Stormwater Management Report

for:

Equine Arena
Willard Road
North Grafton, Massachusetts

Project Proponent:

Cummings School of Veterinary Medicine
at Tufts University
North Grafton, MA 01536

Revised May 2016/ Grafton Stormwater Bylaw

COMMONWEALTH OF MASSACHUSETTS
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5.26.16

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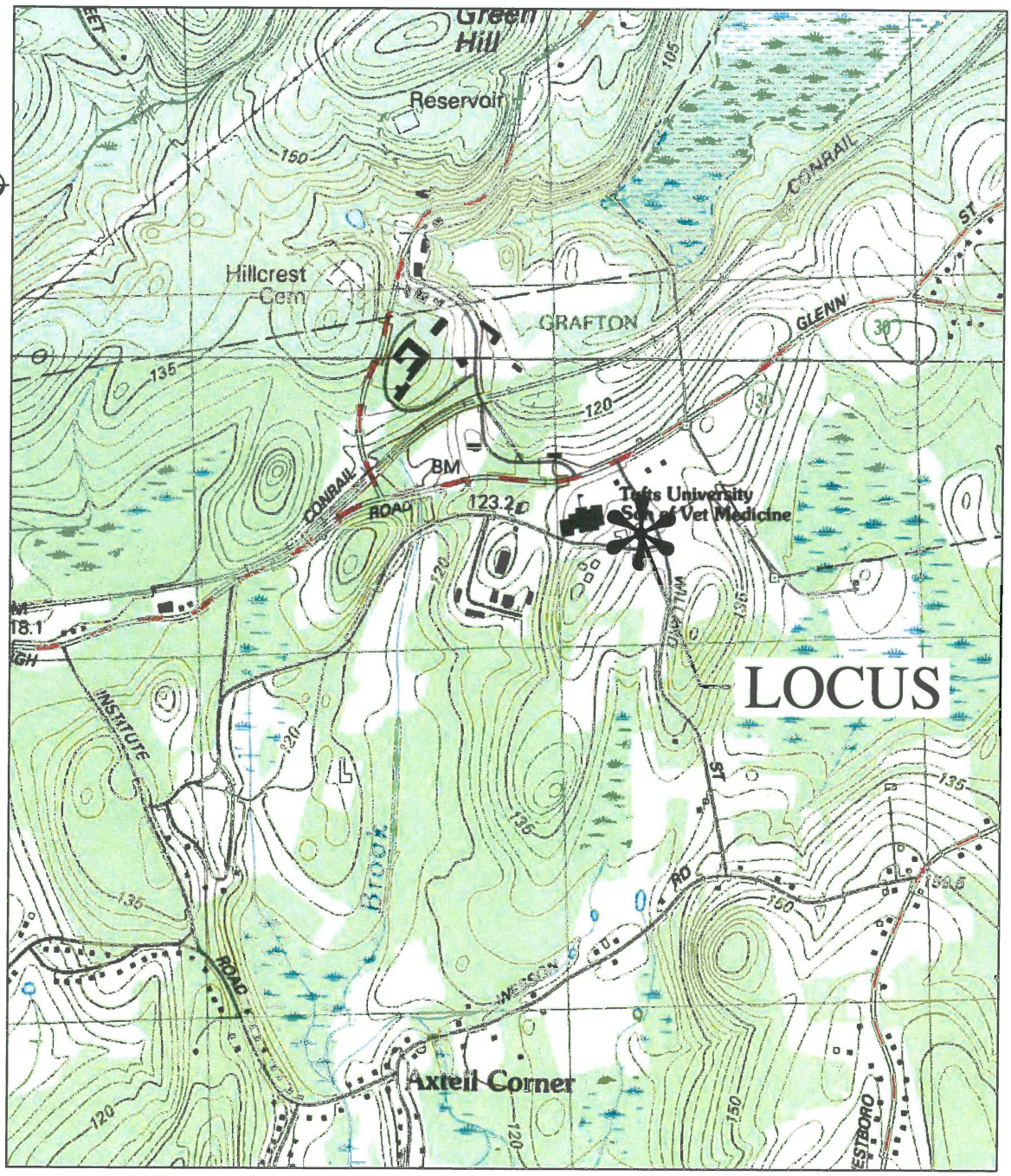


LOCUS MAP

SCALE: 1" = 2083'+/-

PURPOSE

Revised hydrologic and water quality calculations have been performed as part of the Project Plan Review and Stormwater Permit application, for a proposed redevelopment project located in North Grafton, MA. These revised calculations were performed to evaluate the proposed stormwater collection and attenuation facilities for the site and to demonstrate that the project will meet the standards of the Town of Grafton and the Massachusetts Department of Environmental Protection (MassDEP) Stormwater Management Regulations.

This report describes the assessment of the proposed system for the NRCC Cornell rainfall data and the resultant changes made to the proposed stormwater management system to effectively mitigate the greater 100-year return period twenty-four hour rainfall rate than previously assessed (8.5 inches versus 7 inches. The analyses were performed to develop a stormwater management system that will protect public safety and convenience and minimize environmental impacts.

PROJECT SITE

The Project Site contains four (4) plus acres of the Tufts Campus on the west side of Willard Street and south side of Westboro Road. The northern portion of the project site (approximately 1 acre) is presently under construction to complete an earlier expansion of the Foster Hospital for Small Animals building. The remainder of the project site contains a number of horse paddocks and other yard areas for animals. There are no wetlands resources areas on or within the project site and no portion of the site contains land within an area of 100-year flooding (Zone A), as shown on the NFIP Flood Insurance Rate Maps for the Town of Grafton (Community Panel No. 25027C0831F, dated July 16, 2014). The portion of the project site south of Westboro Road generally drains from west to east and south to north, with elevations ranging from 475 to 452. The majority of the site presently drains overland toward Willard Street and Route 30. Willard Street has a limited piped drainage system near the intersection with Westboro Road and one cross drain at the southern end of the project limits near Jumbo's Path. The portion of the project site north of Westboro Road presently drains to the north across undeveloped land, with elevations ranging from 445 to 428. Elevations refer to NGVD 1929. As a result of the redesigned stormwater management system, the project site now includes the lower portion of the Tufts property adjacent to Rte 30 as well as portion of Rte 30 and the field north of route 30.

United States Department of Agriculture Natural Resources Conservation Service (NRCS) mapping identifies the soils of the subject site as Paxton fine sandy loam (Hydrologic Soil Group C, HSG C), and Woodbridge fine sandy loam (HSG C). Soil testing was performed by Waterman Design Associates, Inc. on March 31st and again on May 4th to verify the NRCS mapping. We found the south side of Route 30 (building site) to consist of filled areas over sandy loam and the north side (infiltration basin) to consist of loamy sand. Refer to the site plans for soil type delineations and testing locations, as well as soil logs of the holes and probes performed by WDA.

The attached revised Existing Hydrology Plan shows the project design points and contributing drainage area(s) with existing cover types. The analyzed design points are at the northern end of the project site north of Route 30 and at the southern end of the project site near the intersection of Willard Street and Jumbo's Path.

PROPOSED PROJECT

The project proponent, Tufts University, proposes to demolish a portion of the existing Equine Housing #2 building (barn) and numerous outdoor paddocks, and construct a new 14,400± gross square foot Equine Sports Medicine Center along with new parking, driveway areas, and new paddocks.

Stormwater runoff from the proposed project will be collected in roof leaders and deep-sump, hooded catch basins and conveyed to either a proposed surface infiltration basin immediately north of Route 30, or directly to the existing site stormwater system to the south. The revised design is a result of the soils testing, which indicated seasonal groundwater as high as 3' from ground surface on the south (building area) portion of the project site and as high as 18" on the north side of Route 30. Controlled outflow will be discharged to the existing drainage system at rates equal to or less than existing conditions for the 2-, 10-, and 100-year, 24-hour design storms. As the soils are entirely HSG C, recharge is provided to the extent practicable in the proposed infiltration basin. These revised calculations reflect a change to the outlet structure from 6 inch outlet pipes and 6 inch horizontal orifices to 8 inch outlet pipes with 8 inch horizontal orifices. The main 6 inch vertical orifices remain as originally designed.

Low Impact Development (LID) Considerations:

> The Tufts campus is, in itself, a low impact development. In keeping with the Grafton Campus Development Overlay District regulations, the total impervious area within a 1000-foot radius of the proposed development has been calculated. In this instance only 24.5% of the roughly 70 acres is impervious.

STORMWATER MANAGEMENT STANDARDS

STANDARD #1 – NO NEW UNTREATED DISCHARGES

The stormwater collection system has been designed such that all stormwater runoff from the parking areas are treated through a treatment train consisting of deep-sump, hooded catch basins, and an infiltration basin. Additionally, all outlets have been designed so that there will be no erosion or scour to the wetlands of the Commonwealth.

STANDARD #2 – PEAK RATE ATTENUATION

METHODOLOGY

United States Soil Conservation Service, "Urban Hydrology for Small Watersheds, Technical Release Number 55" (TR-55) methods (HydroCAD 10.00) were utilized to develop runoff hydrographs for watershed areas affected by the proposed development. Existing and proposed runoff hydrographs were developed for the 2-, 10-, and 100-year, 24-hour rainfall events for the purpose of developing a stormwater management system that will limit post-development peak runoff rates to pre-development levels. In addition to the TP-40 rainfall data, the NRCC Cornell 24-hour depth of 8.5 inches for the Grafton area has been utilized.

The proposed stormwater management system has been designed to meet the requirements of the Town of Grafton and the MassDEP Stormwater Management Standards. The project will limit peak rates of runoff from the site and will infiltrate runoff to approximate existing groundwater recharge.

ANALYSIS SUMMARY

In order to assess the impact of the proposed development on peak runoff rates onto down-gradient properties, hydrologic calculations were performed for each of three (3) design storms at the two (2) design points. Calculations of peak runoff rates for existing and proposed site conditions are included and summarized in Table I for each design point for the three (3) design storms. A revised Proposed Hydrology Plan is provided showing the various sub-watersheds draining to the proposed stormwater management facilities. Stormwater runoff from the overland areas not tributary to the stormwater management facilities will drain by sheet flow or shallow concentrated flow along the existing flow patterns to the design points.

Table I demonstrates that the proposed stormwater management system will be effective in limiting peak rates of runoff from the subject property to approximate pre-development levels.

TABLE I: EXISTING AND PROPOSED PEAK RUNOFF

DRAINAGE AREA	DESIGN STORM EVENT / PEAK RUNOFF (cfs)			
	2-Year	10-Year	100-Year (TP-40)	100-Year (Cornell)
EDA-1	8.0	14.6	23.8	30.0
PDA-1	6.8	13.6	21.4	25.3
EDA-2	1.1	2.3	4.1	5.3
PDA-2	1.5	2.8	4.7	6.0

* reduction in overall flow

TABLE II: EXISTING AND PROPOSED RUNOFF VOLUMES

DRAINAGE AREA	DESIGN STORM / RUNOFF VOLUVE (ac-ft)			
	2-Year	10-Year	100-Year (TP-40)	100-Year (Cornell)
EDA-1	0.58	1.06	1.77	2.26
PDA-1	0.64	1.14	1.85	2.36
EDA-2	0.08	0.17	0.30	0.39
PDA-2	0.12	0.21	0.35	0.45

TABLE III: MAXIMUM WATER ELEVATION

STORMWATER FACILITY	100-YEAR STORM EVENT WATER ELEVATION	TOP / BERM ELEVATION
DB-100	439.43 (TP-40)	441.00*
	439.69 (Cornell)	

* spillway at 440.00

STANDARD #3 – STORMWATER RECHARGE

Groundwater recharge is provided to the extent practicable within the surface infiltration basin. The soils across the southern portion of the site (building site) were found to be poorly drained fill and fine sandy loam with the characteristics of Hydrologic Soil Group C, (HSG C) soils. Soils north of Route 30 were found to be fine loamy sand, a more free draining material, albeit with high seasonal groundwater. To be conservative the Rawls Rates for Sandy Clay Loam, an exfiltration rate of 0.17 inches/hour, was used in our hydrologic models for the stormwater infiltration basin. The Static Method was used in assessing the infiltration system.

The table below provides a summary of the attached groundwater recharge calculations. Calculations are based on HSG C. The required volume of groundwater recharge is equal to 0.25 inches over the additional impervious area.

REQUIRED (CF)	PROVIDED (CF)
1,342*	1,394†

* 64,395 SF additional impervious (includes rooftop)

† 2-year recharge volume (0.032 acre-feet)

DRAWDOWN CALCULATIONS

$$Time = \frac{Rv}{(K)(BottomArea)}$$

Rv = Storage Volume (cubic feet)
K = Saturated Hydraulic Conductivity (inches per hour)

$$Time = \frac{1{,}342cf}{(0.17in/hr)(1ft/12in)(3{,}732sf)}$$

Time = 25.4 hours < 72 hours required

STANDARD #4 – WATER QUALITY

Water quality measures are designed to provide a minimum of 80% Total Suspended Solids (TSS) removal, and to treat runoff prior to discharging to the upland areas. The water quality volume is achieved by providing recharge within the infiltration basin as well as treatment within the catch basins.

REQUIRED (CF)	PROVIDED (CF)
2,083*	1,399†

* 64,395 – 14,400 (roof) = 49,995 SF x 0.5 inches
† 2-year recharge volume (0.032 acre-feet); extent practicable

TSS removal is provided through the use of deep-sump, hooded catch basins (25% and a surface stormwater infiltration basin (80%) for a total of 85% removal.

STANDARD #5 – LAND USES WITH HIGHER POTENTIAL POLLUTANT LOADS (LUHPPLS)

The proposed project is not considered a land use with Higher Potential Pollutant Loads therefore, Standard #5 is not applicable.

STANDARD #6 – CRITICAL AREAS

The proposed project is not discharging near or to a Critical Area therefore, Standard #6 is not applicable.

STANDARD #7 – REDEVELOPMENT PROJECT

The proposed project is considered a redevelopment project.Standard #8 – Construction Pollution Prevention and Erosion and Sedimentation Control

As the total project area is over one acre, a Notice of Intent (NOI) must be filed with the US EPA and a Stormwater Pollution Prevention Plan (SWPPP) shall be retained on-site during construction.

STANDARD #9 – OPERATION AND MAINTENANCE PLAN

The attached Operation and Maintenance Plan describes the requisite long-term operation and maintenance of all on-site stormwater Best Management Practices (BMPs) and hydraulic drainage system. The Operation and Maintenance Plan also describes source control for the prevention of pollution to also serve as the Long Term Pollution Prevention Plan (LTPPP).

STANDARD #10 – PROHIBITION OF ILLICIT DISCHARGES

There are no known or proposed Illicit Discharges. Any existing Illicit Discharges discovered during construction shall be disconnected and properly rerouted to sanitary sewer or a holding tank prior to the discharge of stormwater to post-construction BMPs.

MASSACHUSETTS STORMWATER REPORT CHECKLIST (follows)

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
MICHAEL J. SCOTT
CIVIL
No. 40963
REGISTERED PROFESSIONAL ENGINEER

5.5.16

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 for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☒ Required Recharge Volume calculation provided.

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

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

☒ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

☒ Site is comprised solely of C and D soils and/or bedrock at the land surface

☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000

☐ Solid Waste Landfill pursuant to 310 CMR 19.000

☒ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.

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

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

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

Checklist (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.

STORMWATER MANAGEMENT SYSTEM OPERATION AND MAINTENANCE PLAN LONG TERM POLLUTION PREVENTION PLAN

Equine Arena
Cummings School of Veterinary Medicine
North Grafton, MA

Revised May 2016

PREPARED FOR:

Tufts University
200 Westborough Drive
North Grafton, Massachusetts

RESPONSIBILITY:

Owner or assigns will be responsible for implementation of the Operation and Maintenance Plan for the stormwater management system and Long Term Pollution Prevention Plan for the Equine Arena and for any corrective action required.

SITE CONDITIONS:

The stormwater management system for the site includes deep sump, hooded catch basins, closed drainage system, and three (3) subsurface stormwater infiltration systems.

DEEP SUMP CATCH BASINS:

1. Catch basins shall be inspected four (4) times per year and cleaned whenever depth of sediment is greater than twenty-four (24) inches.

2. All sediments and hydrocarbons shall be properly handled and disposed in accordance with local, state, and federal guidelines and regulations.

SURFACE INFILTRATION BASIN:

1. The infiltration basin shall be inspected at least twice per year and after the first several rainfall events and after all major storms. Ponded water inside the infiltration basin after several days may indicate the bottom of the system and/or outlet pipes are clogged.

2. Sediment found at the check dam near Route 30 shall be removed periodically and shall not be allowed to exceed six (6) inches depth.

3. Downhill slopes from infiltration areas shall be monitored weekly during construction and monthly thereafter for the first year of operation for signs of breakout. Seepage from basin slopes shall be an indication of a system failure and corrective action shall be taken.

4. Corrective action may consist of cleaning the basin bottom and replacing the naturally fine loamy sand with similar or freer draining soil material. Correct action may also consist of reconstruction of the basin berm.

SPILL CONTAINMENT:

1. In the event of a reportable spill, the Owner or its representative shall be responsible for protecting system inlets in a timely manner and notifying the appropriate authorities of the spill. In the event that spill materials enter the stormwater management system, the Owner shall be responsible for spill removal and restoration of the basin to its original condition in accordance with all applicable local and state regulations.

LAWN/LANDSCAPE MAINTENANCE:

1. Apply pesticides and fertilizers properly; at the proper time of year and at proper application rates to ensure absorption.

2. Limit lawn watering: choose drought-tolerant landscaping and grasses, and use mulch and compost to retain moisture.

3. Under no circumstance shall the stormwater management system be used for yard waste and landscape debris.

DEICING:

1. The use and loading rates for application of deicing salts should be limited to the minimum required to maintain safe vehicular and pedestrian travel.

2. Alternative materials such as sand, calcium chloride, and calcium magnesium acetate should be considered in areas adjacent to stormwater management facilities and resource areas.

3. Deicing materials shall be covered to prevent loss and migration.

SNOW MANAGEMENT:

1. Snow shall be stockpiled in pervious areas where it can slowly infiltrate. Under no circumstance shall the stormwater management system be used for snow storage.

2. Avoid dumping/piling snow over catch basins or in drainage channels to prevent blockages and localized flooding of the drainage system.

3. The Owner shall be responsible to manage snow storage on-site and to ensure that snow is not stockpiled in the basins.

4. Sediments deposited from the snow storage areas shall be removed every spring.

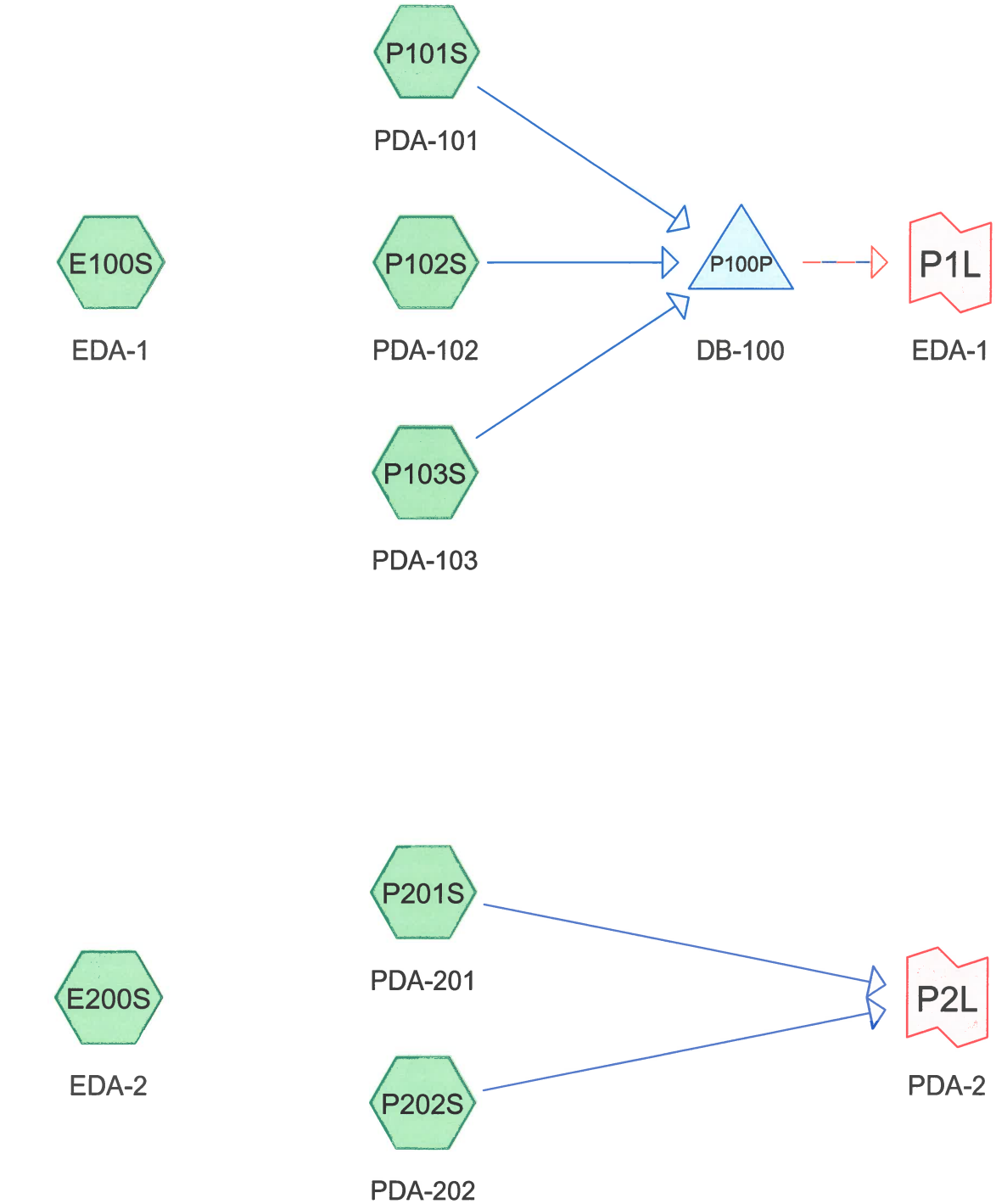
5. Under no circumstances may the infiltration basin be used for snow storage.

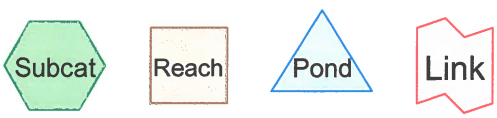
SWEEPING OF PAVED SURFACES:

1. All paved surfaces on-site including driveways, loading areas, and parking areas shall be swept at least once annually to remove accumulations of sand, silt, leaves, and other debris.

2. Sweeping should occur in March/April after snowmelt has occurred and thaw has begun. Sweepings shall be disposed of at an appropriate location away from resource areas (wetlands or waterways) and stormwater management facilities.

EXISTING & PROPOSED HYDROLOGY





Routing Diagram for 1614 Equine Arena May 2016 (Cornell Rainfall)
Prepared by Waterman Design Associates, Inc.
HydroCAD® 10.00-15 s/n 01522 © 2015 HydroCAD Software Solutions LLC

Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 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 E100S: EDA-1 Runoff Area=179,875 sf 44.31% Impervious Runoff Depth=1.68"
Tc=6.0 min CN=84 Runoff=8.0 cfs 0.579 af

Subcatchment E200S: EDA-2 Runoff Area=34,655 sf 14.64% Impervious Runoff Depth=1.27"
Tc=6.0 min CN=78 Runoff=1.1 cfs 0.084 af

Subcatchment P101S: PDA-101 Runoff Area=36,640 sf 19.54% Impervious Runoff Depth=1.27"
Tc=6.0 min CN=78 Runoff=1.2 cfs 0.089 af

Subcatchment P102S: PDA-102 Runoff Area=59,405 sf 48.77% Impervious Runoff Depth=1.84"
Tc=6.0 min CN=86 Runoff=2.9 cfs 0.209 af

Subcatchment P103S: PDA-103 Runoff Area=85,030 sf 65.70% Impervious Runoff Depth=2.17"
Tc=6.0 min CN=90 Runoff=4.8 cfs 0.353 af

Subcatchment P201S: PDA-201 Runoff Area=29,685 sf 8.52% Impervious Runoff Depth=1.27"
Tc=6.0 min CN=78 Runoff=1.0 cfs 0.072 af

Subcatchment P202S: PDA-202 Runoff Area=7,700 sf 100.00% Impervious Runoff Depth=2.97"
Tc=6.0 min CN=98 Runoff=0.5 cfs 0.044 af

Pond P100P: DB-100 Peak Elev=438.76' Storage=2,233 cf Inflow=8.9 cfs 0.651 af
Discarded=0.0 cfs 0.013 af Primary=6.8 cfs 0.638 af Secondary=0.0 cfs 0.000 af Outflow=6.8 cfs 0.651 af

Link P1L: EDA-1 Inflow=6.8 cfs 0.638 af
Primary=6.8 cfs 0.638 af

Link P2L: PDA-2 Inflow=1.5 cfs 0.116 af
Primary=1.5 cfs 0.116 af

Total Runoff Area = 9.940 ac Runoff Volume = 1.430 af Average Runoff Depth = 1.73"
56.81% Pervious = 5.647 ac 43.19% Impervious = 4.293 ac

Summary for Subcatchment E100S: EDA-1

Runoff = 8.0 cfs @ 12.09 hrs, Volume= 0.579 af, Depth= 1.68"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.20"

Area (sf)	CN	Description
90,675	74	>75% Grass cover, Good, HSG C
78,750	98	Paved parking, HSG C
950	98	Roofs, HSG C
9,500	71	Meadow, non-grazed, HSG C
179,875	84	Weighted Average
100,175		55.69% Pervious Area
79,700		44.31% Impervious Area

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

Summary for Subcatchment E200S: EDA-2

Runoff = 1.1 cfs @ 12.10 hrs, Volume= 0.084 af, Depth= 1.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.20"

Area (sf)	CN	Description
29,580	74	>75% Grass cover, Good, HSG C
2,095	98	Paved parking, HSG C
2,980	98	Roofs, HSG C
34,655	78	Weighted Average
29,580		85.36% Pervious Area
5,075		14.64% Impervious Area

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

Summary for Subcatchment P101S: PDA-101

Runoff = 1.2 cfs @ 12.10 hrs, Volume= 0.089 af, Depth= 1.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.20"

Area (sf)	CN	Description
7,160	98	Paved parking, HSG C
19,980	74	>75% Grass cover, Good, HSG C
9,500	71	Meadow, non-grazed, HSG C
36,640	78	Weighted Average
29,480		80.46% Pervious Area
7,160		19.54% Impervious Area

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

Summary for Subcatchment P102S: PDA-102

Runoff = 2.9 cfs @ 12.09 hrs, Volume= 0.209 af, Depth= 1.84"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.20"

Area (sf)	CN	Description
28,020	74	>75% Grass cover, Good, HSG C
2,415	89	Gravel roads, HSG C
27,810	98	Paved parking, HSG C
1,160	98	Roofs, HSG C
59,405	86	Weighted Average
30,435		51.23% Pervious Area
28,970		48.77% Impervious Area

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

Summary for Subcatchment P103S: PDA-103

Runoff = 4.8 cfs @ 12.09 hrs, Volume= 0.353 af, Depth= 2.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.20"

Area (sf)	CN	Description
29,165	74	>75% Grass cover, Good, HSG C
48,305	98	Paved parking, HSG C
7,560	98	Roofs, HSG C
85,030	90	Weighted Average
29,165		34.30% Pervious Area
55,865		65.70% Impervious Area

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

Summary for Subcatchment P201S: PDA-201

Runoff = 1.0 cfs @ 12.10 hrs, Volume= 0.072 af, Depth= 1.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.20"

Area (sf)	CN	Description
23,375	74	>75% Grass cover, Good, HSG C
2,135	98	Paved parking, HSG C
395	98	Roofs, HSG C
3,780	89	Gravel roads, HSG C
29,685	78	Weighted Average
27,155		91.48% Pervious Area
2,530		8.52% Impervious Area

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

Summary for Subcatchment P202S: PDA-202

Runoff = 0.5 cfs @ 12.09 hrs, Volume= 0.044 af, Depth= 2.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 2-year Rainfall=3.20"

Area (sf)	CN	Description
7,700	98	Roofs, HSG C
7,700		100.00% Impervious Area

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

Summary for Pond P100P: DB-100

Inflow Area = 4.157 ac, 50.80% Impervious, Inflow Depth = 1.88" for 2-year event
Inflow = 8.9 cfs @ 12.09 hrs, Volume= 0.651 af
Outflow = 6.8 cfs @ 12.16 hrs, Volume= 0.651 af, Atten= 24%, Lag= 4.4 min
Discarded = 0.0 cfs @ 12.16 hrs, Volume= 0.013 af
Primary = 6.8 cfs @ 12.16 hrs, Volume= 0.638 af
Secondary = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Peak Elev= 438.76' @ 12.16 hrs Surf.Area= 3,880 sf Storage= 2,233 cf

Plug-Flow detention time= 8.4 min calculated for 0.650 af (100% of inflow)
Center-of-Mass det. time= 8.4 min (826.1 - 817.7)

Volume	Invert	Avail.Storage	Storage Description
#1	438.00'	17,970 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
438.00	2,000	0	0
439.00	4,475	3,238	3,238
440.00	7,390	5,933	9,170
441.00	10,210	8,800	17,970

Device	Routing	Invert	Outlet Devices
#1	Discarded	438.00'	**0.170 in/hr Exfiltration over Surface area**
#2	Primary	437.00'	**8.0" Round Culvert X 10.00** L= 72.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 437.00' / 428.00' S= 0.1250 '/' Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 0.35 sf
#3	Device 2	438.00'	**6.0" Vert. Orifice/Grate X 10.00** C= 0.600
#4	Device 2	439.00'	**8.0" Horiz. Orifice/Grate X 10.00** C= 0.600 Limited to weir flow at low heads
#5	Secondary	440.00'	**8.0' long x 15.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=0.0 cfs @ 12.16 hrs HW=438.75' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.0 cfs)

Primary OutFlow Max=6.7 cfs @ 12.16 hrs HW=438.75' (Free Discharge)
└─**2=Culvert** (Passes 6.7 cfs of 20.0 cfs potential flow)
  ├─**3=Orifice/Grate** (Orifice Controls 6.7 cfs @ 3.41 fps)
  └─**4=Orifice/Grate** (Controls 0.0 cfs)

Secondary OutFlow Max=0.0 cfs @ 0.00 hrs HW=438.00' (Free Discharge)
└─**5=Broad-Crested Rectangular Weir** (Controls 0.0 cfs)

Summary for Link P1L: EDA-1

Inflow Area =	4.157 ac,	50.80% Impervious,	Inflow Depth =	1.84"	for 2-year event
Inflow =	6.8 cfs @	12.16 hrs, Volume=	0.638 af		
Primary =	6.8 cfs @	12.16 hrs, Volume=	0.638 af,	Atten= 0%,	Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Summary for Link P2L: PDA-2

Inflow Area =	0.858 ac,	27.36% Impervious,	Inflow Depth =	1.62"	for 2-year event
Inflow =	1.5 cfs @	12.09 hrs, Volume=	0.116 af		
Primary =	1.5 cfs @	12.09 hrs, Volume=	0.116 af,	Atten= 0%,	Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 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 E100S: EDA-1 Runoff Area=179,875 sf 44.31% Impervious Runoff Depth=3.09"
Tc=6.0 min CN=84 Runoff=14.6 cfs 1.063 af

Subcatchment E200S: EDA-2 Runoff Area=34,655 sf 14.64% Impervious Runoff Depth=2.54"
Tc=6.0 min CN=78 Runoff=2.3 cfs 0.169 af

Subcatchment P101S: PDA-101 Runoff Area=36,640 sf 19.54% Impervious Runoff Depth=2.54"
Tc=6.0 min CN=78 Runoff=2.5 cfs 0.178 af

Subcatchment P102S: PDA-102 Runoff Area=59,405 sf 48.77% Impervious Runoff Depth=3.28"
Tc=6.0 min CN=86 Runoff=5.1 cfs 0.373 af

Subcatchment P103S: PDA-103 Runoff Area=85,030 sf 65.70% Impervious Runoff Depth=3.68"
Tc=6.0 min CN=90 Runoff=8.0 cfs 0.599 af

Subcatchment P201S: PDA-201 Runoff Area=29,685 sf 8.52% Impervious Runoff Depth=2.54"
Tc=6.0 min CN=78 Runoff=2.0 cfs 0.144 af

Subcatchment P202S: PDA-202 Runoff Area=7,700 sf 100.00% Impervious Runoff Depth=4.56"
Tc=6.0 min CN=98 Runoff=0.8 cfs 0.067 af

Pond P100P: DB-100 Peak Elev=439.16' Storage=4,010 cf Inflow=15.5 cfs 1.150 af
Discarded=0.0 cfs 0.014 af Primary=13.6 cfs 1.136 af Secondary=0.0 cfs 0.000 af Outflow=13.6 cfs 1.150 af

Link P1L: EDA-1 Inflow=13.6 cfs 1.136 af
Primary=13.6 cfs 1.136 af

Link P2L: PDA-2 Inflow=2.8 cfs 0.212 af
Primary=2.8 cfs 0.212 af

Total Runoff Area = 9.940 ac Runoff Volume = 2.593 af Average Runoff Depth = 3.13"
56.81% Pervious = 5.647 ac 43.19% Impervious = 4.293 ac

Summary for Subcatchment E100S: EDA-1

Runoff = 14.6 cfs @ 12.09 hrs, Volume= 1.063 af, Depth= 3.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=4.80"

Area (sf)	CN	Description
90,675	74	>75% Grass cover, Good, HSG C
78,750	98	Paved parking, HSG C
950	98	Roofs, HSG C
9,500	71	Meadow, non-grazed, HSG C
179,875	84	Weighted Average
100,175		55.69% Pervious Area
79,700		44.31% Impervious Area

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

Summary for Subcatchment E200S: EDA-2

Runoff = 2.3 cfs @ 12.09 hrs, Volume= 0.169 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=4.80"

Area (sf)	CN	Description
29,580	74	>75% Grass cover, Good, HSG C
2,095	98	Paved parking, HSG C
2,980	98	Roofs, HSG C
34,655	78	Weighted Average
29,580		85.36% Pervious Area
5,075		14.64% Impervious Area

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

Summary for Subcatchment P101S: PDA-101

Runoff = 2.5 cfs @ 12.09 hrs, Volume= 0.178 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=4.80"

Area (sf)	CN	Description
7,160	98	Paved parking, HSG C
19,980	74	>75% Grass cover, Good, HSG C
9,500	71	Meadow, non-grazed, HSG C
36,640	78	Weighted Average
29,480		80.46% Pervious Area
7,160		19.54% Impervious Area

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

Summary for Subcatchment P102S: PDA-102

Runoff = 5.1 cfs @ 12.09 hrs, Volume= 0.373 af, Depth= 3.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=4.80"

Area (sf)	CN	Description
28,020	74	>75% Grass cover, Good, HSG C
2,415	89	Gravel roads, HSG C
27,810	98	Paved parking, HSG C
1,160	98	Roofs, HSG C
59,405	86	Weighted Average
30,435		51.23% Pervious Area
28,970		48.77% Impervious Area

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

Summary for Subcatchment P103S: PDA-103

Runoff = 8.0 cfs @ 12.09 hrs, Volume= 0.599 af, Depth= 3.68"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=4.80"

Area (sf)	CN	Description
29,165	74	>75% Grass cover, Good, HSG C
48,305	98	Paved parking, HSG C
7,560	98	Roofs, HSG C
85,030	90	Weighted Average
29,165		34.30% Pervious Area
55,865		65.70% Impervious Area

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

Summary for Subcatchment P201S: PDA-201

Runoff = 2.0 cfs @ 12.09 hrs, Volume= 0.144 af, Depth= 2.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=4.80"

Area (sf)	CN	Description
23,375	74	>75% Grass cover, Good, HSG C
2,135	98	Paved parking, HSG C
395	98	Roofs, HSG C
3,780	89	Gravel roads, HSG C
29,685	78	Weighted Average
27,155		91.48% Pervious Area
2,530		8.52% Impervious Area

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

Summary for Subcatchment P202S: PDA-202

Runoff = 0.8 cfs @ 12.09 hrs, Volume= 0.067 af, Depth= 4.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 10-year Rainfall=4.80"

Area (sf)	CN	Description
7,700	98	Roofs, HSG C
7,700		100.00% Impervious Area

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

Summary for Pond P100P: DB-100

Inflow Area = 4.157 ac, 50.80% Impervious, Inflow Depth = 3.32" for 10-year event
Inflow = 15.5 cfs @ 12.09 hrs, Volume= 1.150 af
Outflow = 13.6 cfs @ 12.15 hrs, Volume= 1.150 af, Atten= 12%, Lag= 3.5 min
Discarded = 0.0 cfs @ 12.15 hrs, Volume= 0.014 af
Primary = 13.6 cfs @ 12.15 hrs, Volume= 1.136 af
Secondary = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Peak Elev= 439.16' @ 12.15 hrs Surf.Area= 4,953 sf Storage= 4,010 cf

Plug-Flow detention time= 7.4 min calculated for 1.150 af (100% of inflow)
Center-of-Mass det. time= 7.4 min (809.8 - 802.3)

Volume	Invert	Avail.Storage	Storage Description
#1	438.00'	17,970 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
438.00	2,000	0	0
439.00	4,475	3,238	3,238
440.00	7,390	5,933	9,170
441.00	10,210	8,800	17,970

Device	Routing	Invert	Outlet Devices
#1	Discarded	438.00'	**0.170 in/hr Exfiltration over Surface area**
#2	Primary	437.00'	**8.0" Round Culvert X 10.00** L= 72.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 437.00' / 428.00' S= 0.1250 '/' Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 0.35 sf
#3	Device 2	438.00'	**6.0" Vert. Orifice/Grate X 10.00** C= 0.600
#4	Device 2	439.00'	**8.0" Horiz. Orifice/Grate X 10.00** C= 0.600 Limited to weir flow at low heads
#5	Secondary	440.00'	**8.0' long x 15.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=0.0 cfs @ 12.15 hrs HW=439.16' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.0 cfs)

Primary OutFlow Max=13.5 cfs @ 12.15 hrs HW=439.16' (Free Discharge)
└─**2=Culvert** (Passes 13.5 cfs of 22.7 cfs potential flow)
  ├─**3=Orifice/Grate** (Orifice Controls 9.0 cfs @ 4.60 fps)
  └─**4=Orifice/Grate** (Weir Controls 4.5 cfs @ 1.32 fps)

Secondary OutFlow Max=0.0 cfs @ 0.00 hrs HW=438.00' (Free Discharge)
└─**5=Broad-Crested Rectangular Weir** (Controls 0.0 cfs)

Summary for Link P1L: EDA-1

Inflow Area =	4.157 ac,	50.80% Impervious,	Inflow Depth =	3.28"	for 10-year event
Inflow =	13.6 cfs @	12.15 hrs, Volume=	1.136 af		
Primary =	13.6 cfs @	12.15 hrs, Volume=	1.136 af,	Atten= 0%,	Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Summary for Link P2L: PDA-2

Inflow Area =	0.858 ac,	27.36% Impervious,	Inflow Depth =	2.96"	for 10-year event
Inflow =	2.8 cfs @	12.09 hrs, Volume=	0.212 af		
Primary =	2.8 cfs @	12.09 hrs, Volume=	0.212 af,	Atten= 0%,	Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 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 E100S: EDA-1 Runoff Area=179,875 sf 44.31% Impervious Runoff Depth=5.14"
Tc=6.0 min CN=84 Runoff=23.8 cfs 1.769 af

Subcatchment E200S: EDA-2 Runoff Area=34,655 sf 14.64% Impervious Runoff Depth=4.47"
Tc=6.0 min CN=78 Runoff=4.1 cfs 0.297 af

Subcatchment P101S: PDA-101 Runoff Area=36,640 sf 19.54% Impervious Runoff Depth=4.47"
Tc=6.0 min CN=78 Runoff=4.3 cfs 0.314 af

Subcatchment P102S: PDA-102 Runoff Area=59,405 sf 48.77% Impervious Runoff Depth=5.37"
Tc=6.0 min CN=86 Runoff=8.1 cfs 0.610 af

Subcatchment P103S: PDA-103 Runoff Area=85,030 sf 65.70% Impervious Runoff Depth=5.82"
Tc=6.0 min CN=90 Runoff=12.3 cfs 0.947 af

Subcatchment P201S: PDA-201 Runoff Area=29,685 sf 8.52% Impervious Runoff Depth=4.47"
Tc=6.0 min CN=78 Runoff=3.5 cfs 0.254 af

Subcatchment P202S: PDA-202 Runoff Area=7,700 sf 100.00% Impervious Runoff Depth=6.76"
Tc=6.0 min CN=98 Runoff=1.2 cfs 0.100 af

Pond P100P: DB-100 Peak Elev=439.43' Storage=5,459 cf Inflow=24.7 cfs 1.871 af
Discarded=0.0 cfs 0.016 af Primary=21.4 cfs 1.854 af Secondary=0.0 cfs 0.000 af Outflow=21.4 cfs 1.871 af

Link P1L: EDA-1 Inflow=21.4 cfs 1.854 af
Primary=21.4 cfs 1.854 af

Link P2L: PDA-2 Inflow=4.7 cfs 0.354 af
Primary=4.7 cfs 0.354 af

Total Runoff Area = 9.940 ac Runoff Volume = 4.290 af Average Runoff Depth = 5.18"
56.81% Pervious = 5.647 ac 43.19% Impervious = 4.293 ac

Summary for Subcatchment E100S: EDA-1

Runoff = 23.8 cfs @ 12.09 hrs, Volume= 1.769 af, Depth= 5.14"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=7.00"

Area (sf)	CN	Description
90,675	74	>75% Grass cover, Good, HSG C
78,750	98	Paved parking, HSG C
950	98	Roofs, HSG C
9,500	71	Meadow, non-grazed, HSG C
179,875	84	Weighted Average
100,175		55.69% Pervious Area
79,700		44.31% Impervious Area

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

Summary for Subcatchment E200S: EDA-2

Runoff = 4.1 cfs @ 12.09 hrs, Volume= 0.297 af, Depth= 4.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=7.00"

Area (sf)	CN	Description
29,580	74	>75% Grass cover, Good, HSG C
2,095	98	Paved parking, HSG C
2,980	98	Roofs, HSG C
34,655	78	Weighted Average
29,580		85.36% Pervious Area
5,075		14.64% Impervious Area

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

Summary for Subcatchment P101S: PDA-101

Runoff = 4.3 cfs @ 12.09 hrs, Volume= 0.314 af, Depth= 4.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=7.00"

Area (sf)	CN	Description
7,160	98	Paved parking, HSG C
19,980	74	>75% Grass cover, Good, HSG C
9,500	71	Meadow, non-grazed, HSG C
36,640	78	Weighted Average
29,480		80.46% Pervious Area
7,160		19.54% Impervious Area

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

Summary for Subcatchment P102S: PDA-102

Runoff = 8.1 cfs @ 12.09 hrs, Volume= 0.610 af, Depth= 5.37"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=7.00"

Area (sf)	CN	Description
28,020	74	>75% Grass cover, Good, HSG C
2,415	89	Gravel roads, HSG C
27,810	98	Paved parking, HSG C
1,160	98	Roofs, HSG C
59,405	86	Weighted Average
30,435		51.23% Pervious Area
28,970		48.77% Impervious Area

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

Summary for Subcatchment P103S: PDA-103

Runoff = 12.3 cfs @ 12.09 hrs, Volume= 0.947 af, Depth= 5.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=7.00"

Area (sf)	CN	Description
29,165	74	>75% Grass cover, Good, HSG C
48,305	98	Paved parking, HSG C
7,560	98	Roofs, HSG C
85,030	90	Weighted Average
29,165		34.30% Pervious Area
55,865		65.70% Impervious Area

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

Summary for Subcatchment P201S: PDA-201

Runoff = 3.5 cfs @ 12.09 hrs, Volume= 0.254 af, Depth= 4.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=7.00"

Area (sf)	CN	Description
23,375	74	>75% Grass cover, Good, HSG C
2,135	98	Paved parking, HSG C
395	98	Roofs, HSG C
3,780	89	Gravel roads, HSG C
29,685	78	Weighted Average
27,155		91.48% Pervious Area
2,530		8.52% Impervious Area

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

Summary for Subcatchment P202S: PDA-202

Runoff = 1.2 cfs @ 12.09 hrs, Volume= 0.100 af, Depth= 6.76"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-year Rainfall=7.00"

Area (sf)	CN	Description
7,700	98	Roofs, HSG C
7,700		100.00% Impervious Area

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

Summary for Pond P100P: DB-100

Inflow Area = 4.157 ac, 50.80% Impervious, Inflow Depth = 5.40" for 100-year event
Inflow = 24.7 cfs @ 12.09 hrs, Volume= 1.871 af
Outflow = 21.4 cfs @ 12.14 hrs, Volume= 1.871 af, Atten= 13%, Lag= 2.8 min
Discarded = 0.0 cfs @ 12.14 hrs, Volume= 0.016 af
Primary = 21.4 cfs @ 12.14 hrs, Volume= 1.854 af
Secondary = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Peak Elev= 439.43' @ 12.14 hrs Surf.Area= 5,743 sf Storage= 5,459 cf

Plug-Flow detention time= 6.6 min calculated for 1.871 af (100% of inflow)
Center-of-Mass det. time= 6.5 min (795.9 - 789.4)

Volume	Invert	Avail.Storage	Storage Description
#1	438.00'	17,970 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
438.00	2,000	0	0
439.00	4,475	3,238	3,238
440.00	7,390	5,933	9,170
441.00	10,210	8,800	17,970

Device	Routing	Invert	Outlet Devices
#1	Discarded	438.00'	**0.170 in/hr Exfiltration over Surface area**
#2	Primary	437.00'	**8.0" Round Culvert X 10.00** L= 72.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 437.00' / 428.00' S= 0.1250 '/' Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 0.35 sf
#3	Device 2	438.00'	**6.0" Vert. Orifice/Grate X 10.00** C= 0.600
#4	Device 2	439.00'	**8.0" Horiz. Orifice/Grate X 10.00** C= 0.600 Limited to weir flow at low heads
#5	Secondary	440.00'	**8.0' long x 15.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=0.0 cfs @ 12.14 hrs HW=439.42' (Free Discharge)
└─1=Exfiltration (Exfiltration Controls 0.0 cfs)

Primary OutFlow Max=21.1 cfs @ 12.14 hrs HW=439.42' (Free Discharge)
└─2=Culvert (Passes 21.1 cfs of 24.3 cfs potential flow)
  ├─3=Orifice/Grate (Orifice Controls 10.2 cfs @ 5.21 fps)
  └─4=Orifice/Grate (Orifice Controls 10.9 cfs @ 3.12 fps)

Secondary OutFlow Max=0.0 cfs @ 0.00 hrs HW=438.00' (Free Discharge)
└─5=Broad-Crested **Rectangular Weir** (Controls 0.0 cfs)

Summary for Link P1L: EDA-1

Inflow Area = 4.157 ac, 50.80% Impervious, Inflow Depth = 5.35" for 100-year event
Inflow = 21.4 cfs @ 12.14 hrs, Volume= 1.854 af
Primary = 21.4 cfs @ 12.14 hrs, Volume= 1.854 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Summary for Link P2L: PDA-2

Inflow Area = 0.858 ac, 27.36% Impervious, Inflow Depth = 4.95" for 100-year event
Inflow = 4.7 cfs @ 12.09 hrs, Volume= 0.354 af
Primary = 4.7 cfs @ 12.09 hrs, Volume= 0.354 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

Time span=0.00-96.00 hrs, dt=0.05 hrs, 1921 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 E100S: EDA-1 Runoff Area=179,875 sf 44.31% Impervious Runoff Depth=6.58"
Tc=6.0 min CN=84 Runoff=30.0 cfs 2.263 af

Subcatchment E200S: EDA-2 Runoff Area=34,655 sf 14.64% Impervious Runoff Depth=5.85"
Tc=6.0 min CN=78 Runoff=5.3 cfs 0.388 af

Subcatchment P101S: PDA-101 Runoff Area=36,640 sf 19.54% Impervious Runoff Depth=5.85"
Tc=6.0 min CN=78 Runoff=5.6 cfs 0.410 af

Subcatchment P102S: PDA-102 Runoff Area=59,405 sf 48.77% Impervious Runoff Depth=6.82"
Tc=6.0 min CN=86 Runoff=10.2 cfs 0.775 af

Subcatchment P103S: PDA-103 Runoff Area=85,030 sf 65.70% Impervious Runoff Depth=7.30"
Tc=6.0 min CN=90 Runoff=15.2 cfs 1.187 af

Subcatchment P201S: PDA-201 Runoff Area=29,685 sf 8.52% Impervious Runoff Depth=5.85"
Tc=6.0 min CN=78 Runoff=4.5 cfs 0.333 af

Subcatchment P202S: PDA-202 Runoff Area=7,700 sf 100.00% Impervious Runoff Depth=8.26"
Tc=6.0 min CN=98 Runoff=1.4 cfs 0.122 af

Pond P100P: DB-100 Peak Elev=439.69' Storage=7,034 cf Inflow=30.9 cfs 2.372 af
Discarded=0.0 cfs 0.017 af Primary=25.3 cfs 2.355 af Secondary=0.0 cfs 0.000 af Outflow=25.4 cfs 2.372 af

Link P1L: EDA-1 Inflow=25.3 cfs 2.355 af
Primary=25.3 cfs 2.355 af

Link P2L: PDA-2 Inflow=6.0 cfs 0.454 af
Primary=6.0 cfs 0.454 af

Total Runoff Area = 9.940 ac Runoff Volume = 5.478 af Average Runoff Depth = 6.61"
56.81% Pervious = 5.647 ac 43.19% Impervious = 4.293 ac

Summary for Subcatchment E100S: EDA-1

Runoff = 30.0 cfs @ 12.09 hrs, Volume= 2.263 af, Depth= 6.58"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year (NRCC Cornell) Rainfall=8.50"

Area (sf)	CN	Description
90,675	74	>75% Grass cover, Good, HSG C
78,750	98	Paved parking, HSG C
950	98	Roofs, HSG C
9,500	71	Meadow, non-grazed, HSG C
179,875	84	Weighted Average
100,175		55.69% Pervious Area
79,700		44.31% Impervious Area

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

Summary for Subcatchment E200S: EDA-2

Runoff = 5.3 cfs @ 12.09 hrs, Volume= 0.388 af, Depth= 5.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year (NRCC Cornell) Rainfall=8.50"

Area (sf)	CN	Description
29,580	74	>75% Grass cover, Good, HSG C
2,095	98	Paved parking, HSG C
2,980	98	Roofs, HSG C
34,655	78	Weighted Average
29,580		85.36% Pervious Area
5,075		14.64% Impervious Area

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

Summary for Subcatchment P101S: PDA-101

Runoff = 5.6 cfs @ 12.09 hrs, Volume= 0.410 af, Depth= 5.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year (NRCC Cornell) Rainfall=8.50"

Area (sf)	CN	Description
7,160	98	Paved parking, HSG C
19,980	74	>75% Grass cover, Good, HSG C
9,500	71	Meadow, non-grazed, HSG C
36,640	78	Weighted Average
29,480		80.46% Pervious Area
7,160		19.54% Impervious Area

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

Summary for Subcatchment P102S: PDA-102

Runoff = 10.2 cfs @ 12.09 hrs, Volume= 0.775 af, Depth= 6.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year (NRCC Cornell) Rainfall=8.50"

Area (sf)	CN	Description
28,020	74	>75% Grass cover, Good, HSG C
2,415	89	Gravel roads, HSG C
27,810	98	Paved parking, HSG C
1,160	98	Roofs, HSG C
59,405	86	Weighted Average
30,435		51.23% Pervious Area
28,970		48.77% Impervious Area

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

Summary for Subcatchment P103S: PDA-103

Runoff = 15.2 cfs @ 12.09 hrs, Volume= 1.187 af, Depth= 7.30"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year (NRCC Cornell) Rainfall=8.50"

Area (sf)	CN	Description
29,165	74	>75% Grass cover, Good, HSG C
48,305	98	Paved parking, HSG C
7,560	98	Roofs, HSG C
85,030	90	Weighted Average
29,165		34.30% Pervious Area
55,865		65.70% Impervious Area

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

Summary for Subcatchment P201S: PDA-201

Runoff = 4.5 cfs @ 12.09 hrs, Volume= 0.333 af, Depth= 5.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year (NRCC Cornell) Rainfall=8.50"

Area (sf)	CN	Description
23,375	74	>75% Grass cover, Good, HSG C
2,135	98	Paved parking, HSG C
395	98	Roofs, HSG C
3,780	89	Gravel roads, HSG C
29,685	78	Weighted Average
27,155		91.48% Pervious Area
2,530		8.52% Impervious Area

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

Summary for Subcatchment P202S: PDA-202

Runoff = 1.4 cfs @ 12.09 hrs, Volume= 0.122 af, Depth= 8.26"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Type III 24-hr 100-Year (NRCC Cornell) Rainfall=8.50"

Area (sf)	CN	Description
7,700	98	Roofs, HSG C
7,700		100.00% Impervious Area

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

Summary for Pond P100P: DB-100

Inflow Area = 4.157 ac, 50.80% Impervious, Inflow Depth = 6.85" for 100-Year (NRCC Cornell) event
Inflow = 30.9 cfs @ 12.09 hrs, Volume= 2.372 af
Outflow = 25.4 cfs @ 12.15 hrs, Volume= 2.372 af, Atten= 18%, Lag= 3.5 min
Discarded = 0.0 cfs @ 12.15 hrs, Volume= 0.017 af
Primary = 25.3 cfs @ 12.15 hrs, Volume= 2.355 af
Secondary = 0.0 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs
Peak Elev= 439.69' @ 12.15 hrs Surf.Area= 6,493 sf Storage= 7,034 cf

Plug-Flow detention time= 6.1 min calculated for 2.371 af (100% of inflow)
Center-of-Mass det. time= 6.1 min (789.4 - 783.3)

Volume	Invert	Avail.Storage	Storage Description
#1	438.00'	17,970 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
438.00	2,000	0	0
439.00	4,475	3,238	3,238
440.00	7,390	5,933	9,170
441.00	10,210	8,800	17,970

Device	Routing	Invert	Outlet Devices
#1	Discarded	438.00'	**0.170 in/hr Exfiltration over Surface area**
#2	Primary	437.00'	**8.0" Round Culvert X 10.00** L= 72.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 437.00' / 428.00' S= 0.1250 '/' Cc= 0.900 n= 0.020 Corrugated PE, corrugated interior, Flow Area= 0.35 sf
#3	Device 2	438.00'	**6.0" Vert. Orifice/Grate X 10.00** C= 0.600
#4	Device 2	439.00'	**8.0" Horiz. Orifice/Grate X 10.00** C= 0.600 Limited to weir flow at low heads
#5	Secondary	440.00'	**8.0' long x 15.0' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 Coef. (English) 2.68 2.70 2.70 2.64 2.63 2.64 2.64 2.63

Discarded OutFlow Max=0.0 cfs @ 12.15 hrs HW=439.69' (Free Discharge)
└─**1=Exfiltration** (Exfiltration Controls 0.0 cfs)

Primary OutFlow Max=25.3 cfs @ 12.15 hrs HW=439.69' (Free Discharge)
└─**2=Culvert** (Passes 25.3 cfs of 25.8 cfs potential flow)
  ├─**3=Orifice/Grate** (Orifice Controls 11.3 cfs @ 5.77 fps)
  └─**4=Orifice/Grate** (Orifice Controls 13.9 cfs @ 3.99 fps)

Secondary OutFlow Max=0.0 cfs @ 0.00 hrs HW=438.00' (Free Discharge)
└─**5=Broad-Crested Rectangular Weir** (Controls 0.0 cfs)

Summary for Link P1L: EDA-1

Inflow Area = 4.157 ac, 50.80% Impervious, Inflow Depth = 6.80" for 100-Year (NRCC Cornell) event
Inflow = 25.3 cfs @ 12.15 hrs, Volume= 2.355 af
Primary = 25.3 cfs @ 12.15 hrs, Volume= 2.355 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

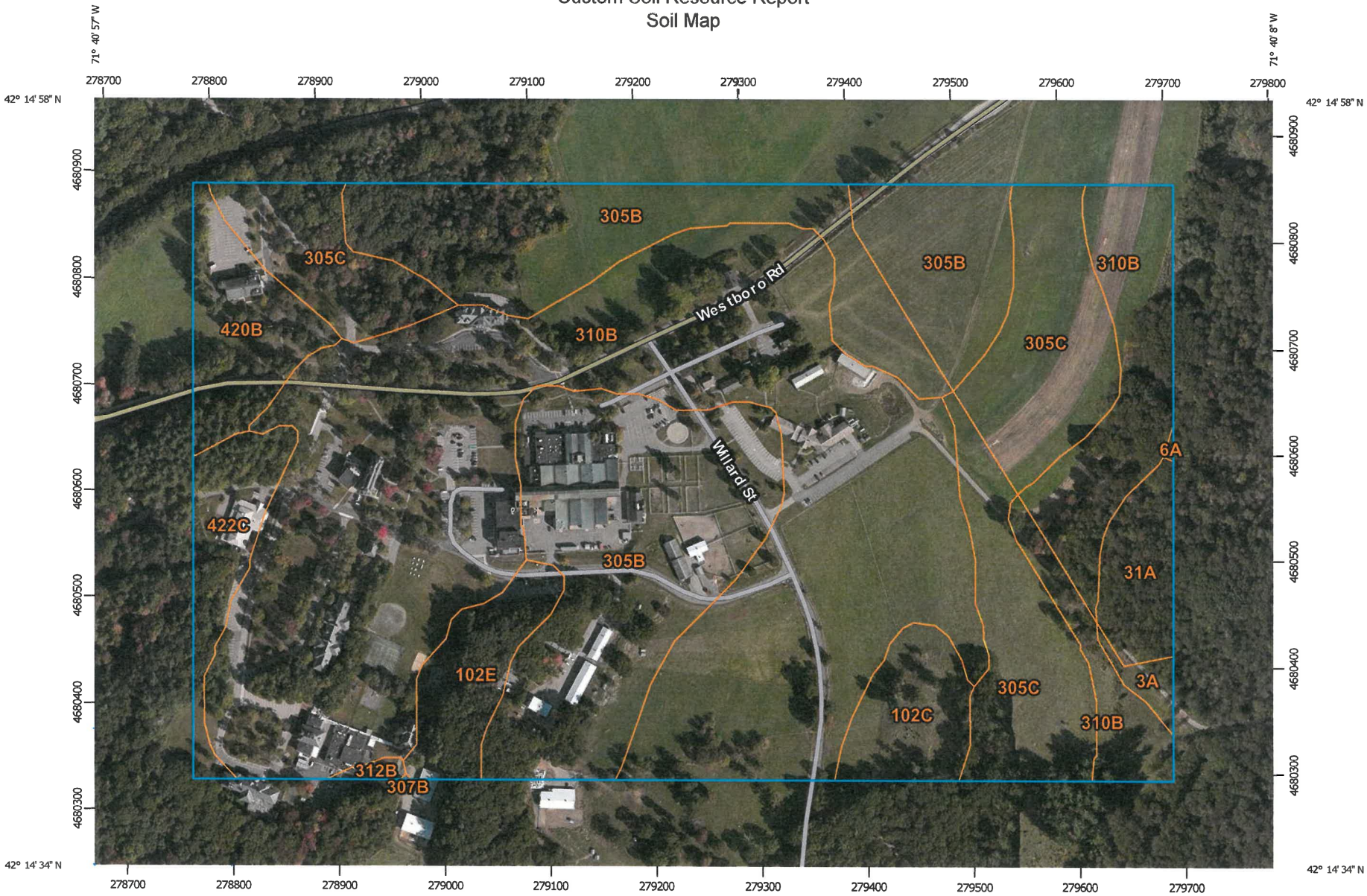
Summary for Link P2L: PDA-2

Inflow Area = 0.858 ac, 27.36% Impervious, Inflow Depth = 6.35" for 100-Year (NRCC Cornell) event
Inflow = 6.0 cfs @ 12.09 hrs, Volume= 0.454 af
Primary = 6.0 cfs @ 12.09 hrs, Volume= 0.454 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-96.00 hrs, dt= 0.05 hrs

APPENDICES

Custom Soil Resource Report
Soil Map



Map Scale: 1:5,090 if printed on A landscape (11" x 8.5") sheet.

N

Meters: 0 50 100 200 300

Feet: 0 200 400 800 1200

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

MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

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

Special Point Features

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

Water Features

- Streams and Canals

Transportation

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

Background

- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at scales ranging from 1:20,000 to 1:25,000.

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

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

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

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

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

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

Soil Survey Area: Worcester County, Massachusetts, Northeastern Part
Survey Area Data: Version 10, Sep 28, 2015

Soil Survey Area: Worcester County, Massachusetts, Southern Part
Survey Area Data: Version 8, Sep 28, 2015

Your area of interest (AOI) includes more than one soil survey area. These survey areas may have been mapped at different scales, with a different land use in mind, at different times, or at different levels of detail. This may result in map unit symbols, soil properties, and interpretations that do not completely agree across soil survey area boundaries.

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

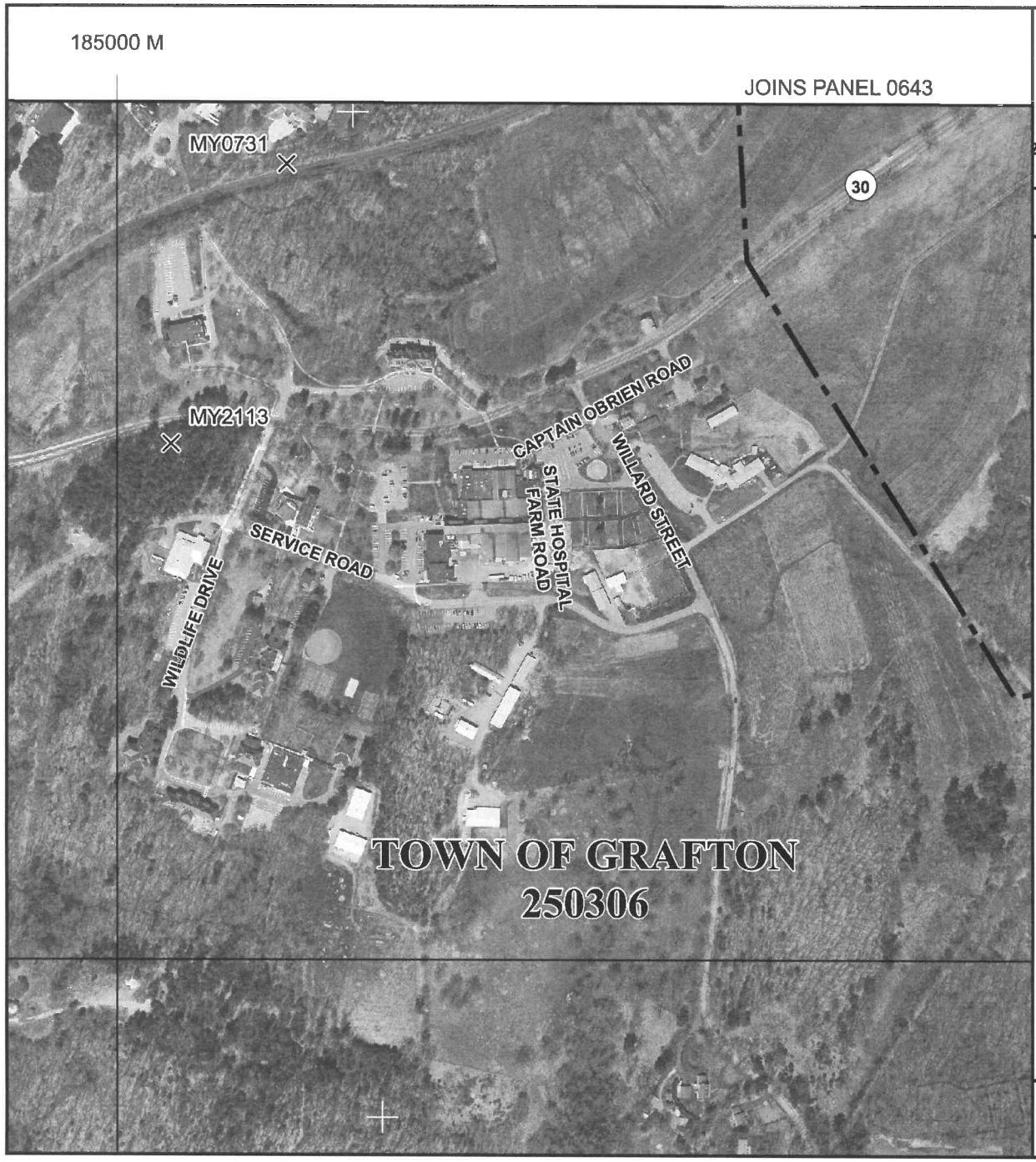
Date(s) aerial images were photographed: Sep 12, 2014—Sep 28, 2014

The orthophoto or other base map on which the soil lines were

Map Unit Legend

Worcester County, Massachusetts, Northeastern Part (MA613)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
6A	Scarboro mucky fine sandy loam, 0 to 3 percent slopes	0.0	0.0%
31A	Walpole sandy loam, 0 to 3 percent slopes	2.7	2.1%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	5.0	3.9%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	6.6	5.1%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	6.6	5.1%
Subtotals for Soil Survey Area		**20.9**	**16.2%**
Totals for Area of Interest		**128.7**	**100.0%**

Worcester County, Massachusetts, Southern Part (MA615)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
3A	Scarboro and Walpole soils, 0 to 3 percent slopes	0.6	0.5%
102C	Chatfield-Hollis-Rock outcrop complex, 3 to 15 percent slopes	3.5	2.7%
102E	Chatfield-Hollis-Rock outcrop complex, 15 to 35 percent slopes	3.6	2.8%
305B	Paxton fine sandy loam, 3 to 8 percent slopes	27.4	21.3%
305C	Paxton fine sandy loam, 8 to 15 percent slopes	10.5	8.2%
307B	Paxton fine sandy loam, 0 to 8 percent slopes, extremely stony	0.0	0.0%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	54.0	41.9%
312B	Woodbridge fine sandy loam, 0 to 8 percent slopes, extremely stony	0.2	0.2%
420B	Canton fine sandy loam, 3 to 8 percent slopes	4.5	3.5%
422C	Canton fine sandy loam, 8 to 15 percent slopes, extremely stony	3.5	2.7%
Subtotals for Soil Survey Area		**107.8**	**83.8%**
Totals for Area of Interest		**128.7**	**100.0%**



MAP SCALE 1" = 500'

250 0 500 1000 FEET

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0831F

FIRM

FLOOD INSURANCE RATE MAP

WORCESTER COUNTY, MASSACHUSETTS (ALL JURISDICTIONS)

PANEL 831 OF 1075

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
GRAFTON, TOWN OF	250306	0831	F
WESTBOROUGH, TOWN OF	250344	0831	F

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

MAP NUMBER 25027C0831F

MAP REVISED JULY 16, 2014

Federal Emergency Management Agency

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

Conduit FlexTable: WDA Report (0016380.stc)

Label	Start Node	Elevation Ground (Start) (ft)	Hydraulic Grade Line (In) (ft)	Invert (Upstream) (ft)	Stop Node	Elevation Ground (Stop) (ft)	Hydraulic Grade Line (Out) (ft)	Invert (Downstream) (ft)	Upstream Inlet Area (ft^2)	Upstream Inlet C	Upstream Intensity (in/h)	System Rational Flow (ft^3/s)	System Fixed Flow (ft^3/s)	Capacity (Full Flow) (ft^3/s)	Velocity (Average) (ft/s)	Diameter (in)	Length (Unified) (ft)	Slope (ft/ft)
D-3	DMH-3	447.80	441.59	439.95	FE-2	440.00	440.70	439.50	(N/A)	(N/A)	6.212	9.68	0.00	7.43	5.48	18.0	90.0	0.005
D-4	DMH-4	452.80	446.45	445.25	DMH-3	447.80	444.13	443.30	(N/A)	(N/A)	6.250	9.74	0.00	16.94	9.92	18.0	75.0	0.026
D-5	DMH-5	452.30	449.30	448.75	DMH-4	452.80	448.41	448.00	(N/A)	(N/A)	6.563	1.69	0.00	4.88	5.64	12.0	40.0	0.019
D-6	CB-6	453.50	449.92	449.50	DMH-5	452.30	449.30	448.75	9,215.000	0.718	6.600	1.01	0.00	6.05	5.71	12.0	26.0	0.029
D-7	DMH-7	455.35	451.97	451.00	DMH-4	452.80	448.88	448.00	(N/A)	(N/A)	6.298	6.91	0.00	6.58	9.49	12.0	88.0	0.034
D-8	DMH-8	457.50	453.78	452.55	DMH-7	455.35	451.97	451.00	(N/A)	(N/A)	6.340	6.00	0.00	5.54	7.64	12.0	64.0	0.024
D-9	DCB-9	455.40	451.94	451.40	DMH-7	455.35	451.97	451.00	8,620.000	0.758	6.600	1.00	0.00	5.04	5.00	12.0	20.0	0.020
D-10	CB-10	460.30	456.69	456.30	DMH-8	457.50	453.77	453.50	8,170.000	0.697	6.600	0.87	0.00	5.61	5.19	12.0	113.0	0.025
D-11	DMH-11	460.20	455.78	453.50	DMH-8	457.50	453.78	452.55	(N/A)	(N/A)	6.410	5.22	0.00	3.60	6.65	12.0	93.0	0.010
D-12	DCB-12	458.40	456.20	454.40	DMH-11	460.20	455.78	453.50	27,750.000	0.588	6.600	2.49	0.00	3.64	3.17	12.0	86.0	0.010
D-13	CB-13	461.95	458.46	457.95	DMH-11	460.20	456.53	456.20	16,420.000	0.588	6.600	1.47	0.00	6.35	6.59	12.0	55.0	0.032
D-14	CB-14	464.15	462.00	461.50	DMH-11	460.20	456.55	456.20	10,880.000	0.849	6.600	1.41	0.00	5.49	5.86	12.0	223.0	0.024
D-15	Ex.CB-1	452.63	448.74	448.26	DMH-4	452.80	448.35	448.00	2,908.000	0.858	6.258	1.28	0.00	5.74	5.88	12.0	10.0	0.026
Ex D-2	Ex CB-2	454.87	451.83	451.43	Ex.CB-1	452.63	448.74	448.26	4,110.000	0.796	6.316	0.93	0.00	7.37	6.41	12.0	74.0	0.043
Ex D-3	Ex CB-3	456.92	453.65	453.37	Ex CB-2	454.87	451.83	451.48	4,110.000	0.746	6.600	0.47	0.00	3.64	3.19	12.0	181.0	0.010
Ex D-4	Ex CB-4	451.59	449.29	448.91	DMH-5	452.30	449.30	448.75	6,460.000	0.695	6.600	0.69	0.00	2.97	3.08	12.0	23.0	0.007

Technical Notes

ADS
ADVANCED DRAINAGE SYSTEMS, INC.

Technical Note 2.105
Re: Outflow From Perforated Pipe
Date: September 1, 1995

Introduction

In order to provide guidance to engineers in designing drainage or recharge systems, ADS conducted a series of exfiltration tests on pipe with standard perforations. It should be emphasized that these values are based on a free outlet (no backfill) through the perforations. Infiltration is assumed to equal the measured exfiltration rates.

Tests were conducted in accordance with AASHTO standard specification M176 for porous concrete pipe. Although intended for use with porous concrete pipe, the test method is applicable to perforated pipes of all types.

Test Procedure

A 2-foot-long section was used for each size tested. The level of water in the pipe was measured by means of a floating staff scale accurate to 1/16th of an inch.

For small diameter pipes, the flow rate was determined by the time to fill a 21.25 liter bucket. For larger sizes, a V-notch weir was used.

Results

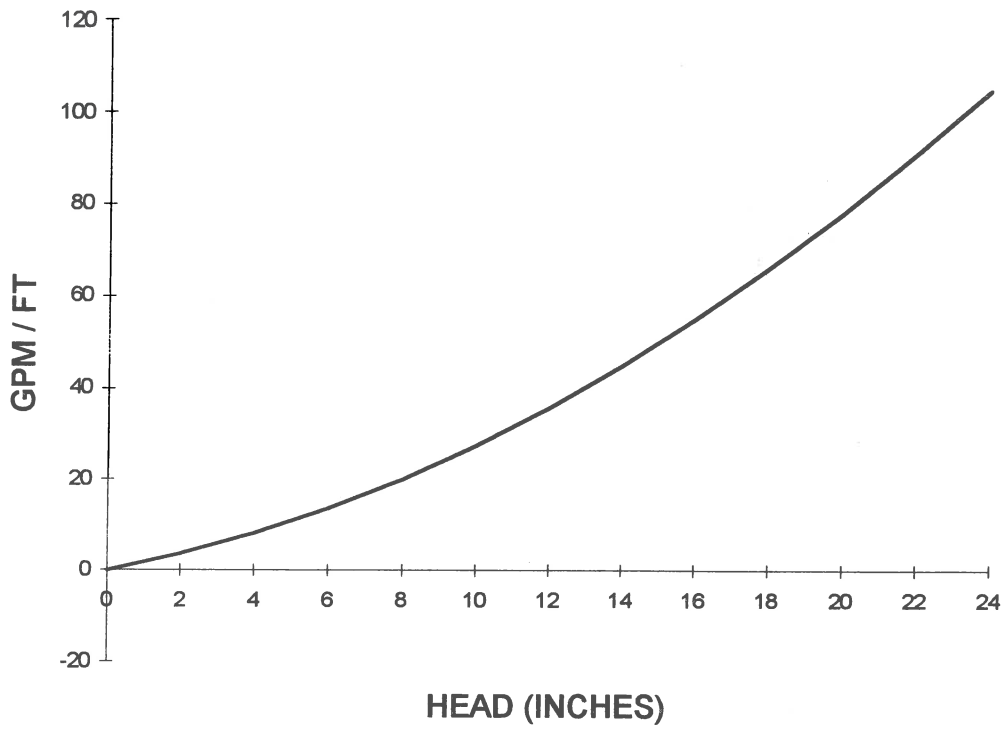
The results of the tests showed a consistency in the manner in which flow rate increased with increasing height of water in the pipe and were in line with the theory of flow through orifices. Variation in the inlet area of the perforations impacted the flow rates in a linear manner with flow increasing uniformly with increased open area for equal head.

A quadratic equation is used to represent the data. The best fit curves by the method of least squares using a logarithmic transformation are shown for each size. The equation constants are included in the graphs and tables.

The equation is: $Q = A_0 + A_1H + A_2H^2$

Where:
Q = Quantity of water in GPM/ft.
H = Head of water above pipe invert in inches
A_0, A_1, & A_2 are equation coefficients

OUTFLOWS - ADS PIPE
12" SINGLE WALL PIPE TYPE C



126' Outlet - 4' (10 TEES) = 86' of 12" Perf. CPE

FACTORS FOR OUTFLOW CALCULATIONS
ADS 12" SINGLE WALL PIPE TYPE C

OPEN AREA	AO	A1	A2	H2	H	Q=GPM/FT
3.3	-0.06239	1.5525	0.11702	0	0	-0.06
3.3	-0.06239	1.5525	0.11702	4	2	3.51
3.3	-0.06239	1.5525	0.11702	16	4	8.02
3.3	-0.06239	1.5525	0.11702	36	6	13.47
3.3	-0.06239	1.5525	0.11702	64	8	19.85
3.3	-0.06239	1.5525	0.11702	100	10	27.16
3.3	-0.06239	1.5525	0.11702	144	12	35.42
3.3	-0.06239	1.5525	0.11702	196	14	44.61
3.3	-0.06239	1.5525	0.11702	256	16	54.73
3.3	-0.06239	1.5525	0.11702	324	18	65.80
3.3	-0.06239	1.5525	0.11702	400	20	77.80
3.3	-0.06239	1.5525	0.11702	484	22	90.73
3.3	-0.06239	1.5525	0.11702	576	24	104.60
					30	151.8 ⇒ 0.34 cfs/ft.

NOTE: Q = AO + (A1*H) + (A2*H2)

86' (0.34) ⇒ 29.24 cfs @ 30" Head

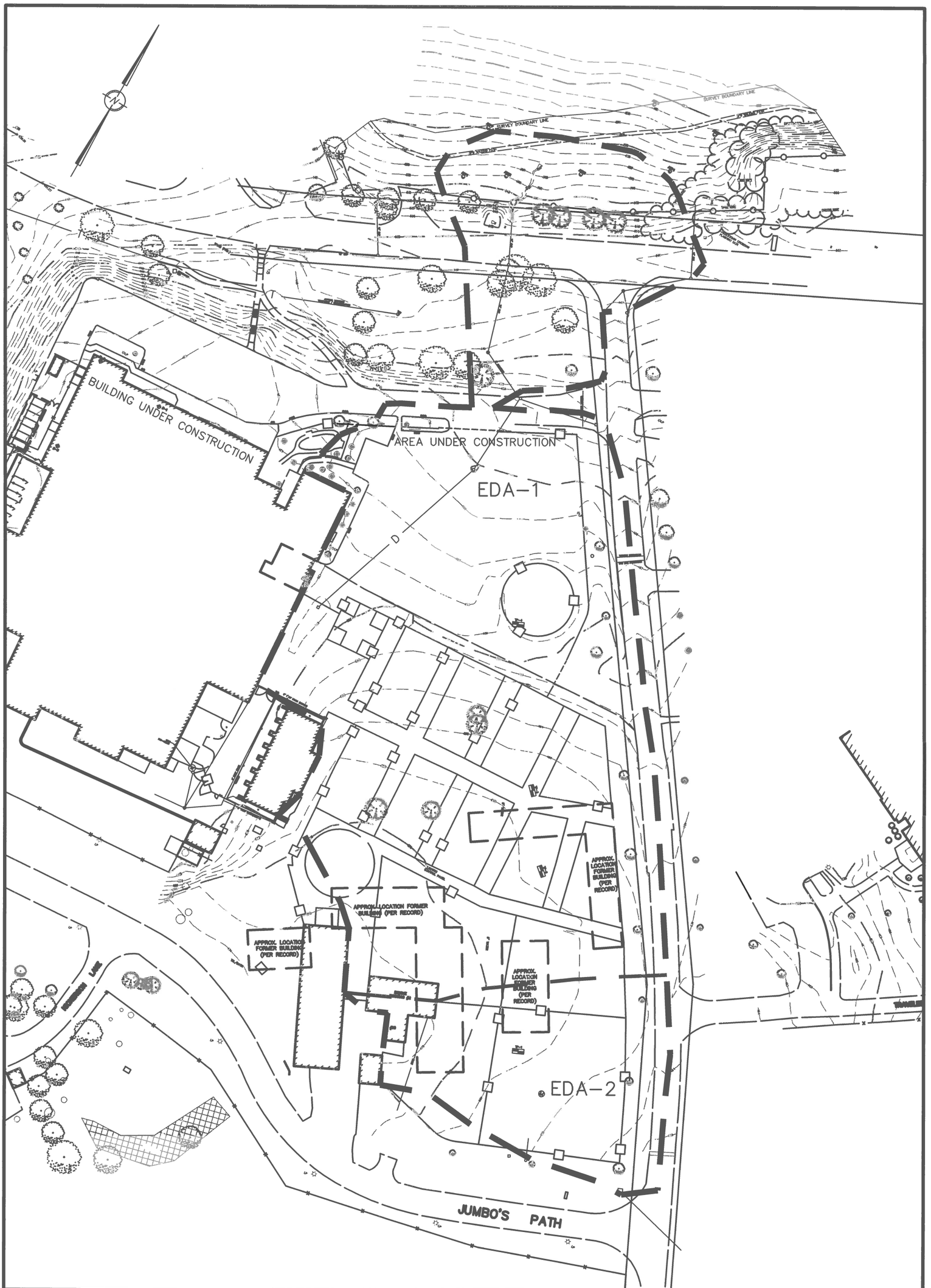
29.24 > 25.34 (Q100 From DB-100)

• Cornell Rainfall

Stage-Area-Storage for Pond P100P: DB-100

Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)	Elevation (feet)	Surface (sq-ft)	Storage (cubic-feet)
438.00	2,000	0	439.30	5,350	4,711	440.60	9,082	14,112
438.02	2,049	40	439.32	5,408	4,819	440.62	9,138	14,294
438.04	2,099	82	439.34	5,466	4,927	440.64	9,195	14,477
438.06	2,149	124	439.36	5,524	5,037	440.66	9,251	14,662
438.08	2,198	168	439.38	5,583	5,148	440.68	9,308	14,847
438.10	2,248	212	439.40	5,641	5,261	440.70	9,364	15,034
438.12	2,297	258	439.42	5,699	5,374	440.72	9,420	15,222
438.14	2,346	304	439.44	5,758	5,489	440.74	9,477	15,411
438.16	2,396	352	439.46	5,816	5,604	440.76	9,533	15,601
438.18	2,446	400	439.48	5,874	5,721	440.78	9,590	15,792
438.20	2,495	449	439.50	5,933	5,839	440.80	9,646	15,984
438.22	2,545	500	439.52	5,991	5,959	440.82	9,702	16,178
438.24	2,594	551	439.54	6,049	6,079	440.84	9,759	16,372
438.26	2,643	604	439.56	6,107	6,201	440.86	9,815	16,568
438.28	2,693	657	439.58	6,166	6,323	440.88	9,872	16,765
438.30	2,743	711	439.60	6,224	6,447	440.90	9,928	16,963
438.32	2,792	767	439.62	6,282	6,572	440.92	9,984	17,162
438.34	2,841	823	439.64	6,341	6,698	440.94	10,041	17,362
438.36	2,891	880	439.66	6,399	6,826	440.96	10,097	17,564
438.38	2,940	939	439.68	6,457	6,954	440.98	10,154	17,766
438.40	2,990	998	439.70	6,515	7,084	441.00	**10,210**	**17,970**
438.42	3,040	1,058	439.72	6,574	7,215			
438.44	3,089	1,120	439.74	6,632	7,347			
438.46	3,138	1,182	439.76	6,690	7,480			
438.48	3,188	1,245	439.78	6,749	7,615			
438.50	3,238	1,309	439.80	6,807	7,750			
438.52	3,287	1,375	439.82	6,865	7,887			
438.54	3,337	1,441	439.84	6,924	8,025			
438.56	3,386	1,508	439.86	6,982	8,164			
438.58	3,435	1,576	439.88	7,040	8,304			
438.60	3,485	1,646	439.90	7,098	8,446			
438.62	3,535	1,716	439.92	7,157	8,588			
438.64	3,584	1,787	439.94	7,215	8,732			
438.66	3,634	1,859	439.96	7,273	8,877			
438.68	3,683	1,932	439.98	7,332	9,023			
438.70	3,732	2,006	440.00	7,390	9,170			
438.72	3,782	2,082	440.02	7,446	9,318			
438.74	3,832	2,158	440.04	7,503	9,468			
438.76	3,881	2,235	440.06	7,559	9,618			
438.78	3,930	2,313	440.08	7,616	9,770			
438.80	3,980	2,392	440.10	7,672	9,923			
438.82	4,029	2,472	440.12	7,728	10,077			
438.84	4,079	2,553	440.14	7,785	10,232			
438.86	4,129	2,635	440.16	7,841	10,388			
438.88	4,178	2,718	440.18	7,898	10,546			
438.90	4,227	2,802	440.20	7,954	10,704			
438.92	4,277	2,887	440.22	8,010	10,864			
438.94	4,326	2,973	440.24	8,067	11,025			
438.96	4,376	3,060	440.26	8,123	11,187			
438.98	4,426	3,148	440.28	8,180	11,350			
439.00	4,475	3,238	440.30	8,236	11,514			
439.02	4,533	3,328	440.32	8,292	11,679			
439.04	4,592	3,419	440.34	8,349	11,846			
439.06	4,650	3,511	440.36	8,405	12,013			
439.08	4,708	3,605	440.38	8,462	12,182			
439.10	4,767	3,700	440.40	8,518	12,352			
439.12	4,825	3,795	440.42	8,574	12,523			
439.14	4,883	3,893	440.44	8,631	12,695			
439.16	4,941	3,991	440.46	8,687	12,868			
439.18	5,000	4,090	440.48	8,744	13,042			
439.20	5,058	4,191	440.50	8,800	13,218			
439.22	5,116	4,293	440.52	8,856	13,394			
439.24	5,175	4,395	440.54	8,913	13,572			
439.26	5,233	4,500	440.56	8,969	13,751			
439.28	5,291	4,605	440.58	9,026	13,931			

2 YEAR PONDING DEPTH FOR DRAWDOWN CALC'S



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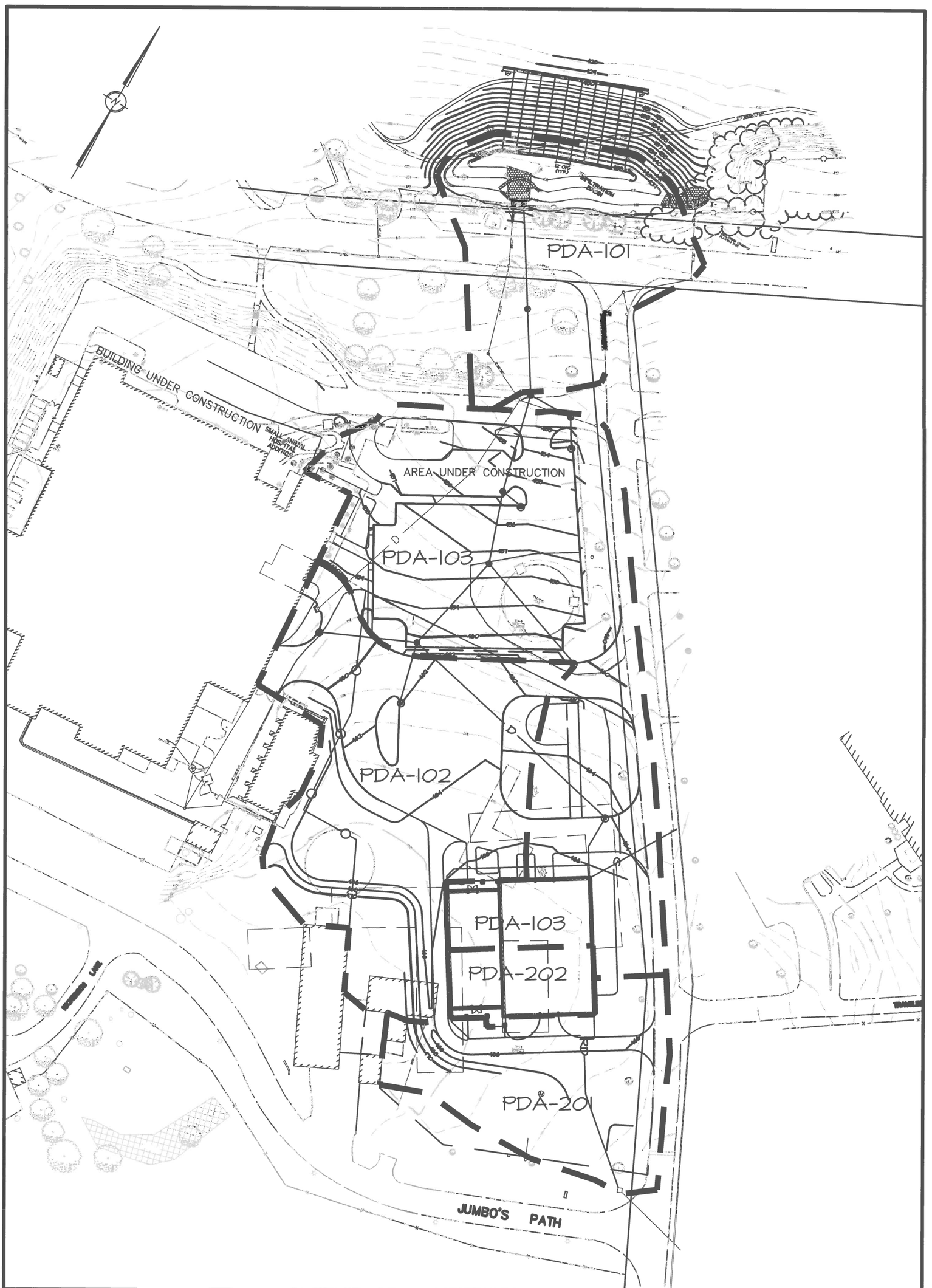
TITLE: EXISTING HYDROLOGY PLAN
Willard Road
North Grafton, MA

PREPARED FOR:
THE CUMMINGS SCHOOL OF VETERINARY MEDICINE AT TUFTS UNIVERSITY
200 Westborough Drive
North Grafton, MA

DATE:	3/30/16	FILE NO.:	0016380	SCALE:	1" = 80'
JOB NO.:	0016.14	DWG NO.:	0016381B	DRAWN BY:	MJS
		REV. NO.:	B	REV. DATE:	



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TITLE: PROPOSED HYDROLOGY PLAN
Willard Road
North Grafton, MA

PREPARED FOR:
THE CUMMINGS SCHOOL OF VETERINARY MEDICINE AT TUFTS UNIVERSITY
200 Westborough Drive
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		REV. NO.:	B	REV. DATE:	5/5/16