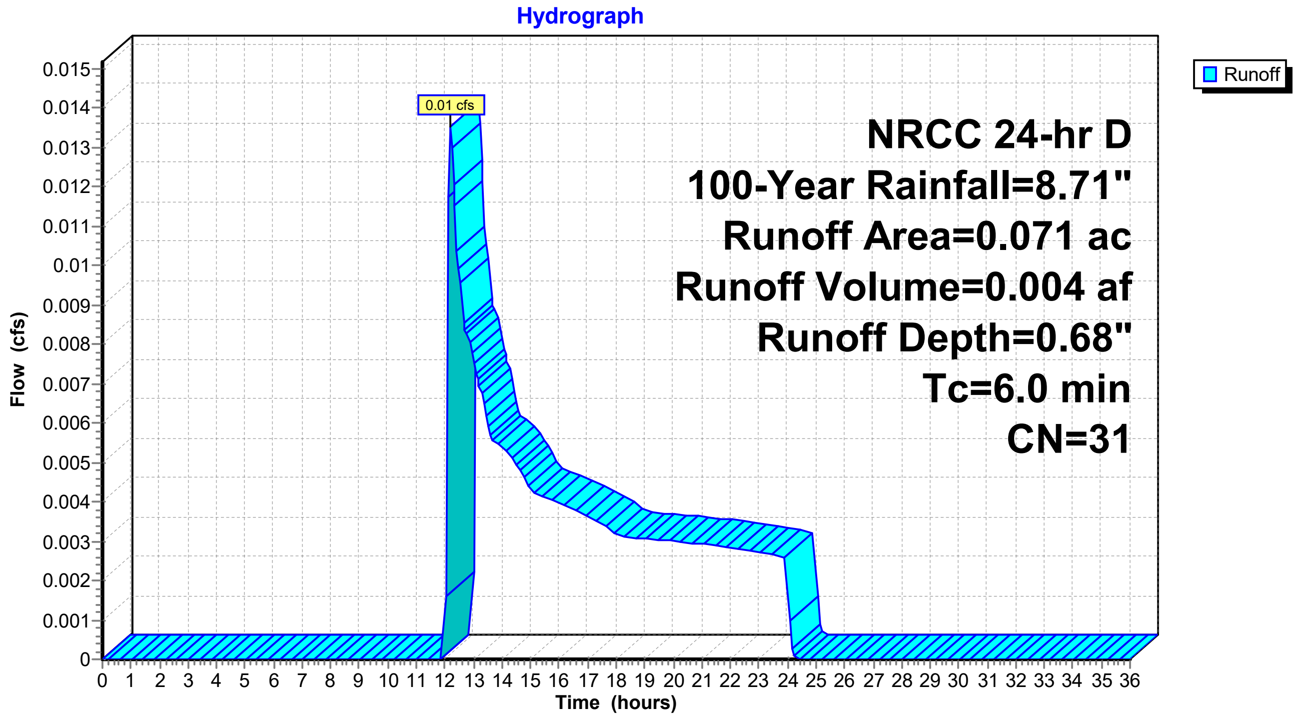
Runoff = 0.01 cfs @ 12.21 hrs, Volume= 0.004 af, Depth= 0.68"
Routed to Reach 30R : DP-3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.005	39	>75% Grass cover, Good, HSG A
0.066	30	Woods, Good, HSG A
0.071	31	Weighted Average
0.071		100.00% Pervious Area

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

Subcatchment 300S: PDA-3



Summary for Subcatchment 401S: PDA-4A

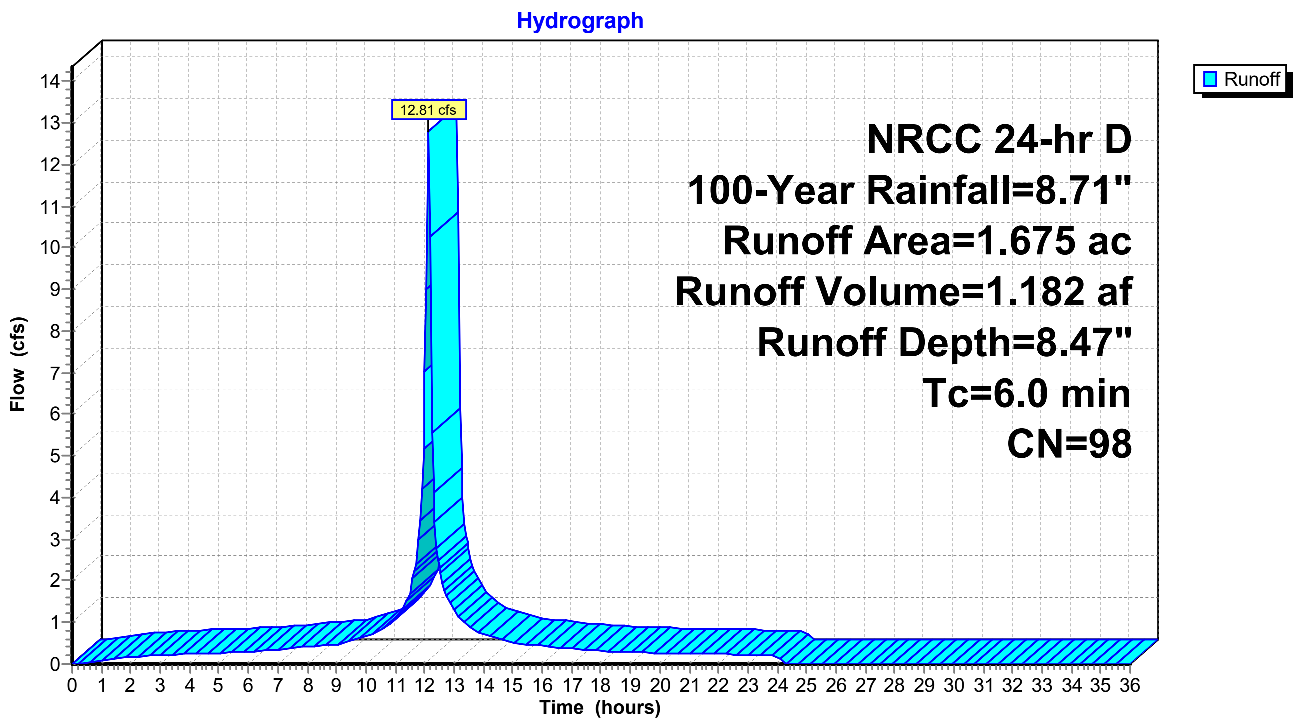
Runoff = 12.81 cfs @ 12.13 hrs, Volume= 1.182 af, Depth= 8.47"
Routed to Pond 230P : BASIN #3

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
0.131	98	Roofs, HSG A
1.544	98	Roofs, HSG B
1.675	98	Weighted Average
1.675		100.00% Impervious Area

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

Subcatchment 401S: PDA-4A



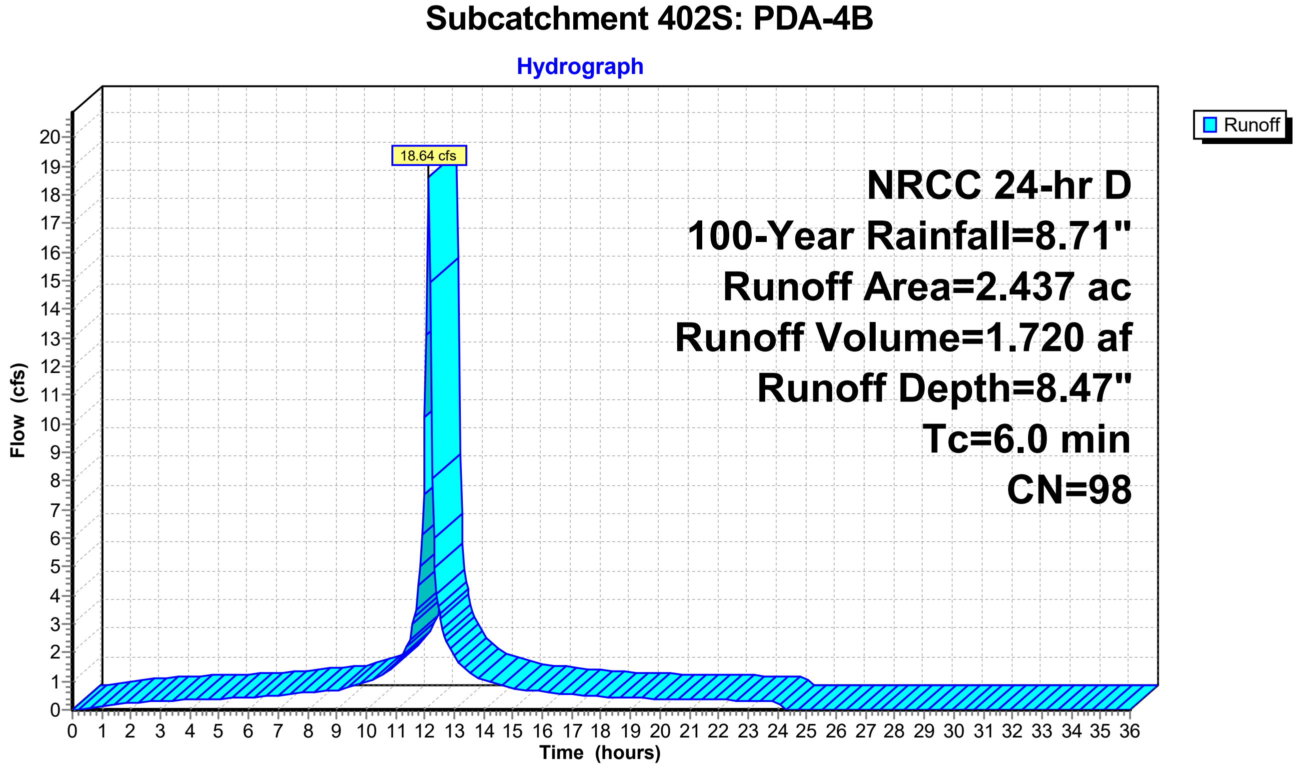
Summary for Subcatchment 402S: PDA-4B

Runoff = 18.64 cfs @ 12.13 hrs, Volume= 1.720 af, Depth= 8.47"
Routed to Pond 120P : BASIN #2

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
NRCC 24-hr D 100-Year Rainfall=8.71"

Area (ac)	CN	Description
1.298	98	Roofs, HSG A
0.807	98	Roofs, HSG B
0.332	98	Roofs, HSG D
2.437	98	Weighted Average
2.437		100.00% Impervious Area

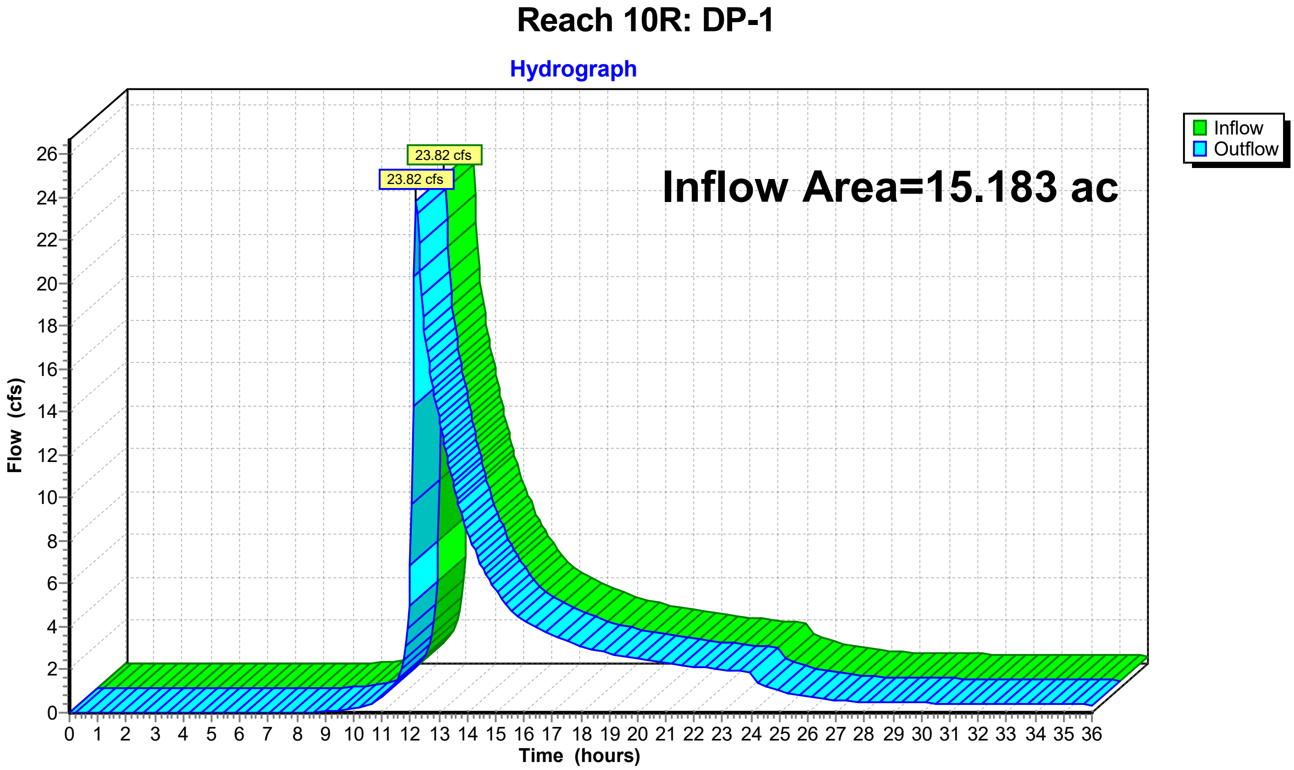
Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.0					**Direct Entry, MIN**



Summary for Reach 10R: DP-1

Inflow Area = 15.183 ac, 45.47% Impervious, Inflow Depth > 4.60" for 100-Year event
Inflow = 23.82 cfs @ 12.22 hrs, Volume= 5.824 af
Outflow = 23.82 cfs @ 12.22 hrs, Volume= 5.824 af, Atten= 0%, Lag= 0.0 min

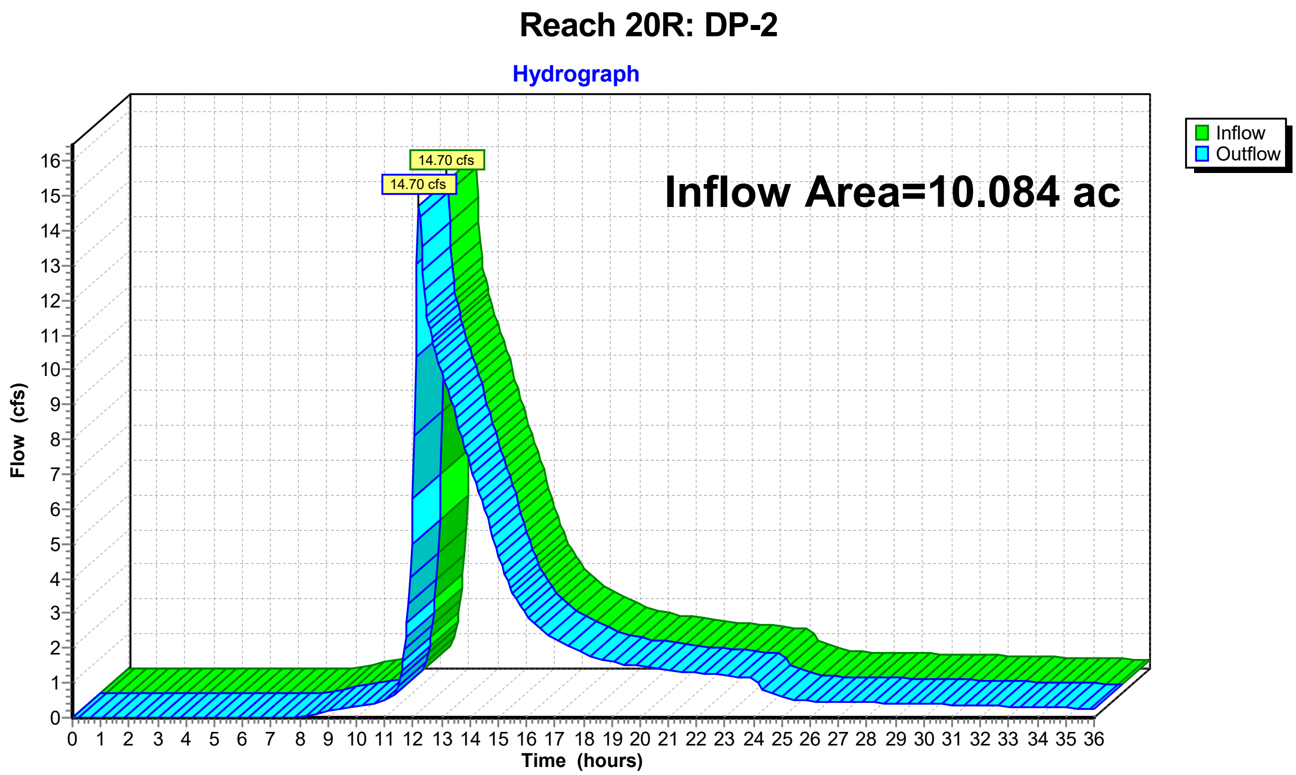
Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs



Summary for Reach 20R: DP-2

Inflow Area =	10.084 ac,	41.88% Impervious,	Inflow Depth > 4.93"	for 100-Year event
Inflow =	14.70 cfs @	12.22 hrs, Volume=	4.144 af	
Outflow =	14.70 cfs @	12.22 hrs, Volume=	4.144 af,	Atten= 0%, Lag= 0.0 min

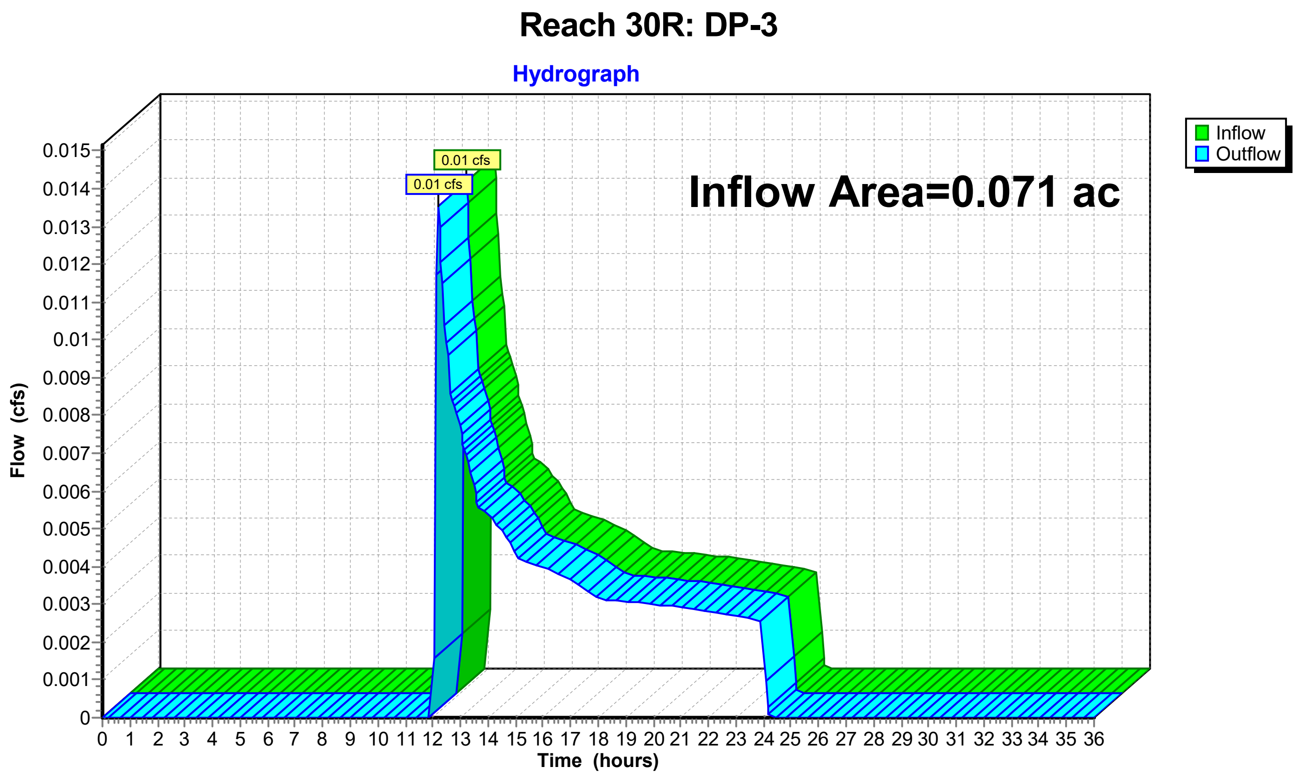
Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs



Summary for Reach 30R: DP-3

Inflow Area =	0.071 ac,	0.00% Impervious, Inflow Depth = 0.68"	for 100-Year event	
Inflow =	0.01 cfs @	12.21 hrs, Volume=	0.004 af	
Outflow =	0.01 cfs @	12.21 hrs, Volume=	0.004 af,	Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs



Summary for Pond 110P: BASIN #1

Inflow Area = 1.053 ac, 30.22% Impervious, Inflow Depth = 5.32" for 100-Year event
Inflow = 5.98 cfs @ 12.13 hrs, Volume= 0.467 af
Outflow = 1.05 cfs @ 12.57 hrs, Volume= 0.393 af, Atten= 82%, Lag= 26.6 min
Primary = 1.05 cfs @ 12.57 hrs, Volume= 0.393 af
Routed to Reach 10R : DP-1

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 327.43' @ 12.57 hrs Surf.Area= 4,678 sf Storage= 8,924 cf

Plug-Flow detention time= 246.3 min calculated for 0.393 af (84% of inflow)
Center-of-Mass det. time= 169.6 min (1,007.0 - 837.3)

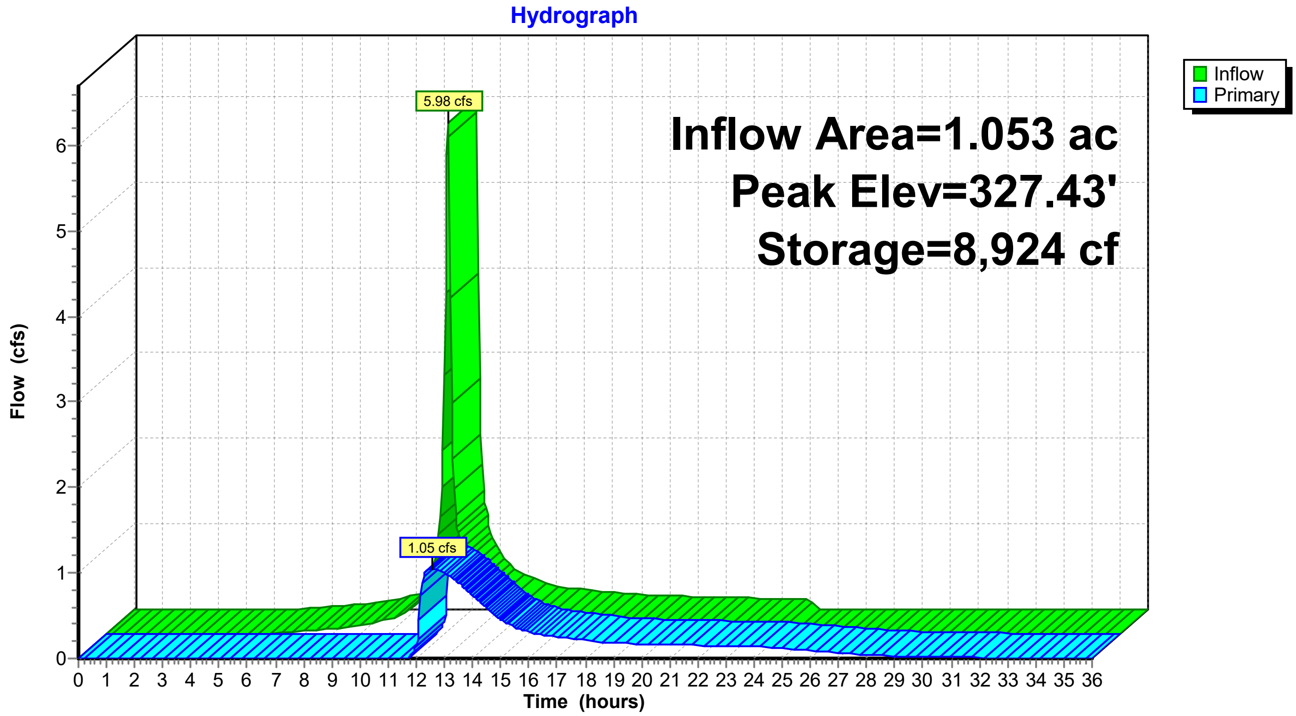
Volume	Invert	Avail.Storage	Storage Description
#1	325.00'	17,373 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
325.00	2,718	0	0
326.00	3,481	3,100	3,100
327.00	4,301	3,891	6,991
328.00	5,177	4,739	11,730
329.00	6,109	5,643	17,373

Device	Routing	Invert	Outlet Devices
#1	Primary	323.00'	**12.0" Round Culvert** L= 50.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 323.00' / 322.00' S= 0.0200 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.79 sf
#2	Device 1	326.00'	**3.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Device 1	326.50'	**6.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=1.05 cfs @ 12.57 hrs HW=327.43' (Free Discharge)
1=Culvert (Passes 1.05 cfs of 7.50 cfs potential flow)
2=Orifice/Grate (Orifice Controls 0.27 cfs @ 5.50 fps)
3=Orifice/Grate (Orifice Controls 0.78 cfs @ 3.97 fps)

Pond 110P: BASIN #1



Summary for Pond 120P: BASIN #2

Inflow Area = 8.531 ac, 74.52% Impervious, Inflow Depth = 7.26" for 100-Year event
Inflow = 58.11 cfs @ 12.14 hrs, Volume= 5.162 af
Outflow = 11.74 cfs @ 12.50 hrs, Volume= 3.977 af, Atten= 80%, Lag= 21.8 min
Primary = 11.74 cfs @ 12.50 hrs, Volume= 3.977 af
Routed to Reach 10R : DP-1

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 344.73' @ 12.50 hrs Surf.Area= 29,340 sf Storage= 116,610 cf

Plug-Flow detention time= 359.9 min calculated for 3.977 af (77% of inflow)
Center-of-Mass det. time= 259.2 min (1,042.7 - 783.4)

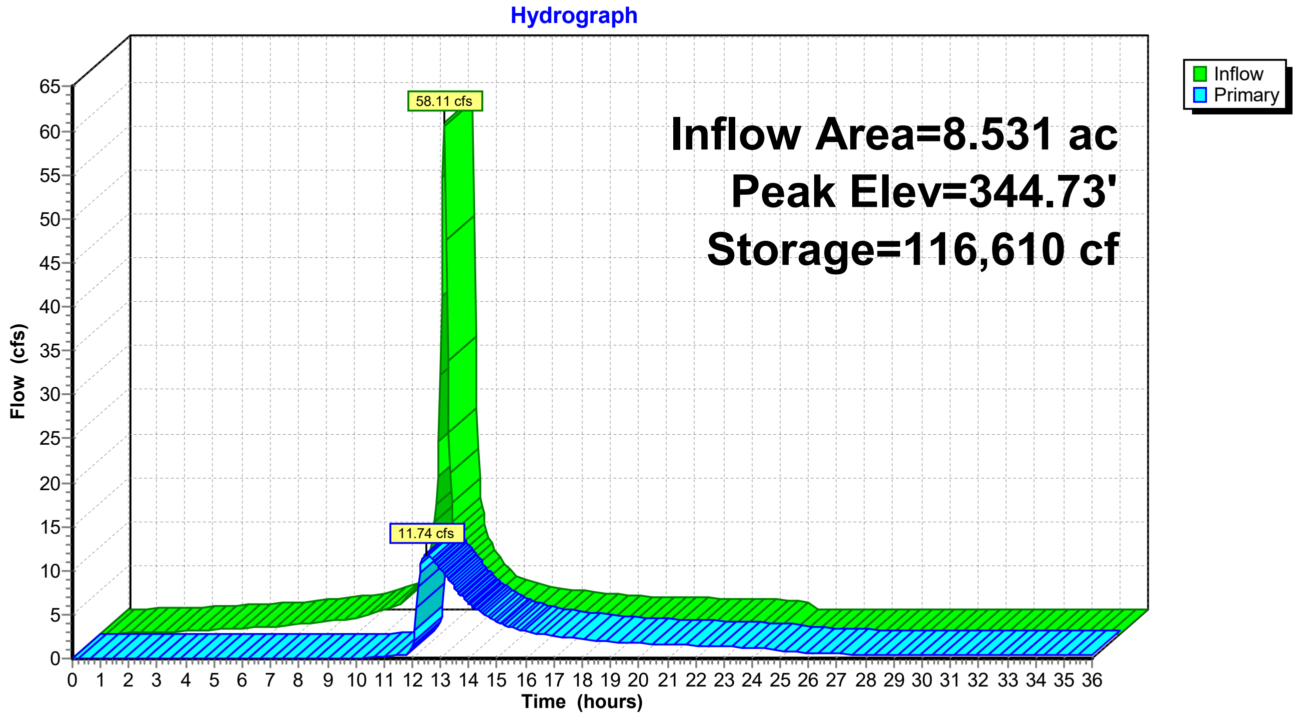
Volume	Invert	Avail.Storage	Storage Description
#1	340.00'	155,684 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
340.00	20,215	0	0
341.00	22,040	21,128	21,128
342.00	23,920	22,980	44,108
343.00	25,858	24,889	68,997
344.00	27,852	26,855	95,852
345.00	29,902	28,877	124,729
346.00	32,009	30,956	155,684

Device	Routing	Invert	Outlet Devices
#1	Primary	338.00'	**18.0" Round Culvert** L= 200.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 338.00' / 334.00' S= 0.0200 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#2	Device 1	341.40'	**4.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Device 1	342.80'	**1.0' long x 2.30' rise Sharp-Crested Rectangular Weir** 2 End Contraction(s) 2.8' Crest Height
#4	Device 1	343.60'	**1.5' long x 1.40' rise Sharp-Crested Rectangular Weir** 2 End Contraction(s) 3.6' Crest Height

Primary OutFlow Max=11.74 cfs @ 12.50 hrs HW=344.73' (Free Discharge)
└─**1=Culvert** (Passes 11.74 cfs of 18.97 cfs potential flow)
 ├─**2=Orifice/Grate** (Orifice Controls 0.75 cfs @ 8.56 fps)
 ├─**3=Sharp-Crested Rectangular Weir** (Weir Controls 5.83 cfs @ 4.92 fps)
 └─**4=Sharp-Crested Rectangular Weir** (Weir Controls 5.17 cfs @ 3.60 fps)

Pond 120P: BASIN #2



Summary for Pond 230P: BASIN #3

Inflow Area = 6.679 ac, 63.23% Impervious, Inflow Depth = 6.93" for 100-Year event
Inflow = 40.64 cfs @ 12.15 hrs, Volume= 3.857 af
Outflow = 9.23 cfs @ 12.53 hrs, Volume= 3.477 af, Atten= 77%, Lag= 22.5 min
Primary = 9.23 cfs @ 12.53 hrs, Volume= 3.477 af
Routed to Reach 20R : DP-2

Routing by Stor-Ind method, Time Span= 0.00-36.00 hrs, dt= 0.05 hrs
Peak Elev= 351.34' @ 12.53 hrs Surf.Area= 19,416 sf Storage= 75,369 cf

Plug-Flow detention time= 266.4 min calculated for 3.477 af (90% of inflow)
Center-of-Mass det. time= 212.0 min (1,005.0 - 793.0)

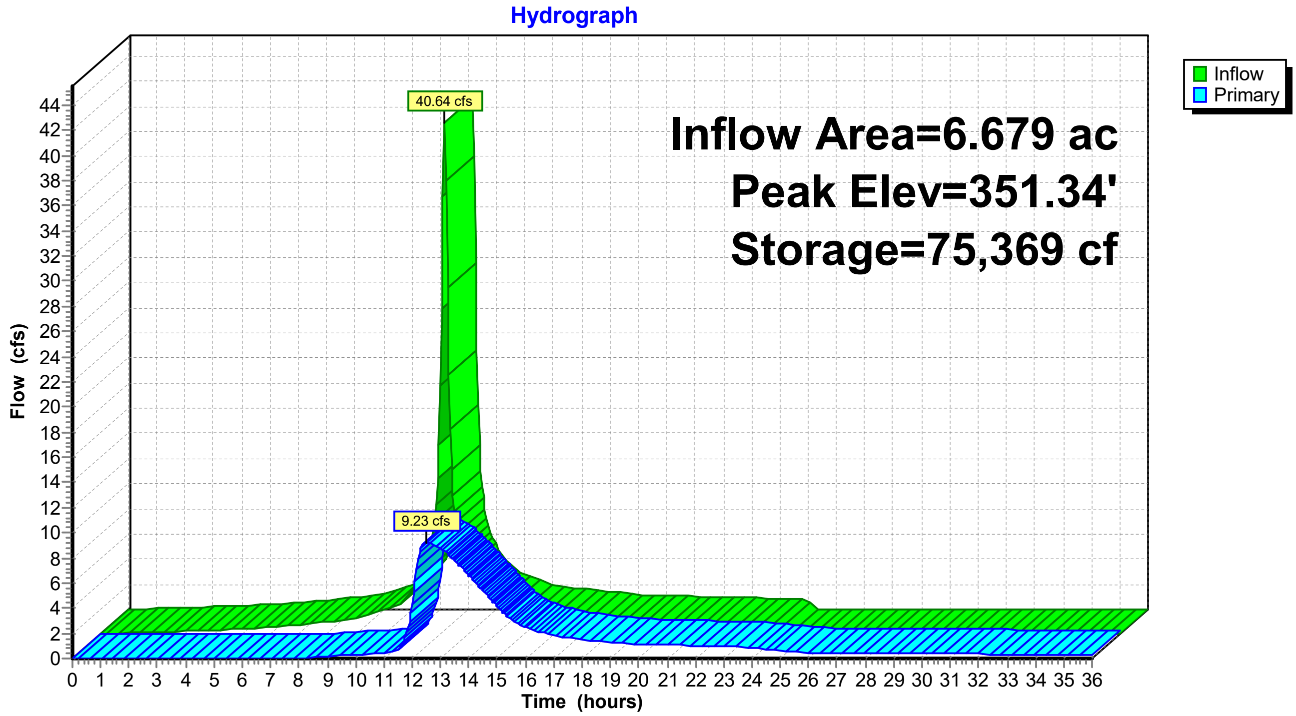
Volume	Invert	Avail.Storage	Storage Description
#1	346.50'	98,931 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
346.50	11,916	0	0
347.00	12,628	6,136	6,136
348.00	14,094	13,361	19,497
349.00	15,617	14,856	34,353
350.00	17,196	16,407	50,759
351.00	18,832	18,014	68,773
352.00	20,525	19,679	88,452
352.50	21,392	10,479	98,931

Device	Routing	Invert	Outlet Devices
#1	Primary	346.50'	**18.0" Round Culvert** L= 70.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 346.50' / 346.00' S= 0.0071 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#2	Device 1	347.25'	**4.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Device 1	348.70'	**15.0" Vert. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Primary OutFlow Max=9.23 cfs @ 12.53 hrs HW=351.34' (Free Discharge)
└─**1=Culvert** (Passes 9.23 cfs of 16.68 cfs potential flow)
  ├─**2=Orifice/Grate** (Orifice Controls 0.83 cfs @ 9.54 fps)
  └─**3=Orifice/Grate** (Orifice Controls 8.40 cfs @ 6.84 fps)

Pond 230P: BASIN #3



Attachment 4
Hydraulic Calculations

PROPOSED STORMWATER HYDRAULICS CALCULATION SUMMARY

OBJECTIVE
To design a stormwater collection system to capture and convey runoff to the stormwater best management practices and outfalls. To design outfalls to meet the standards of the Massachusetts DEP Stormwater Management Handbook for erosion and scour protection.

CONCLUSIONS
The system will adequately convey the 25-year rational storm, and stormwater will not surcharge rims/grates during the 25-year or 100-year rational storm events. Analyzing the 100-year rational storm with maximum basin tailwater elevations is a worst-case scenario for the event.

CALCULATION METHODS
1. Drainage system was designed using the Rational Formula and Manning's Formula.
2. Drainage system was modeled and analyzed with StormCAD Version 10.03.04.53 by Bentley Systems, Inc.

ASSUMPTIONS
1. Runoff coefficient of C=0.9 for impervious areas (i.e. building, pavement) and C=0.3 for pervious areas (i.e. grass, landscape) adapted from the America Society of Civil Engineers Manual on Engineering Practice No. 37).
2. Manning's n-values of n=0.012 for HDPE pipe and n=0.013 for RCP.
3. Minimum Tc of 5 minutes.
4. Target minimum flowing-full velocity of 2 feet per second.
5. Target maximum flowing-full velocity of 10 feet per second.
6. Tailwater elevations are based on the peak 100-year storm water surface elevation at the respective stormwater basins.

SOURCES OF DATA/ EQUATIONS
1. Proposed Hydraulic Watershed Map prepared by Beals and Thomas, Inc. (307706P037C-003).
2. Rational Method (Q=CiA) was used for peak rates of runoff.
3. Manning's Formula was used to determine pipe capacities.
4. Intensities (IN/HR) for the Worcester County 25-year & 100-year rational storm events obtained from Intensity/Duration/Frequency rainfall curves from S.C.S. Technical Paper No. 40.
5. Massachusetts DEP Stormwater Management Handbook, February 2008.

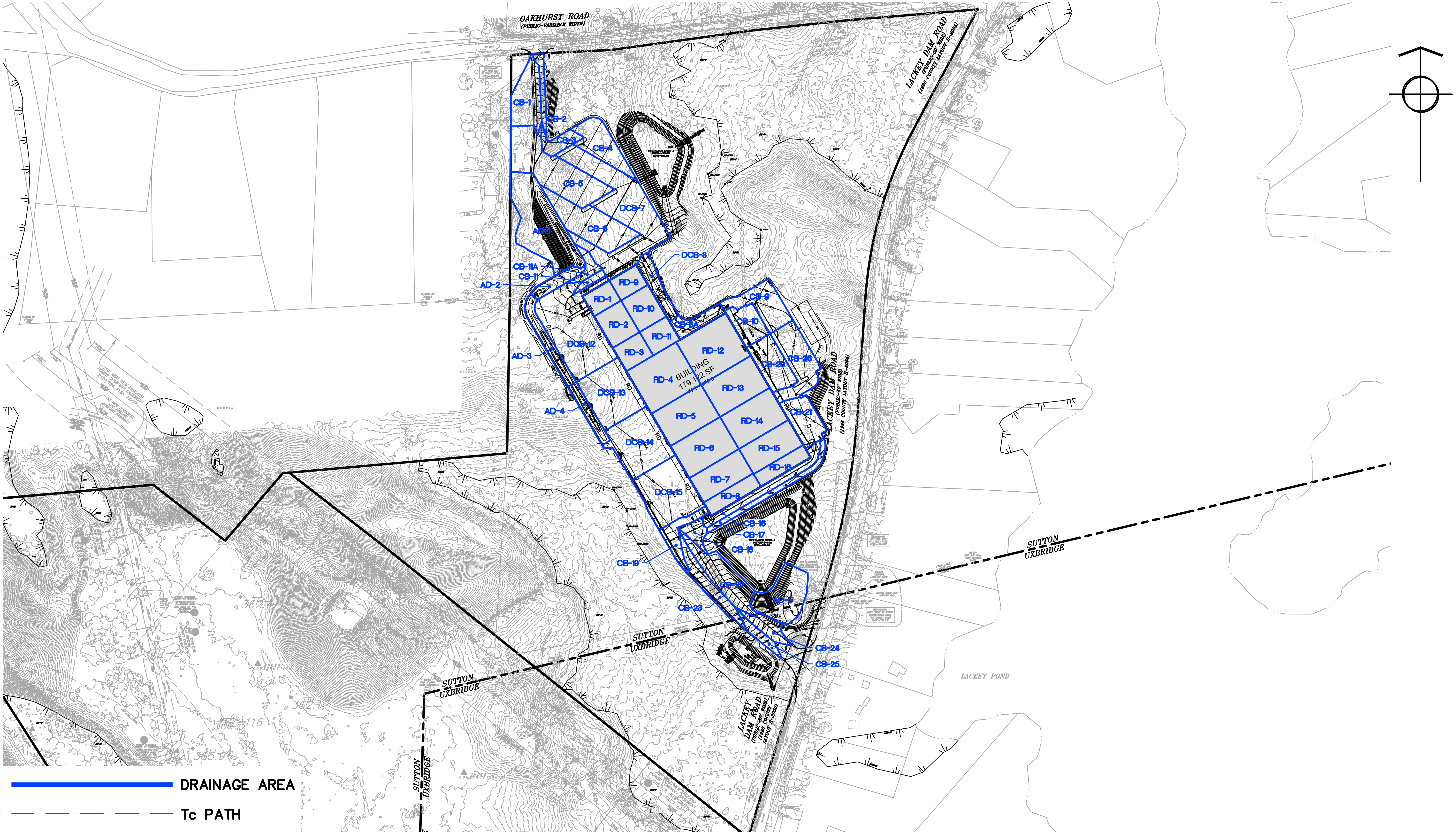
LIST OF ATTACHMENTS
1. Hydraulic Watershed Map
2. StormCAD Hydraulic Spreadsheets
3. Catch Basin Grate Sizing Spreadsheet
4. Riprap Apron Sizing Spreadsheet

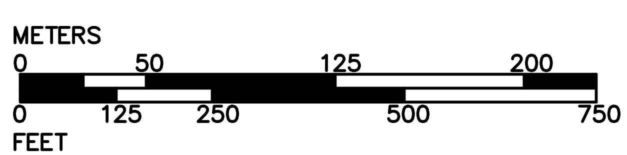
REV	CALC. BY	DATE	CHECKED BY	DATE	APPROVED BY	DATE
0	TJM	6/6/2022	RFK	6/7/2022	DMF	6/8/2022
1	JRM	9/2/2022	RFK	9/6/2022	DMF	9/6/2022

307706CS004B

Lackey Dam Logistics Center

Sutton/Uxbridge, Massachusetts





BEALS + THOMAS

B+T Drawing No. 307706P037C-003 Date: 09/01/2022 Scale: 1" = 250'

Hydraulic

Watershed Map

Figure

3

25-Year Rational Storm Event for Worcester County - No Tailwater

Conduit FlexTable: B+T Hydraulic Spreadsheet

Start Node	Stop Node	System Flow Time (min)	System CA (acres)	System Intensity (in/h)	Flow (cfs)	Elevation Ground (Start) (ft)	Elevation Ground (Stop) (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Diameter (in)	Manning's n	Slope (Calculated) (ft/ft)	Material	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Excess Capacity (Full Flow) (cfs)
CB-1	DMH-1	4.980	0.114	6.606	0.76	366.27	365.30	362.20	362.01	12.0	0.012	0.006	Corrugated HDPE (Smooth Interior)	3.04	3.21	2.28
CB-2	DMH-1	4.980	0.062	6.606	0.41	366.27	365.30	362.20	362.01	12.0	0.012	0.008	Corrugated HDPE (Smooth Interior)	3.56	3.02	3.14
DMH-1	DMH-2	5.139	0.176	6.558	1.17	365.30	363.30	361.91	359.10	12.0	0.012	0.027	Corrugated HDPE (Smooth Interior)	6.37	6.17	5.20
CB-3	DMH-2	4.980	0.090	6.606	0.60	363.38	363.30	359.38	359.10	12.0	0.012	0.015	Corrugated HDPE (Smooth Interior)	4.72	4.12	4.12
DMH-2	DMH-8	5.418	0.266	6.475	1.74	363.30	359.90	359.00	353.96	12.0	0.012	0.030	Corrugated HDPE (Smooth Interior)	6.67	7.14	4.93
CB-5	DMH-8	4.980	0.422	6.606	2.81	360.58	359.90	356.58	355.40	12.0	0.012	0.020	Corrugated HDPE (Smooth Interior)	5.46	7.01	2.65
AD-1	DMH-4	4.980	0.191	6.606	1.27	357.50	357.20	352.50	351.90	12.0	0.012	0.018	Corrugated HDPE (Smooth Interior)	5.18	5.45	3.90
OCS-3	FE-12	0.000	0.000	6.624	9.24	351.40	346.00	346.50	346.00	18.0	0.012	0.007	Corrugated HDPE (Smooth Interior)	9.50	6.12	0.26
CB-6	DMH-3	4.980	0.367	6.606	2.45	357.25	358.10	353.25	352.95	12.0	0.012	0.017	Corrugated HDPE (Smooth Interior)	5.08	6.41	2.64
DCB-7	WQI-7	4.980	0.787	6.606	5.24	358.30	358.50	348.74	348.37	15.0	0.012	0.041	Corrugated HDPE (Smooth Interior)	14.18	10.68	8.94
WQI-7	FE-13	6.378	1.441	6.224	9.04	358.50	347.00	347.87	347.00	21.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	17.15	7.22	8.10
CB-4	DMH-8	4.980	0.234	6.606	1.56	359.85	359.90	355.81	355.64	12.0	0.012	0.024	Corrugated HDPE (Smooth Interior)	5.98	6.40	4.42
WQI-1	FE-1	5.819	0.923	6.354	5.91	360.10	350.16	350.71	350.16	24.0	0.012	0.014	Corrugated HDPE (Smooth Interior)	28.94	7.24	23.03
AD-5	FE-8	4.980	0.104	6.606	0.69	331.50	326.00	326.50	326.00	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.61	2.81	1.92
OCS-1	FE-9	0.000	0.000	6.624	1.05	327.90	322.00	323.00	322.00	12.0	0.012	0.020	Corrugated HDPE (Smooth Interior)	5.46	5.37	4.41
OCS-2	DMH-22	0.000	0.000	6.624	11.72	344.90	334.00	331.70	330.50	18.0	0.012	0.019	Corrugated HDPE (Smooth Interior)	15.88	9.83	4.16
DMH-22	FE-11	0.104	0.000	8.069	11.72	334.00	326.00	328.61	326.00	18.0	0.012	0.019	Corrugated HDPE (Smooth Interior)	15.61	9.70	3.89
CB-22	WQI-5	4.980	0.187	6.606	1.24	331.90	331.60	327.90	327.39	12.0	0.012	0.012	Corrugated HDPE (Smooth Interior)	4.21	4.67	2.97
CB-23	WQI-5	4.980	0.151	6.606	1.01	331.90	331.60	327.55	327.39	12.0	0.012	0.025	Corrugated HDPE (Smooth Interior)	6.06	5.72	5.06
WQI-5	FE-7	5.133	0.338	6.560	2.24	331.60	327.00	327.39	327.00	12.0	0.012	0.013	Corrugated HDPE (Smooth Interior)	4.37	5.60	2.14
WQI-6	FE-10	5.183	0.138	6.545	0.91	325.10	321.00	321.39	321.00	12.0	0.013	0.005	Concrete	2.58	3.00	1.67
CB-24	WQI-6	4.980	0.075	6.606	0.50	325.80	325.10	321.80	321.39	12.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	3.85	3.39	3.34
CB-25	WQI-6	4.980	0.063	6.606	0.42	325.60	325.10	321.55	321.39	12.0	0.012	0.013	Corrugated HDPE (Smooth Interior)	4.33	3.49	3.91
CB-11	DMH-4	4.980	0.032	6.606	0.22	355.00	357.20	351.00	350.30	12.0	0.013	0.013	Concrete	4.09	2.76	3.88
AD-2	DMH-9	4.980	0.032	6.606	0.21	350.50	350.00	347.00	345.26	12.0	0.013	0.010	Concrete	3.47	2.44	3.26
DMH-9	DMH-10	6.230	0.760	6.254	4.79	350.00	350.60	344.76	344.45	18.0	0.013	0.005	Concrete	7.17	4.35	2.38
DMH-10	DMH-11	6.485	0.760	6.203	4.75	350.60	350.00	344.35	343.96	18.0	0.013	0.004	Concrete	7.04	4.27	2.28
DMH-11	DMH-12	6.824	1.205	6.135	7.45	350.00	350.06	343.71	343.10	21.0	0.013	0.004	Concrete	9.99	4.55	2.53
DMH-12	DMH-13	7.386	1.622	5.984	9.78	350.06	350.06	342.85	342.23	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.55	5.23	5.77
DMH-13	DMH-14	7.877	2.051	5.837	12.07	350.06	349.90	342.13	341.60	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	16.20	5.65	4.13
DMH-14	WQI-3	8.234	2.051	5.777	11.94	349.90	348.40	341.50	341.10	24.0	0.012	0.007	Corrugated HDPE (Smooth Interior)	20.04	6.66	8.10
WQI-3	FE-4	8.384	2.529	5.762	14.69	348.40	340.86	341.10	340.86	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	16.37	5.90	1.68
DMH-15	WQI-3	5.053	0.301	6.584	2.00	349.10	348.40	341.42	341.10	12.0	0.012	0.016	Corrugated HDPE (Smooth Interior)	4.90	2.54	2.91
CB-16	DMH-15	4.980	0.188	6.606	1.25	349.50	349.10	345.51	345.13	12.0	0.012	0.016	Corrugated HDPE (Smooth Interior)	4.95	5.26	3.70
CB-17	DMH-15	4.980	0.112	6.606	0.75	349.50	349.10	345.51	345.13	12.0	0.012	0.025	Corrugated HDPE (Smooth Interior)	6.11	5.28	5.36
CB-19	DMH-16	4.980	0.107	6.606	0.71	346.00	347.20	342.48	341.91	12.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	3.89	3.77	3.18
DMH-16	WQI-3	5.228	0.178	6.532	1.17	347.20	348.40	341.91	341.60	12.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	3.86	4.32	2.69
CB-18	DMH-16	4.980	0.071	6.606	0.47	346.00	347.20	342.41	341.91	12.0	0.012	0.024	Corrugated HDPE (Smooth Interior)	5.98	4.54	5.51
CB-10	DMH-18A	4.980	0.160	6.606	1.07	353.90	355.50	349.90	349.80	12.0	0.012	0.012	Corrugated HDPE (Smooth Interior)	4.19	4.45	3.12
DMH-5	WQI-2	6.421	0.242	6.216	1.52	358.40	356.30	348.13	347.58	15.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	4.94	3.54	3.42
WQI-2	FE-3	6.940	0.242	6.112	1.49	356.30	347.00	347.58	347.00	15.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	4.99	3.55	3.50
CB-26	DMH-19	4.980	0.310	6.606	2.06	351.80	353.70	348.80	346.95	12.0	0.012	0.020	Corrugated HDPE (Smooth Interior)	5.43	6.44	3.37
CB-9	DMH-18A	4.980	0.239	6.606	1.59	353.10	355.50	348.75	348.04	12.0	0.012	0.009	Corrugated HDPE (Smooth Interior)	3.75	4.58	2.15
CB-20	DMH-18	4.980	0.226	6.606	1.50	352.90	353.60	346.60	345.95	12.0	0.012	0.032	Corrugated HDPE (Smooth Interior)	6.94	7.06	5.43
DMH-18	DMH-19	6.046	0.626	6.291	3.97	353.60	353.70	345.70	345.45	15.0	0.012	0.009	Corrugated HDPE (Smooth Interior)	6.53	5.58	2.56
CB-21	DMH-19	4.980	0.199	6.606	1.32	352.90	353.70	348.90	348.31	12.0	0.012	0.022	Corrugated HDPE (Smooth Interior)	5.73	5.93	4.40
DMH-19	DMH-20	6.132	1.134	6.274	7.17	353.70	353.80	345.20	343.41	18.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	11.28	6.76	4.10
DMH-20	WQI-4	6.581	1.134	6.184	7.07	353.80	352.40	343.31	342.14	18.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	11.18	6.69	4.11

25-Year Rational Storm Event for Worcester County - No Tailwater

Conduit FlexTable: B+T Hydraulic Spreadsheet

Start Node	Stop Node	System Flow Time (min)	System CA (acres)	System Intensity (in/h)	Flow (cfs)	Elevation Ground (Start) (ft)	Elevation Ground (Stop) (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Diameter (in)	Manning's n	Slope (Calculated) (ft/ft)	Material	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Excess Capacity (Full Flow) (cfs)
WQI-4	FE-6	6.883	1.134	6.123	7.00	352.40	341.84	342.14	341.84	18.0	0.012	0.007	Corrugated HDPE (Smooth Interior)	9.32	5.79	2.33
RD-1	CO-2	4.980	0.109	6.606	0.73	356.00	355.20	348.25	348.17	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.82	3.01	2.09
RD-2	RD-2-CONN	4.980	0.171	6.606	1.14	352.00	351.85	348.00	347.57	12.0	0.012	0.027	Corrugated HDPE (Smooth Interior)	6.29	6.07	5.15
CO-2	RD-2-CONN	5.063	0.109	6.581	0.72	355.20	351.85	348.07	347.57	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.77	2.97	2.05
RD-2-CONN	RD-3-CONN	5.609	0.280	6.417	1.81	351.85	351.85	347.32	346.82	15.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	4.95	3.72	3.14
RD-3	RD-3-CONN	4.980	0.126	6.606	0.84	352.00	351.85	347.50	347.07	12.0	0.012	0.027	Corrugated HDPE (Smooth Interior)	6.29	5.57	5.45
RD-3-CONN	RD-4-CONN	6.057	0.406	6.289	2.57	351.85	351.85	346.57	345.95	18.0	0.012	0.006	Corrugated HDPE (Smooth Interior)	8.78	4.31	6.21
RD-4	RD-4-CONN	4.980	0.424	6.606	2.82	352.00	351.85	347.75	347.07	12.0	0.012	0.042	Corrugated HDPE (Smooth Interior)	7.91	9.23	5.08
RD-4-CONN	RD-5-CONN	6.459	0.830	6.208	5.19	351.85	351.85	345.95	345.49	18.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	7.64	4.65	2.45
RD-5-CONN	RD-6-CONN	6.825	1.153	6.135	7.13	351.85	351.85	345.24	344.74	21.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	12.13	5.25	5.00
RD-6-CONN	RD-7-CONN	7.143	1.473	6.057	9.00	351.85	351.85	344.74	344.24	21.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	12.14	5.53	3.14
RD-5	RD-5-CONN	4.980	0.323	6.606	2.15	352.00	351.85	346.50	345.94	12.0	0.012	0.035	Corrugated HDPE (Smooth Interior)	7.18	7.99	5.02
RD-6	RD-6-CONN	4.980	0.320	6.606	2.13	352.00	351.85	346.25	345.59	12.0	0.012	0.041	Corrugated HDPE (Smooth Interior)	7.79	8.46	5.66
RD-7-CONN	RD-8-CONN	7.444	1.716	5.967	10.32	351.85	354.70	343.99	343.63	24.0	0.012	0.007	Corrugated HDPE (Smooth Interior)	20.38	6.51	10.06
RD-8-CONN	DMH-17	7.578	1.849	5.927	11.05	354.70	351.50	343.63	343.57	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.29	5.30	4.24
DMH-17	FE-5	7.626	1.849	5.912	11.02	351.50	343.14	343.47	343.14	24.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	17.68	5.94	6.66
RD-7	RD-7-CONN	4.980	0.243	6.606	1.62	352.00	351.85	345.75	345.24	12.0	0.012	0.031	Corrugated HDPE (Smooth Interior)	6.85	7.14	5.23
RD-8	RD-8-CONN	4.980	0.133	6.606	0.89	352.00	354.70	345.25	344.73	12.0	0.012	0.032	Corrugated HDPE (Smooth Interior)	6.91	6.05	6.03
RD-16	CO-1	4.980	0.126	6.606	0.84	356.00	355.00	352.25	352.12	12.0	0.012	0.009	Corrugated HDPE (Smooth Interior)	3.57	3.71	2.73
CO-1	RD-15-CONN	5.048	0.126	6.586	0.84	355.00	354.40	352.12	351.90	12.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	2.41	2.79	1.57
RD-15-CONN	RD-14-CONN	5.386	0.377	6.484	2.46	354.40	354.30	351.65	351.25	15.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	4.42	3.70	1.96
RD-14-CONN	RD-13-CONN	5.836	0.697	6.349	4.46	354.30	355.30	351.00	350.59	18.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	7.29	4.33	2.82
RD-13-CONN	RD-12-CONN	6.221	1.018	6.256	6.42	355.30	355.50	350.34	349.94	21.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	10.85	4.70	4.43
RD-12-CONN	DMH-26	6.576	1.445	6.185	9.01	355.50	354.90	349.94	349.65	21.0	0.012	0.003	Corrugated HDPE (Smooth Interior)	9.32	4.42	0.31
RD-11-CONN	RD-10-CONN	7.436	1.571	5.969	9.46	355.00	353.60	348.82	348.42	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.50	5.18	6.05
RD-10-CONN	RD-9-CONN	7.757	1.742	5.873	10.31	353.60	357.50	348.42	348.04	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.37	5.24	5.06
RD-9-CONN	DMH-24	8.064	1.851	5.794	10.81	357.50	358.50	348.04	347.89	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.06	5.21	4.25
DMH-24	DMH-23	8.191	1.851	5.781	10.79	358.50	357.50	347.89	347.44	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.54	5.34	4.75
RD-15	RD-15-CONN	4.980	0.251	6.606	1.67	356.00	354.40	352.25	352.00	12.0	0.012	0.015	Corrugated HDPE (Smooth Interior)	4.79	5.56	3.12
RD-14	RD-14-CONN	4.980	0.320	6.606	2.13	356.00	354.30	351.75	351.14	12.0	0.012	0.038	Corrugated HDPE (Smooth Interior)	7.49	8.21	5.36
RD-13	RD-13-CONN	4.980	0.320	6.606	2.13	356.00	355.30	351.25	350.64	12.0	0.012	0.038	Corrugated HDPE (Smooth Interior)	7.49	8.21	5.36
RD-12	RD-12-CONN	4.980	0.428	6.606	2.85	356.00	355.50	350.50	349.94	12.0	0.012	0.035	Corrugated HDPE (Smooth Interior)	7.18	8.60	4.33
RD-11	RD-11-CONN	4.980	0.126	6.606	0.84	356.00	355.00	350.00	349.51	12.0	0.012	0.030	Corrugated HDPE (Smooth Interior)	6.71	5.82	5.87
RD-10	RD-10-CONN	4.980	0.171	6.606	1.14	356.00	353.60	349.50	348.91	12.0	0.012	0.036	Corrugated HDPE (Smooth Interior)	7.37	6.80	6.23
RD-9	RD-9-CONN	4.980	0.109	6.606	0.73	356.00	357.50	348.50	348.04	12.0	0.012	0.028	Corrugated HDPE (Smooth Interior)	6.50	5.47	5.78
AD-3	DMH-9	4.980	0.048	6.606	0.32	348.20	350.00	345.36	345.26	12.0	0.013	0.014	Concrete	4.26	3.20	3.94
DCB-12	DMH-9	4.980	0.680	6.606	4.53	349.90	350.00	345.40	345.26	12.0	0.013	0.022	Concrete	5.24	7.51	0.71
AD-4	DMH-11	4.980	0.033	6.606	0.22	348.20	350.00	344.20	344.16	12.0	0.013	0.006	Concrete	2.75	2.09	2.54
DCB-13	DMH-11	4.980	0.412	6.606	2.74	349.90	350.00	345.40	345.30	12.0	0.013	0.014	Concrete	4.26	5.76	1.51
DCB-14	DMH-12	4.980	0.417	6.606	2.77	349.90	350.06	345.40	345.30	12.0	0.013	0.013	Concrete	4.10	5.61	1.33
DCB-15	DMH-13	4.980	0.429	6.606	2.86	349.90	350.06	345.40	345.10	12.0	0.012	0.036	Corrugated HDPE (Smooth Interior)	7.35	8.77	4.49
CB-11A	DMH-4	4.980	0.064	6.606	0.43	355.00	357.20	351.00	350.30	12.0	0.013	0.016	Concrete	4.51	3.61	4.08
DMH-4	DMH-3	5.301	0.288	6.510	1.89	357.20	358.10	350.30	349.25	12.0	0.013	0.005	Concrete	2.61	3.62	0.72
DMH-3	WQI-7	6.203	0.655	6.259	4.13	358.10	358.50	349.00	348.37	15.0	0.013	0.011	Concrete	6.62	5.69	2.49
DMH-8	WQI-1	5.812	0.923	6.356	5.91	359.90	360.10	350.78	350.71	24.0	0.012	0.020	Corrugated HDPE (Smooth Interior)	34.66	8.23	28.74
DMH-18A	DMH-18	5.254	0.400	6.524	2.63	355.50	353.60	348.04	345.95	12.0	0.012	0.009	Corrugated HDPE (Smooth Interior)	3.61	5.02	0.99
DMH-26	DMH-25	6.947	1.445	6.111	8.90	354.90	355.65	349.65	349.11	21.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	10.70	4.98	1.80
DMH-23	FE-2	8.541	1.851	5.746	10.72	357.50	347.00	347.44	347.00	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.44	5.31	4.71

25-Year Rational Storm Event for Worcester County - No Tailwater

Conduit FlexTable: B+T Hydraulic Spreadsheet

Start Node	Stop Node	System Flow Time (min)	System CA (acres)	System Intensity (in/h)	Flow (cfs)	Elevation Ground (Start) (ft)	Elevation Ground (Stop) (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Diameter (in)	Manning's n	Slope (Calculated) (ft/ft)	Material	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Excess Capacity (Full Flow) (cfs)
DMH-25	RD-11-CONN	7.412	1.445	5.976	8.71	355.65	355.00	349.11	349.07	21.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	12.30	5.54	3.59
DMH-6	DMH-5	5.866	0.242	6.340	1.55	353.50	358.40	348.70	348.13	15.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	4.87	3.53	3.33
DCB-8	DMH-6	4.980	0.131	6.606	0.87	353.30	353.50	349.05	348.95	12.0	0.012	0.015	Corrugated HDPE (Smooth Interior)	4.78	4.63	3.91
DMH-7	DMH-6	5.250	0.111	6.525	0.73	354.50	353.50	349.48	348.95	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.70	2.92	1.98
CB-8A	DMH-7	4.980	0.111	6.606	0.74	353.65	354.50	349.70	349.48	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.65	2.89	1.91

100-Year Rational Storm Event for Worcester County - 100-Year Tailwater

Conduit FlexTable: B+T Hydraulic Spreadsheet

Start Node	Stop Node	System Flow Time (min)	System CA (acres)	System Intensity (in/h)	Flow (cfs)	Elevation Ground (Start) (ft)	Elevation Ground (Stop) (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Diameter (in)	Manning's n	Slope (Calculated) (ft/ft)	Material	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Excess Capacity (Full Flow) (cfs)
CB-1	DMH-1	4.980	0.114	8.006	0.92	366.27	365.30	362.20	362.01	12.0	0.012	0.006	Corrugated HDPE (Smooth Interior)	3.04	3.39	2.11
CB-2	DMH-1	4.980	0.062	8.006	0.50	366.27	365.30	362.20	362.01	12.0	0.012	0.008	Corrugated HDPE (Smooth Interior)	3.56	3.20	3.05
DMH-1	DMH-2	5.131	0.176	7.961	1.42	365.30	363.30	361.91	359.10	12.0	0.012	0.027	Corrugated HDPE (Smooth Interior)	6.37	6.52	4.95
CB-3	DMH-2	4.980	0.090	8.006	0.73	363.38	363.30	359.38	359.10	12.0	0.012	0.015	Corrugated HDPE (Smooth Interior)	4.72	4.36	4.00
DMH-2	DMH-8	5.395	0.266	7.882	2.12	363.30	359.90	359.00	353.96	12.0	0.012	0.030	Corrugated HDPE (Smooth Interior)	6.67	7.53	4.55
CB-5	DMH-8	4.980	0.422	8.006	3.41	360.58	359.90	356.58	355.40	12.0	0.012	0.020	Corrugated HDPE (Smooth Interior)	5.46	7.34	2.05
AD-1	DMH-4	4.980	0.191	8.006	1.54	357.50	357.20	352.50	351.90	12.0	0.012	0.018	Corrugated HDPE (Smooth Interior)	5.18	5.75	3.63
OCS-3	FE-12	0.000	0.000	8.024	9.24	351.40	346.00	346.50	346.00	18.0	0.012	0.007	Corrugated HDPE (Smooth Interior)	9.50	6.12	0.26
CB-6	DMH-3	4.980	0.367	8.006	2.96	357.25	358.10	353.25	352.95	12.0	0.012	0.017	Corrugated HDPE (Smooth Interior)	5.08	6.72	2.12
DCB-7	WQI-7	4.980	0.787	8.006	6.35	358.30	358.50	348.74	348.37	15.0	0.012	0.041	Corrugated HDPE (Smooth Interior)	14.18	5.17	7.83
WQI-7	FE-13	9.146	1.441	6.756	9.82	358.50	347.00	347.87	347.00	21.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	17.15	4.08	7.33
CB-4	DMH-8	4.980	0.234	8.006	1.89	359.85	359.90	355.81	355.64	12.0	0.012	0.024	Corrugated HDPE (Smooth Interior)	5.98	6.75	4.09
WQI-1	FE-1	5.775	0.923	7.767	7.23	360.10	350.16	350.71	350.16	24.0	0.012	0.014	Corrugated HDPE (Smooth Interior)	28.94	7.65	21.72
AD-5	FE-8	4.980	0.104	8.006	0.84	331.50	326.00	326.50	326.00	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.61	2.96	1.77
OCS-1	FE-9	0.000	0.000	8.024	1.05	327.90	322.00	323.00	322.00	12.0	0.012	0.020	Corrugated HDPE (Smooth Interior)	5.46	5.37	4.41
OCS-2	DMH-22	0.000	0.000	8.024	11.72	344.90	334.00	331.70	330.50	18.0	0.012	0.019	Corrugated HDPE (Smooth Interior)	15.88	9.83	4.16
DMH-22	FE-11	0.104	0.000	9.469	11.72	334.00	326.00	328.61	326.00	18.0	0.012	0.019	Corrugated HDPE (Smooth Interior)	15.61	9.70	3.89
CB-22	WQI-5	4.980	0.187	8.006	1.51	331.90	331.60	327.90	327.39	12.0	0.012	0.012	Corrugated HDPE (Smooth Interior)	4.21	4.92	2.71
CB-23	WQI-5	4.980	0.151	8.006	1.22	331.90	331.60	327.55	327.39	12.0	0.012	0.025	Corrugated HDPE (Smooth Interior)	6.06	6.04	4.84
WQI-5	FE-7	5.125	0.338	7.962	2.71	331.60	327.00	327.39	327.00	12.0	0.012	0.013	Corrugated HDPE (Smooth Interior)	4.37	5.86	1.66
WQI-6	FE-10	5.172	0.138	7.948	1.11	325.10	321.00	321.39	321.00	12.0	0.013	0.005	Concrete	2.58	3.16	1.47
CB-24	WQI-6	4.980	0.075	8.006	0.61	325.80	325.10	321.80	321.39	12.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	3.85	3.58	3.24
CB-25	WQI-6	4.980	0.063	8.006	0.51	325.60	325.10	321.55	321.39	12.0	0.012	0.013	Corrugated HDPE (Smooth Interior)	4.33	3.69	3.82
CB-11	DMH-4	4.980	0.032	8.006	0.26	355.00	357.20	351.00	350.30	12.0	0.013	0.013	Concrete	4.09	0.33	3.83
AD-2	DMH-9	4.980	0.032	8.006	0.25	350.50	350.00	347.00	345.26	12.0	0.013	0.010	Concrete	3.47	2.58	3.22
DMH-9	DMH-10	6.162	0.760	7.651	5.86	350.00	350.60	344.76	344.45	18.0	0.013	0.005	Concrete	7.17	3.32	1.31
DMH-10	DMH-11	6.496	0.760	7.551	5.79	350.60	350.00	344.35	343.96	18.0	0.013	0.004	Concrete	7.04	3.27	1.25
DMH-11	DMH-12	6.938	1.205	7.418	9.01	350.00	350.06	343.71	343.10	21.0	0.013	0.004	Concrete	9.99	3.75	0.97
DMH-12	DMH-13	7.622	1.622	7.151	11.69	350.06	350.06	342.85	342.23	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.55	3.72	3.86
DMH-13	DMH-14	8.311	2.051	6.938	14.34	350.06	349.90	342.13	341.60	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	16.20	4.57	1.86
DMH-14	WQI-3	8.754	2.051	6.849	14.16	349.90	348.40	341.50	341.10	24.0	0.012	0.007	Corrugated HDPE (Smooth Interior)	20.04	4.51	5.88
WQI-3	FE-4	8.975	2.529	6.805	17.35	348.40	340.86	341.10	340.86	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	16.37	5.52	-0.98
DMH-15	WQI-3	5.049	0.301	7.985	2.42	349.10	348.40	341.42	341.10	12.0	0.012	0.016	Corrugated HDPE (Smooth Interior)	4.90	3.08	2.48
CB-16	DMH-15	4.980	0.188	8.006	1.52	349.50	349.10	345.51	345.13	12.0	0.012	0.016	Corrugated HDPE (Smooth Interior)	4.95	5.55	3.44
CB-17	DMH-15	4.980	0.112	8.006	0.91	349.50	349.10	345.51	345.13	12.0	0.012	0.025	Corrugated HDPE (Smooth Interior)	6.11	5.58	5.20
CB-19	DMH-16	4.980	0.107	8.006	0.86	346.00	347.20	342.48	341.91	12.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	3.89	1.10	3.03
DMH-16	WQI-3	5.832	0.178	7.750	1.39	347.20	348.40	341.91	341.60	12.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	3.86	1.77	2.47
CB-18	DMH-16	4.980	0.071	8.006	0.57	346.00	347.20	342.41	341.91	12.0	0.012	0.024	Corrugated HDPE (Smooth Interior)	5.98	0.73	5.41
CB-10	DMH-18A	4.980	0.160	8.006	1.29	353.90	355.50	349.90	349.80	12.0	0.012	0.012	Corrugated HDPE (Smooth Interior)	4.19	4.70	2.89
DMH-5	WQI-2	8.639	0.242	6.872	1.68	358.40	356.30	348.13	347.58	15.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	4.94	1.37	3.26
WQI-2	FE-3	9.985	0.242	6.504	1.59	356.30	347.00	347.58	347.00	15.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	4.99	1.29	3.41
CB-26	DMH-19	4.980	0.310	8.006	2.50	351.80	353.70	348.80	346.95	12.0	0.012	0.020	Corrugated HDPE (Smooth Interior)	5.43	6.77	2.93
CB-9	DMH-18A	4.980	0.239	8.006	1.93	353.10	355.50	348.75	348.04	12.0	0.012	0.009	Corrugated HDPE (Smooth Interior)	3.75	4.81	1.82
CB-20	DMH-18	4.980	0.226	8.006	1.82	352.90	353.60	346.60	345.95	12.0	0.012	0.032	Corrugated HDPE (Smooth Interior)	6.94	7.45	5.12
DMH-18	DMH-19	6.006	0.626	7.698	4.85	353.60	353.70	345.70	345.45	15.0	0.012	0.009	Corrugated HDPE (Smooth Interior)	6.53	5.83	1.67
CB-21	DMH-19	4.980	0.199	8.006	1.61	352.90	353.70	348.90	348.31	12.0	0.012	0.022	Corrugated HDPE (Smooth Interior)	5.73	6.25	4.12
DMH-19	DMH-20	6.088	1.134	7.674	8.77	353.70	353.80	345.20	343.41	18.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	11.28	4.96	2.50
DMH-20	WQI-4	6.700	1.134	7.490	8.56	353.80	352.40	343.31	342.14	18.0	0.012	0.010	Corrugated HDPE (Smooth Interior)	11.18	4.84	2.62

100-Year Rational Storm Event for Worcester County - 100-Year Tailwater

Conduit FlexTable: B+T Hydraulic Spreadsheet

Start Node	Stop Node	System Flow Time (min)	System CA (acres)	System Intensity (in/h)	Flow (cfs)	Elevation Ground (Start) (ft)	Elevation Ground (Stop) (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Diameter (in)	Manning's n	Slope (Calculated) (ft/ft)	Material	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Excess Capacity (Full Flow) (cfs)
WQI-4	FE-6	7.117	1.134	7.353	8.41	352.40	341.84	342.14	341.84	18.0	0.012	0.007	Corrugated HDPE (Smooth Interior)	9.32	4.76	0.92
RD-1	CO-2	4.980	0.109	8.006	0.88	356.00	355.20	348.25	348.17	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.82	3.17	1.94
RD-2	RD-2-CONN	4.980	0.171	8.006	1.38	352.00	351.85	348.00	347.57	12.0	0.012	0.027	Corrugated HDPE (Smooth Interior)	6.29	6.42	4.91
CO-2	RD-2-CONN	5.059	0.109	7.982	0.88	355.20	351.85	348.07	347.57	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.77	3.13	1.89
RD-2-CONN	RD-3-CONN	5.576	0.280	7.827	2.21	351.85	351.85	347.32	346.82	15.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	4.95	3.92	2.74
RD-3	RD-3-CONN	4.980	0.126	8.006	1.02	352.00	351.85	347.50	347.07	12.0	0.012	0.027	Corrugated HDPE (Smooth Interior)	6.29	5.88	5.27
RD-3-CONN	RD-4-CONN	6.002	0.406	7.699	3.15	351.85	351.85	346.57	345.95	18.0	0.012	0.006	Corrugated HDPE (Smooth Interior)	8.78	4.56	5.63
RD-4	RD-4-CONN	4.980	0.424	8.006	3.42	352.00	351.85	347.75	347.07	12.0	0.012	0.042	Corrugated HDPE (Smooth Interior)	7.91	9.71	4.49
RD-4-CONN	RD-5-CONN	6.383	0.830	7.585	6.34	351.85	351.85	345.95	345.49	18.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	7.64	4.84	1.30
RD-5-CONN	RD-6-CONN	6.734	1.153	7.480	8.69	351.85	351.85	345.24	344.74	21.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	12.13	5.48	3.44
RD-6-CONN	RD-7-CONN	7.038	1.473	7.385	10.97	351.85	351.85	344.74	344.24	21.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	12.14	5.71	1.17
RD-5	RD-5-CONN	4.980	0.323	8.006	2.61	352.00	351.85	346.50	345.94	12.0	0.012	0.035	Corrugated HDPE (Smooth Interior)	7.18	8.41	4.57
RD-6	RD-6-CONN	4.980	0.320	8.006	2.59	352.00	351.85	346.25	345.59	12.0	0.012	0.041	Corrugated HDPE (Smooth Interior)	7.79	8.91	5.20
RD-7-CONN	RD-8-CONN	7.330	1.716	7.268	12.57	351.85	354.70	343.99	343.63	24.0	0.012	0.007	Corrugated HDPE (Smooth Interior)	20.38	6.83	7.81
RD-8-CONN	DMH-17	7.457	1.849	7.217	13.45	354.70	351.50	343.63	343.57	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.29	5.49	1.83
DMH-17	FE-5	7.504	1.849	7.198	13.42	351.50	343.14	343.47	343.14	24.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	17.68	6.19	4.26
RD-7	RD-7-CONN	4.980	0.243	8.006	1.96	352.00	351.85	345.75	345.24	12.0	0.012	0.031	Corrugated HDPE (Smooth Interior)	6.85	7.52	4.89
RD-8	RD-8-CONN	4.980	0.133	8.006	1.07	352.00	354.70	345.25	344.73	12.0	0.012	0.032	Corrugated HDPE (Smooth Interior)	6.91	6.40	5.84
RD-16	CO-1	4.980	0.126	8.006	1.02	356.00	355.00	352.25	352.12	12.0	0.012	0.009	Corrugated HDPE (Smooth Interior)	3.57	1.29	2.55
CO-1	RD-15-CONN	5.176	0.126	7.947	1.01	355.00	354.40	352.12	351.90	12.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	2.41	1.29	1.40
RD-15-CONN	RD-14-CONN	5.908	0.377	7.728	2.94	354.40	354.30	351.65	351.25	15.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	4.42	2.39	1.49
RD-14-CONN	RD-13-CONN	6.605	0.697	7.518	5.29	354.30	355.30	351.00	350.59	18.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	7.29	2.99	2.00
RD-13-CONN	RD-12-CONN	7.162	1.018	7.335	7.53	355.30	355.50	350.34	349.94	21.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	10.85	3.13	3.32
RD-12-CONN	DMH-26	7.695	1.445	7.122	10.38	355.50	354.90	349.94	349.65	21.0	0.012	0.003	Corrugated HDPE (Smooth Interior)	9.32	4.31	-1.05
RD-11-CONN	RD-10-CONN	8.653	1.571	6.869	10.88	355.00	353.60	348.82	348.42	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.50	3.46	4.62
RD-10-CONN	RD-9-CONN	9.134	1.742	6.760	11.87	353.60	357.50	348.42	348.04	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.37	3.78	3.50
RD-9-CONN	DMH-24	9.560	1.851	6.632	12.38	357.50	358.50	348.04	347.89	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.06	3.94	2.68
DMH-24	DMH-23	9.728	1.851	6.581	12.28	358.50	357.50	347.89	347.44	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.54	3.91	3.26
RD-15	RD-15-CONN	4.980	0.251	8.006	2.03	356.00	354.40	352.25	352.00	12.0	0.012	0.015	Corrugated HDPE (Smooth Interior)	4.79	2.58	2.77
RD-14	RD-14-CONN	4.980	0.320	8.006	2.59	356.00	354.30	351.75	351.14	12.0	0.012	0.038	Corrugated HDPE (Smooth Interior)	7.49	3.29	4.90
RD-13	RD-13-CONN	4.980	0.320	8.006	2.59	356.00	355.30	351.25	350.64	12.0	0.012	0.038	Corrugated HDPE (Smooth Interior)	7.49	3.29	4.90
RD-12	RD-12-CONN	4.980	0.428	8.006	3.45	356.00	355.50	350.50	349.94	12.0	0.012	0.035	Corrugated HDPE (Smooth Interior)	7.18	4.39	3.73
RD-11	RD-11-CONN	4.980	0.126	8.006	1.02	356.00	355.00	350.00	349.51	12.0	0.012	0.030	Corrugated HDPE (Smooth Interior)	6.71	1.29	5.70
RD-10	RD-10-CONN	4.980	0.171	8.006	1.38	356.00	353.60	349.50	348.91	12.0	0.012	0.036	Corrugated HDPE (Smooth Interior)	7.37	1.76	5.99
RD-9	RD-9-CONN	4.980	0.109	8.006	0.88	356.00	357.50	348.50	348.04	12.0	0.012	0.028	Corrugated HDPE (Smooth Interior)	6.50	1.12	5.62
AD-3	DMH-9	4.980	0.048	8.006	0.39	348.20	350.00	345.36	345.26	12.0	0.013	0.014	Concrete	4.26	0.50	3.87
DCB-12	DMH-9	4.980	0.680	8.006	5.49	349.90	350.00	345.40	345.26	12.0	0.013	0.022	Concrete	5.24	6.99	-0.25
AD-4	DMH-11	4.980	0.033	8.006	0.26	348.20	350.00	344.20	344.16	12.0	0.013	0.006	Concrete	2.75	0.34	2.49
DCB-13	DMH-11	4.980	0.412	8.006	3.33	349.90	350.00	345.40	345.30	12.0	0.013	0.014	Concrete	4.26	4.24	0.93
DCB-14	DMH-12	4.980	0.417	8.006	3.36	349.90	350.06	345.40	345.30	12.0	0.013	0.013	Concrete	4.10	5.83	0.74
DCB-15	DMH-13	4.980	0.429	8.006	3.46	349.90	350.06	345.40	345.10	12.0	0.012	0.036	Corrugated HDPE (Smooth Interior)	7.35	9.22	3.89
CB-11A	DMH-4	4.980	0.064	8.006	0.52	355.00	357.20	351.00	350.30	12.0	0.013	0.016	Concrete	4.51	0.66	3.99
DMH-4	DMH-3	7.638	0.288	7.145	2.07	357.20	358.10	350.30	349.25	12.0	0.013	0.005	Concrete	2.61	2.64	0.54
DMH-3	WQI-7	8.874	0.655	6.825	4.51	358.10	358.50	349.00	348.37	15.0	0.013	0.011	Concrete	6.62	3.67	2.12
DMH-8	WQI-1	5.768	0.923	7.769	7.23	359.90	360.10	350.78	350.71	24.0	0.012	0.020	Corrugated HDPE (Smooth Interior)	34.66	8.72	27.43
DMH-18A	DMH-18	5.241	0.400	7.928	3.19	355.50	353.60	348.04	345.95	12.0	0.012	0.009	Corrugated HDPE (Smooth Interior)	3.61	5.19	0.42
DMH-26	DMH-25	8.075	1.445	6.985	10.18	354.90	355.65	349.65	349.11	21.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	10.70	4.23	0.52
DMH-23	FE-2	10.206	1.851	6.459	12.05	357.50	347.00	347.44	347.00	24.0	0.012	0.004	Corrugated HDPE (Smooth Interior)	15.44	3.84	3.38

100-Year Rational Storm Event for Worcester County - 100-Year Tailwater

Conduit FlexTable: B+T Hydraulic Spreadsheet

Start Node	Stop Node	System Flow Time (min)	System CA (acres)	System Intensity (in/h)	Flow (cfs)	Elevation Ground (Start) (ft)	Elevation Ground (Stop) (ft)	Invert (Upstream) (ft)	Invert (Downstream) (ft)	Diameter (in)	Manning's n	Slope (Calculated) (ft/ft)	Material	Capacity (Full Flow) (cfs)	Velocity (ft/s)	Excess Capacity (Full Flow) (cfs)
DMH-25	RD-11-CONN	8.622	1.445	6.876	10.02	355.65	355.00	349.11	349.07	21.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	12.30	4.16	2.28
DMH-6	DMH-5	7.288	0.242	7.285	1.78	353.50	358.40	348.70	348.13	15.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	4.87	1.45	3.10
DCB-8	DMH-6	4.980	0.131	8.006	1.06	353.30	353.50	349.05	348.95	12.0	0.012	0.015	Corrugated HDPE (Smooth Interior)	4.78	1.35	3.72
DMH-7	DMH-6	5.665	0.111	7.801	0.87	354.50	353.50	349.48	348.95	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.70	1.11	1.83
CB-8A	DMH-7	4.980	0.111	8.006	0.89	353.65	354.50	349.70	349.48	12.0	0.012	0.005	Corrugated HDPE (Smooth Interior)	2.65	1.14	1.75

BEALS + THOMAS

Catch Basin Grate Sizing

CB #	25-YEAR STORM DESIGN FLOW (CFS)	HEAD (ft) Lebaron LF248-2 (Single grate)	HEAD (ft) Lebaron LV2448-2 (Double grate)	RECOMMENDED GRATE
		A= 1.5625 SF	A= 3.125 SF	
CB-1	0.76	0.010204665	0.0025512	Single
CB-2	0.41	0.002969883	0.0007425	Single
CB-3	0.60	0.006360248	0.0015901	Single
CB-4	1.56	0.04299528	0.0107488	Single
CB-5	2.81	0.139503216	0.0348758	Single
CB-6	2.45	0.106048309	0.0265121	Single
DCB-7	5.24	0.485103216	0.1212758	Double
DCB-8	0.87	0.013372422	0.0033431	Single*
CB-8A	0.74	0.009674645	0.0024187	Single
CB-9	1.59	0.044664845	0.0111662	Single
CB-10	1.07	0.020227357	0.0050568	Single
CB-11	0.22	0.0008551	0.0002138	Single
CB-11A	0.43	0.003266694	0.0008167	Single
DCB-12	4.53	0.362550062	0.0906375	Double
DCB-13	2.74	0.132639448	0.0331599	Single*
DCB-14	2.77	0.135559862	0.03389	Single*
DCB-15	2.86	0.144511912	0.036128	Single*
CB-16	1.25	0.027605245	0.0069013	Single
CB-17	0.75	0.009937888	0.0024845	Single
CB-18	0.47	0.003902719	0.0009757	Single
CB-19	0.71	0.008906115	0.0022265	Single
CB-20	1.50	0.039751553	0.0099379	Single
CB-21	1.32	0.030783602	0.0076959	Single
CB-22	1.24	0.027165328	0.0067913	Single
CB-23	1.01	0.018022471	0.0045056	Single
CB-24	0.50	0.004416839	0.0011042	Single
CB-25	0.42	0.003116522	0.0007791	Single
CB-26	2.06	0.074973195	0.0187433	Single

Notes:

1.) Capacity based on Orifice Flow (ponded condition).

2.) *Although DCB-8, DCB-13, DCB-14, and DCB-15 could theoretically be sized as single grate CBs, based on the contributing flows, they were conservatively designed to be double grate CBs.

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FILE: Lackey Dam Logistics Center DATE: 09/02/22 DATE: 09/06/22

BEALS + THOMAS

Riprap Apron Sizing

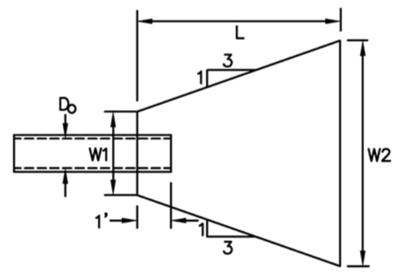
Median Stone Sizing:

$$D_{50} = 0.2D_0\left(\frac{Q}{\sqrt{g}D_0^{2.5}}\right)^{\frac{4}{3}}\left(\frac{D_0}{TW}\right)$$

Where:
D_0 = Maximum Inside Pipe Diameter (ft)
D_{50} = Median Riprap Diameter (ft)
Q = Peak Discharge Rate from Hydraulic Design (cfs)
TW = Tailwater Depth (ft); (Use $0.4D_0$ if TW is unknown, max $1.0D_0$)
g = Gravitational Acceleration Constant = 32.2 ft/s^2

Apron Sizing:

D_{50} [In]	Apron Length (L) [ft}	Apron Depth [In]	Apron Width At Beginning	Apron Width At End
5	$4D_0$	$3.5D_{50}$	$3D_0$	$3D_0 + ⅔L$
6	$4D_0$	$3.3D_{50}$	$3D_0$	$3D_0 + ⅔L$
10	$5D_0$	$2.4D_{50}$	$3D_0$	$3D_0 + ⅔L$
14	$6D_0$	$2.2D_{50}$	$3D_0$	$3D_0 + ⅔L$
20	$7D_0$	$2.0D_{50}$	$3D_0$	$3D_0 + ⅔L$
22	$8D_0$	$2.0D_{50}$	$3D_0$	$3D_0 + ⅔L$



FLARED END SECTION	PIPE DIAMETER (D_0) (FEET)	100-YEAR STORM FLOW (Q) (CFS)	TAILWATER (TW) [ft]	MEDIAN STONE DIAMETER (D_{50}) (INCHES)	APRON LENGTH (L) (FEET)	APRON DEPTH [In]	APRON WIDTH AT BEGINING (W_1) [ft]	APRON WIDTH AT END (W_2) [ft]
FE-1	2.00	7.20	0.8	5	8.00	17.5	6.0	11.3
FE-2	2.00	11.87	0.8	5	8.00	17.5	6.0	11.3
FE-3	1.25	1.52	0.5	5	5.00	17.5	3.8	7.1
FE-4	2.00	17.23	0.8	6	8.00	19.8	6.0	11.3
FE-5	2.00	13.29	0.8	5	8.00	17.5	6.0	11.3
FE-6	1.50	8.33	0.6	5	6.00	17.5	4.5	8.5
FE-7	1.00	2.71	0.4	5	4.00	17.5	3.0	5.7
FE-8	1.00	0.82	0.4	5	4.00	17.5	3.0	5.7
FE-9	1.00	1.05	0.4	5	4.00	17.5	3.0	5.7
FE-10	1.00	1.09	0.4	5	4.00	17.5	3.0	5.7
FE-11	1.50	11.72	0.6	10	7.50	24	4.5	9.5
FE-12	1.50	9.24	0.6	5	6.00	17.5	4.5	8.5
FE-13	1.75	9.66	0.7	5	7.00	17.5	5.3	9.9

Notes

[1] Calculations performed in accordance with Hydraulic Engineering Circular No. 14, Third Edition; Hydraulic Design of Energy Dissipaters for Culverts and Channels, dated July 2006.
[2] Pipe shall extend 1 foot into riprap.
[3] For maximum pipe size of 60".

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Attachment 5
Groundwater Recharge, Drawdown, Water Quality Volume, and TSS Removal Calculations

BEALS + THOMAS

Standard 3: Groundwater Recharge

Groundwater Recharge Volume Required:

Rv = F x Impervious Area, where:

Rv = Required Recharge Volume [Ac-ft]

F = Target Depth Factor associated with each Hydrologic Soil Group (HSG) [in]

New Impervious Area = Total Pavement and Rooftop Area under Post-development Conditions [Ac]

			Impervious Area [Acres]	Required Recharge Volume [Ac-ft]	
HSG "A", use F =	0.6	in	3.358	0.168	
HSG "B", use F =	0.35	in	5.000	0.146	
HSG "C", use F =	0.25	in	2.643	0.055	
HSG "D", use F =	0.1	in	0.000	0.000	
Total Required Recharge Volume (Rv) =				**0.369**	**Ac-ft**

Capture Area Adjustment: (Ref: DEP Handbook V.3 Ch.1 P.27-28)

Total New Site Impervious Area (Total)=	11.001	Acres
Impervious Area Draining to Infiltrative BMPs (infil) =	10.78	Acres
Percent Imp. Area Draining to Infiltrative BMPs =	98.0%	
Capture Area Adjustment Factor = (Total)/(Infil) = Ca =	1.02	
Adjusted Required Recharge Volume = Ca x Rv	**0.376**	**Ac-ft**

Groundwater Recharge Volume Provided :

BMP	Provided Recharge Volume [Ac-ft]	
Infiltration Basin 1 =	0.071	
Infiltration Basin 2 =	0.691	
Infiltration Basin 3 =	0.214	
Total Provided Recharge Volume =	**0.976**	**Ac-ft**

PROVIDED GROUNDWATER RECHARGE VOLUME IS GREATER THAN OR EQUAL TO THE REQUIRED RECHARGE VOLUME, THEREFORE PROPOSED STORMWATER MANAGEMENT DESIGN IS IN COMPLIANCE WITH STANDARD 3.

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Standard 3: Drawdown

$$\text{Drawdown Time} = \frac{Rv}{(K)\,(\text{Bottom Area})}$$

where:

Rv = Storage Volume Below Outlet [Ac-ft]

K= Infiltration Rate [in/hr]

Bottom Area= Bottom Area of Recharge System [Ac]

Infiltration Basin 1

Rv =	0.071	Ac-ft	
K =	0.520	in/hr	
Bottom Area =	0.059	Acres	
Drawdown Time =	**27.631**	**Hours**	*< 72 Hours, Design is in compliance with the standard.*

Infiltration Basin 2

Rv =	0.691	Ac-ft	
K =	0.520	in/hr	
Bottom Area =	0.396	Acres	
Drawdown Time =	**40.319**	**Hours**	*< 72 Hours, Design is in compliance with the standard.*

Infiltration Basin 3

Rv =	0.214	Ac-ft	
K =	0.520	in/hr	
Bottom Area =	0.384	Acres	
Drawdown Time =	**12.858**	**Hours**	*< 72 Hours, Design is in compliance with the standard.*

Note:

1. The infiltration BMPs have been designed to fully drain within 72 hours, therefore the proposed stormwater management design is in compliance with Standard 3 .

2. Infiltration Rate based on Volume 3, Chapter 1, Table 2.3.3 *Rawls Rates* from the 2008 MA DEP Stormwater Management Handbook.

JOB NO.	3077.06	COMPUTED BY:	RFK	CHECKED BY:	JRM
JOB:	Lackey Dam Logistics Center	DATE:	09/01/22	DATE:	09/06/22

Stage-Area-Storage for Pond 110P: BASIN #1

Elevation (feet)	Surface (acres)	Storage (acre-feet)
325.00	0.062	0.000
325.05	0.063	0.003
325.10	0.064	0.006
325.15	0.065	0.010
325.20	0.066	0.013
325.25	0.067	0.016
325.30	0.068	0.020
325.35	0.069	0.023
325.40	0.069	0.026
325.45	0.070	0.030
325.50	0.071	0.033
325.55	0.072	0.037
325.60	0.073	0.041
325.65	0.074	0.044
325.70	0.075	0.048
325.75	0.076	0.052
325.80	0.076	0.056
325.85	0.077	0.059
325.90	0.078	0.063
325.95	0.079	0.067
326.00	0.080	0.071
326.05	0.081	0.075
326.10	0.082	0.079
326.15	0.083	0.083
326.20	0.084	0.088
326.25	0.085	0.092
326.30	0.086	0.096
326.35	0.087	0.100
326.40	0.087	0.105
326.45	0.088	0.109
326.50	0.089	0.113
326.55	0.090	0.118
326.60	0.091	0.122
326.65	0.092	0.127
326.70	0.093	0.132
326.75	0.094	0.136
326.80	0.095	0.141
326.85	0.096	0.146
326.90	0.097	0.151
326.95	0.098	0.156
327.00	0.099	0.160
327.05	0.100	0.165
327.10	0.101	0.170
327.15	0.102	0.176
327.20	0.103	0.181
327.25	0.104	0.186
327.30	0.105	0.191
327.35	0.106	0.196
327.40	0.107	0.202
327.45	0.108	0.207
327.50	0.109	0.212
327.55	0.110	0.218
327.60	0.111	0.223
327.65	0.112	0.229
327.70	0.113	0.235
327.75	0.114	0.240
327.80	0.115	0.246
327.85	0.116	0.252
327.90	0.117	0.257
327.95	0.118	0.263
328.00	0.119	0.269
328.05	0.120	0.275
328.10	0.121	0.281
328.15	0.122	0.287
328.20	0.123	0.293
328.25	0.124	0.300
328.30	0.125	0.306
328.35	0.126	0.312
328.40	0.127	0.319
328.45	0.128	0.325
328.50	0.130	0.331
328.55	0.131	0.338
328.60	0.132	0.344
328.65	0.133	0.351
328.70	0.134	0.358
328.75	0.135	0.364
328.80	0.136	0.371
328.85	0.137	0.378
328.90	0.138	0.385
328.95	0.139	0.392
329.00	**0.140**	**0.399**

Stage-Area-Storage for Pond 120P: BASIN #2

Elevation (feet)	Surface (acres)	Storage (acre-feet)
340.00	0.464	0.000
340.10	0.468	0.047
340.20	0.472	0.094
340.30	0.477	0.141
340.40	0.481	0.189
340.50	0.485	0.237
340.60	0.489	0.286
340.70	0.493	0.335
340.80	0.498	0.385
340.90	0.502	0.435
341.00	0.506	0.485
341.10	0.510	0.536
341.20	0.515	0.587
341.30	0.519	0.639
341.40	0.523	0.691
341.50	0.528	0.743
341.60	0.532	0.796
341.70	0.536	0.850
341.80	0.540	0.904
341.90	0.545	0.958
342.00	0.549	1.013
342.10	0.554	1.068
342.20	0.558	1.123
342.30	0.562	1.179
342.40	0.567	1.236
342.50	0.571	1.293
342.60	0.576	1.350
342.70	0.580	1.408
342.80	0.585	1.466
342.90	0.589	1.525
343.00	0.594	1.584
343.10	0.598	1.644
343.20	0.603	1.704
343.30	0.607	1.764
343.40	0.612	1.825
343.50	0.617	1.886
343.60	0.621	1.948
343.70	0.626	2.011
343.80	0.630	2.073
343.90	0.635	2.137
344.00	0.639	2.200
344.10	0.644	2.265
344.20	0.649	2.329
344.30	0.654	2.394
344.40	0.658	2.460
344.50	0.663	2.526
344.60	0.668	2.593
344.70	0.672	2.660
344.80	0.677	2.727
344.90	0.682	2.795
345.00	0.686	2.863
345.10	0.691	2.932
345.20	0.696	3.002
345.30	0.701	3.071
345.40	0.706	3.142
345.50	0.711	3.213
345.60	0.715	3.284
345.70	0.720	3.356
345.80	0.725	3.428
345.90	0.730	3.501
346.00	**0.735**	**3.574**

Stage-Area-Storage for Pond 230P: BASIN #3

Elevation (feet)	Surface (acres)	Storage (acre-feet)	Elevation (feet)	Surface (acres)	Storage (acre-feet)
346.50	0.274	0.000	347.02	0.291	0.147
346.51	0.274	0.003	347.03	0.291	0.150
346.52	0.274	0.005	347.04	0.291	0.152
346.53	0.275	0.008	347.05	0.292	0.155
346.54	0.275	0.011	347.06	0.292	0.158
346.55	0.275	0.014	347.07	0.292	0.161
346.56	0.276	0.016	347.08	0.293	0.164
346.57	0.276	0.019	347.09	0.293	0.167
346.58	0.276	0.022	347.10	0.293	0.170
346.59	0.276	0.025	347.11	0.294	0.173
346.60	0.277	0.028	347.12	0.294	0.176
346.61	0.277	0.030	347.13	0.294	0.179
346.62	0.277	0.033	347.14	0.295	0.182
346.63	0.278	0.036	347.15	0.295	0.185
346.64	0.278	0.039	347.16	0.295	0.188
346.65	0.278	0.041	347.17	0.296	0.191
346.66	0.279	0.044	347.18	0.296	0.194
346.67	0.279	0.047	347.19	0.296	0.197
346.68	0.279	0.050	347.20	0.297	0.200
346.69	0.280	0.053	347.21	0.297	0.202
346.70	0.280	0.055	347.22	0.297	0.205
346.71	0.280	0.058	347.23	0.298	0.208
346.72	0.281	0.061	347.24	0.298	0.211
346.73	0.281	0.064	347.25	0.298	0.214
346.74	0.281	0.067	347.26	0.299	0.217
346.75	0.282	0.069	347.27	0.299	0.220
346.76	0.282	0.072	347.28	0.299	0.223
346.77	0.282	0.075	347.29	0.300	0.226
346.78	0.283	0.078	347.30	0.300	0.229
346.79	0.283	0.081	347.31	0.300	0.232
346.80	0.283	0.084	347.32	0.301	0.235
346.81	0.284	0.086	347.33	0.301	0.238
346.82	0.284	0.089	347.34	0.301	0.241
346.83	0.284	0.092	347.35	0.302	0.244
346.84	0.285	0.095	347.36	0.302	0.247
346.85	0.285	0.098	347.37	0.302	0.250
346.86	0.285	0.101	347.38	0.303	0.253
346.87	0.286	0.103	347.39	0.303	0.256
346.88	0.286	0.106	347.40	0.303	0.260
346.89	0.286	0.109	347.41	0.304	0.263
346.90	0.287	0.112	347.42	0.304	0.266
346.91	0.287	0.115	347.43	0.304	0.269
346.92	0.287	0.118	347.44	0.305	0.272
346.93	0.288	0.121	347.45	0.305	0.275
346.94	0.288	0.124	347.46	0.305	0.278
346.95	0.288	0.126	347.47	0.306	0.281
346.96	0.289	0.129	347.48	0.306	0.284
346.97	0.289	0.132	347.49	0.306	0.287
346.98	0.289	0.135	347.50	0.307	0.290
346.99	0.290	0.138	347.51	0.307	0.293
347.00	0.290	0.141	347.52	0.307	0.296
347.01	0.290	0.144	347.53	0.308	0.299

BEALS + THOMAS

Standard 4: Water Quality Volume Summary

$$V_{WQ} = (D_{WQ} / 12 \text{ in/ft}) \times (A_{IMP} \times 43{,}560 \text{ SF/Ac}) \text{ where:}$$

V_{WQ} = Required Water Quality Volume [CF]

D_{WQ} = Water Quality Depth : 1-inch for discharges within a Zone II or Interim Wellhead Protection Area, to or near critical areas, runoff from LUHPPL, or exfiltration to soil with infiltration rate 2.4 in/hr or greater; ½-inch for discharges to other areas.

A_{IMP} = Post-development Impervious Area; may exclude roof top areas [Ac]

Required Water Quality Volume:

Drainage Area/ Treatment Train	A_{IMP} [Ac]	D_{WQ} [in]	V_{WQ} Required [CF]	
PDA-1A	0.000	1	0	
PDA-1B	0.227	1	824	
PDA-1C	0.318	1	1,154	
PDA-1D	3.920	1	14,230	
PDA-2A	0.000	1	0	
PDA-2B	2.549	1	9,253	
PDA-3	0.000	1	0	
PDA-4A	0.000	1	0	
PDA-4B	0.000	1	0	
Total Required Water Quality Volume:			25,461	Cubic Feet

Provided Water Quality Volume:

Drainage Area/ Treatment Train	BMP	Water Quality Volume Provided [CF]	
PDA-1B	WQI-6	508	
PDA-1C	WQI-5	1,154	
PDA-1D	WQI-3 & WQI-4	13,326	
PDA-2B	WQI-1, WQI-2, WQI-7	9,249	
PDA-1C	Infiltration Basin #1	3,100	
PDA-1D	Infiltration Basin #2	30,094	
PDA-2B	Infiltration Basin #3	9,339	
Total Provided Water Quality Volume:		66,771	Cubic Feet

WATER QUALITY VOLUME PROVIDED IS GREATER THAN OR EQUAL TO THE REQUIRED WATER QUALITY VOLUME, THEREFORE PROPOSED STORMWATER MANAGEMENT DESIGN IS IN COMPLIANCE WITH STANDARD 4.

JOB NO. 3077.06 COMPUTED BY: RFK CHECKED BY: JRM

JOB: Lackey Dam Logistics Center DATE: 09/01/22 DATE: 09/06/22

BEALS + THOMAS
Proprietary Water Quality Inlet Sizing

Step 1: Define Minimum Flow Rate per Water Quality Inlet to Treat Desired Water Quality Volume

Water quality inlets are sized based on flow rate; therefore expressing Water Quality Volume as a flow rate based on the percentage of cumulative average volume captured ensures systems are sized to achieve the desired Water Quality treatment level.

$Q = (q_u)(A)(WQV)$ where:

Q = peak flow rate associated with first 1.0-inch of runoff [CFS]

q_u = The Peak Discharge [CFS/mi^2/in] Massachusetts DEP Standard Method to Convert Required Water Quality Volume to a Discharge Rate for Sizing Flow Based Manufactured Proprietary Stormwater Treatment Practices

A = Contributing Drainage Area, Impervious Surface Only [Ac]

WQV = The Water Quality Treatment Depth [In]

WQI No.	A (Ac)	Tc (Min)	WQV (in)	q_u (csm/in)	Q (cfs)
WQI-1	0.890	5.0	1.0	795	1.11
WQI-2	0.269	5.0	1.0	795	0.33
WQI-3	2.662	5.0	1.0	795	3.31
WQI-4	1.009	5.0	1.0	795	1.25
WQI-5	0.318	5.0	1.0	795	0.40
WQI-6	0.140	5.0	1.0	795	0.17
WQI-7	1.389	5.0	1.0	795	1.73
Total	6.68	Acres			

Step 2: Size Water Quality Inlet as recommended by Manufacturer

See attached Sizing Report(s) for recommended model(s).

Step 3: Water Quality Volume Provided by WQI unit(s)

Total Impervious Area Treated by WQI unit(s): 6.68 Acres

290,850 SF

Treated Water Quality Depth : 1.0 inches

(accounted for by Average Water Quality Flow Rate)

Total Water Quality Volume provided by Water Quality Inlets: 24,238 CF

JOB NO. 3077.06 COMPUTED BY: RFK CHECKED BY: JRM

JOB: Lackey Dam Logistics Center DATE: 09/01/22 DATE: 09/06/22

Stage-Area-Storage for Pond 110P: BASIN #1

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
325.00	2,718	0	327.60	4,827	9,729
325.05	2,756	137	327.65	4,870	9,971
325.10	2,794	276	327.70	4,914	10,216
325.15	2,832	416	327.75	4,958	10,463
325.20	2,871	559	327.80	5,002	10,712
325.25	2,909	703	327.85	5,046	10,963
325.30	2,947	850	327.90	5,089	11,216
325.35	2,985	998	327.95	5,133	11,472
325.40	3,023	1,148	328.00	5,177	11,730
325.45	3,061	1,300	328.05	5,224	11,990
325.50	3,100	1,454	328.10	5,270	12,252
325.55	3,138	1,610	328.15	5,317	12,517
325.60	3,176	1,768	328.20	5,363	12,784
325.65	3,214	1,928	328.25	5,410	13,053
325.70	3,252	2,090	328.30	5,457	13,325
325.75	3,290	2,253	328.35	5,503	13,599
325.80	3,328	2,419	328.40	5,550	13,875
325.85	3,367	2,586	328.45	5,596	14,154
325.90	3,405	2,755	328.50	5,643	14,435
325.95	3,443	2,926	328.55	5,690	14,718
326.00	3,481	3,100	328.60	5,736	15,003
326.05	3,522	3,275	328.65	5,783	15,291
326.10	3,563	3,452	328.70	5,829	15,582
326.15	3,604	3,631	328.75	5,876	15,874
326.20	3,645	3,812	328.80	5,923	16,169
326.25	3,686	3,995	328.85	5,969	16,467
326.30	3,727	4,181	328.90	6,016	16,766
326.35	3,768	4,368	328.95	6,062	17,068
326.40	3,809	4,557	329.00	**6,109**	**17,373**
326.45	3,850	4,749			
326.50	3,891	4,943			
326.55	3,932	5,138			
326.60	3,973	5,336			
326.65	4,014	5,535			
326.70	4,055	5,737			
326.75	4,096	5,941			
326.80	4,137	6,147			
326.85	4,178	6,355			
326.90	4,219	6,564			
326.95	4,260	6,776			
327.00	4,301	6,991			
327.05	4,345	7,207			
327.10	4,389	7,425			
327.15	4,432	7,646			
327.20	4,476	7,868			
327.25	4,520	8,093			
327.30	4,564	8,320			
327.35	4,608	8,550			
327.40	4,651	8,781			
327.45	4,695	9,015			
327.50	4,739	9,251			
327.55	4,783	9,489			

Stage-Area-Storage for Pond 120P: BASIN #2

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
340.00	20,215	0
340.10	20,398	2,031
340.20	20,580	4,079
340.30	20,763	6,147
340.40	20,945	8,232
340.50	21,128	10,336
340.60	21,310	12,458
340.70	21,492	14,598
340.80	21,675	16,756
340.90	21,857	18,933
341.00	22,040	21,128
341.10	22,228	23,341
341.20	22,416	25,573
341.30	22,604	27,824
341.40	22,792	30,094
341.50	22,980	32,383
341.60	23,168	34,690
341.70	23,356	37,016
341.80	23,544	39,361
341.90	23,732	41,725
342.00	23,920	44,108
342.10	24,114	46,509
342.20	24,308	48,930
342.30	24,501	51,371
342.40	24,695	53,831
342.50	24,889	56,310
342.60	25,083	58,808
342.70	25,277	61,326
342.80	25,470	63,864
342.90	25,664	66,420
343.00	25,858	68,997
343.10	26,057	71,592
343.20	26,257	74,208
343.30	26,456	76,844
343.40	26,656	79,499
343.50	26,855	82,175
343.60	27,054	84,870
343.70	27,254	87,586
343.80	27,453	90,321
343.90	27,653	93,076
344.00	27,852	95,852
344.10	28,057	98,647
344.20	28,262	101,463
344.30	28,467	104,299
344.40	28,672	107,156
344.50	28,877	110,034
344.60	29,082	112,932
344.70	29,287	115,850
344.80	29,492	118,789
344.90	29,697	121,749
345.00	29,902	124,729
345.10	30,113	127,729
345.20	30,323	130,751
345.30	30,534	133,794
345.40	30,745	136,858
345.50	30,956	139,943
345.60	31,166	143,049
345.70	31,377	146,176
345.80	31,588	149,324
345.90	31,798	152,494
346.00	**32,009**	**155,684**

Stage-Area-Storage for Pond 230P: BASIN #3

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
346.50	11,916	0	347.02	12,657	6,389
346.51	11,930	119	347.03	12,672	6,515
346.52	11,944	239	347.04	12,687	6,642
346.53	11,959	358	347.05	12,701	6,769
346.54	11,973	478	347.06	12,716	6,896
346.55	11,987	598	347.07	12,731	7,024
346.56	12,001	718	347.08	12,745	7,151
346.57	12,016	838	347.09	12,760	7,278
346.58	12,030	958	347.10	12,775	7,406
346.59	12,044	1,078	347.11	12,789	7,534
346.60	12,058	1,199	347.12	12,804	7,662
346.61	12,073	1,319	347.13	12,819	7,790
346.62	12,087	1,440	347.14	12,833	7,918
346.63	12,101	1,561	347.15	12,848	8,047
346.64	12,115	1,682	347.16	12,863	8,175
346.65	12,130	1,803	347.17	12,877	8,304
346.66	12,144	1,925	347.18	12,892	8,433
346.67	12,158	2,046	347.19	12,907	8,562
346.68	12,172	2,168	347.20	12,921	8,691
346.69	12,187	2,290	347.21	12,936	8,820
346.70	12,201	2,412	347.22	12,951	8,950
346.71	12,215	2,534	347.23	12,965	9,079
346.72	12,229	2,656	347.24	12,980	9,209
346.73	12,244	2,778	347.25	12,995	9,339
346.74	12,258	2,901	347.26	13,009	9,469
346.75	12,272	3,024	347.27	13,024	9,599
346.76	12,286	3,146	347.28	13,038	9,729
346.77	12,300	3,269	347.29	13,053	9,860
346.78	12,315	3,392	347.30	13,068	9,990
346.79	12,329	3,516	347.31	13,082	10,121
346.80	12,343	3,639	347.32	13,097	10,252
346.81	12,357	3,762	347.33	13,112	10,383
346.82	12,372	3,886	347.34	13,126	10,514
346.83	12,386	4,010	347.35	13,141	10,646
346.84	12,400	4,134	347.36	13,156	10,777
346.85	12,414	4,258	347.37	13,170	10,909
346.86	12,429	4,382	347.38	13,185	11,040
346.87	12,443	4,506	347.39	13,200	11,172
346.88	12,457	4,631	347.40	13,214	11,304
346.89	12,471	4,756	347.41	13,229	11,437
346.90	12,486	4,880	347.42	13,244	11,569
346.91	12,500	5,005	347.43	13,258	11,702
346.92	12,514	5,130	347.44	13,273	11,834
346.93	12,528	5,256	347.45	13,288	11,967
346.94	12,543	5,381	347.46	13,302	12,100
346.95	12,557	5,506	347.47	13,317	12,233
346.96	12,571	5,632	347.48	13,332	12,366
346.97	12,585	5,758	347.49	13,346	12,500
346.98	12,600	5,884	347.50	13,361	12,633
346.99	12,614	6,010	347.51	13,376	12,767
347.00	12,628	6,136	347.52	13,390	12,901
347.01	12,643	6,262	347.53	13,405	13,035

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

1. Sheet is nonautomated. Print sheet and complete using hand calculations. Column A and B: See MassDEP Structural BMP Table
2. The calculations must be completed using the Column Headings specified in Chart and Not the Excel Column Headings
3. To complete Chart Column D, multiple Column B value within Row x Column C value within Row
4. To complete Chart Column E value, subtract Column D value within Row from Column C within Row
5. Total TSS Removal = Sum All Values in Column D

Location: **PDA-1B**

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep Sump and Hooded Catch Basin	0.25	**1.00**	0.25	0.75
Water Quality Structure*	0.80	0.75	0.60	0.15

*Proprietary Structure will provide greater than 80% TSS Removal. TSS removal rates forthcoming from manufacturer.

Total TSS Removal = 85%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Lackey Dam Logistics Center

Prepared By: RFK

Date: 09/06/2022

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed

1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

1. Sheet is nonautomated. Print sheet and complete using hand calculations. Column A and B: See MassDEP Structural BMP Table
2. The calculations must be completed using the Column Headings specified in Chart and Not the Excel Column Headings
3. To complete Chart Column D, multiple Column B value within Row x Column C value within Row
4. To complete Chart Column E value, subtract Column D value within Row from Column C within Row
5. Total TSS Removal = Sum All Values in Column D

Location: **PDA-1C**

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep Sump and Hooded Catch Basin	0.25	**1.00**	0.25	0.75
Water Quality Structure*	0.80	0.75	0.60	0.15
Infiltration Basin	0.80	0.15	0.12	0.03

*Proprietary Structure will provide greater than 80% TSS Removal.
TSS removal rates forthcoming from manufacturer.

Total TSS Removal = 97%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Lackey Dam Logistics Center
Prepared By: RFK
Date: 09/06/2022

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

1. Sheet is nonautomated. Print sheet and complete using hand calculations. Column A and B: See MassDEP Structural BMP Table
2. The calculations must be completed using the Column Headings specified in Chart and Not the Excel Column Headings
3. To complete Chart Column D, multiple Column B value within Row x Column C value within Row
4. To complete Chart Column E value, subtract Column D value within Row from Column C within Row
5. Total TSS Removal = Sum All Values in Column D

Location: **PDA-1D**

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep Sump and Hooded Catch Basin	0.25	**1.00**	0.25	0.75
Water Quality Structure*	0.80	0.75	0.60	0.15
Infiltration Basin	0.80	0.15	0.12	0.03

*Proprietary Structure will provide greater than 80% TSS Removal. TSS removal rates forthcoming from manufacturer.

Total TSS Removal = 97%

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Lackey Dam Logistics Center

Prepared By: RFK

Date: 09/06/2022

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed

1. From MassDEP Stormwater Handbook Vol. 1

INSTRUCTIONS:

Non-automated: Mar. 4, 2008

1. Sheet is nonautomated. Print sheet and complete using hand calculations. Column A and B: See MassDEP Structural BMP Table
2. The calculations must be completed using the Column Headings specified in Chart and Not the Excel Column Headings
3. To complete Chart Column D, multiple Column B value within Row x Column C value within Row
4. To complete Chart Column E value, subtract Column D value within Row from Column C within Row
5. Total TSS Removal = Sum All Values in Column D

Location: **PDA-2B**

TSS Removal Calculation Worksheet

A BMP[1]	B TSS Removal Rate[1]	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep Sump and Hooded Catch Basin	0.25	**1.00**	0.25	0.75
Water Quality Structure*	0.80	0.75	0.60	0.15
Infiltration Basin	0.80	0.15	0.12	0.03

*Proprietary Structure will provide greater than 80% TSS Removal. TSS removal rates forthcoming from manufacturer.

Total TSS Removal = **97%**

Separate Form Needs to be Completed for Each Outlet or BMP Train

Project: Lackey Dam Logistics Center

Prepared By: RFK

Date: 09/06/2022

*Equals remaining load from previous BMP (E) which enters the BMP

Non-automated TSS Calculation Sheet must be used if Proprietary BMP Proposed
1. From MassDEP Stormwater Handbook Vol. 1

Mass. Dept. of Environmental Protection

Attachment 6
Site Owner's Manual

Site Owner’s Manual

LACKEY DAM LOGISTICS CENTER

Lackey Dam Road
Sutton and Uxbridge, Massachusetts

Prepared for:
US MA Development, LLC
8801 River Crossing Boulevard, Suite 300
Indianapolis, IN, 46240

Prepared by:

BEALS + THOMAS

September 6, 2022

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FIGURES

APPENDICES

1.0 INTRODUCTION

The Site Owner's Manual complies with the Long-Term Pollution Prevention Plan (Standard 4) and the Long-Term Operation and Maintenance Plan (Standard 9) requirements of the 2008 Massachusetts Department of Environmental Protection (DEP) Stormwater Handbook. The Manual outlines source control and pollution prevention measures and maintenance requirements of stormwater best management practices (BMPs) associated with the proposed development.

2.0 SITE OWNER'S AGREEMENT

2.1 Operation and Maintenance Compliance Statement

Site Owner: US MA Development, LLC
8801 River Crossing Boulevard, Suite 300
Indianapolis, IN 46240

Responsible Party: US MA Development, LLC

US MA Development, LLC or their successors shall maintain ownership of the on-site stormwater management system as well as the responsibility for operation and maintenance during the post-development stages of the project. The site has been inspected for erosion and appropriate measures have been taken to permanently stabilize any eroded areas. All aspects of stormwater best management practices (BMPs) have been inspected for damage, wear and malfunction, and appropriate steps have been taken to repair or replace the system or portions of the system so that the stormwater at the site may be managed in accordance with the Stormwater Management Standards. Future responsible parties shall be notified of their continuing legal responsibility to operate and maintain the BMPs. The operation and maintenance plan for the stormwater BMPs is being implemented.

______________________________ ____________
Responsible Party Signature Date

2.2 Stormwater Maintenance Easements

There are no off-site areas utilized for stormwater control, therefore no stormwater management easements are required. The Site Owner will have access to all stormwater practices for inspection and maintenance, including direct maintenance access by heavy equipment to structures requiring regular maintenance.

2.3 Record Keeping

The Site Owner shall maintain a rolling log in which all inspections and maintenance activities for the past three years shall be recorded. The Operation and Maintenance Log includes information pertaining to inspections, repairs, and disposal relevant to the project's stormwater management system. The Log is located in Appendix A.

The Operation and Maintenance Log shall be made available to the Conservation Commission and the DEP upon request. The Conservation Commission and the DEP shall be allowed to enter and inspect the premises to evaluate and ensure that the responsible party complies with the maintenance requirements for each BMP.

2.4 Training

Employees involved in grounds maintenance and emergency response will be educated on the general concepts of stormwater management and groundwater protection. The Site Owner's Manual will be reviewed with the maintenance staff. The staff will be trained on the proper course of action for specific events expected to be incurred during routine maintenance or emergency situations.

3.0 LONG-TERM POLLUTION PREVENTION PLAN

In compliance with Standard 4 of the 2008 DEP Stormwater Management Handbook, this section outlines source control and pollution prevention measures to be employed on-site after construction.

3.1 Storage of Materials and Waste

The site shall be kept clear of trash and debris at all times. Certain materials and waste products shall be stored inside or outside upon an impervious surface and covered, as required by local and state regulations.

3.2 Vehicle Washing

No commercial vehicle washing shall take place on site.

3.3 Routine Inspections and Maintenance of Stormwater BMPs

See Section 4.0 Long-Term Operation and Maintenance Plan, for routine inspection and maintenance requirements for all proposed stormwater BMPs.

3.4 Spill Prevention and Response

A contingency plan shall be implemented to address the spill or release of petroleum products and hazardous materials and will include the following measures:

1. Equipment necessary to quickly attend to inadvertent spills or leaks shall be stored on-site in a secure but accessible location. Such equipment shall include but not be limited to the following: safety goggles, chemically resistant gloves and overshoe boots, water and chemical fire extinguishers, sand and shovels, suitable absorbent materials, storage containers and first aid equipment (i.e. Indian Valley Industries, Inc. 55-gallon Spill Containment kit or approved equivalent).

2. Spills or leaks shall be treated properly according to material type, volume of spillage and location of spill. Mitigation shall include preventing further spillage, containing the spilled material in the smallest practical area, removing spilled material in a safe and environmentally-friendly manner, and remediation of any damage to the environment.

3. For large spills, Massachusetts DEP Hazardous Waste Incident Response Group shall be notified immediately at 888-304-1133 and an emergency response contractor shall be consulted.

3.5 Maintenance of Lawns, Gardens, and other Landscaped Areas

Lawns, gardens, and other landscaped areas shall be maintained regularly by the site owner. Vegetated and landscaped BMPs will be maintained as outlined in Section 4.0.

3.6 Storage and Use of Fertilizers, Herbicides, and Pesticides

All fertilizers, herbicides, and pesticides shall be stored in accordance with local, state, and federal regulations. The application rate and use of fertilizers, herbicides, and pesticides on the site shall at no time exceed local, state, or federal specifications.

3.7 Operation and Management of Septic Systems

The proposed development includes a septic system to treat wastewater. The septic system shall be operated and maintained in accordance with local and state regulations.

3.8 Snow and Deicing Chemical Management

Snow removal and use of deicing chemicals at the proposed development shall comply with the following requirements:

- Plowed snow shall be placed in the areas outside of wetland boundaries and stormwater best management practices. The following maintenance measures shall be undertaken at all snow disposal sites:
  - Debris shall be cleared from an area prior to using it for snow disposal.
  - Debris and accumulated sediments shall be cleared from the site and properly disposed of at the end of the snow season and no later than May 15.
- In accordance with the Massachusetts General Laws, Chapter 85, Section 7A, salt and other de-icing chemicals will be stored at an indoor location. Salt and other deicing chemicals shall be stored in accordance with Massachusetts General Law.
- Sand piles shall be contained and stabilized to prevent the discharge of sand to wetlands or water bodies, and, where feasible, covered.
- Salt storage piles shall be located outside of the 100-year floodplain.
- The application of salt on the proposed parking areas and driveway shall at no time exceed state or local requirements.

4.0 LONG-TERM OPERATION AND MAINTENANCE PLAN

This section outlines the stormwater best management practices (BMPs) associated with the proposed stormwater management system and identifies the long-term inspection and maintenance requirements for each BMP.

4.1 Stormwater Management System Components

The following table outlines the type and quantity of the BMPs and their general location. Please reference the site plans provided in the Figures section for exact location. All BMPs are accessible for maintenance from either the development driveway or parking areas.

BMP Type	Quantity	Location
Catch Basin	28	Throughout the paved parking area and access drives.
Area Drain	5	Along the western side of the site and adjacent to Infiltration Basin 2.
Water Quality Structure	7	Upstream of pipe outfalls into the infiltration basins.
Infiltration Basin	3	At the northeast and southern portions of the site.
Stormwater Outfalls	16	Flared end inlets into infiltration basins, at basin outfall pipes, and rip-rap overflow spillways.

4.2 Inspection and Maintenance Schedules

4.2.1 General Maintenance for Mosquito Control

If necessary to minimize mosquito breeding, a licensed pesticide applicator shall apply larvicides, such as Bacillus sphaericus (Bs) to all catch basins sumps, and water quality inlets. Larvicides shall be applied in compliance with all pesticide label requirements, and will be applied during or immediately after wet weather, unless the product used can withstand extended dry periods. Ensure all manhole covers, and inspection ports are secure to reduce the likelihood of mosquitoes laying eggs in standing water.

4.2.2 Deep Sump and Hooded Catch Basins

Catch basins shall be inspected four times per year, including after the foliage season. Other inspection and maintenance requirements include:

- Units shall be cleaned (organic material, sediment and hydrocarbons removed) four times per year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom of the invert of the lowest pipe in the basin.

- Cleanout shall always occur after street sweeping.

- If any evidence of hydrocarbons is found during inspection, the material shall be immediately removed using absorbent pads or other suitable measures and disposed of legally.
- Remove other accumulated debris as necessary.
- Transport and disposal of accumulated sediment off-site shall be in accordance with applicable local, state and federal guidelines and regulations.

4.2.3 Area Drains

Area drains shall be inspected and/or cleaned at least once per year.

4.2.4 Water Quality Structure

Maintenance of water quality structures shall be performed according the recommendations set forth by the manufacturer (see Appendix C. Proprietary Water Quality Structure Technical Manual for complete installation, operation and maintenance procedures). Inspection and maintenance procedures for proprietary devices are provided below:

- Units shall be inspected post-construction, prior to being put into service.
- Units shall be inspected not less than twice per year following installation and no less than once per year thereafter.
- Units shall be inspected immediately after any oil, fuel or chemical spill.
- All inspections shall include checking the oil level and sediment depth in the unit.
- Removal of sediments/oils shall occur per manufacturer recommendations.
- A licensed waste management company shall remove captured petroleum waste products from any oil, chemical or fuel spills and dispose.
- OSHA confined space entry protocols shall be followed if entry into the unit is required.

4.2.5 Infiltration Basins

Infiltration basins shall be inspected and maintained after major storm events (rainfall totals greater than 2.5 inches in 24 hours) during the first three months of operation and twice a year and when there are discharges through the outlet control structure thereafter. Additionally, all pretreatment BMPs shall be inspected in accordance with the minimal requirements specified for those practices and after all major storm events. Inspections shall include the following measures:

- During and after major storm events, the length of time standing water remains in the basin shall be recorded.
    - If the time is greater than 72 hours, thoroughly inspect the basin for signs of clogging.
    - A corrective action plan shall be developed by a qualified professional to restore infiltrative function. The Site Owner shall take immediate action to implement these corrective measures.
- Examine the outlet structure for evidence of clogging or outflow release velocities that are greater than the design velocity.
- Identify areas of sediment accumulation, differential settlement, cracking, and erosion within the basin.
- Inspect embankments for leakage and tree growth.
- Examine the health of the vegetation within the basin and on the embankments.

Corrective measures shall be taken immediately as warranted by the inspections. If any evidence of hydrocarbons is found during inspection, the material shall be immediately removed using absorbent pads or other suitable measures and legally disposed.

Preventative maintenance shall include the following activities:

- Mow the buffer area and basin bottom and side slopes, if vegetated.
- Remove trash, debris, and accumulated organic matter.
- Remove clippings after mowing.

4.2.6 Stormwater Outfalls

Flared end sections and associated riprap spillways shall be inspected at least once per year and after major storm events (rainfall totals greater than 2.5 inches in 24 hours) to ensure that the stability of the outlet area is maintained. The outfall area shall be kept clear of debris such as trash, branches, and sediment. Repairs shall be made immediately if riprap displacement or downstream channel scour is observed.

4.3 Estimated Operation and Maintenance Budget

An operations and maintenance budget was prepared to approximate the annual cost of the inspections required in compliance with the DEP Stormwater Management Policy. The table below estimates the annual cost to inspect and maintain each proposed BMP, based on the requirements in Section 4.2.

BMP Type	# of BMPS	Annual O&M Cost (per BMP)[1]	Total Cost
Mosquito Control	28	$50-$100	$1,400-$2,800
Catch Basin	28	$200-$400	$5,600-$11,200
Area Drain	5	$50-$100	$250-$500
Water Quality Structure	7	$100-$300	$700-$2,100
Infiltration Basin	3	$200 - $400	$600-$1,200
Stormwater Outfalls (Flared Ends & Spillways)	16	$50-$100	$800-$1,600
		Total	**$9,350-$19,400**

4.4 Public Safety Features

Multiple safety measures are proposed to protect the public and prevent pollutant contamination of the stormwater management system and other water resources. Guardrails along the access driveway will prevent cars from inadvertently detouring down steep side slopes and into adjacent stormwater basins. They will provide protection to the public and prevent pollutant contamination of the stormwater management system and the municipal drainage system.

[1] Annual maintenance cost is based on estimate of the cost to complete all inspection and maintenance measures outlined in Section 4.2. For BMPs that require sediment removal at regular intervals (i.e. every 5 or 10 years), the annual cost includes the annual percentage of that cost.

Figures

Figure 1: Site Plans
(Refer to the Issued Permitting Plans)

Appendices

Appendix A

Operation and Maintenance Log

OPERATION AND MAINTENANCE LOG

This template is intended to comply with the operation and maintenance log requirements of the 2008 DEP Stormwater Management Handbook. Copies of this log should be made for all inspections and kept on file for three years from the inspection date.

Name/Company of Inspector:	
Date/Time of Inspection:	
Weather Conditions: (Note current weather and any recent precipitation events)	

Stormwater BMP	Inspection Observations	Actions Required

Appendix B

List of Emergency Contacts

List of Emergency Contacts:

Massachusetts DEP Hazardous Waste Incident Response Group
Tel: (617) 792-7653

Sutton Fire Department
Emergencies: Dial 911
4 Uxbridge Road
Sutton, MA 01590
Tel: (508) 865-8737

Sutton Police Department
Emergencies: Dial 911
489 Central Turnpike
Sutton, MA 01590
Tel: (508) 865-4449

Uxbridge Fire Department
Emergencies: Dial 911
31 South Main Street
Uxbridge, MA 01569
Tel: (508) 278-2787

Uxbridge Police Department
Emergencies: Dial 911
275 Douglas Street
Uxbridge, MA 01569
Tel: (508) 278-7755

Appendix C

Proprietary Separator Technical Manual

CONTECH®
ENGINEERED SOLUTIONS

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.

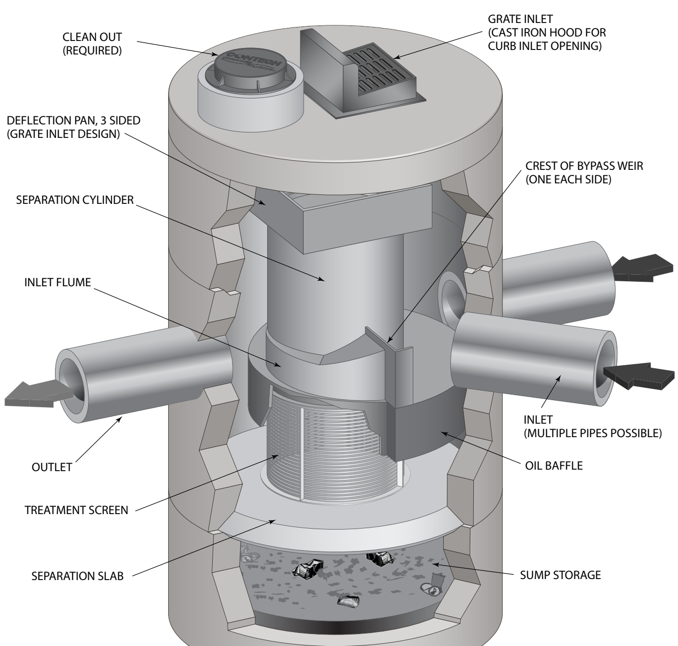
Operation Overview

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 and Probabilistic Method is used when a specific removal efficiency of the net annual sediment load is required.

Typically in the Unites 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 (d50 = 20 to 30 μm) covering a wide size range (Coefficient of Uniformity, C 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 d50 (d50 for NJDEP is approximately 50 μm) (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 (d50) of 106 microns. The PSDs for the test material are shown in Figure 1.

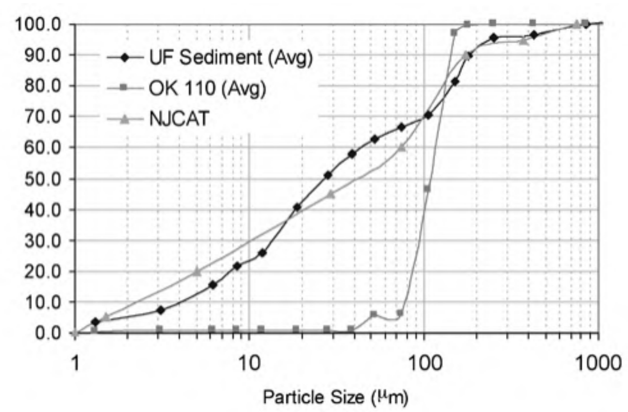


Figure 1. Particle size distributions

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.

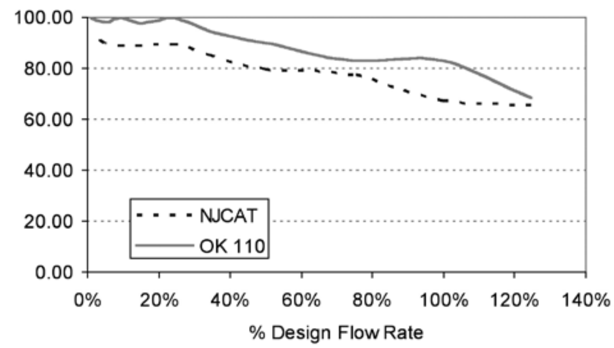


Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

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 (d50) 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 (d50 = 125 μm).

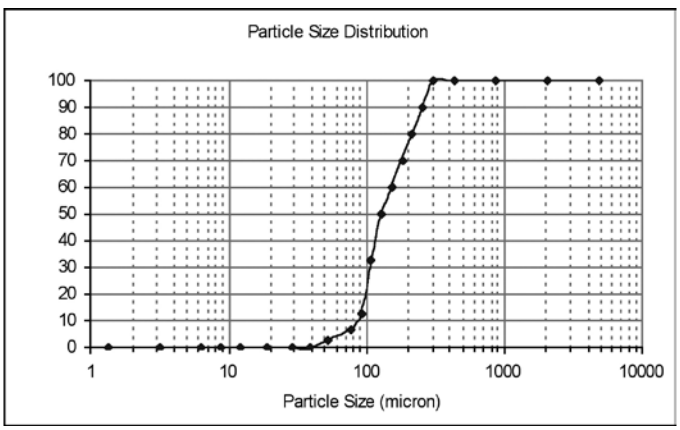


Figure 3. WASDOE PSD

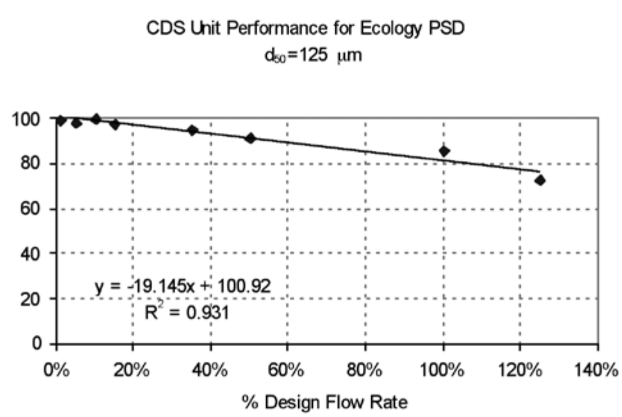


Figure 4. Modeled performance for WASDOE PSD.

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 allows 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 weather 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 systems 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.

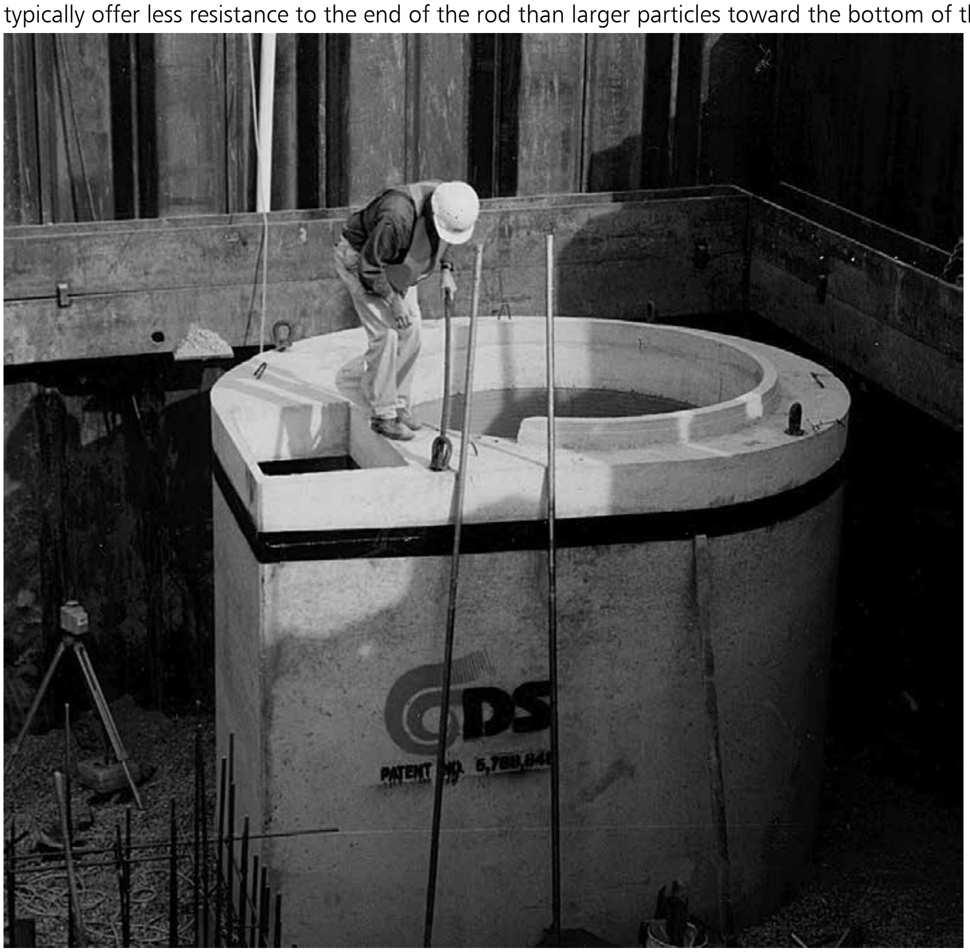
In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill. Motor oil and other hydrocarbons that accumulate on a more routine basis should 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^3	m^3
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: ______________________________

Date	Water depth to sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

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.
- Site-specific design support is available from our engineers.

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