STORMWATER MANAGEMENT REPORT

Oak Crest Cove Boat Ramp - Sandwich, MA

November 2023

Cape Cod Boat Ramp Stormwater Retrofit Project

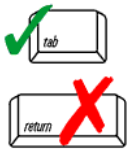
Partner: Association to Preserve Cape Cod
Owner/Operator: Town of Sandwich

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.

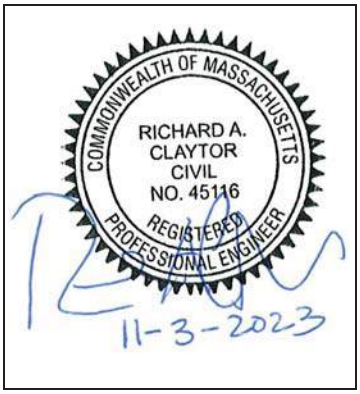
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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



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): Porous Pavement

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 for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

☐ Limited Project

☐ Small Residential Projects: 5-9 single family houses or 5-9 units in a multi-family development provided there is no discharge that may potentially affect a critical area.

☐ Small Residential Projects: 2-4 single family houses or 2-4 units in a multi-family development with a discharge to a critical area

☐ Marina and/or boatyard provided the hull painting, service and maintenance areas are protected from exposure to rain, snow, snow melt and runoff

☐ Bike Path and/or Foot Path

☒ Redevelopment Project

☐ Redevelopment portion of mix of new and redevelopment.

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

Standard 9: Operation and Maintenance Plan

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

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

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

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

Standard 10: Prohibition of Illicit Discharges

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

☐ An Illicit Discharge Compliance Statement is attached;

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

STORMWATER MANAGEMENT REPORT

OAK CREST COVE BOAT RAMP
CAPE COD BOAT RAMP STORMWATER RETROFIT PROJECT
SANDWICH, MA

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EXECUTIVE SUMMARY

The purpose of this report is to describe existing and proposed site drainage conditions at the Oak Crest Cove Boat Ramp, as well as measures to prevent stormwater pollution during and after construction. This project is part of a regional effort led by the Association to Preserve Cape Cod (APCC) to improve water quality at public boat ramps on Cape Cod by implementing green stormwater infrastructure (GSI) retrofits. The main goal for this site is to better manage and treat stormwater runoff that is flowing into Peters Pond via the boat ramp. The project also aims to address erosion problems occurring on the steep slope along the summer camp access road and provide public outreach on the benefits of GSI and overarching watershed issues using interpretive signage.

The project includes the following structural and non-structural stormwater control measures (SCMs):

- Sediment Forebays for Pretreatment
- Bioretention Areas for Treatment
- Surface and Underground Infiltration
- Porous Pavement
- Slope Stabilization
- Public Educational Signage

Since the proposed stormwater management system is a retrofit project undertaken solely to improve water quality at the site, it falls under the redevelopment category in accordance with the Massachusetts Stormwater Management Standards (MASMS 2008), as described in Massachusetts Stormwater Handbook, Volume 1 Chapter 1. As a redevelopment project, the design is required to meet the MASMS standards to the maximum extent practicable (MEP).

As shown in **Table 1,** the proposed project meets or exceeds each standard**,** except the water quality/critical area standards, which are met to the MEP. While each of the proposed treatment SCMs are designed to capture and treat the full one inch of runoff of their contributing drainage areas, a portion of the site's runoff could not be captured due to site constraints. However, through the integration of surface and underground infiltration, the proposed design reduces total peak runoff flow rates and volumes for the 2-, 10-, 25-, and 100-year storms. Overall, this project will significantly improve conditions at the Oak Crest Cove Boat Ramp and reduce on-going impacts to Peter's Pond.

Table 1. Project MASMS Compliance Summary

	Minimum Standard	Type	Compliance	Report Reference(s)
1	**New Stormwater Conveyances**	Narrative	Yes	Section 3.2
2	**Water Quantity**	Calculation	Yes	Section 4.3/Table 7/Appendix B
3	**Recharge**	Calculation	Yes	Section 4.2/Table 6/Appendix B
4	**Water Quality**	Calculation	MEP	Section 4.1/Table 4/Table 5/Appendix B
5	**Land Uses with Higher Potential Pollutant Loading**	Narrative	Not Applicable	Section 2
6	**Critical Areas**	Narrative	MEP	Section 4.1
7	**Redevelopment**	Narrative	Yes	Section 4
8	**Erosion Control**	Narrative	Yes	Section 4.4/Appendix G
9	**Operation and Maintenance**	Narrative	Yes	Section 4.5/Appendix E
10	**Illicit Discharges**	Narrative	Yes	Section 4.6

1. INTRODUCTION

This report provides a summary of the stormwater management systems proposed for the Oak Crest Cove Boat Ramp in Sandwich, MA, a Town owned and operated boat ramp (**Figure 1**). The Sandwich Departments of Recreation, Natural Resources, and Public Works are proposing this project in collaboration with the Association to Preserve Cape Cod (APCC) as a part of a regional effort (Cape Cod Boat Ramp Stormwater Retrofit Project) to improve water quality at public boat ramps across Cape Cod. The proposed project has been designed to retrofit existing impervious areas for water quality improvements while also managing runoff from larger storms and improving overall site conditions. This report describes the existing and proposed site conditions and the practices to be implemented to reduce stormwater discharges and pollutants during and after construction. As required for retrofit projects, the stormwater system for the project has been designed to conform to the requirements of the Massachusetts Stormwater Standards (MASMS) to the maximum extent practicable.

1.1 Background

Freshwater ponds and coastal embayments across Cape Cod are significantly degraded by nutrient and bacteria impairment. Land uses, including stormwater runoff and fertilizer use, contribute on average 20% of the controllable nitrogen load within our coastal watersheds (Cape Cod Commission 208 Plan, 2015) and bacterial contamination, including cyanobacteria, regularly causes closures of beaches. In report (APCC's 2022 State of the Waters), 90% of the coastal embayments and 39% of the freshwater ponds assessed received unacceptable water quality scores. These high nutrient loads are of concern for the environment, our coastal economy, and public health as they negatively impact habitat for fish and shellfish and can result in unsafe conditions for swimming, fishing and boating. Public boat ramps are a common source of pollution in areas of high recreational use. As such, these locations have been targeted by APCC's regional project.

As part of an EPA Southeast New England Program (SNEP) Watershed Grant, APCC and partners first identified 20 public boat ramps across 10 Cape Cod towns in need of improved stormwater management. Concept designs for each of these twenty sites were ranked based on various criteria including potential pollutant removal (i.e., load and drainage area), water quality status of the associated waterbody, construction cost and feasibility, and additional human use and resource benefits (restored shellfish and anadromous fish habitat, proximity to environmental justice communities, improved climate resiliency, opportunity for public education, etc.). With additional funding from a CZM FY23 Coastal Habitat and Water Quality Grant, 25% and 75% designs were developed for seven high-ranking priority sites, including this one at Oak Crest Cove on Peter's Pond. Throughout the project, the team has been working closely with the Friends of Peter's Pond to discuss and review plans for this site.

1.2 Project Goals

The purpose of this project is to improve water quality in Peter's Pond by reducing or eliminating pollutant loads from stormwater runoff at the public boat ramp using green stormwater infrastructure (GSI) stormwater control measures (SCMs). Specifically, the project aims to maximize pollutant removal (% bacteria, nitrogen and phosphorus) and water quality volume treated. Over time, we hope this work

leads to a reduction in the frequency and/or length of beach closures related to bacteria contamination or cyanobacteria blooms; reduction in nutrients and associated impacts; and improvements to freshwater habitat.

1.3 Design Methodology

The design was completed by the following tasks:

- Preliminary field assessment of the site and contributing drainage area to identify usage, physical and environmental constraints and opportunities, and long-term operation and maintenance concerns
- Determination of drainage areas and land coverage within the project area
- Selection of structural and non-structural SCMs best suited to site conditions and project goals
- Structural SCM sizing and performance estimates (described further below)
- Hydrologic/Hydraulic Modeling (described further below)
- Grading and layout of site plan
- Erosion control plan development
- Operation and maintenance (O&M) plan development

SCM Performance Estimates

The proposed SCMs were selected and sized to maximize pollutant load removals. Since there is a nearby public beach and Peter's Pond has water quality impairments, the SCMs were chosen to maximize not only total suspended solids (TSS) removal, but total phosphorus (TP), total nitrogen (TN), and bacteria load reductions as well. MASMS was used as a reference for TSS removal estimates for bioretentions, but the more recently developed pollutant load removal curves (USEPA 2021 & Paradigm Environmental 2019) were used for TP, TN, and bacteria.[1]

Hydrologic/Hydraulic Modeling

Existing and proposed conditions for the project area were modeled using HydroCAD software, which combines USDA Soil Conservation Service hydrology and hydraulic techniques (commonly known as SCS TR-55 and TR-20) to generate hydrographs. Conditions were evaluated for the water quality event (storm that produces 1 inch of runoff, or a roughly 1.2-inch rain event) as well as larger storm events, including the 2-, 10-, 25- and 100-year 24-hour Type III storm events. The rainfall depths used for each storm event are the NOAA+ values (NOAA Atlas 14 90% Upper Confidence value multiplied by 0.9) (NOAA NWS, 2017). Rainfall values are included in **Appendix A**.

2. Existing Conditions

The Oak Crest Cove Boat Ramp is a popular water access point on the north end of Peter's Pond, adjacent to a public beach, and accessed by Quaker Meetinghouse Road. It is located within a mile of a

[1] It is important to note that these curves have a crosswalk to help users determine which specific curve to reference: for infiltrating bioretentions (no liners/underdrains), the appropriate curve is the Surface Infiltration (Soil infiltration rate = 2.41 in/hr) Performance Curve.

mapped income environmental justice population (**Figure 3**). The site's land use is not classified as a land use with higher potential pollutant loads (LUHPPL) and thus, is not subject to MASMS **Standard 5**.

The project site includes a large parking area at the recreation (rec) center, a driveway down to the boat ramp, and a basketball court (**Figure 2**). There is no parking at the boat ramp - cars park at either the rec center or public beach parking lots. Catch basins from the rec center parking lot are directed untreated down the driveway to the boat ramp. Additionally, runoff from the access road to the summer camp area flows down the steep slope behind the basketball court, over the basketball court, and down the boat ramp. This runoff has caused large amounts of erosion on the vegetated slope and sediment build-up on the basketball court.

2.1 Receiving Water and Watershed

Oak Crest Cove Boat Ramp discharges stormwater into Peter's Pond, a groundwater-fed kettle pond with no outlets. Peter's Pond (MA96244) is located in the greater Cape Cod Watershed. The pond provides important freshwater habitat for a variety of fish and invertebrate species and is adjacent to a public beach. However, it is listed as impaired for mercury in fish tissue by the most recent Massachusetts DEP 303(d) – 2022 Integrated list of Waters (Category 4A – TMDL completed) **(Figure 4)**, and APCC's State of the Waters Report lists it as unacceptable for nutrient loading. In addition, the pond has been experiencing cyanobacteria blooms in recent years.

2.2 Drainage Area

The boat ramp's existing contributing drainage area is approximately 9.42 acres. This area is mostly undisturbed forest, with 1.36 acres of impervious cover. The entirety of DA1 directly drains to the boat ramp, modeled as Study Point 1 (SP1). An additional study point, Study Point 2 (SP2) was modeled, which is located at the discharge point in the southeastern corner of the rec center parking lot and flows to the pond at the public beach. The contributing drainage area (DA2) is approximately 0.21 acres, of which most is impervious area (0.19 acres). DA2 consists of roughly half of the rec center parking lot. See the existing conditions drainage area map and a detailed breakdown of land cover in **Appendix A,** as well as the existing HydroCAD model report in **Appendix B.**

2.3 Resource Areas

HW wetland biologists delineated several resource areas at the site in December 2022. A full description of these resource areas is included in **Appendix C**, and their locations and associated buffers are shown on the plans in **Appendix G**. The wetland resource areas include an Isolated Vegetated Wetland (IVW) (locally Freshwater Wetland); Bank (locally Inland Bank); and the 50-Foot Naturally Vegetated Buffer Strip and 100-foot Buffer Zone to IVW/Freshwater Wetland and Bank/Inland Bank. Bank/Inland Bank is present around the perimeter of Peter's Pond. The forested hillside to the north and west of the court area and the slopes adjacent to the driveway leading down to the boat ramp contained a high density of invasive plant species including multiflora rose, Asiatic bittersweet (*Celastrus orbiculatus*), shrub honeysuckle (*Lonicera sp.*), Japanese honeysuckle and border privet (*Ligustrum obtusifolium*). Additionally, the Bank along the pond edge contained significant densities of invasive gray willow.

According to the most recent version of the *Massachusetts Natural Heritage Atlas* (15th Edition, August 1, 2021), there are no areas of *Estimated Habitat of Rare Wildlife and Certified Vernal Pools* and/or *Priority Habitat of Rare Species* located at the site, as designated by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) (**Figure 3**). The area is not located within a FEMA Flood Hazard Zone, as shown in the wetland memo (**Appendix C**). Since the site discharges near a public beach area, it is considered a critical area and subject to MASMS **Standard 6**.

2.4 Soils

Soils data from the Natural Resources Conservation Service (NRCS) indicate that the soils within the drainage areas to the site are composed of Hinckley Loamy Sand, 15-35% slopes and Enfield silt loam, 0-3% slopes. The distribution of hydrologic soil groups (HSGs) of those soils within the contributing drainage areas are outlined in **Table 2** and shown in **Appendix A**.

Table 2. NRCS Soils Data for Drainage Areas

Soil Type	HSG	Acres in Total Drainage Area (% of Total)
Hinckley loamy sand	A	5.94 (62%)
Enfield silt loam	B	3.70 (38%)
	TOTAL	***9.63 (100%)***

Two test pits were conducted at the site on January 24, 2023 to evaluate subsurface conditions and estimated seasonal high groundwater (ESHGW) based on evidence of mottling or redox. The test pits were excavated and witnessed by the Town's DPW staff and logged by HW certified Massachusetts Soil Evaluators. Results are shown in **Table 3**; the first test pit was conducted just off the east edge of the basketball court, and the second was just off the west edge of the upper parking area. The soil at both locations was found to be sandy loam overlaying sand and no groundwater features were observed in either test pit. See **Appendix B** for the test pit soil logs.

Since groundwater indicators were not observed in the test pits, regional groundwater information was reviewed to get a better understanding of estimated groundwater elevations for the stormwater designs. Average regional groundwater contours were developed from a MODFLOW groundwater model for a study conducted by USGS in 2005 titled "Simulated Water Sources and Effects of Pumping on Surface and Ground Water, Sagamore and Monomoy Flow Lenses, Cape Cod, Massachusetts." The model estimates groundwater elevations at the site to be between 65 feet and 64 feet, roughly 5 feet below the bottom of TP-1 (69.3 feet). Based on this model, the test pits, and the elevation of the pond at the time of surveying (<65 feet), the ESHGW was assumed to be at 65 feet for this project design.

Table 3. Test Pit (TP) Results

Test Pit ID	Surface Elevation at TP (ft)	Pit Bottom Elevation (ft)	ESHGW Elevation (ft)	Soil Texture(s)	Design Infiltration Rate (in/hr)	Notes
TP-1	78.8	69.3	65	Sand	8.27	ESHGW assumed based on regional data
TP-2	92.4	83.4	65	Sand	8.27	ESHGW assumed based on regional data

3. Proposed Conditions

The proposed project consists of the following stormwater and related site development improvements:

- Installation of porous pavement for parking lot and basketball court, while meeting required drive aisle and parking space dimensions;
- GSI including bioretention areas and infiltration;
- Slope stabilization on existing eroded steep slope; and
- Protection of as many existing mature trees as possible.

The proposed GSI system is designed to meet the following major objectives:

- Capture, treat, and infiltrate at least the first one inch of runoff;
- Reduce peak flows and runoff volumes from the site by infiltrating the 2-year storm runoff volume; and
- Engage the community with interpretive signage.

3.1 Drainage Areas

The boat ramp (SP1)'s contributing drainage area (DA1) under proposed conditions is very similar to existing, with a total of approximately 9.47 acres. However, the proposed project is reducing impervious cover to SP1 by converting approximately 0.37 acres of traditional pavement to porous pavement, dropping the total impervious cover to approximately 10%. DA1 is subdivided for the proposed conditions in order to model flows to the proposed SCMs. The proposed DA1 drainage areas are DA1A (Summer Camp), DA1B (Woods), and DA1C (Boat Ramp). The proposed SCMs were added as "ponds" in the HydroCAD model. The entirety of DA1 will discharge runoff to Study Point 1 (SP1), similar to in existing conditions.

SP2's contributing drainage area (DA2) under proposed conditions is also very similar to existing conditions. A small portion of the boat ramp driveway has been redirected to continue down the driveway and not flow on to the porous pavement. Impervious area in this drainage area has been eliminated by converting 0.17 acres of traditional pavement to porous pavement.

The proposed porous asphalt on the entire site was modeled with a reduced curve number (CN = 40) per the Rhode Island Stormwater Design and Installation Standards Manual (2015). See the proposed conditions drainage area map and a detailed breakdown of land cover in **Appendix A,** as well as the proposed HydroCAD model report in **Appendix B.**

3.2 Structural Stormwater Control Measures (SCMs)

The proposed stormwater management includes a GSI approach to capture, treat, infiltrate, and detain runoff by using the following SCMs. There are five stormwater GSI practices proposed throughout the site – including a bioretention area, surface infiltration basin, underground infiltration, and two areas of porous pavement. Pretreatment will be provided with sediment forebays, and overflows from extreme events will flow through structures and spillways. The stormwater management systems were designed

to meet **Standard 1**, so that no new untreated stormwater runoff will be directed to any off-site areas or resource areas. Runoff from contributing impervious areas will be treated by the proposed practices.

Sediment Forebays

Porous sediment forebays are provided for pretreatment of the runoff from the paved surfaces to allow for sediment and other debris to settle out prior to conveyance into the bioretention areas.

Bioretention Areas (BIO)

A bioretention area (BIO) is a shallow depression used to treat stormwater runoff using a specific planting soil and plants to filter runoff. The method combines physical filtering and adsorption with bio-geochemical processes to remove pollutants. The system consists of an inflow component, a pretreatment element, a shallow ponding area planted with appropriate native plant species (tolerant to both wet and dry periods as well as other site conditions such as wind, salt, shade, etc.), an overflow structure, and an emergency overflow weir. Some BIOs located in areas with poor drainage or high groundwater are lined and/or have underdrains, while others located in sandy soils greater than 2 feet above ESHGW can just infiltrate the treated runoff.

An infiltrating BIO system is proposed downgradient of the summer camp access drive. This BIO captures, treats, and infiltrates the first inch of runoff from the contributing drainage areas. Additional runoff from larger storm events will be diverted and piped to underground infiltration via the diversion drainage manhole. An emergency overflow weir is also provided to help safely direct flows in extreme events or failure of other infrastructure. The BIO has greater than 2-feet separation to ESHGW as required. The BIO will be planted with low-maintenance, native plants tolerant of the shady site conditions. Appropriate plants from the Cultural List were used as possible.

Surface Infiltration

Infiltration basins are surface stormwater facilities designed to collect and temporarily store runoff before infiltration into the subsoil. Infiltration basins allow stored water to infiltrate and recharge groundwater.

An infiltration basin is proposed on the northern side of the basketball courts to capture the runoff from the wooded area north of the basketball courts. Additionally, the emergency overflow from the BIO is directed to this basin via a spillway. Overflow from the infiltration basin is directed to underground infiltration via an overflow structure.

Underground Infiltration

Underground infiltration is a subsurface stormwater facility that is designed to collect and temporarily store runoff before infiltration into the subsoil to recharge groundwater. For this site, a 48” perforated pipe (surrounded by stone) and recharge basin are designed to provide additional infiltration during large storm events. The 2-year storm event is fully retained and infiltrated in these structures. Once the pipe and recharge basin reach capacity, the flow will overflow out of the recharge basin grate and down to the boat ramp.

Porous Pavement

Porous pavement is designed to capture and infiltrate runoff while providing the stability of traditional pavement. The system consists of a porous layer over a layer of crushed stone. For small storms, the runoff falling directly on the porous pavement will completely infiltrate. For larger, intense storms, rainfall rate can exceed the infiltration rate of the porous pavement surface. Once this occurs, runoff will flow across the surface to the low point/drainage structure. Porous pavement should be placed to minimize "run-on" from adjacent traditional impervious pavement, as this can lead to premature clogging.

Porous pavement is proposed in the rec center parking lot and the basketball court, and the site is designed to prevent "run-on" to these areas. During those larger, intense storm events, runoff from the porous pavement at the rec center parking lot will flow into the existing catch basins in the parking lot, and runoff from the basketball court porous pavement will flow down the boat ramp driveway and into Peter's Pond.

3.3 Non-structural SCMs

The non-structural SCMs proposed at the site include slope stabilization and public educational signage. The eroded gullies on the steep slope around the site are proposed to be regraded and revegetated to provide stabilization. In addition, an interpretive sign is proposed at the rec center parking lot, looking toward the BIO, infiltration basin, and porous basketball courts. This sign will explain the GSI at the site as a part of the larger watershed issues discussed above and encourage GSI actions at home.

4. Stormwater Design Components

The proposed SCMs were designed to meet a variety of goals and regulatory requirements as discussed above. As a retrofit project for managing existing impervious cover, this design must specifically comply with the redevelopment standard (MASMS **Standard 7)** by meeting all standards to the maximum extent practicable. The project fully meets this standard, as described in detail below.

4.1 Water Quality

The main purpose of this retrofit project is to improve water quality. This section describes the treatment volumes and pollutant load reductions achieved by the proposed design and how they compare to the MASMS standards.

Treatment Volume

Per **Standard 4** of MASMS, the stormwater management system for a new development site discharging to a critical area must be sized to treat the first one inch of runoff and remove 80% or more of the annual post-construction load of total suspended solids (TSS). As a retrofit (falls under **Standard 7** - Redevelopment), the project is only required to meet this to the maximum extent practicable. While the proposed bioretention and porous pavement systems are sized to treat the full one-inch water quality volume (WQv) for their contributing drainage areas, the rest of the impervious area in the boat ramp

drainage area could not be captured and treated (DA1C). The proposed HydroCAD model results showing treatment volumes are included in **Appendix B** and summarized below in **Table 4**.

Table 4. Compliance with Water Quality Volume Requirements

DA ID	SCM ID	IA* (ac)	WQv Goal (ac-ft)	WQv Provided (ac-ft)**	% WQv Provided	Meets Requirement?	Notes
DA1A	BIO1	0.55	0.046	0.046	100%	Y	Bioretention treats 1-inch runoff. Roofs in this DA are considered unconnected IA and not included in the WQv Goal.
DA1B	D1	0	0	0	NA	Y	Wooded Area – no impervious
DA1C	PP*	0.72	0.060	0.029	48%	MEP	Treatment provided by porous pavement.
DA2	PP*	0.17	0.014	0.014	100%	Y	Treatment provided by porous pavement.
TOTAL SITE:		**1.43**	**0.120**	**0.089**	**73.8%**	**MEP**	**MEP for Retrofit Projects**

**Impervious Area (IA), Porous Pavement (PP)*
***From HydroCAD results – see Attachment B for volume "discarded" for WQv Event*

Pollutant Load Reductions

The bioretention and porous pavement areas exceed the MASMS requirements for TSS removal and maximize removal of the other pollutants of concern for their contributing drainage area. Estimated TSS, phosphorus (TP), nitrogen (TN), and bacteria removals for the proposed project are provided in **Table 5.** The proposed O&M Guide in **Appendix E** was developed to ensure that the stormwater system continues to function as it was designed into the future to maintain these levels of pollutant removal.

Table 5. Compliance with Water Quality Pollutant Load Reduction Requirements

DA ID	SCM ID	IA* (ac)	WQv Provided (ac-ft)**	Runoff Depth Treated (in)	TSS Removal (%)***	TP Removal (%)****	TN Removal (%)****	Bacteria Removal (%)*****	Meets Reqt?
DA1A	BIO1	0.55	0.046	1.0	90%	98%	100%	100%	Y
DA1B	D1	0	0	0	NA	NA	NA	NA	Y
DA1C	PP*	0.72	0.029	0.5	38%	47%	47%	47%	MEP
DA2	PP*	0.17	0.014	1.0	80%	98%	100%	100%	Y
TOTAL SITE:		**1.43**	**0.089**	**0.7**	**63%**	**73%**	**73%**	**73%**	**MEP**

**Impervious Area (IA), Porous Pavement (PP)*
***From HydroCAD results – see Attachment B for volume "discarded" for WQv Event*
****From MASMS*
*****From MS4 NPDES Permit Appendix F Attachment 3 (USEPA 2021)*
******From Paradigm Environmental (2019)*

In addition, since the site is located in a critical area (near a public beach) and must meet MASMS **Standard 6**, pretreatment practices before infiltration should remove 44% TSS or more. As shown above in **Table 5,** a bioretention with sediment forebay is provided for pretreatment prior to infiltration into the underlying soil, providing 90% TSS removal. Additionally, the upper layers of the porous pavement

act as pretreatment to the lower stone reservoir layer. Sediment will be held in the porous pavement and provide 80% TSS removal. The frequent cleaning and maintenance of the pavement will ensure it does not clog and continues to function properly. The combination of these two SCMs provides more than the required TSS removal by **Standard 6**.

Long-term Pollution Prevention Plan

Source control is important to ensure long-term functionality of the proposed SCMs and protect downstream resources and habitat. A long-term pollution prevention plan specific to this site is provided as a part of the O&M Guide in **Appendix E**.

4.2 Recharge

Infiltrating treated runoff into the underlying native sands is a goal of this project. For new development projects, the MASMS requires a specific annual "recharge" volume (Rev) based on the HSG of the soil covered by new impervious surfaces, with a higher volume required for sandy soils (HSG A) and lower for silty, clayey soils (HSG D). This project is only required to recharge to the maximum extent practicable as a redevelopment project, as there is already pavement at the site.

However, the proposed SCMs provide more than required by **Standard 3**. A portion of stormwater runoff at the site is being directed to the infiltrating bioretention system in comparison to the existing conditions where runoff is mostly directly draining to the pond. Additionally, 23,342sf of pavement is being converted into porous pavement, providing additional recharge. Another requirement of **Standard 3** is that infiltrating SCMs must fully drain in 72 hours. The proposed HydroCAD model results showing full recharge of the first inch of runoff by the bioretention area and the drawdown times (from full basins to empty) are included in **Appendix B** and summarized below in **Table 6**.

Table 6. Compliance with Recharge Requirements

DA ID	SCM ID	IA *(ac)	Soil HSG	Required Recharge Depth (in)	Rev Goal (ac-ft)	Rev Provided (ac-ft)**	% Rev Provided	Draw-down Time (hrs)***	Meets Reqt?	Notes
DA1A	BIO1	0.30	A	0.6	0.015	0.046	207%	12	Y	Bioretention treats 1-inch runoff. Roofs in this DA are considered unconnected IA and not included in the Rev Goal.
		0.25	B	0.35	0.007					
DA1B	D1	0	A	0.6	NA	NA	NA	NA	Y	Wooded Area – no runoff
DA1C	PP*	0.72	A	0.6	0.036	0.029	79%	12	MEP	Recharge provided by porous pavement.
DA2	PP*	0.17	A	0.6	0.008	0.014	167%	12	Y	Recharge provided by porous pavement.
TOTAL SITE:		**1.43**			**0.067**	**0.088**	**133%**		**Y**	**Exceeds Requirement for Site**

**Impervious Area (IA), Porous Pavement (PP)*
***From HydroCAD results – see Attachment B for volume "discarded" for WQv Event*
****From HydroCAD results – see Attachment B for hydrograph showing time from peak elevation to fully drained basins (WQv Event)*

4.3 Water Quantity

The main goal of this project is to improve water quality and habitat, but reducing water quantity impacts during large storm events was also incorporated. As such, the infiltration basin, perforated pipe, recharge basin, and porous pavement all help to reduce peak flows and runoff volumes for the 2-, 10-, 25- and 100-year storms. The existing and proposed HydroCAD model results for these larger storm events are included in **Appendix B,** and the resulting peak flows and runoff volumes are summarized below in **Table 7** for both existing (EX) and proposed (PR) conditions. These results show that the proposed improvements will reduce peak flows and runoff volumes for all evaluated storms, and thus, fully meet the requirements of **Standard 2** of the MASMS.

Table 7. Summary of Existing and Proposed Condition Peak Flow Rates and Runoff Volumes

Study Point		Peak Flow, cfs				Runoff Volume, acre-ft			
		2-yr	10-yr	25-yr	100-yr	2-yr	10-yr	25-yr	100-yr
SP1	EX	0.39	3.18	6.59	13.39	0.128	0.530	0.951	1.773
	PR	0.03	1.90	5.47	11.16	0.019	0.238	0.621	1.439
Reduction	**%**	***92%***	***40%***	***17%***	***17%***	***85%***	***55%***	***35%***	***19%***
SP2	EX	0.65	1.03	1.30	1.73	0.044	0.072	0.092	0.125
	PR	0.00	0.02	0.06	0.23	0.000	0.004	0.010	0.021
Reduction	**%**	***100%***	***98%***	***95%***	***87%***	***100%***	***94%***	***89%***	***83%***

4.4 Erosion Control

Controlling erosion and sedimentation from the construction site is important to meet the overall water quality goals of this retrofit project, as well as to meet MASMS **Standard 8**. Given this site's size (< 1 acre of disturbance), a NPDES Construction General Permit Stormwater Pollution Prevention Plan (SWPPP) is not required. However, planning for effective erosion and sediment controls (ESCs) is important to this project's design, and an ESC Plan is included in the design plans (**Appendix G**), along with a detailed sequence of construction activities and ESC notes. Visibility fence and/or silt socks are proposed at the limit of work to protect off-site areas and trees; and silt socks and silt fences are proposed along the downgradient edges of areas of disturbance. Inlet protection is proposed on all existing and proposed catch basins to prevent sediment from entering the drainage systems. A construction entrance will be installed on the corner of the basketball courts to minimize tracking of sediment. Areas for sediment traps/basins have been identified for when the pavement is removed from the courts and parking lot, exposing a large area of soil. Disturbed areas will be stabilized as soon as possible to minimize erosion and sedimentation with pavement, seeding and/or erosion control blankets, if necessary. A pipe slope drain is proposed during construction to connect the 12" pipe discharging onto the steep slope to a sediment trap located on the edge of the court area. This will prevent runoff from flowing down the steep slope and causing erosion and sediment build up during construction. A Pollutant Controls During Construction guide is also included in **Appendix F** that discusses these controls in more detail. With

these layered ESCs implemented throughout the site, discharge of sediment-laden runoff during construction should be minimized to the maximum extent practicable.

The contractor will be required to establish these erosion controls prior to beginning any other project-related work. The ESC Plan will also establish the limit of work, beyond which the contractor will not be allowed to perform any work. It is the contractor's responsibility to monitor and correct erosion control practices throughout the duration of the project. Erosion control measures will not be removed until the project reaches completion as directed by the project engineer or landscape architect.

4.5 Operation and Maintenance

Ongoing maintenance is vital for long-term success at the site. All SCMs were designed to be low-maintenance in nature. These SCMs will be operated and maintained appropriately during construction and post-construction as required on the construction drawings and O&M Guide per MASMS **Standard 9** (**Appendix E and G**).

4.6 Illicit Discharges

There will be no illicit discharges to the existing system by the proposed project per MASMS **Standard 10**. The Long-Term Pollution Prevention Plan in the O&M Guide (**Appendix E**) includes measures to prevent future illicit discharges.

5. REFERENCES

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FIGURES

Horsley Witten Group
Sustainable Environmental Solutions

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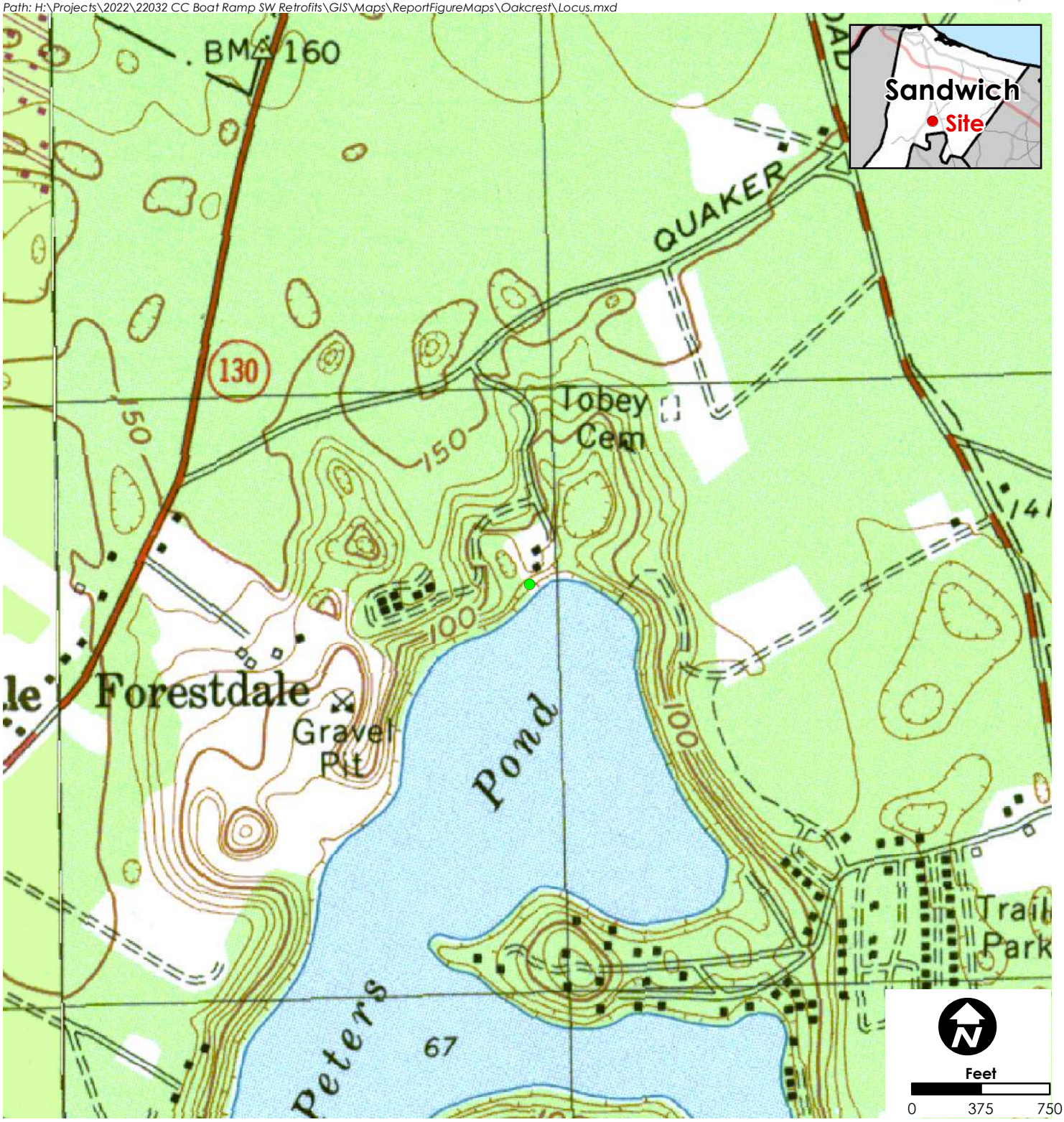

Date: 8/24/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

● Oak Crest Boat Ramp

OAK CREST COVE Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Sandwich, MA

Figure 1
Locus Map

Horsley Witten Group
Sustainable Environmental Solutions

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Date: 8/24/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

Oak Crest Boat Ramp
Town Parcels

OAK CREST COVE Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Sandwich, MA

Figure 2
Aerial

Horsley Witten Group
Sustainable Environmental Solutions

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Date: 8/24/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Oak Crest Boat Ramp
- Town Parcels
- Potential Vernal Pools
- Shoreline
- Wetland Limit
- Wooded marsh
- Open Water

OAK CREST COVE Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Sandwich, MA

Figure 3
Constraints

Horsley Witten Group
Sustainable Environmental Solutions

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Date: 8/24/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Oak Crest Boat Ramp
- Town Parcels

2018/2020 Integrated List Data

- 4A - Impaired - TMDL is completed
- Municipal Boundary

OAK CREST COVE Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Sandwich, MA

Figure 4
Impaired Waters

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Date: 9/27/2023
Data Sources: Bureau of Geographic Information (MassGIS), ESRI, USGS

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Oak Crest Boat Ramp
- Groundwater Contours
- Town Parcels

Hydrologic Soil Group
- <Null>
- A

OAK CREST COVE Boat Ramp
Cape Cod Boat Ramp Stormwater Retrofit Project
Sandwich, MA

Figure 5
Soils

APPENDIX A – Drainage Areas

- Existing and Proposed Drainage Areas Maps
- Land Coverage Summaries

LEGEND

DRAINAGE AREA BOUNDARY

*IMP. AREA** / **TOTAL AREA** (ACRES)

1.00 / 5.00

*UNCONNECTED IMPERVIOUS (IMP.) AREA IS NOT INCLUDED IN TOTAL IMP. AREA

- WOODS
- WATER
- ROOFTOP
- GRASS
- PAVEMENT

DA1 DRAINAGE AREA

SP1 STUDY POINT

P1 POND

SOIL BOUNDARY

TIME OF CONCENTRATION FLOW PATH

2' CONTOUR

SOIL TYPES

242D HINCKLEY LOAMY SAND
15 TO 35 PERCENT SLOPES (HSG A)

265A ENFIELD SILT LOAM
0 TO 3 PERCENT SLOPES (HSG B)

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Date: NOVEMBER 2023
Design By: JLV
Drawn By: JLV
Checked By: MW

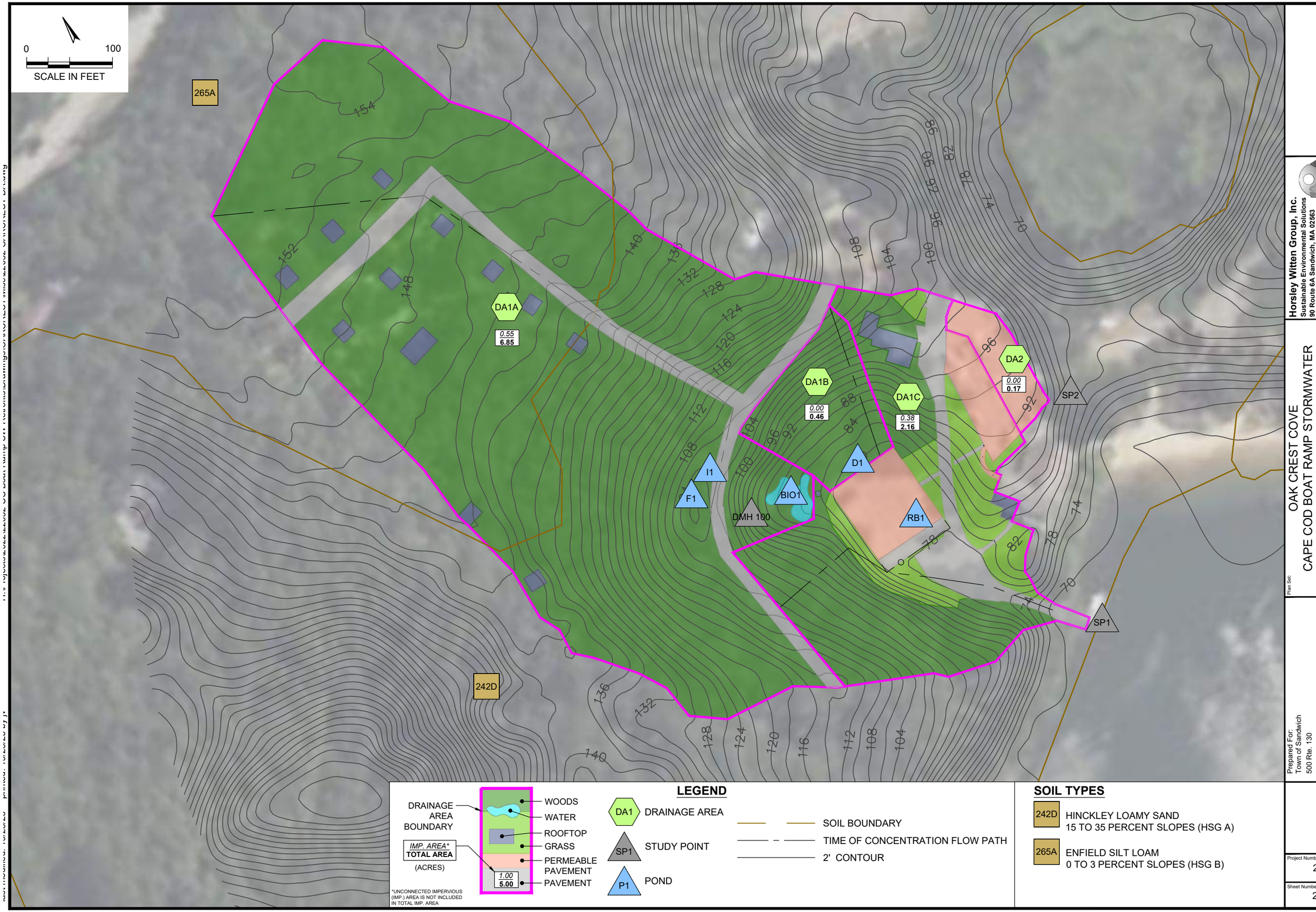
Plan Set:
OAK CREST COVE
CAPE COD BOAT RAMP STORMWATER
RETROFIT PROJECT- PERMITTING PLANS
SANDWICH, MA

Plan Title:
EXISTING DRAINAGE AREA MAP

Prepared For:
Town of Sandwich
500 Rte. 130
Sandwich, MA
Phone: 508-833-8003

Project Number: 22032

Sheet Number: 1 of 2



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Checked By: MW
Drawn By: JLV
Design By: JLV
Date: NOVEMBER 2023

Plan Set:
OAK CREST COVE
CAPE COD BOAT RAMP STORMWATER
RETROFIT PROJECT- PERMITTING PLANS
SANDWICH, MA

Plan Title:
PROPOSED DRAINAGE AREA MAP

Prepared For:
Town of Sandwich
500 Rte. 130
Sandwich, MA
Phone: 508-833-8003

Project Number:
22032

Sheet Number:
2 of 2

CAPE COD BOAT RAMPS- OAKCREST SANDWICH, MA	Calc'd by:	JLV
	Checked by:	MW
Existing Drainage Conditions	Date:	9/20/2023

DRAINAGE AREAS	
DA1	BOAT RAMP
DA2	PARKING LOT- EAST

NOAA 14+ 24-hr Type III (inches)	
WQv	1.21
1-yr	3.09
2-yr	3.65
5-yr	4.58
10-yr	5.36
25-yr	6.62
100-yr	8.62
500-yr	11.43

DA1	BOAT RAMP		
Cover type	Area, ft^2	Area, *ac*	Note
Paved (HSG A)	40,784	0.94	
Paved (HSG B)	10,717	0.25	
Permeable	0	0.00	
Roof (HSG A)	3,286	0.08	
Roof (HSG B)*	4,320	0.10	
Water	0	0.00	
Woods (HSG A)	187,244	4.30	
Woods (HSG B)	146,058	3.35	
Grass (HSG A)	18,062	0.41	
TOTAL	410,471	9.42	

Impervious		
Area, ft^2 *	Area, *ac* *	Percent
54,787	1.26	13

*unconnected impervious area not included in total impervious area (total = 1.36 acres).

DA2	PARKING LOT		
Cover type	Area, ft^2	Area, *ac*	Note
Paved (HSG A)	8,187	0.19	
Permeable	0	0.00	
Roof (HSG A)	0	0.00	
Water	0	0.00	
Woods (HSG A)	985	0.02	
Grass (HSG A)	0	0.00	
TOTAL	9,172	0.21	

Impervious		
Area, ft^2	Area, *ac*	Percent
8,187	0.19	89

ALL	*ALL EXISTING AREAS COMBINED*		
Cover type	Area, ft^2	Area, *ac*	Note
Paved (HSG A)	48,971	1.12	
Paved (HSG B)	10,717	0.25	
Permeable	0	0.00	
Roof (HSG A)	3,286	0.08	
Roof (HSG B)*	4,320	0.10	
Water	0	0.00	
Woods (HSG A)	188,229	4.32	
Woods (HSG B)	146,058	3.35	
Grass (HSG A)	18,062	0.41	
TOTAL	419,643	9.63	

Impervious		
Area, ft^2	Area, *ac*	Percent
62,974	1.45	15

CAPE COD BOAT RAMPS- OAKCREST SANDWICH, MA	Calc'd by:	JV
	Checked by:	MW
Proposed Drainage Conditions	Date:	10/30/2023

DRAINAGE AREAS	
DA1A	**SUMMER CAMP**
DA1B	**WOODS**
DA1C	**BOAT RAMP**
DA2	**PARKING LOT-EAST**

NOAA 14+ 24-hr Type III (inches)	
WQv	1.21
1-yr	3.09
2-yr	3.65
5-yr	4.58
10-yr	5.36
25-yr	6.62
100-yr	8.62
500-yr	11.43

DA1A	**SUMMER CAMP**		
Cover type	Area, ft^2	Area, *ac*	Note
Paved (HSG A)	13,148	0.30	
Paved (HSG B)	10,717	0.25	
Permeable	0	0.00	
Roof (HSG A)*	588	0.01	
Roof (HSG B)*	4,320	0.10	
Water	1,201	0.03	
Woods (HSG A)	122,375	2.81	
Woods (HSG B)	146,058	3.35	
Grass (HSG A)	0	0.00	
TOTAL	298,407	6.85	

Impervious		
Area, ft^2 *	Area, *ac* *	Percent
23,865	0.55	8

*unconnected impervious area not included in total impervious area (total = 0.69 acres).

DA1B	**WOODS**		
Cover type	Area, ft^2	Area, *ac*	Note
Paved (HSG A)	0	0.00	
Permeable	0	0.00	
Roof (HSG A)	0	0.00	
Water	0	0.00	
Woods (HSG A)	19,988	0.46	
Grass (HSG A)	0	0.00	
TOTAL	19,988	0.46	

Impervious		
Area, ft^2	Area, *ac*	Percent
0	0.00	0

DA1C	BOAT RAMP					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved (HSG A)	13,758	0.32				
Permeable	14,907	0.34				
Roof (HSG A)	2,698	0.06				
Water	0	0.00				
Woods (HSG A)	43,640	1.00		**Impervious**		
Grass (HSG A)	19,021	0.44		Area, ft^2	Area, *ac*	Percent
TOTAL	94,024	2.16		16,456	0.38	18

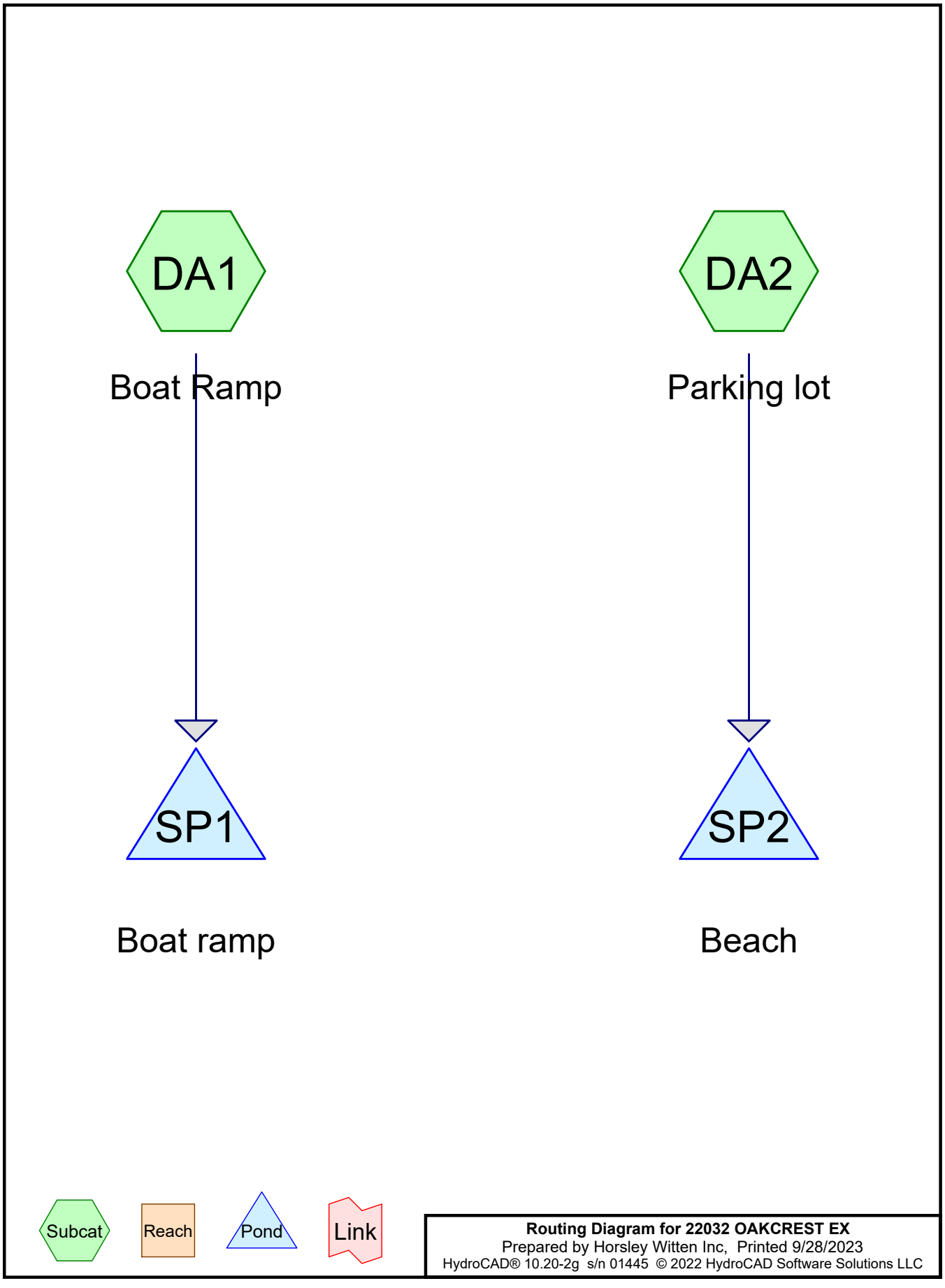
DA2	PARKING LOT-EAST					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved (HSG A)	0	0.00				
Permeable	7,221	0.17				
Roof (HSG A)	0	0.00				
Water	0	0.00				
Woods (HSG A)	0	0.00		**Impervious**		
Grass (HSG A)	0	0.00		Area, ft^2	Area, *ac*	Percent
TOTAL	7,221	0.17		0	0.00	0

ALL	***ALL PROPOSED AREAS COMBINED***					
Cover type	Area, ft^2	Area, *ac*	Note			
Paved (HSG A)	26,906	0.62				
Paved (HSG B)	10,717	0.25				
Permeable	22,128	0.51				
Roof (HSG A)	3,286	0.08				
Roof (HSG B)*	4,320	0.10				
Water	1,201	0.03				
Woods (HSG A)	186,003	4.27				
Woods (HSG B)	146,058	3.35		**Impervious**		
Grass (HSG A)	19,021	0.44		Area, ft^2	Area, *ac*	Percent
TOTAL	419,640	9.63		40,909	0.94	10

APPENDIX B – Hydrologic/Hydraulic Model Results

HydroCAD® Results

- Existing
- Proposed



Routing Diagram for 22032 OAKCREST EX
Prepared by Horsley Witten Inc, Printed 9/28/2023

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	WQV	Type III 24-hr		Default	24.00	1	1.21	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.415	39	>75% Grass cover, Good, HSG A (DA1)
1.124	98	Paved parking, HSG A (DA1, DA2)
0.246	98	Paved parking, HSG B (DA1)
0.075	98	Unconnected roofs, HSG A (DA1)
0.099	98	Unconnected roofs, HSG B (DA1)
4.321	30	Woods, Good, HSG A (DA1, DA2)
3.353	55	Woods, Good, HSG B (DA1)
9.634	**50**	**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
0.415	0.000	0.000	0.000	0.000	0.415	>75% Grass cover, Good	DA1
1.124	0.246	0.000	0.000	0.000	1.370	Paved parking	DA1, DA2
0.075	0.099	0.000	0.000	0.000	0.175	Unconnected roofs	DA1
4.321	3.353	0.000	0.000	0.000	7.674	Woods, Good	DA1, DA2
5.935	**3.698**	**0.000**	**0.000**	**0.000**	**9.634**	**TOTAL AREA**	

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 points
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv. UI as Pervious
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1: Boat Ramp Runoff Area=410,471 sf 12.55% Impervious Runoff Depth>0.12"
Flow Length=1,173' Tc=35.8 min CN=42/98 Runoff=0.69 cfs 0.092 af

Subcatchment DA2: Parking lot Runoff Area=9,172 sf 89.26% Impervious Runoff Depth>0.84"
Tc=5.0 min CN=30/98 Runoff=0.21 cfs 0.015 af

Pond SP1: Boat ramp Inflow=0.69 cfs 0.092 af
Primary=0.69 cfs 0.092 af

Pond SP2: Beach Inflow=0.21 cfs 0.015 af
Primary=0.21 cfs 0.015 af

Total Runoff Area = 9.634 ac Runoff Volume = 0.107 af Average Runoff Depth = 0.13"
85.78% Pervious = 8.263 ac 14.22% Impervious = 1.370 ac

Summary for Subcatchment DA1: Boat Ramp

Runoff = 0.69 cfs @ 12.47 hrs, Volume= 0.092 af, Depth> 0.12"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv. UI as Pervious, Time Span= 5.00-20.00 hrs, dt= 0.05
Type III 24-hr WQV Rainfall=1.21"

Area (sf)	CN	Description
40,784	98	Paved parking, HSG A
10,717	98	Paved parking, HSG B
3,286	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
18,062	39	>75% Grass cover, Good, HSG A
146,058	55	Woods, Good, HSG B
187,244	30	Woods, Good, HSG A
410,471	49	Weighted Average
358,970	42	87.45% Pervious Area
51,501	98	12.55% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
7.7	730	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	343	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
35.8	1,173	Total			

Summary for Subcatchment DA2: Parking lot

[49] Hint: Tc<2dt may require smaller dt

Runoff = 0.21 cfs @ 12.07 hrs, Volume= 0.015 af, Depth> 0.84"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv. UI as Pervious, Time Span= 5.00-20.00 hrs, dt= 0.05
Type III 24-hr WQV Rainfall=1.21"

Area (sf)	CN	Description
8,187	98	Paved parking, HSG A
985	30	Woods, Good, HSG A
9,172	91	Weighted Average
985	30	10.74% Pervious Area
8,187	98	89.26% Impervious Area

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

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.423 ac, 12.55% Impervious, Inflow Depth > 0.12" for WQV event
Inflow = 0.69 cfs @ 12.47 hrs, Volume= 0.092 af
Primary = 0.69 cfs @ 12.47 hrs, Volume= 0.092 af, Atten= 0%, Lag= 0.0 min

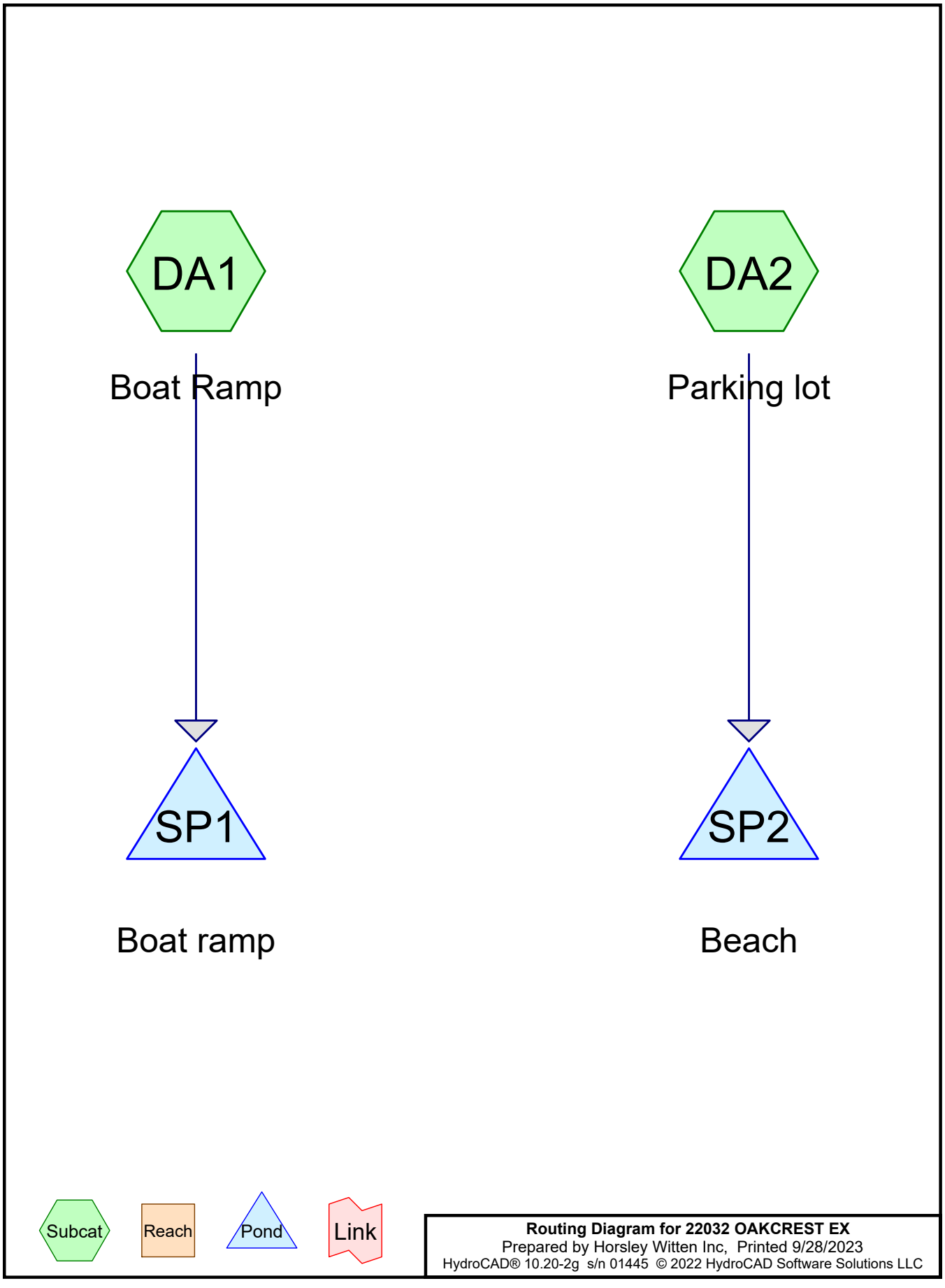
Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.211 ac, 89.26% Impervious, Inflow Depth > 0.84" for WQV event
Inflow = 0.21 cfs @ 12.07 hrs, Volume= 0.015 af
Primary = 0.21 cfs @ 12.07 hrs, Volume= 0.015 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs



Routing Diagram for 22032 OAKCREST EX
Prepared by Horsley Witten Inc, Printed 9/28/2023

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2 yr	Type III 24-hr		Default	24.00	1	3.65	2
2	10 yr	Type III 24-hr		Default	24.00	1	5.36	2
3	25 yr	Type III 24-hr		Default	24.00	1	6.62	2
4	100 yr	Type III 24-hr		Default	24.00	1	8.62	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.415	39	>75% Grass cover, Good, HSG A (DA1)
1.124	98	Paved parking, HSG A (DA1, DA2)
0.246	98	Paved parking, HSG B (DA1)
0.075	98	Unconnected roofs, HSG A (DA1)
0.099	98	Unconnected roofs, HSG B (DA1)
4.321	30	Woods, Good, HSG A (DA1, DA2)
3.353	55	Woods, Good, HSG B (DA1)
9.634	**50**	**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
0.415	0.000	0.000	0.000	0.000	0.415	>75% Grass cover, Good	DA1
1.124	0.246	0.000	0.000	0.000	1.370	Paved parking	DA1, DA2
0.075	0.099	0.000	0.000	0.000	0.175	Unconnected roofs	DA1
4.321	3.353	0.000	0.000	0.000	7.674	Woods, Good	DA1, DA2
5.935	**3.698**	**0.000**	**0.000**	**0.000**	**9.634**	**TOTAL AREA**	

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 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 DA1: Boat Ramp Runoff Area=410,471 sf 14.40% Impervious Runoff Depth>0.16"
Flow Length=1,173' Tc=35.8 min CN=49 Runoff=0.39 cfs 0.128 af

Subcatchment DA2: Parking lot Runoff Area=9,172 sf 89.26% Impervious Runoff Depth>2.53"
Tc=5.0 min CN=91 Runoff=0.65 cfs 0.044 af

Pond SP1: Boat ramp Inflow=0.39 cfs 0.128 af
Primary=0.39 cfs 0.128 af

Pond SP2: Beach Inflow=0.65 cfs 0.044 af
Primary=0.65 cfs 0.044 af

Total Runoff Area = 9.634 ac Runoff Volume = 0.172 af Average Runoff Depth = 0.21"
83.96% Pervious = 8.089 ac 16.04% Impervious = 1.545 ac

Summary for Subcatchment DA1: Boat Ramp

Runoff = 0.39 cfs @ 12.90 hrs, Volume= 0.128 af, Depth> 0.16"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2 yr Rainfall=3.65"

Area (sf)	CN	Description
40,784	98	Paved parking, HSG A
10,717	98	Paved parking, HSG B
3,286	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
18,062	39	>75% Grass cover, Good, HSG A
146,058	55	Woods, Good, HSG B
187,244	30	Woods, Good, HSG A
410,471	49	Weighted Average
351,364	41	85.60% Pervious Area
59,107	98	14.40% Impervious Area
7,606		12.87% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
7.7	730	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	343	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
35.8	1,173	Total			

Summary for Subcatchment DA2: Parking lot

[49] Hint: Tc<2dt may require smaller dt

Runoff = 0.65 cfs @ 12.07 hrs, Volume= 0.044 af, Depth> 2.53"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 2 yr Rainfall=3.65"

Area (sf)	CN	Description
8,187	98	Paved parking, HSG A
985	30	Woods, Good, HSG A
9,172	91	Weighted Average
985	30	10.74% Pervious Area
8,187	98	89.26% Impervious Area

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

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.423 ac, 14.40% Impervious, Inflow Depth > 0.16" for 2 yr event
Inflow = 0.39 cfs @ 12.90 hrs, Volume= 0.128 af
Primary = 0.39 cfs @ 12.90 hrs, Volume= 0.128 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.211 ac, 89.26% Impervious, Inflow Depth > 2.53" for 2 yr event
Inflow = 0.65 cfs @ 12.07 hrs, Volume= 0.044 af
Primary = 0.65 cfs @ 12.07 hrs, Volume= 0.044 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 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 DA1: Boat Ramp Runoff Area=410,471 sf 14.40% Impervious Runoff Depth>0.68"
Flow Length=1,173' Tc=35.8 min CN=49 Runoff=3.18 cfs 0.530 af

Subcatchment DA2: Parking lot Runoff Area=9,172 sf 89.26% Impervious Runoff Depth>4.10"
Tc=5.0 min CN=91 Runoff=1.03 cfs 0.072 af

Pond SP1: Boat ramp Inflow=3.18 cfs 0.530 af
Primary=3.18 cfs 0.530 af

Pond SP2: Beach Inflow=1.03 cfs 0.072 af
Primary=1.03 cfs 0.072 af

Total Runoff Area = 9.634 ac Runoff Volume = 0.602 af Average Runoff Depth = 0.75"
83.96% Pervious = 8.089 ac 16.04% Impervious = 1.545 ac

Summary for Subcatchment DA1: Boat Ramp

Runoff = 3.18 cfs @ 12.64 hrs, Volume= 0.530 af, Depth> 0.68"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 yr Rainfall=5.36"

Area (sf)	CN	Description
40,784	98	Paved parking, HSG A
10,717	98	Paved parking, HSG B
3,286	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
18,062	39	>75% Grass cover, Good, HSG A
146,058	55	Woods, Good, HSG B
187,244	30	Woods, Good, HSG A
410,471	49	Weighted Average
351,364	41	85.60% Pervious Area
59,107	98	14.40% Impervious Area
7,606		12.87% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
7.7	730	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	343	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
35.8	1,173	Total			

Summary for Subcatchment DA2: Parking lot

[49] Hint: Tc<2dt may require smaller dt

Runoff = 1.03 cfs @ 12.07 hrs, Volume= 0.072 af, Depth> 4.10"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 yr Rainfall=5.36"

Area (sf)	CN	Description
8,187	98	Paved parking, HSG A
985	30	Woods, Good, HSG A
9,172	91	Weighted Average
985	30	10.74% Pervious Area
8,187	98	89.26% Impervious Area

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

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.423 ac, 14.40% Impervious, Inflow Depth > 0.68" for 10 yr event
Inflow = 3.18 cfs @ 12.64 hrs, Volume= 0.530 af
Primary = 3.18 cfs @ 12.64 hrs, Volume= 0.530 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.211 ac, 89.26% Impervious, Inflow Depth > 4.10" for 10 yr event
Inflow = 1.03 cfs @ 12.07 hrs, Volume= 0.072 af
Primary = 1.03 cfs @ 12.07 hrs, Volume= 0.072 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 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 DA1: Boat Ramp Runoff Area=410,471 sf 14.40% Impervious Runoff Depth>1.21"
Flow Length=1,173' Tc=35.8 min CN=49 Runoff=6.59 cfs 0.951 af

Subcatchment DA2: Parking lot Runoff Area=9,172 sf 89.26% Impervious Runoff Depth>5.26"
Tc=5.0 min CN=91 Runoff=1.30 cfs 0.092 af

Pond SP1: Boat ramp Inflow=6.59 cfs 0.951 af
Primary=6.59 cfs 0.951 af

Pond SP2: Beach Inflow=1.30 cfs 0.092 af
Primary=1.30 cfs 0.092 af

Total Runoff Area = 9.634 ac Runoff Volume = 1.043 af Average Runoff Depth = 1.30"
83.96% Pervious = 8.089 ac 16.04% Impervious = 1.545 ac

Summary for Subcatchment DA1: Boat Ramp

Runoff = 6.59 cfs @ 12.59 hrs, Volume= 0.951 af, Depth> 1.21"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 yr Rainfall=6.62"

Area (sf)	CN	Description
40,784	98	Paved parking, HSG A
10,717	98	Paved parking, HSG B
3,286	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
18,062	39	>75% Grass cover, Good, HSG A
146,058	55	Woods, Good, HSG B
187,244	30	Woods, Good, HSG A
410,471	49	Weighted Average
351,364	41	85.60% Pervious Area
59,107	98	14.40% Impervious Area
7,606		12.87% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
7.7	730	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	343	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
35.8	1,173	Total			

Summary for Subcatchment DA2: Parking lot

[49] Hint: Tc<2dt may require smaller dt

Runoff = 1.30 cfs @ 12.07 hrs, Volume= 0.092 af, Depth> 5.26"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 yr Rainfall=6.62"

Area (sf)	CN	Description
8,187	98	Paved parking, HSG A
985	30	Woods, Good, HSG A
9,172	91	Weighted Average
985	30	10.74% Pervious Area
8,187	98	89.26% Impervious Area

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

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.423 ac, 14.40% Impervious, Inflow Depth > 1.21" for 25 yr event
Inflow = 6.59 cfs @ 12.59 hrs, Volume= 0.951 af
Primary = 6.59 cfs @ 12.59 hrs, Volume= 0.951 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.211 ac, 89.26% Impervious, Inflow Depth > 5.26" for 25 yr event
Inflow = 1.30 cfs @ 12.07 hrs, Volume= 0.092 af
Primary = 1.30 cfs @ 12.07 hrs, Volume= 0.092 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Time span=5.00-20.00 hrs, dt=0.05 hrs, 301 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 DA1: Boat Ramp Runoff Area=410,471 sf 14.40% Impervious Runoff Depth>2.26"
Flow Length=1,173' Tc=35.8 min CN=49 Runoff=13.39 cfs 1.773 af

Subcatchment DA2: Parking lot Runoff Area=9,172 sf 89.26% Impervious Runoff Depth>7.10"
Tc=5.0 min CN=91 Runoff=1.73 cfs 0.125 af

Pond SP1: Boat ramp Inflow=13.39 cfs 1.773 af
Primary=13.39 cfs 1.773 af

Pond SP2: Beach Inflow=1.73 cfs 0.125 af
Primary=1.73 cfs 0.125 af

Total Runoff Area = 9.634 ac Runoff Volume = 1.898 af Average Runoff Depth = 2.36"
83.96% Pervious = 8.089 ac 16.04% Impervious = 1.545 ac

Summary for Subcatchment DA1: Boat Ramp

Runoff = 13.39 cfs @ 12.55 hrs, Volume= 1.773 af, Depth> 2.26"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 yr Rainfall=8.62"

Area (sf)	CN	Description
40,784	98	Paved parking, HSG A
10,717	98	Paved parking, HSG B
3,286	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
18,062	39	>75% Grass cover, Good, HSG A
146,058	55	Woods, Good, HSG B
187,244	30	Woods, Good, HSG A
410,471	49	Weighted Average
351,364	41	85.60% Pervious Area
59,107	98	14.40% Impervious Area
7,606		12.87% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
7.7	730	0.1000	1.58		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	343	0.0300	3.52		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
35.8	1,173	Total			

Summary for Subcatchment DA2: Parking lot

[49] Hint: Tc<2dt may require smaller dt

Runoff = 1.73 cfs @ 12.07 hrs, Volume= 0.125 af, Depth> 7.10"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 yr Rainfall=8.62"

Area (sf)	CN	Description
8,187	98	Paved parking, HSG A
985	30	Woods, Good, HSG A
9,172	91	Weighted Average
985	30	10.74% Pervious Area
8,187	98	89.26% Impervious Area

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

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.423 ac, 14.40% Impervious, Inflow Depth > 2.26" for 100 yr event
Inflow = 13.39 cfs @ 12.55 hrs, Volume= 1.773 af
Primary = 13.39 cfs @ 12.55 hrs, Volume= 1.773 af, Atten= 0%, Lag= 0.0 min

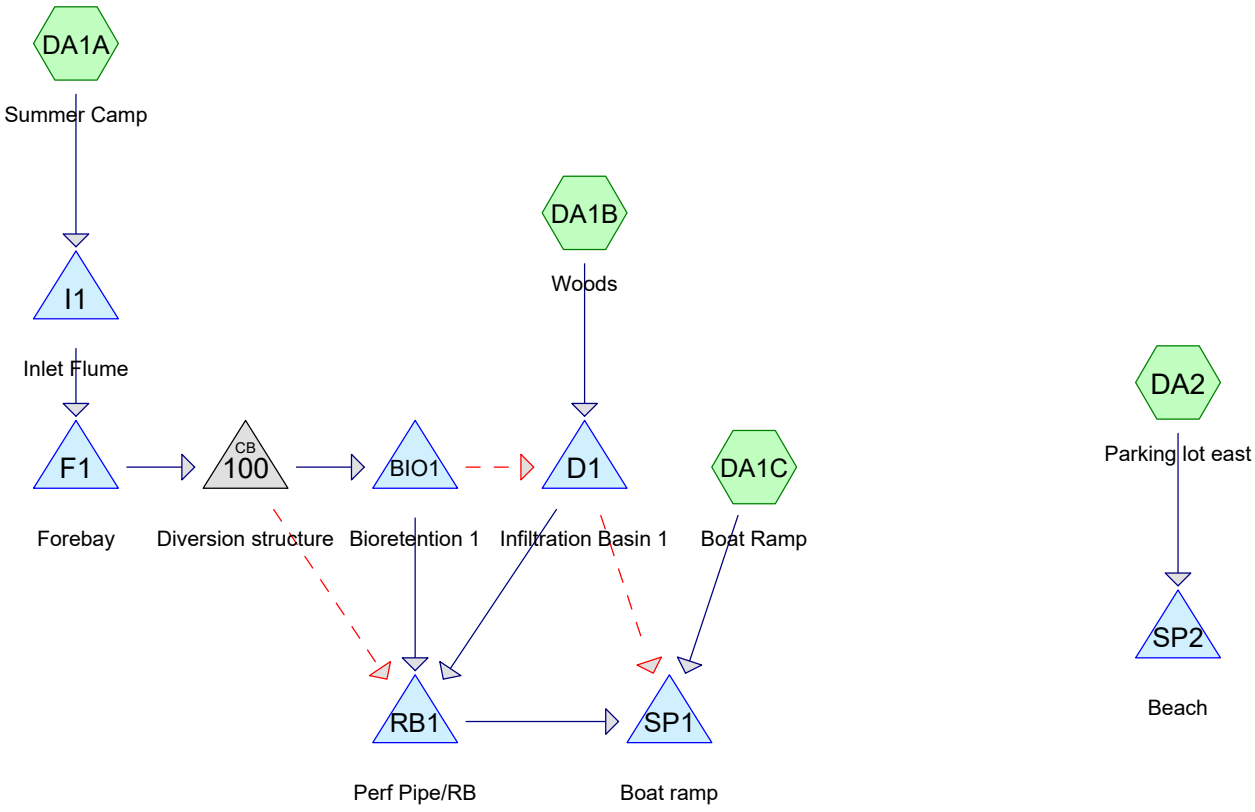
Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.211 ac, 89.26% Impervious, Inflow Depth > 7.10" for 100 yr event
Inflow = 1.73 cfs @ 12.07 hrs, Volume= 0.125 af
Primary = 1.73 cfs @ 12.07 hrs, Volume= 0.125 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 5.00-20.00 hrs, dt= 0.05 hrs



Subcat Reach Pond Link

Routing Diagram for 22032 OAKCREST PR
Prepared by Horsley Witten Inc, Printed 10/30/2023

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	WQV	Type III 24-hr		Default	24.00	1	1.21	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.437	39	>75% Grass cover, Good, HSG A (DA1C)
0.618	98	Paved parking, HSG A (DA1A, DA1C)
0.246	98	Paved parking, HSG B (DA1A)
0.342	40	Permeable pavers (DA1C)
0.166	40	Permeable pavers, HSG A (DA2)
0.062	98	Roofs, HSG A (DA1C)
0.013	98	Unconnected roofs, HSG A (DA1A)
0.099	98	Unconnected roofs, HSG B (DA1A)
0.028	98	Water Surface, HSG A (DA1A)
4.270	30	Woods, Good, HSG A (DA1A, DA1B, DA1C)
3.353	55	Woods, Good, HSG B (DA1A)
9.634	**47**	**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
0.437	0.000	0.000	0.000	0.000	0.437	>75% Grass cover, Good	DA1C
0.618	0.246	0.000	0.000	0.000	0.864	Paved parking	DA1A, DA1C
0.166	0.000	0.000	0.000	0.342	0.508	Permeable pavers	DA1C, DA2
0.062	0.000	0.000	0.000	0.000	0.062	Roofs	DA1C
0.013	0.099	0.000	0.000	0.000	0.113	Unconnected roofs	DA1A
0.028	0.000	0.000	0.000	0.000	0.028	Water Surface	DA1A
4.270	3.353	0.000	0.000	0.000	7.623	Woods, Good	DA1A, DA1B, DA1C
5.593	**3.698**	**0.000**	**0.000**	**0.342**	**9.634**	**TOTAL AREA**	

Time span=1.00-72.00 hrs, dt=0.05 hrs, 1421 points
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv. UI as Pervious
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment DA1A: Summer Camp Runoff Area=298,408 sf 8.40% Impervious Runoff Depth=0.08"
Flow Length=810' Tc=31.6 min CN=45/98 Runoff=0.35 cfs 0.048 af

Subcatchment DA1B: Woods Runoff Area=19,988 sf 0.00% Impervious Runoff Depth=0.00"
Flow Length=182' Slope=0.1600 '/' Tc=9.5 min CN=30/0 Runoff=0.00 cfs 0.000 af

Subcatchment DA1C: Boat Ramp Runoff Area=94,024 sf 17.50% Impervious Runoff Depth=0.17"
Flow Length=327' Slope=0.1000 '/' Tc=11.2 min CN=34/98 Runoff=0.35 cfs 0.031 af

Subcatchment DA2: Parking lot east Runoff Area=7,221 sf 0.00% Impervious Runoff Depth=0.00"
Tc=5.0 min CN=40/0 Runoff=0.00 cfs 0.000 af

Pond 100: Diversion structure Peak Elev=84.97' Inflow=0.35 cfs 0.046 af
Primary=0.35 cfs 0.046 af Secondary=0.00 cfs 0.000 af Outflow=0.35 cfs 0.046 af

Pond BIO1: Bioretention 1 Peak Elev=82.46' Storage=638 cf Inflow=0.35 cfs 0.046 af
Discarded=0.09 cfs 0.046 af Primary=0.00 cfs 0.000 af Secondary=0.00 cfs 0.000 af Outflow=0.09 cfs 0.046 af

Pond D1: Infiltration Basin 1 Peak Elev=78.50' Storage=0 cf Inflow=0.00 cfs 0.000 af
Discarded=0.00 cfs 0.000 af Primary=0.00 cfs 0.000 af Secondary=0.00 cfs 0.000 af Outflow=0.00 cfs 0.000 af

Pond F1: Forebay Peak Elev=100.57' Storage=82 cf Inflow=0.35 cfs 0.048 af
Outflow=0.35 cfs 0.046 af

Pond I1: Inlet Flume Peak Elev=103.09' Storage=9 cf Inflow=0.35 cfs 0.048 af
Outflow=0.35 cfs 0.048 af

Pond RB1: Perf Pipe/RB Peak Elev=69.30' Storage=0 cf Inflow=0.00 cfs 0.000 af
Discarded=0.00 cfs 0.000 af Primary=0.00 cfs 0.000 af Outflow=0.00 cfs 0.000 af

Pond SP1: Boat ramp Inflow=0.35 cfs 0.031 af
Primary=0.35 cfs 0.031 af

Pond SP2: Beach Inflow=0.00 cfs 0.000 af
Primary=0.00 cfs 0.000 af

Total Runoff Area = 9.634 ac Runoff Volume = 0.079 af Average Runoff Depth = 0.10"
90.11% Pervious = 8.680 ac 9.89% Impervious = 0.953 ac

Summary for Subcatchment DA1A: Summer Camp

Runoff = 0.35 cfs @ 12.42 hrs, Volume= 0.048 af, Depth= 0.08"
Routed to Pond I1 : Inlet Flume

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv. UI as Pervious, Time Span= 1.00-72.00 hrs, dt= 0.05
Type III 24-hr WQV Rainfall=1.21"

Area (sf)	CN	Description
10,717	98	Paved parking, HSG B
13,149	98	Paved parking, HSG A
588	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
146,058	55	Woods, Good, HSG B
122,375	30	Woods, Good, HSG A
1,201	98	Water Surface, HSG A
298,408	49	Weighted Average
273,341	45	91.60% Pervious Area
25,067	98	8.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
3.5	150	0.0200	0.71		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	560	0.0800	5.74		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
31.6	810	Total			

Summary for Subcatchment DA1B: Woods

[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"
Routed to Pond D1 : Infiltration Basin 1

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv. UI as Pervious, Time Span= 1.00-72.00 hrs, dt= 0.05
Type III 24-hr WQV Rainfall=1.21"

Area (sf)	CN	Description
19,988	30	Woods, Good, HSG A
19,988	30	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	100	0.1600	0.19		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.7	82	0.1600	2.00		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.5	182	Total			

Summary for Subcatchment DA1C: Boat Ramp

Runoff = 0.35 cfs @ 12.15 hrs, Volume= 0.031 af, Depth= 0.17"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv. UI as Pervious, Time Span= 1.00-72.00 hrs, dt= 0.05
Type III 24-hr WQV Rainfall=1.21"

	Area (sf)	CN	Description
	43,640	30	Woods, Good, HSG A
	2,698	98	Roofs, HSG A
	13,758	98	Paved parking, HSG A
	19,021	39	>75% Grass cover, Good, HSG A
*	14,907	40	Permeable pavers
	94,024	45	Weighted Average
	77,568	34	82.50% Pervious Area
	16,456	98	17.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	100	0.1000	0.16		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.6	227	0.1000	6.42		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
11.2	327	Total			

Summary for Subcatchment DA2: Parking lot east

[49] Hint: Tc<2dt may require smaller dt
[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv. UI as Pervious, Time Span= 1.00-72.00 hrs, dt= 0.05
Type III 24-hr WQV Rainfall=1.21"

	Area (sf)	CN	Description
*	7,221	40	Permeable pavers, HSG A
	7,221	40	100.00% Pervious Area

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

Summary for Pond 100: Diversion structure

[57] Hint: Peaked at 84.97' (Flood elevation advised)

Inflow Area = 6.851 ac, 8.40% Impervious, Inflow Depth = 0.08" for WQV event
Inflow = 0.35 cfs @ 12.43 hrs, Volume= 0.046 af
Outflow = 0.35 cfs @ 12.43 hrs, Volume= 0.046 af, Atten= 0%, Lag= 0.0 min
Primary = 0.35 cfs @ 12.43 hrs, Volume= 0.046 af
Routed to Pond BIO1 : Bioretention 1
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond RB1 : Perf Pipe/RB

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 84.97' @ 12.43 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	84.50'	**6.0" Round To Bio** L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 84.50' / 84.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.20 sf
#2	Device 3	82.00'	**18.0" Round To overflow** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 82.00' / 78.00' S= 0.0667 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#3	Secondary	85.00'	**4.0' long x 0.5' breadth Weir in structure** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.35 cfs @ 12.43 hrs HW=84.97' (Free Discharge)
└**1=To Bio** (Inlet Controls 0.35 cfs @ 1.84 fps)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=82.00' (Free Discharge)
└**3=Weir in structure** (Controls 0.00 cfs)
└**2=To overflow** (Controls 0.00 cfs)

Summary for Pond BIO1: Bioretention 1

Inflow Area = 6.851 ac, 8.40% Impervious, Inflow Depth = 0.08" for WQV event
Inflow = 0.35 cfs @ 12.43 hrs, Volume= 0.046 af
Outflow = 0.09 cfs @ 13.19 hrs, Volume= 0.046 af, Atten= 75%, Lag= 45.7 min
Discarded = 0.09 cfs @ 13.19 hrs, Volume= 0.046 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond D1 : Infiltration Basin 1

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 82.46' @ 13.19 hrs Surf.Area= 1,569 sf Storage= 638 cf

Plug-Flow detention time= 55.7 min calculated for 0.046 af (100% of inflow)
Center-of-Mass det. time= 55.6 min (876.3 - 820.6)

Volume	Invert	Avail.Storage	Storage Description
#1	82.00'	2,825 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
82.00	1,200	0	0
82.50	1,600	700	700
83.00	2,200	950	1,650
83.50	2,500	1,175	2,825

Device	Routing	Invert	Outlet Devices
#1	Primary	82.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	82.75'	**8.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	82.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.09 cfs @ 13.19 hrs HW=82.46' (Free Discharge)
↑—**3=Exfiltration** (Exfiltration Controls 0.09 cfs)

Primary OutFlow Max=0.00 cfs @ 1.00 hrs HW=82.00' (Free Discharge)
↑—**1=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=82.00' (Free Discharge)
↑—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond D1: Infiltration Basin 1

Inflow Area = 0.459 ac, 0.00% Impervious, Inflow Depth = 0.00" for WQV event
Inflow = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
Discarded = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 78.50' @ 1.00 hrs Surf.Area= 350 sf Storage= 0 cf

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

Volume	Invert	Avail.Storage	Storage Description
#1	78.50'	1,038 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.50	350	0	0
79.00	600	238	238
80.00	1,000	800	1,038

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.40'	**12.0' long x 0.5' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00
			Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	78.50'	**1.020 in/hr Exfiltration over Surface area**
#3	Primary	79.25'	**24.0" Horiz. Orifice/Grate** C= 0.600
			Limited to weir flow at low heads

Discarded OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
└**2=Exfiltration** (Passes 0.00 cfs of 0.01 cfs potential flow)

Primary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
└**3=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond F1: Forebay

[44] Hint: Outlet device #2 is below defined storage

Inflow Area = 6.851 ac, 8.40% Impervious, Inflow Depth = 0.08" for WQV event
Inflow = 0.35 cfs @ 12.42 hrs, Volume= 0.048 af
Outflow = 0.35 cfs @ 12.43 hrs, Volume= 0.046 af, Atten= 0%, Lag= 0.5 min
Primary = 0.35 cfs @ 12.43 hrs, Volume= 0.046 af
Routed to Pond 100 : Diversion structure

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 100.57' @ 12.43 hrs Surf.Area= 196 sf Storage= 82 cf

Plug-Flow detention time= 33.2 min calculated for 0.046 af (97% of inflow)
Center-of-Mass det. time= 13.2 min (820.6 - 807.4)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	3,460 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	100	0	0
100.50	180	70	70
101.00	300	120	190
102.00	720	510	700
103.00	1,350	1,035	1,735
104.00	2,100	1,725	3,460

Device	Routing	Invert	Outlet Devices
#1	Primary	100.50'	**24.0" Horiz. Orifice/Grate** C= 0.600
			Limited to weir flow at low heads
#2	Device 1	92.00'	**18.0" Round Culvert**
			L= 54.0' CMP, projecting, no headwall, Ke= 0.900
			Inlet / Outlet Invert= 92.00' / 90.00' S= 0.0370 '/' Cc= 0.900

n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf

Primary OutFlow Max=0.35 cfs @ 12.43 hrs HW=100.57' (Free Discharge)
↑**1=Orifice/Grate** (Weir Controls 0.35 cfs @ 0.84 fps)
↑**2=Culvert** (Passes 0.35 cfs of 1.72 cfs potential flow)

Summary for Pond I1: Inlet Flume

Inflow Area = 6.851 ac, 8.40% Impervious, Inflow Depth = 0.08" for WQV event
Inflow = 0.35 cfs @ 12.42 hrs, Volume= 0.048 af
Outflow = 0.35 cfs @ 12.42 hrs, Volume= 0.048 af, Atten= 0%, Lag= 0.1 min
Primary = 0.35 cfs @ 12.42 hrs, Volume= 0.048 af
Routed to Pond F1 : Forebay

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 103.09' @ 12.42 hrs Surf.Area= 16 sf Storage= 9 cf

Plug-Flow detention time= 4.3 min calculated for 0.048 af (100% of inflow)
Center-of-Mass det. time= 2.0 min (807.4 - 805.5)

Volume	Invert	Avail.Storage	Storage Description
#1	102.50'	30 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
102.50	15	0	0
103.00	15	8	8
104.00	30	23	30

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**5.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.35 cfs @ 12.42 hrs HW=103.09' (Free Discharge)
↑**1=Broad-Crested Rectangular Weir** (Weir Controls 0.35 cfs @ 0.82 fps)

Summary for Pond RB1: Perf Pipe/RB

Inflow Area = 7.309 ac, 7.87% Impervious, Inflow Depth = 0.00" for WQV event
Inflow = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
Discarded = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 69.30' @ 1.00 hrs Surf.Area= 79 sf Storage= 0 cf

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

Volume	Invert	Avail.Storage	Storage Description
#1	74.50'	1,759 cf	**48.0" Round Pipe Storage** Inside #5 L= 140.0' S= 0.0057 '/'
#2	70.30'	226 cf	**6.00'D x 8.00'H Recharge Basin** Inside #3 308 cf Overall - 6.0" Wall Thickness = 226 cf
#3	69.30'	132 cf	**10.00'D x 9.00'H RB Stone** 707 cf Overall - 308 cf Embedded = 399 cf x 33.0% Voids
#4	78.20'	16 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)
#5	73.50'	1,092 cf	**6.00'W x 140.00'L x 6.00'H Pipe Stone** 5,040 cf Overall - 1,759 cf Embedded = 3,281 cf x 33.3% Voids
		3,226 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.20	20	0	0
79.00	20	16	16

Device	Routing	Invert	Outlet Devices
#1	Discarded	69.30'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'
#2	Primary	78.30'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.00 cfs @ 1.00 hrs HW=69.30' (Free Discharge)
↑—**1=Exfiltration** (Controls 0.00 cfs)

Primary OutFlow Max=0.00 cfs @ 1.00 hrs HW=69.30' (Free Discharge)
↑—**2=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.468 ac, 10.07% Impervious, Inflow Depth = 0.04" for WQV event
Inflow = 0.35 cfs @ 12.15 hrs, Volume= 0.031 af
Primary = 0.35 cfs @ 12.15 hrs, Volume= 0.031 af, Atten= 0%, Lag= 0.0 min

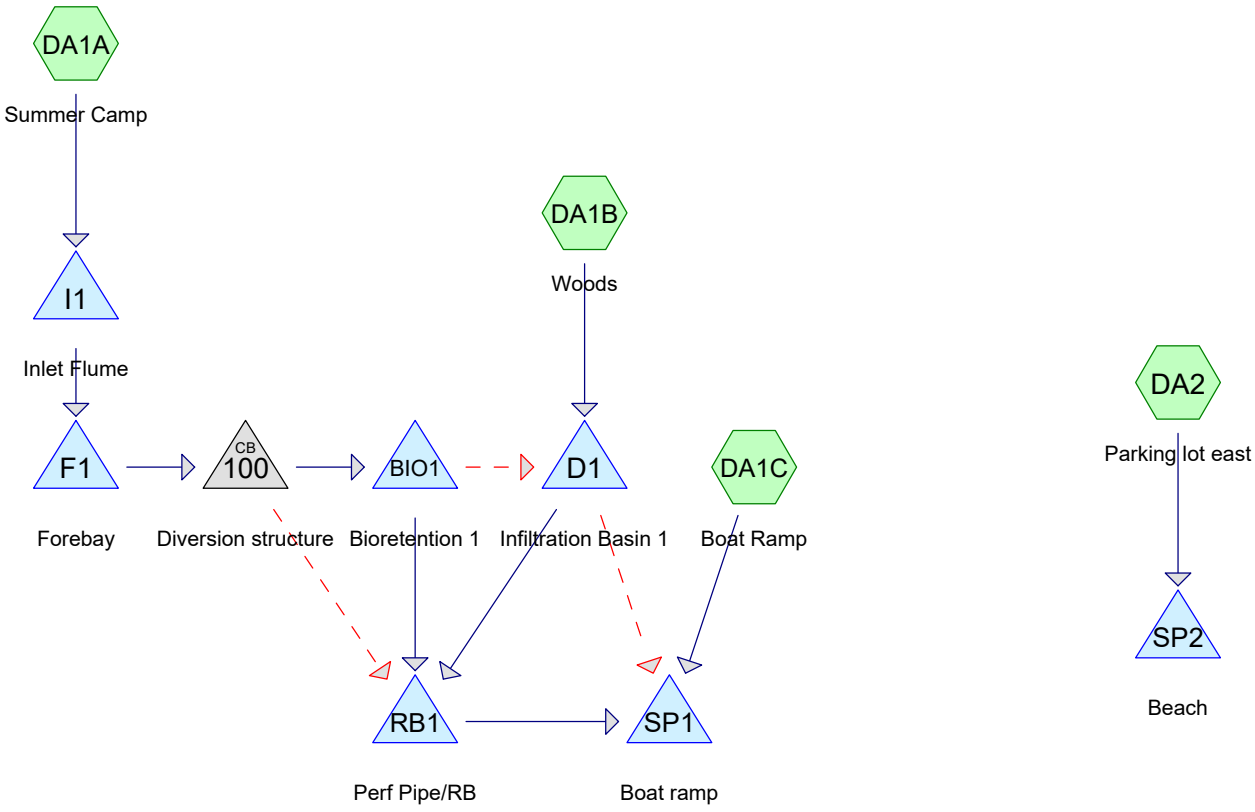
Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.166 ac, 0.00% Impervious, Inflow Depth = 0.00" for WQV event
Inflow = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs



Subcat Reach Pond Link

Routing Diagram for 22032 OAKCREST PR
Prepared by Horsley Witten Inc, Printed 10/30/2023

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2 yr	Type III 24-hr		Default	24.00	1	3.65	2
2	10 yr	Type III 24-hr		Default	24.00	1	5.36	2
3	25 yr	Type III 24-hr		Default	24.00	1	6.62	2
4	100 yr	Type III 24-hr		Default	24.00	1	8.62	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.437	39	>75% Grass cover, Good, HSG A (DA1C)
0.618	98	Paved parking, HSG A (DA1A, DA1C)
0.246	98	Paved parking, HSG B (DA1A)
0.342	40	Permeable pavers (DA1C)
0.166	40	Permeable pavers, HSG A (DA2)
0.062	98	Roofs, HSG A (DA1C)
0.013	98	Unconnected roofs, HSG A (DA1A)
0.099	98	Unconnected roofs, HSG B (DA1A)
0.028	98	Water Surface, HSG A (DA1A)
4.270	30	Woods, Good, HSG A (DA1A, DA1B, DA1C)
3.353	55	Woods, Good, HSG B (DA1A)
9.634	**47**	**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
0.437	0.000	0.000	0.000	0.000	0.437	>75% Grass cover, Good	DA1C
0.618	0.246	0.000	0.000	0.000	0.864	Paved parking	DA1A, DA1C
0.166	0.000	0.000	0.000	0.342	0.508	Permeable pavers	DA1C, DA2
0.062	0.000	0.000	0.000	0.000	0.062	Roofs	DA1C
0.013	0.099	0.000	0.000	0.000	0.113	Unconnected roofs	DA1A
0.028	0.000	0.000	0.000	0.000	0.028	Water Surface	DA1A
4.270	3.353	0.000	0.000	0.000	7.623	Woods, Good	DA1A, DA1B, DA1C
5.593	**3.698**	**0.000**	**0.000**	**0.342**	**9.634**	**TOTAL AREA**	

Time span=1.00-72.00 hrs, dt=0.05 hrs, 1421 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 DA1A: Summer Camp Runoff Area=298,408 sf 10.04% Impervious Runoff Depth=0.21"
Flow Length=810' Tc=31.6 min CN=49 Runoff=0.30 cfs 0.117 af

Subcatchment DA1B: Woods Runoff Area=19,988 sf 0.00% Impervious Runoff Depth=0.00"
Flow Length=182' Slope=0.1600 '/' Tc=9.5 min CN=30 Runoff=0.00 cfs 0.000 af

Subcatchment DA1C: Boat Ramp Runoff Area=94,024 sf 17.50% Impervious Runoff Depth=0.11"
Flow Length=327' Slope=0.1000 '/' Tc=11.2 min CN=45 Runoff=0.03 cfs 0.019 af

Subcatchment DA2: Parking lot east Runoff Area=7,221 sf 0.00% Impervious Runoff Depth=0.03"
Tc=5.0 min CN=40 Runoff=0.00 cfs 0.000 af

Pond 100: Diversion structure Peak Elev=84.91' Inflow=0.30 cfs 0.115 af
Primary=0.30 cfs 0.115 af Secondary=0.00 cfs 0.000 af Outflow=0.30 cfs 0.115 af

Pond BIO1: Bioretention 1 Peak Elev=82.53' Storage=750 cf Inflow=0.30 cfs 0.115 af
Discarded=0.09 cfs 0.094 af Primary=0.11 cfs 0.022 af Secondary=0.00 cfs 0.000 af Outflow=0.21 cfs 0.115 af

Pond D1: Infiltration Basin 1 Peak Elev=78.50' Storage=0 cf Inflow=0.00 cfs 0.000 af
Discarded=0.00 cfs 0.000 af Primary=0.00 cfs 0.000 af Secondary=0.00 cfs 0.000 af Outflow=0.00 cfs 0.000 af

Pond F1: Forebay Peak Elev=100.56' Storage=81 cf Inflow=0.31 cfs 0.117 af
Outflow=0.30 cfs 0.115 af

Pond I1: Inlet Flume Peak Elev=103.08' Storage=9 cf Inflow=0.30 cfs 0.117 af
Outflow=0.31 cfs 0.117 af

Pond RB1: Perf Pipe/RB Peak Elev=73.49' Storage=158 cf Inflow=0.11 cfs 0.022 af
Discarded=0.14 cfs 0.022 af Primary=0.00 cfs 0.000 af Outflow=0.14 cfs 0.022 af

Pond SP1: Boat ramp Inflow=0.03 cfs 0.019 af
Primary=0.03 cfs 0.019 af

Pond SP2: Beach Inflow=0.00 cfs 0.000 af
Primary=0.00 cfs 0.000 af

Total Runoff Area = 9.634 ac Runoff Volume = 0.137 af Average Runoff Depth = 0.17"
88.94% Pervious = 8.568 ac 11.06% Impervious = 1.066 ac

Summary for Subcatchment DA1A: Summer Camp

Runoff = 0.30 cfs @ 12.81 hrs, Volume= 0.117 af, Depth= 0.21"
Routed to Pond I1 : Inlet Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2 yr Rainfall=3.65"

Area (sf)	CN	Description
10,717	98	Paved parking, HSG B
13,149	98	Paved parking, HSG A
588	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
146,058	55	Woods, Good, HSG B
122,375	30	Woods, Good, HSG A
1,201	98	Water Surface, HSG A
298,408	49	Weighted Average
268,433	44	89.96% Pervious Area
29,975	98	10.04% Impervious Area
4,908		16.37% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
3.5	150	0.0200	0.71		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	560	0.0800	5.74		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
31.6	810	Total			

Summary for Subcatchment DA1B: Woods

[45] Hint: Runoff=Zero

Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"
Routed to Pond D1 : Infiltration Basin 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2 yr Rainfall=3.65"

Area (sf)	CN	Description
19,988	30	Woods, Good, HSG A
19,988	30	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	100	0.1600	0.19		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.7	82	0.1600	2.00		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.5	182	Total			

Summary for Subcatchment DA1C: Boat Ramp

Runoff = 0.03 cfs @ 13.87 hrs, Volume= 0.019 af, Depth= 0.11"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2 yr Rainfall=3.65"

	Area (sf)	CN	Description
	43,640	30	Woods, Good, HSG A
	2,698	98	Roofs, HSG A
	13,758	98	Paved parking, HSG A
	19,021	39	>75% Grass cover, Good, HSG A
*	14,907	40	Permeable pavers
	94,024	45	Weighted Average
	77,568	34	82.50% Pervious Area
	16,456	98	17.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	100	0.1000	0.16		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.6	227	0.1000	6.42		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
11.2	327	Total			

Summary for Subcatchment DA2: Parking lot east

[49] Hint: Tc<2dt may require smaller dt

Runoff = 0.00 cfs @ 17.05 hrs, Volume= 0.000 af, Depth= 0.03"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 2 yr Rainfall=3.65"

	Area (sf)	CN	Description
*	7,221	40	Permeable pavers, HSG A
	7,221	40	100.00% Pervious Area

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

Summary for Pond 100: Diversion structure

[57] Hint: Peaked at 84.91' (Flood elevation advised)

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.20" for 2 yr event
Inflow = 0.30 cfs @ 12.82 hrs, Volume= 0.115 af
Outflow = 0.30 cfs @ 12.82 hrs, Volume= 0.115 af, Atten= 0%, Lag= 0.0 min
Primary = 0.30 cfs @ 12.82 hrs, Volume= 0.115 af
Routed to Pond BIO1 : Bioretention 1
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond RB1 : Perf Pipe/RB

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 84.91' @ 12.82 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	84.50'	**6.0" Round To Bio** L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 84.50' / 84.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.20 sf
#2	Device 3	82.00'	**18.0" Round To overflow** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 82.00' / 78.00' S= 0.0667 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#3	Secondary	85.00'	**4.0' long x 0.5' breadth Weir in structure** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.30 cfs @ 12.82 hrs HW=84.91' (Free Discharge)
└**1=To Bio** (Inlet Controls 0.30 cfs @ 1.72 fps)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=82.00' (Free Discharge)
└**3=Weir in structure** (Controls 0.00 cfs)
└**2=To overflow** (Controls 0.00 cfs)

Summary for Pond BIO1: Bioretention 1

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.20" for 2 yr event
Inflow = 0.30 cfs @ 12.82 hrs, Volume= 0.115 af
Outflow = 0.21 cfs @ 14.03 hrs, Volume= 0.115 af, Atten= 31%, Lag= 72.8 min
Discarded = 0.09 cfs @ 14.03 hrs, Volume= 0.094 af
Primary = 0.11 cfs @ 14.03 hrs, Volume= 0.022 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond D1 : Infiltration Basin 1

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Peak Elev= 82.53' @ 14.03 hrs Surf.Area= 1,637 sf Storage= 750 cf

Plug-Flow detention time= 89.9 min calculated for 0.115 af (100% of inflow)
Center-of-Mass det. time= 89.9 min (1,100.1 - 1,010.2)

Volume	Invert	Avail.Storage	Storage Description
#1	82.00'	2,825 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
82.00	1,200	0	0
82.50	1,600	700	700
83.00	2,200	950	1,650
83.50	2,500	1,175	2,825

Device	Routing	Invert	Outlet Devices
#1	Primary	82.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	82.75'	**8.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	82.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.09 cfs @ 14.03 hrs HW=82.53' (Free Discharge)
3=Exfiltration (Exfiltration Controls 0.09 cfs)

Primary OutFlow Max=0.11 cfs @ 14.03 hrs HW=82.53' (Free Discharge)
1=Orifice/Grate (Weir Controls 0.11 cfs @ 0.57 fps)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=82.00' (Free Discharge)
2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond D1: Infiltration Basin 1

Inflow Area = 0.459 ac, 0.00% Impervious, Inflow Depth = 0.00" for 2 yr event
Inflow = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Outflow = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min
Discarded = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 78.50' @ 1.00 hrs Surf.Area= 350 sf Storage= 0 cf

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

Volume	Invert	Avail.Storage	Storage Description
#1	78.50'	1,038 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.50	350	0	0
79.00	600	238	238
80.00	1,000	800	1,038

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.40'	**12.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	78.50'	**1.020 in/hr Exfiltration over Surface area**
#3	Primary	79.25'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**2=Exfiltration** (Passes 0.00 cfs of 0.01 cfs potential flow)

Primary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**3=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond F1: Forebay

[44] Hint: Outlet device #2 is below defined storage

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.21" for 2 yr event
Inflow = 0.31 cfs @ 12.80 hrs, Volume= 0.117 af
Outflow = 0.30 cfs @ 12.82 hrs, Volume= 0.115 af, Atten= 4%, Lag= 0.9 min
Primary = 0.30 cfs @ 12.82 hrs, Volume= 0.115 af
Routed to Pond 100 : Diversion structure

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 100.56' @ 12.82 hrs Surf.Area= 194 sf Storage= 81 cf

Plug-Flow detention time= 10.7 min calculated for 0.115 af (99% of inflow)
Center-of-Mass det. time= 4.4 min (1,010.2 - 1,005.8)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	3,460 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	100	0	0
100.50	180	70	70
101.00	300	120	190
102.00	720	510	700
103.00	1,350	1,035	1,735
104.00	2,100	1,725	3,460

Device	Routing	Invert	Outlet Devices
#1	Primary	100.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Device 1	92.00'	**18.0" Round Culvert** L= 54.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 92.00' / 90.00' S= 0.0370 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf

Primary OutFlow Max=0.30 cfs @ 12.82 hrs HW=100.56' (Free Discharge)
└**1=Orifice/Grate** (Weir Controls 0.30 cfs @ 0.80 fps)
└**2=Culvert** (Passes 0.30 cfs of 1.63 cfs potential flow)

Summary for Pond I1: Inlet Flume

[88] Warning: Qout>Qin may require smaller dt or Finer Routing
[85] Warning: Oscillations may require smaller dt or Finer Routing (severity=18)

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.21" for 2 yr event
Inflow = 0.30 cfs @ 12.81 hrs, Volume= 0.117 af
Outflow = 0.31 cfs @ 12.80 hrs, Volume= 0.117 af, Atten= 0%, Lag= 0.0 min
Primary = 0.31 cfs @ 12.80 hrs, Volume= 0.117 af
Routed to Pond F1 : Forebay

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 103.08' @ 12.80 hrs Surf.Area= 16 sf Storage= 9 cf

Plug-Flow detention time= 1.2 min calculated for 0.117 af (100% of inflow)
Center-of-Mass det. time= 0.5 min (1,005.8 - 1,005.3)

Volume	Invert	Avail.Storage	Storage Description
#1	102.50'	30 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
102.50	15	0	0
103.00	15	8	8
104.00	30	23	30

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**5.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.31 cfs @ 12.80 hrs HW=103.08' (Free Discharge)
1=Broad-Crested Rectangular Weir (Weir Controls 0.31 cfs @ 0.79 fps)

Summary for Pond RB1: Perf Pipe/RB

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

Inflow Area = 7.309 ac, 9.41% Impervious, Inflow Depth = 0.04" for 2 yr event
Inflow = 0.11 cfs @ 14.03 hrs, Volume= 0.022 af
Outflow = 0.14 cfs @ 14.27 hrs, Volume= 0.022 af, Atten= 0%, Lag= 14.5 min
Discarded = 0.14 cfs @ 14.27 hrs, Volume= 0.022 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 73.49' @ 14.25 hrs Surf.Area= 79 sf Storage= 158 cf

Plug-Flow detention time= 50.0 min calculated for 0.022 af (100% of inflow)
Center-of-Mass det. time= 54.3 min (970.0 - 915.7)

Volume	Invert	Avail.Storage	Storage Description
#1	74.50'	1,759 cf	**48.0" Round Pipe Storage** Inside #5 L= 140.0' S= 0.0057 '/'
#2	70.30'	226 cf	**6.00'D x 8.00'H Recharge Basin** Inside #3 308 cf Overall - 6.0" Wall Thickness = 226 cf
#3	69.30'	132 cf	**10.00'D x 9.00'H RB Stone** 707 cf Overall - 308 cf Embedded = 399 cf x 33.0% Voids
#4	78.20'	16 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)
#5	73.50'	1,092 cf	**6.00'W x 140.00'L x 6.00'H Pipe Stone** 5,040 cf Overall - 1,759 cf Embedded = 3,281 cf x 33.3% Voids
		3,226 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.20	20	0	0
79.00	20	16	16

Device	Routing	Invert	Outlet Devices
#1	Discarded	69.30'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'
#2	Primary	78.30'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.02 cfs @ 14.27 hrs HW=73.49' (Free Discharge)
1=Exfiltration (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 1.00 hrs HW=69.30' (Free Discharge)
2=Orifice/Grate (Controls 0.00 cfs)

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.468 ac, 11.26% Impervious, Inflow Depth = 0.02" for 2 yr event
Inflow = 0.03 cfs @ 13.87 hrs, Volume= 0.019 af
Primary = 0.03 cfs @ 13.87 hrs, Volume= 0.019 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.166 ac, 0.00% Impervious, Inflow Depth = 0.03" for 2 yr event
Inflow = 0.00 cfs @ 17.05 hrs, Volume= 0.000 af
Primary = 0.00 cfs @ 17.05 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Time span=1.00-72.00 hrs, dt=0.05 hrs, 1421 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 DA1A: Summer Camp Runoff Area=298,408 sf 10.04% Impervious Runoff Depth=0.79"
Flow Length=810' Tc=31.6 min CN=49 Runoff=2.45 cfs 0.448 af

Subcatchment DA1B: Woods Runoff Area=19,988 sf 0.00% Impervious Runoff Depth=0.02"
Flow Length=182' Slope=0.1600 '/' Tc=9.5 min CN=30 Runoff=0.00 cfs 0.001 af

Subcatchment DA1C: Boat Ramp Runoff Area=94,024 sf 17.50% Impervious Runoff Depth=0.56"
Flow Length=327' Slope=0.1000 '/' Tc=11.2 min CN=45 Runoff=0.58 cfs 0.101 af

Subcatchment DA2: Parking lot east Runoff Area=7,221 sf 0.00% Impervious Runoff Depth=0.32"
Tc=5.0 min CN=40 Runoff=0.02 cfs 0.004 af

Pond 100: Diversion structure Peak Elev=85.30' Inflow=2.45 cfs 0.447 af
Primary=0.55 cfs 0.294 af Secondary=1.89 cfs 0.153 af Outflow=2.45 cfs 0.447 af

Pond BIO1: Bioretention 1 Peak Elev=82.58' Storage=824 cf Inflow=0.55 cfs 0.294 af
Discarded=0.09 cfs 0.110 af Primary=0.43 cfs 0.183 af Secondary=0.00 cfs 0.000 af Outflow=0.52 cfs 0.294 af

Pond D1: Infiltration Basin 1 Peak Elev=78.50' Storage=1 cf Inflow=0.00 cfs 0.001 af
Discarded=0.00 cfs 0.001 af Primary=0.00 cfs 0.000 af Secondary=0.00 cfs 0.000 af Outflow=0.00 cfs 0.001 af

Pond F1: Forebay Peak Elev=100.74' Storage=120 cf Inflow=2.46 cfs 0.448 af
Outflow=2.45 cfs 0.447 af

Pond I1: Inlet Flume Peak Elev=103.31' Storage=13 cf Inflow=2.45 cfs 0.448 af
Outflow=2.46 cfs 0.448 af

Pond RB1: Perf Pipe/RB Peak Elev=78.48' Storage=2,859 cf Inflow=1.99 cfs 0.336 af
Discarded=0.18 cfs 0.199 af Primary=1.66 cfs 0.137 af Outflow=1.84 cfs 0.336 af

Pond SP1: Boat ramp Inflow=1.90 cfs 0.238 af
Primary=1.90 cfs 0.238 af

Pond SP2: Beach Inflow=0.02 cfs 0.004 af
Primary=0.02 cfs 0.004 af

Total Runoff Area = 9.634 ac Runoff Volume = 0.554 af Average Runoff Depth = 0.69"
88.94% Pervious = 8.568 ac 11.06% Impervious = 1.066 ac

Summary for Subcatchment DA1A: Summer Camp

Runoff = 2.45 cfs @ 12.58 hrs, Volume= 0.448 af, Depth= 0.79"
Routed to Pond I1 : Inlet Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 yr Rainfall=5.36"

Area (sf)	CN	Description
10,717	98	Paved parking, HSG B
13,149	98	Paved parking, HSG A
588	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
146,058	55	Woods, Good, HSG B
122,375	30	Woods, Good, HSG A
1,201	98	Water Surface, HSG A
298,408	49	Weighted Average
268,433	44	89.96% Pervious Area
29,975	98	10.04% Impervious Area
4,908		16.37% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
3.5	150	0.0200	0.71		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	560	0.0800	5.74		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
31.6	810	Total			

Summary for Subcatchment DA1B: Woods

Runoff = 0.00 cfs @ 21.79 hrs, Volume= 0.001 af, Depth= 0.02"
Routed to Pond D1 : Infiltration Basin 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 yr Rainfall=5.36"

Area (sf)	CN	Description
19,988	30	Woods, Good, HSG A
19,988	30	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	100	0.1600	0.19		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.7	82	0.1600	2.00		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.5	182	Total			

Summary for Subcatchment DA1C: Boat Ramp

Runoff = 0.58 cfs @ 12.34 hrs, Volume= 0.101 af, Depth= 0.56"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 yr Rainfall=5.36"

	Area (sf)	CN	Description
	43,640	30	Woods, Good, HSG A
	2,698	98	Roofs, HSG A
	13,758	98	Paved parking, HSG A
	19,021	39	>75% Grass cover, Good, HSG A
*	14,907	40	Permeable pavers
	94,024	45	Weighted Average
	77,568	34	82.50% Pervious Area
	16,456	98	17.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	100	0.1000	0.16		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.6	227	0.1000	6.42		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
11.2	327	Total			

Summary for Subcatchment DA2: Parking lot east

[49] Hint: Tc<2dt may require smaller dt

Runoff = 0.02 cfs @ 12.37 hrs, Volume= 0.004 af, Depth= 0.32"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 yr Rainfall=5.36"

	Area (sf)	CN	Description
*	7,221	40	Permeable pavers, HSG A
	7,221	40	100.00% Pervious Area

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

Summary for Pond 100: Diversion structure

[57] Hint: Peaked at 85.30' (Flood elevation advised)

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.78" for 10 yr event
Inflow = 2.45 cfs @ 12.58 hrs, Volume= 0.447 af
Outflow = 2.45 cfs @ 12.58 hrs, Volume= 0.447 af, Atten= 0%, Lag= 0.0 min
Primary = 0.55 cfs @ 12.58 hrs, Volume= 0.294 af
Routed to Pond BIO1 : Bioretention 1
Secondary = 1.89 cfs @ 12.58 hrs, Volume= 0.153 af
Routed to Pond RB1 : Perf Pipe/RB

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 85.30' @ 12.58 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	84.50'	**6.0" Round To Bio** L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 84.50' / 84.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.20 sf
#2	Device 3	82.00'	**18.0" Round To overflow** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 82.00' / 78.00' S= 0.0667 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#3	Secondary	85.00'	**4.0' long x 0.5' breadth Weir in structure** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.55 cfs @ 12.58 hrs HW=85.30' (Free Discharge)
└**1=To Bio** (Inlet Controls 0.55 cfs @ 2.82 fps)

Secondary OutFlow Max=1.89 cfs @ 12.58 hrs HW=85.30' (Free Discharge)
└**3=Weir in structure** (Weir Controls 1.89 cfs @ 1.57 fps)
└**2=To overflow** (Passes 1.89 cfs of 3.68 cfs potential flow)

Summary for Pond BIO1: Bioretention 1

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.51" for 10 yr event
Inflow = 0.55 cfs @ 12.58 hrs, Volume= 0.294 af
Outflow = 0.52 cfs @ 12.87 hrs, Volume= 0.294 af, Atten= 6%, Lag= 17.8 min
Discarded = 0.09 cfs @ 12.87 hrs, Volume= 0.110 af
Primary = 0.43 cfs @ 12.87 hrs, Volume= 0.183 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond D1 : Infiltration Basin 1

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 82.58' @ 12.87 hrs Surf.Area= 1,690 sf Storage= 824 cf

Plug-Flow detention time= 47.7 min calculated for 0.294 af (100% of inflow)
Center-of-Mass det. time= 47.8 min (1,060.6 - 1,012.8)

Volume	Invert	Avail.Storage	Storage Description
#1	82.00'	2,825 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
82.00	1,200	0	0
82.50	1,600	700	700
83.00	2,200	950	1,650
83.50	2,500	1,175	2,825

Device	Routing	Invert	Outlet Devices
#1	Primary	82.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	82.75'	**8.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	82.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.09 cfs @ 12.87 hrs HW=82.58' (Free Discharge)
3=Exfiltration (Exfiltration Controls 0.09 cfs)

Primary OutFlow Max=0.42 cfs @ 12.87 hrs HW=82.58' (Free Discharge)
1=Orifice/Grate (Weir Controls 0.42 cfs @ 0.90 fps)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=82.00' (Free Discharge)
2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond D1: Infiltration Basin 1

Inflow Area = 0.459 ac, 0.00% Impervious, Inflow Depth = 0.02" for 10 yr event
Inflow = 0.00 cfs @ 21.79 hrs, Volume= 0.001 af
Outflow = 0.00 cfs @ 21.97 hrs, Volume= 0.001 af, Atten= 0%, Lag= 10.9 min
Discarded = 0.00 cfs @ 21.97 hrs, Volume= 0.001 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 78.50' @ 21.97 hrs Surf.Area= 351 sf Storage= 1 cf

Plug-Flow detention time= 10.5 min calculated for 0.001 af (100% of inflow)
Center-of-Mass det. time= 10.5 min (1,234.6 - 1,224.1)

Volume	Invert	Avail.Storage	Storage Description
#1	78.50'	1,038 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.50	350	0	0
79.00	600	238	238
80.00	1,000	800	1,038

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.40'	**12.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	78.50'	**1.020 in/hr Exfiltration over Surface area**
#3	Primary	79.25'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.01 cfs @ 21.97 hrs HW=78.50' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**3=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond F1: Forebay

[44] Hint: Outlet device #2 is below defined storage

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.78" for 10 yr event
Inflow = 2.46 cfs @ 12.59 hrs, Volume= 0.448 af
Outflow = 2.45 cfs @ 12.58 hrs, Volume= 0.447 af, Atten= 1%, Lag= 0.0 min
Primary = 2.45 cfs @ 12.58 hrs, Volume= 0.447 af
Routed to Pond 100 : Diversion structure

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 100.74' @ 12.58 hrs Surf.Area= 238 sf Storage= 120 cf

Plug-Flow detention time= 3.2 min calculated for 0.447 af (100% of inflow)
Center-of-Mass det. time= 1.3 min (936.3 - 935.1)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	3,460 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	100	0	0
100.50	180	70	70
101.00	300	120	190
102.00	720	510	700
103.00	1,350	1,035	1,735
104.00	2,100	1,725	3,460

Device	Routing	Invert	Outlet Devices
#1	Primary	100.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Device 1	92.00'	**18.0" Round Culvert** L= 54.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 92.00' / 90.00' S= 0.0370 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf

Primary OutFlow Max=2.43 cfs @ 12.58 hrs HW=100.74' (Free Discharge)
└**1=Orifice/Grate** (Weir Controls 2.43 cfs @ 1.61 fps)
└**2=Culvert** (Passes 2.43 cfs of 3.30 cfs potential flow)

Summary for Pond I1: Inlet Flume

[88] Warning: Qout>Qin may require smaller dt or Finer Routing

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.79" for 10 yr event
Inflow = 2.45 cfs @ 12.58 hrs, Volume= 0.448 af
Outflow = 2.46 cfs @ 12.59 hrs, Volume= 0.448 af, Atten= 0%, Lag= 0.7 min
Primary = 2.46 cfs @ 12.59 hrs, Volume= 0.448 af
Routed to Pond F1 : Forebay

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 103.31' @ 12.59 hrs Surf.Area= 20 sf Storage= 13 cf

Plug-Flow detention time= 0.3 min calculated for 0.448 af (100% of inflow)
Center-of-Mass det. time= 0.1 min (935.1 - 934.9)

Volume	Invert	Avail.Storage	Storage Description
#1	102.50'	30 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
102.50	15	0	0
103.00	15	8	8
104.00	30	23	30

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**5.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=2.45 cfs @ 12.59 hrs HW=103.31' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 2.45 cfs @ 1.59 fps)

Summary for Pond RB1: Perf Pipe/RB

Inflow Area = 7.309 ac, 9.41% Impervious, Inflow Depth = 0.55" for 10 yr event
Inflow = 1.99 cfs @ 12.73 hrs, Volume= 0.336 af
Outflow = 1.84 cfs @ 12.87 hrs, Volume= 0.336 af, Atten= 8%, Lag= 8.5 min
Discarded = 0.18 cfs @ 12.80 hrs, Volume= 0.199 af
Primary = 1.66 cfs @ 12.87 hrs, Volume= 0.137 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 78.48' @ 12.85 hrs Surf.Area= 939 sf Storage= 2,859 cf

Plug-Flow detention time= 119.6 min calculated for 0.336 af (100% of inflow)

Center-of-Mass det. time= 119.8 min (1,021.4 - 901.6)

Volume	Invert	Avail.Storage	Storage Description
#1	74.50'	1,759 cf	**48.0" Round Pipe Storage** Inside #5 L= 140.0' S= 0.0057 '/'
#2	70.30'	226 cf	**6.00'D x 8.00'H Recharge Basin** Inside #3 308 cf Overall - 6.0" Wall Thickness = 226 cf
#3	69.30'	132 cf	**10.00'D x 9.00'H RB Stone** 707 cf Overall - 308 cf Embedded = 399 cf x 33.0% Voids
#4	78.20'	16 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)
#5	73.50'	1,092 cf	**6.00'W x 140.00'L x 6.00'H Pipe Stone** 5,040 cf Overall - 1,759 cf Embedded = 3,281 cf x 33.3% Voids
		3,226 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.20	20	0	0
79.00	20	16	16

Device	Routing	Invert	Outlet Devices
#1	Discarded	69.30'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'
#2	Primary	78.30'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.18 cfs @ 12.80 hrs HW=78.42' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.18 cfs)

Primary OutFlow Max=1.56 cfs @ 12.87 hrs HW=78.48' (Free Discharge)
↑—**2=Orifice/Grate** (Weir Controls 1.56 cfs @ 1.38 fps)

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.468 ac, 11.26% Impervious, Inflow Depth = 0.30" for 10 yr event
Inflow = 1.90 cfs @ 12.87 hrs, Volume= 0.238 af
Primary = 1.90 cfs @ 12.87 hrs, Volume= 0.238 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.166 ac, 0.00% Impervious, Inflow Depth = 0.32" for 10 yr event
Inflow = 0.02 cfs @ 12.37 hrs, Volume= 0.004 af
Primary = 0.02 cfs @ 12.37 hrs, Volume= 0.004 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Time span=1.00-72.00 hrs, dt=0.05 hrs, 1421 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 DA1A: Summer Camp Runoff Area=298,408 sf 10.04% Impervious Runoff Depth=1.38"
Flow Length=810' Tc=31.6 min CN=49 Runoff=5.07 cfs 0.787 af

Subcatchment DA1B: Woods Runoff Area=19,988 sf 0.00% Impervious Runoff Depth=0.15"
Flow Length=182' Slope=0.1600 '/' Tc=9.5 min CN=30 Runoff=0.01 cfs 0.006 af

Subcatchment DA1C: Boat Ramp Runoff Area=94,024 sf 17.50% Impervious Runoff Depth=1.06"
Flow Length=327' Slope=0.1000 '/' Tc=11.2 min CN=45 Runoff=1.57 cfs 0.191 af

Subcatchment DA2: Parking lot east Runoff Area=7,221 sf 0.00% Impervious Runoff Depth=0.70"
Tc=5.0 min CN=40 Runoff=0.06 cfs 0.010 af

Pond 100: Diversion structure Peak Elev=85.51' Inflow=5.06 cfs 0.785 af
Primary=0.65 cfs 0.381 af Secondary=4.41 cfs 0.404 af Outflow=5.06 cfs 0.785 af

Pond BIO1: Bioretention 1 Peak Elev=82.59' Storage=846 cf Inflow=0.65 cfs 0.381 af
Discarded=0.10 cfs 0.113 af Primary=0.54 cfs 0.268 af Secondary=0.00 cfs 0.000 af Outflow=0.64 cfs 0.381 af

Pond D1: Infiltration Basin 1 Peak Elev=78.52' Storage=8 cf Inflow=0.01 cfs 0.006 af
Discarded=0.01 cfs 0.006 af Primary=0.00 cfs 0.000 af Secondary=0.00 cfs 0.000 af Outflow=0.01 cfs 0.006 af

Pond F1: Forebay Peak Elev=101.07' Storage=211 cf Inflow=5.07 cfs 0.787 af
Outflow=5.06 cfs 0.785 af

Pond I1: Inlet Flume Peak Elev=103.49' Storage=17 cf Inflow=5.07 cfs 0.787 af
Outflow=5.07 cfs 0.787 af

Pond RB1: Perf Pipe/RB Peak Elev=78.67' Storage=2,950 cf Inflow=4.85 cfs 0.672 af
Discarded=0.18 cfs 0.238 af Primary=4.66 cfs 0.430 af Outflow=4.83 cfs 0.668 af

Pond SP1: Boat ramp Inflow=5.47 cfs 0.621 af
Primary=5.47 cfs 0.621 af

Pond SP2: Beach Inflow=0.06 cfs 0.010 af
Primary=0.06 cfs 0.010 af

Total Runoff Area = 9.634 ac Runoff Volume = 0.993 af Average Runoff Depth = 1.24"
88.94% Pervious = 8.568 ac 11.06% Impervious = 1.066 ac

Summary for Subcatchment DA1A: Summer Camp

Runoff = 5.07 cfs @ 12.53 hrs, Volume= 0.787 af, Depth= 1.38"
Routed to Pond I1 : Inlet Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 yr Rainfall=6.62"

Area (sf)	CN	Description
10,717	98	Paved parking, HSG B
13,149	98	Paved parking, HSG A
588	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
146,058	55	Woods, Good, HSG B
122,375	30	Woods, Good, HSG A
1,201	98	Water Surface, HSG A
298,408	49	Weighted Average
268,433	44	89.96% Pervious Area
29,975	98	10.04% Impervious Area
4,908		16.37% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
3.5	150	0.0200	0.71		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	560	0.0800	5.74		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
31.6	810	Total			

Summary for Subcatchment DA1B: Woods

Runoff = 0.01 cfs @ 14.85 hrs, Volume= 0.006 af, Depth= 0.15"
Routed to Pond D1 : Infiltration Basin 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 yr Rainfall=6.62"

Area (sf)	CN	Description
19,988	30	Woods, Good, HSG A
19,988	30	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	100	0.1600	0.19		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.7	82	0.1600	2.00		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.5	182	Total			

Summary for Subcatchment DA1C: Boat Ramp

Runoff = 1.57 cfs @ 12.21 hrs, Volume= 0.191 af, Depth= 1.06"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 yr Rainfall=6.62"

	Area (sf)	CN	Description
	43,640	30	Woods, Good, HSG A
	2,698	98	Roofs, HSG A
	13,758	98	Paved parking, HSG A
	19,021	39	>75% Grass cover, Good, HSG A
*	14,907	40	Permeable pavers
	94,024	45	Weighted Average
	77,568	34	82.50% Pervious Area
	16,456	98	17.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	100	0.1000	0.16		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.6	227	0.1000	6.42		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
11.2	327	Total			

Summary for Subcatchment DA2: Parking lot east

[49] Hint: Tc<2dt may require smaller dt

Runoff = 0.06 cfs @ 12.15 hrs, Volume= 0.010 af, Depth= 0.70"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 yr Rainfall=6.62"

	Area (sf)	CN	Description
*	7,221	40	Permeable pavers, HSG A
	7,221	40	100.00% Pervious Area

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

Summary for Pond 100: Diversion structure

[57] Hint: Peaked at 85.51' (Flood elevation advised)

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 1.37" for 25 yr event
Inflow = 5.06 cfs @ 12.55 hrs, Volume= 0.785 af
Outflow = 5.06 cfs @ 12.55 hrs, Volume= 0.785 af, Atten= 0%, Lag= 0.0 min
Primary = 0.65 cfs @ 12.55 hrs, Volume= 0.381 af
Routed to Pond BIO1 : Bioretention 1
Secondary = 4.41 cfs @ 12.55 hrs, Volume= 0.404 af
Routed to Pond RB1 : Perf Pipe/RB

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 85.51' @ 12.55 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	84.50'	**6.0" Round To Bio** L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 84.50' / 84.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.20 sf
#2	Device 3	82.00'	**18.0" Round To overflow** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 82.00' / 78.00' S= 0.0667 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#3	Secondary	85.00'	**4.0' long x 0.5' breadth Weir in structure** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=0.65 cfs @ 12.55 hrs HW=85.51' (Free Discharge)
└**1=To Bio** (Inlet Controls 0.65 cfs @ 3.32 fps)

Secondary OutFlow Max=4.40 cfs @ 12.55 hrs HW=85.51' (Free Discharge)
└**3=Weir in structure** (Weir Controls 4.40 cfs @ 2.15 fps)
└**2=To overflow** (Passes 4.40 cfs of 4.80 cfs potential flow)

Summary for Pond BIO1: Bioretention 1

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.67" for 25 yr event
Inflow = 0.65 cfs @ 12.55 hrs, Volume= 0.381 af
Outflow = 0.64 cfs @ 12.70 hrs, Volume= 0.381 af, Atten= 3%, Lag= 9.4 min
Discarded = 0.10 cfs @ 12.70 hrs, Volume= 0.113 af
Primary = 0.54 cfs @ 12.70 hrs, Volume= 0.268 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond D1 : Infiltration Basin 1

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 82.59' @ 12.70 hrs Surf.Area= 1,706 sf Storage= 846 cf

Plug-Flow detention time= 38.4 min calculated for 0.380 af (100% of inflow)
Center-of-Mass det. time= 38.5 min (1,072.3 - 1,033.8)

Volume	Invert	Avail.Storage	Storage Description
#1	82.00'	2,825 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
82.00	1,200	0	0
82.50	1,600	700	700
83.00	2,200	950	1,650
83.50	2,500	1,175	2,825

Device	Routing	Invert	Outlet Devices
#1	Primary	82.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	82.75'	**8.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	82.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.10 cfs @ 12.70 hrs HW=82.59' (Free Discharge)
3=Exfiltration (Exfiltration Controls 0.10 cfs)

Primary OutFlow Max=0.54 cfs @ 12.70 hrs HW=82.59' (Free Discharge)
1=Orifice/Grate (Weir Controls 0.54 cfs @ 0.97 fps)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=82.00' (Free Discharge)
2=Broad-Crested Rectangular Weir (Controls 0.00 cfs)

Summary for Pond D1: Infiltration Basin 1

Inflow Area = 0.459 ac, 0.00% Impervious, Inflow Depth = 0.15" for 25 yr event
Inflow = 0.01 cfs @ 14.85 hrs, Volume= 0.006 af
Outflow = 0.01 cfs @ 15.67 hrs, Volume= 0.006 af, Atten= 8%, Lag= 49.2 min
Discarded = 0.01 cfs @ 15.67 hrs, Volume= 0.006 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 78.52' @ 15.67 hrs Surf.Area= 362 sf Storage= 8 cf

Plug-Flow detention time= 11.6 min calculated for 0.006 af (100% of inflow)
Center-of-Mass det. time= 11.5 min (1,075.5 - 1,063.9)

Volume	Invert	Avail.Storage	Storage Description
#1	78.50'	1,038 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.50	350	0	0
79.00	600	238	238
80.00	1,000	800	1,038

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.40'	**12.0' long x 0.5' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00
			Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	78.50'	**1.020 in/hr Exfiltration over Surface area**
#3	Primary	79.25'	**24.0" Horiz. Orifice/Grate** C= 0.600
			Limited to weir flow at low heads

Discarded OutFlow Max=0.01 cfs @ 15.67 hrs HW=78.52' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**3=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond F1: Forebay

[44] Hint: Outlet device #2 is below defined storage

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 1.38" for 25 yr event
Inflow = 5.07 cfs @ 12.53 hrs, Volume= 0.787 af
Outflow = 5.06 cfs @ 12.55 hrs, Volume= 0.785 af, Atten= 0%, Lag= 1.2 min
Primary = 5.06 cfs @ 12.55 hrs, Volume= 0.785 af
Routed to Pond 100 : Diversion structure

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 101.07' @ 12.55 hrs Surf.Area= 328 sf Storage= 211 cf

Plug-Flow detention time= 2.0 min calculated for 0.784 af (100% of inflow)
Center-of-Mass det. time= 0.9 min (913.6 - 912.8)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	3,460 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	100	0	0
100.50	180	70	70
101.00	300	120	190
102.00	720	510	700
103.00	1,350	1,035	1,735
104.00	2,100	1,725	3,460

Device	Routing	Invert	Outlet Devices
#1	Primary	100.50'	**24.0" Horiz. Orifice/Grate** C= 0.600
			Limited to weir flow at low heads
#2	Device 1	92.00'	**18.0" Round Culvert**
			L= 54.0' CMP, projecting, no headwall, Ke= 0.900
			Inlet / Outlet Invert= 92.00' / 90.00' S= 0.0370 '/' Cc= 0.900
			n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf

Primary OutFlow Max=5.06 cfs @ 12.55 hrs HW=101.07' (Free Discharge)
└**1=Orifice/Grate** (Passes 5.06 cfs of 8.76 cfs potential flow)
└**2=Culvert** (Inlet Controls 5.06 cfs @ 2.86 fps)

Summary for Pond I1: Inlet Flume

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 1.38" for 25 yr event
Inflow = 5.07 cfs @ 12.53 hrs, Volume= 0.787 af
Outflow = 5.07 cfs @ 12.53 hrs, Volume= 0.787 af, Atten= 0%, Lag= 0.0 min
Primary = 5.07 cfs @ 12.53 hrs, Volume= 0.787 af
Routed to Pond F1 : Forebay

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 103.49' @ 12.53 hrs Surf.Area= 22 sf Storage= 17 cf

Plug-Flow detention time= 0.2 min calculated for 0.787 af (100% of inflow)
Center-of-Mass det. time= 0.1 min (912.8 - 912.7)

Volume	Invert	Avail.Storage	Storage Description
#1	102.50'	30 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
102.50	15	0	0
103.00	15	8	8
104.00	30	23	30

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**5.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=5.05 cfs @ 12.53 hrs HW=103.49' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 5.05 cfs @ 2.08 fps)

Summary for Pond RB1: Perf Pipe/RB

Inflow Area = 7.309 ac, 9.41% Impervious, Inflow Depth = 1.10" for 25 yr event
Inflow = 4.85 cfs @ 12.58 hrs, Volume= 0.672 af
Outflow = 4.83 cfs @ 12.59 hrs, Volume= 0.668 af, Atten= 0%, Lag= 0.5 min
Discarded = 0.18 cfs @ 12.45 hrs, Volume= 0.238 af
Primary = 4.66 cfs @ 12.59 hrs, Volume= 0.430 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 78.67' @ 12.59 hrs Surf.Area= 939 sf Storage= 2,950 cf

Plug-Flow detention time= 83.5 min calculated for 0.668 af (99% of inflow)
Center-of-Mass det. time= 80.0 min (972.7 - 892.7)

Volume	Invert	Avail.Storage	Storage Description
#1	74.50'	1,759 cf	**48.0" Round Pipe Storage** Inside #5 L= 140.0' S= 0.0057 '/'
#2	70.30'	226 cf	**6.00'D x 8.00'H Recharge Basin** Inside #3 308 cf Overall - 6.0" Wall Thickness = 226 cf
#3	69.30'	132 cf	**10.00'D x 9.00'H RB Stone** 707 cf Overall - 308 cf Embedded = 399 cf x 33.0% Voids
#4	78.20'	16 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)
#5	73.50'	1,092 cf	**6.00'W x 140.00'L x 6.00'H Pipe Stone** 5,040 cf Overall - 1,759 cf Embedded = 3,281 cf x 33.3% Voids
		3,226 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.20	20	0	0
79.00	20	16	16

Device	Routing	Invert	Outlet Devices
#1	Discarded	69.30'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'
#2	Primary	78.30'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.18 cfs @ 12.45 hrs HW=78.28' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.18 cfs)

Primary OutFlow Max=4.62 cfs @ 12.59 hrs HW=78.67' (Free Discharge)
↑—**2=Orifice/Grate** (Weir Controls 4.62 cfs @ 1.99 fps)

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.468 ac, 11.26% Impervious, Inflow Depth = 0.79" for 25 yr event
Inflow = 5.47 cfs @ 12.55 hrs, Volume= 0.621 af
Primary = 5.47 cfs @ 12.55 hrs, Volume= 0.621 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.166 ac, 0.00% Impervious, Inflow Depth = 0.70" for 25 yr event
Inflow = 0.06 cfs @ 12.15 hrs, Volume= 0.010 af
Primary = 0.06 cfs @ 12.15 hrs, Volume= 0.010 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Time span=1.00-72.00 hrs, dt=0.05 hrs, 1421 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 DA1A: Summer Camp Runoff Area=298,408 sf 10.04% Impervious Runoff Depth=2.52"
Flow Length=810' Tc=31.6 min CN=49 Runoff=10.32 cfs 1.440 af

Subcatchment DA1B: Woods Runoff Area=19,988 sf 0.00% Impervious Runoff Depth=0.57"
Flow Length=182' Slope=0.1600 '/' Tc=9.5 min CN=30 Runoff=0.09 cfs 0.022 af

Subcatchment DA1C: Boat Ramp Runoff Area=94,024 sf 17.50% Impervious Runoff Depth=2.07"
Flow Length=327' Slope=0.1000 '/' Tc=11.2 min CN=45 Runoff=3.75 cfs 0.373 af

Subcatchment DA2: Parking lot east Runoff Area=7,221 sf 0.00% Impervious Runoff Depth=1.53"
Tc=5.0 min CN=40 Runoff=0.23 cfs 0.021 af

Pond 100: Diversion structure Peak Elev=86.71' Inflow=9.82 cfs 1.438 af
Primary=1.04 cfs 0.489 af Secondary=8.78 cfs 0.949 af Outflow=9.82 cfs 1.438 af

Pond BIO1: Bioretention 1 Peak Elev=82.63' Storage=914 cf Inflow=1.04 cfs 0.489 af
Discarded=0.10 cfs 0.118 af Primary=0.94 cfs 0.371 af Secondary=0.00 cfs 0.000 af Outflow=1.04 cfs 0.489 af

Pond D1: Infiltration Basin 1 Peak Elev=79.22' Storage=379 cf Inflow=0.09 cfs 0.022 af
Discarded=0.02 cfs 0.022 af Primary=0.00 cfs 0.000 af Secondary=0.00 cfs 0.000 af Outflow=0.02 cfs 0.022 af

Pond F1: Forebay Peak Elev=102.64' Storage=1,288 cf Inflow=10.31 cfs 1.440 af
Outflow=9.82 cfs 1.438 af

Pond I1: Inlet Flume Peak Elev=103.74' Storage=23 cf Inflow=10.32 cfs 1.440 af
Outflow=10.31 cfs 1.440 af

Pond RB1: Perf Pipe/RB Peak Elev=78.90' Storage=3,043 cf Inflow=9.71 cfs 1.320 af
Discarded=0.18 cfs 0.250 af Primary=9.52 cfs 1.066 af Outflow=9.70 cfs 1.317 af

Pond SP1: Boat ramp Inflow=11.16 cfs 1.439 af
Primary=11.16 cfs 1.439 af

Pond SP2: Beach Inflow=0.23 cfs 0.021 af
Primary=0.23 cfs 0.021 af

Total Runoff Area = 9.634 ac Runoff Volume = 1.856 af Average Runoff Depth = 2.31"
88.94% Pervious = 8.568 ac 11.06% Impervious = 1.066 ac

Summary for Subcatchment DA1A: Summer Camp

Runoff = 10.32 cfs @ 12.49 hrs, Volume= 1.440 af, Depth= 2.52"
Routed to Pond I1 : Inlet Flume

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 yr Rainfall=8.62"

Area (sf)	CN	Description
10,717	98	Paved parking, HSG B
13,149	98	Paved parking, HSG A
588	98	Unconnected roofs, HSG A
4,320	98	Unconnected roofs, HSG B
146,058	55	Woods, Good, HSG B
122,375	30	Woods, Good, HSG A
1,201	98	Water Surface, HSG A
298,408	49	Weighted Average
268,433	44	89.96% Pervious Area
29,975	98	10.04% Impervious Area
4,908		16.37% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
26.5	100	0.0100	0.06		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
3.5	150	0.0200	0.71		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
1.6	560	0.0800	5.74		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
31.6	810	Total			

Summary for Subcatchment DA1B: Woods

Runoff = 0.09 cfs @ 12.42 hrs, Volume= 0.022 af, Depth= 0.57"
Routed to Pond D1 : Infiltration Basin 1

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 yr Rainfall=8.62"

Area (sf)	CN	Description
19,988	30	Woods, Good, HSG A
19,988	30	100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.8	100	0.1600	0.19		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.7	82	0.1600	2.00		**Shallow Concentrated Flow,** Woodland Kv= 5.0 fps
9.5	182	Total			

Summary for Subcatchment DA1C: Boat Ramp

Runoff = 3.75 cfs @ 12.18 hrs, Volume= 0.373 af, Depth= 2.07"
Routed to Pond SP1 : Boat ramp

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 yr Rainfall=8.62"

	Area (sf)	CN	Description
	43,640	30	Woods, Good, HSG A
	2,698	98	Roofs, HSG A
	13,758	98	Paved parking, HSG A
	19,021	39	>75% Grass cover, Good, HSG A
*	14,907	40	Permeable pavers
	94,024	45	Weighted Average
	77,568	34	82.50% Pervious Area
	16,456	98	17.50% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
10.6	100	0.1000	0.16		**Sheet Flow,** Woods: Light underbrush n= 0.400 P2= 3.65"
0.6	227	0.1000	6.42		**Shallow Concentrated Flow,** Paved Kv= 20.3 fps
11.2	327	Total			

Summary for Subcatchment DA2: Parking lot east

[49] Hint: Tc<2dt may require smaller dt

Runoff = 0.23 cfs @ 12.10 hrs, Volume= 0.021 af, Depth= 1.53"
Routed to Pond SP2 : Beach

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 yr Rainfall=8.62"

	Area (sf)	CN	Description
*	7,221	40	Permeable pavers, HSG A
	7,221	40	100.00% Pervious Area

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

Summary for Pond 100: Diversion structure

[57] Hint: Peaked at 86.71' (Flood elevation advised)

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 2.52" for 100 yr event
Inflow = 9.82 cfs @ 12.58 hrs, Volume= 1.438 af
Outflow = 9.82 cfs @ 12.58 hrs, Volume= 1.438 af, Atten= 0%, Lag= 0.0 min
Primary = 1.04 cfs @ 12.58 hrs, Volume= 0.489 af
Routed to Pond BIO1 : Bioretention 1
Secondary = 8.78 cfs @ 12.58 hrs, Volume= 0.949 af
Routed to Pond RB1 : Perf Pipe/RB

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 86.71' @ 12.58 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	84.50'	**6.0" Round To Bio** L= 10.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 84.50' / 84.00' S= 0.0500 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 0.20 sf
#2	Device 3	82.00'	**18.0" Round To overflow** L= 60.0' CMP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 82.00' / 78.00' S= 0.0667 '/' Cc= 0.900 n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf
#3	Secondary	85.00'	**4.0' long x 0.5' breadth Weir in structure** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=1.04 cfs @ 12.58 hrs HW=86.70' (Free Discharge)
└**1=To Bio** (Inlet Controls 1.04 cfs @ 5.31 fps)

Secondary OutFlow Max=8.76 cfs @ 12.58 hrs HW=86.70' (Free Discharge)
└**3=Weir in structure** (Passes 8.76 cfs of 29.45 cfs potential flow)
└**2=To overflow** (Inlet Controls 8.76 cfs @ 4.96 fps)

Summary for Pond BIO1: Bioretention 1

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 0.86" for 100 yr event
Inflow = 1.04 cfs @ 12.58 hrs, Volume= 0.489 af
Outflow = 1.04 cfs @ 12.63 hrs, Volume= 0.489 af, Atten= 1%, Lag= 2.7 min
Discarded = 0.10 cfs @ 12.63 hrs, Volume= 0.118 af
Primary = 0.94 cfs @ 12.63 hrs, Volume= 0.371 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond D1 : Infiltration Basin 1

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 82.63' @ 12.63 hrs Surf.Area= 1,753 sf Storage= 914 cf

Plug-Flow detention time= 31.6 min calculated for 0.489 af (100% of inflow)
Center-of-Mass det. time= 31.7 min (1,070.8 - 1,039.2)

Volume	Invert	Avail.Storage	Storage Description
#1	82.00'	2,825 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
82.00	1,200	0	0
82.50	1,600	700	700
83.00	2,200	950	1,650
83.50	2,500	1,175	2,825

Device	Routing	Invert	Outlet Devices
#1	Primary	82.50'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#2	Secondary	82.75'	**8.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32
#3	Discarded	82.00'	**2.410 in/hr Exfiltration over Surface area**

Discarded OutFlow Max=0.10 cfs @ 12.63 hrs HW=82.63' (Free Discharge)
↑—**3=Exfiltration** (Exfiltration Controls 0.10 cfs)

Primary OutFlow Max=0.94 cfs @ 12.63 hrs HW=82.63' (Free Discharge)
↑—**1=Orifice/Grate** (Weir Controls 0.94 cfs @ 1.17 fps)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=82.00' (Free Discharge)
↑—**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond D1: Infiltration Basin 1

Inflow Area = 0.459 ac, 0.00% Impervious, Inflow Depth = 0.57" for 100 yr event
Inflow = 0.09 cfs @ 12.42 hrs, Volume= 0.022 af
Outflow = 0.02 cfs @ 17.83 hrs, Volume= 0.022 af, Atten= 82%, Lag= 324.6 min
Discarded = 0.02 cfs @ 17.83 hrs, Volume= 0.022 af
Primary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond RB1 : Perf Pipe/RB
Secondary = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 79.22' @ 17.83 hrs Surf.Area= 688 sf Storage= 379 cf

Plug-Flow detention time= 296.6 min calculated for 0.022 af (100% of inflow)
Center-of-Mass det. time= 296.7 min (1,268.2 - 971.5)

Volume	Invert	Avail.Storage	Storage Description
#1	78.50'	1,038 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.50	350	0	0
79.00	600	238	238
80.00	1,000	800	1,038

Device	Routing	Invert	Outlet Devices
#1	Secondary	79.40'	**12.0' long x 0.5' breadth Broad-Crested Rectangular Weir**
			Head (feet) 0.20 0.40 0.60 0.80 1.00
			Coef. (English) 2.80 2.92 3.08 3.30 3.32
#2	Discarded	78.50'	**1.020 in/hr Exfiltration over Surface area**
#3	Primary	79.25'	**24.0" Horiz. Orifice/Grate** C= 0.600
			Limited to weir flow at low heads

Discarded OutFlow Max=0.02 cfs @ 17.83 hrs HW=79.22' (Free Discharge)
↑—**2=Exfiltration** (Exfiltration Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**3=Orifice/Grate** (Controls 0.00 cfs)

Secondary OutFlow Max=0.00 cfs @ 1.00 hrs HW=78.50' (Free Discharge)
↑—**1=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Pond F1: Forebay

[44] Hint: Outlet device #2 is below defined storage

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 2.52" for 100 yr event
Inflow = 10.31 cfs @ 12.49 hrs, Volume= 1.440 af
Outflow = 9.82 cfs @ 12.58 hrs, Volume= 1.438 af, Atten= 5%, Lag= 5.6 min
Primary = 9.82 cfs @ 12.58 hrs, Volume= 1.438 af
Routed to Pond 100 : Diversion structure

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 102.64' @ 12.58 hrs Surf.Area= 1,122 sf Storage= 1,288 cf

Plug-Flow detention time= 1.7 min calculated for 1.438 af (100% of inflow)
Center-of-Mass det. time= 1.0 min (893.1 - 892.1)

Volume	Invert	Avail.Storage	Storage Description
#1	100.00'	3,460 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
100.00	100	0	0
100.50	180	70	70
101.00	300	120	190
102.00	720	510	700
103.00	1,350	1,035	1,735
104.00	2,100	1,725	3,460

Device	Routing	Invert	Outlet Devices
#1	Primary	100.50'	**24.0" Horiz. Orifice/Grate** C= 0.600
			Limited to weir flow at low heads
#2	Device 1	92.00'	**18.0" Round Culvert**
			L= 54.0' CMP, projecting, no headwall, Ke= 0.900
			Inlet / Outlet Invert= 92.00' / 90.00' S= 0.0370 '/' Cc= 0.900
			n= 0.013 Concrete pipe, bends & connections, Flow Area= 1.77 sf

Primary OutFlow Max=9.80 cfs @ 12.58 hrs HW=102.63' (Free Discharge)
└**1=Orifice/Grate** (Passes 9.80 cfs of 22.07 cfs potential flow)
└**2=Culvert** (Inlet Controls 9.80 cfs @ 5.55 fps)

Summary for Pond I1: Inlet Flume

Inflow Area = 6.851 ac, 10.04% Impervious, Inflow Depth = 2.52" for 100 yr event
Inflow = 10.32 cfs @ 12.49 hrs, Volume= 1.440 af
Outflow = 10.31 cfs @ 12.49 hrs, Volume= 1.440 af, Atten= 0%, Lag= 0.0 min
Primary = 10.31 cfs @ 12.49 hrs, Volume= 1.440 af
Routed to Pond F1 : Forebay

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs
Peak Elev= 103.74' @ 12.49 hrs Surf.Area= 26 sf Storage= 23 cf

Plug-Flow detention time= 0.2 min calculated for 1.440 af (100% of inflow)
Center-of-Mass det. time= 0.1 min (892.1 - 892.1)

Volume	Invert	Avail.Storage	Storage Description
#1	102.50'	30 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
102.50	15	0	0
103.00	15	8	8
104.00	30	23	30

Device	Routing	Invert	Outlet Devices
#1	Primary	103.00'	**5.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Primary OutFlow Max=10.29 cfs @ 12.49 hrs HW=103.74' (Free Discharge)
└**1=Broad-Crested Rectangular Weir** (Weir Controls 10.29 cfs @ 2.78 fps)

Summary for Pond RB1: Perf Pipe/RB

Inflow Area = 7.309 ac, 9.41% Impervious, Inflow Depth = 2.17" for 100 yr event
Inflow = 9.71 cfs @ 12.59 hrs, Volume= 1.320 af
Outflow = 9.70 cfs @ 12.59 hrs, Volume= 1.317 af, Atten= 0%, Lag= 0.2 min
Discarded = 0.18 cfs @ 12.30 hrs, Volume= 0.250 af
Primary = 9.52 cfs @ 12.59 hrs, Volume= 1.066 af
Routed to Pond SP1 : Boat ramp

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs / 2
Peak Elev= 78.90' @ 12.59 hrs Surf.Area= 939 sf Storage= 3,043 cf

Plug-Flow detention time= 45.0 min calculated for 1.317 af (100% of inflow)
Center-of-Mass det. time= 43.3 min (924.5 - 881.2)

Volume	Invert	Avail.Storage	Storage Description
#1	74.50'	1,759 cf	**48.0" Round Pipe Storage** Inside #5 L= 140.0' S= 0.0057 '/'
#2	70.30'	226 cf	**6.00'D x 8.00'H Recharge Basin** Inside #3 308 cf Overall - 6.0" Wall Thickness = 226 cf
#3	69.30'	132 cf	**10.00'D x 9.00'H RB Stone** 707 cf Overall - 308 cf Embedded = 399 cf x 33.0% Voids
#4	78.20'	16 cf	**Custom Stage Data (Prismatic)** Listed below (Recalc)
#5	73.50'	1,092 cf	**6.00'W x 140.00'L x 6.00'H Pipe Stone** 5,040 cf Overall - 1,759 cf Embedded = 3,281 cf x 33.3% Voids
		3,226 cf	Total Available Storage

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
78.20	20	0	0
79.00	20	16	16

Device	Routing	Invert	Outlet Devices
#1	Discarded	69.30'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'
#2	Primary	78.30'	**24.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads

Discarded OutFlow Max=0.18 cfs @ 12.30 hrs HW=78.77' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.18 cfs)

Primary OutFlow Max=9.50 cfs @ 12.59 hrs HW=78.90' (Free Discharge)
↑—**2=Orifice/Grate** (Weir Controls 9.50 cfs @ 2.53 fps)

Summary for Pond SP1: Boat ramp

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 9.468 ac, 11.26% Impervious, Inflow Depth = 1.82" for 100 yr event
Inflow = 11.16 cfs @ 12.51 hrs, Volume= 1.439 af
Primary = 11.16 cfs @ 12.51 hrs, Volume= 1.439 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

Summary for Pond SP2: Beach

[40] Hint: Not Described (Outflow=Inflow)

Inflow Area = 0.166 ac, 0.00% Impervious, Inflow Depth = 1.53" for 100 yr event
Inflow = 0.23 cfs @ 12.10 hrs, Volume= 0.021 af
Primary = 0.23 cfs @ 12.10 hrs, Volume= 0.021 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind method, Time Span= 1.00-72.00 hrs, dt= 0.05 hrs

APPENDIX C – Wetland Resources Summary Memo

Horsley Witten Group
Sustainable Environmental Solutions
90 Route 6A • Unit 1 • Sandwich, MA 02563
508-833-6600 • horsleywitten.com

MEMORANDUM

To: Jordan Mora, APCC

From: Ben Wollman, Wetland Scientist

Date: December 2, 2022

Re: Wetland Resources – Oak Crest Cove Boat Ramp Stormwater Retrofit Site, Sandwich, MA

HW has prepared the following memo and site figures to document the wetland resource areas at the referenced site and to provide regulatory context for future work.

General Site Description

The site is located at the northern extent of Peters Pond at the southern end of Sandwich, MA, adjacent to the Oakcrest Cove Lodge, focused on the recreation center parking lot and tennis court areas, as well as the vegetated woodland area just northwest of the tennis courts.

FEMA Designation

According to the FEMA National Flood Hazard Map (Community Panel No. 25001C0528J, effective July 16, 2014), the site is located outside of any Flood Hazard Areas; however, there is a Zone X area (Other Flood Hazard Areas with 0.2% annual chance of flooding) adjacent to the site, along the edge of the Peters Pond (**Figure 1**).

State-listed Rare Species Habitat and Open Space

According to the most recent version of the *Massachusetts Natural Heritage Atlas* (15th Edition, August 1, 2021), there are no areas of *Estimated Habitat of Rare Wildlife and Certified Vernal Pools* and/or *Priority Habitat of Rare Species* located at the site, as designated by the Massachusetts Natural Heritage and Endangered Species Program (NHESP); however, there is an area of *Priority Habitat of Rare Species* (PH 334) located approximately ¼ mile to the northeast of the site and (**Figure 2**).

Wetland Resource Areas

The site supports freshwater wetland resource areas, as defined under the Massachusetts *Wetlands Protection Act* (M.G.L. Ch. 131 § 40) and the Town of Sandwich Wetland Protection By-law (Chapter 7) and their respective regulations. Horsley Witten Group, Inc. (HW) wetland biologists identified and delineated these resource areas during a site visit on December 2, 2022. Jurisdictional areas identified on or adjacent to the site include Bank; Vegetated Wetland (isolated); Land Under Waterbodies and Waterways (LUW); and the 50-foot No Disturb and 100-foot Buffer Zones to Bank and Vegetated Wetland.

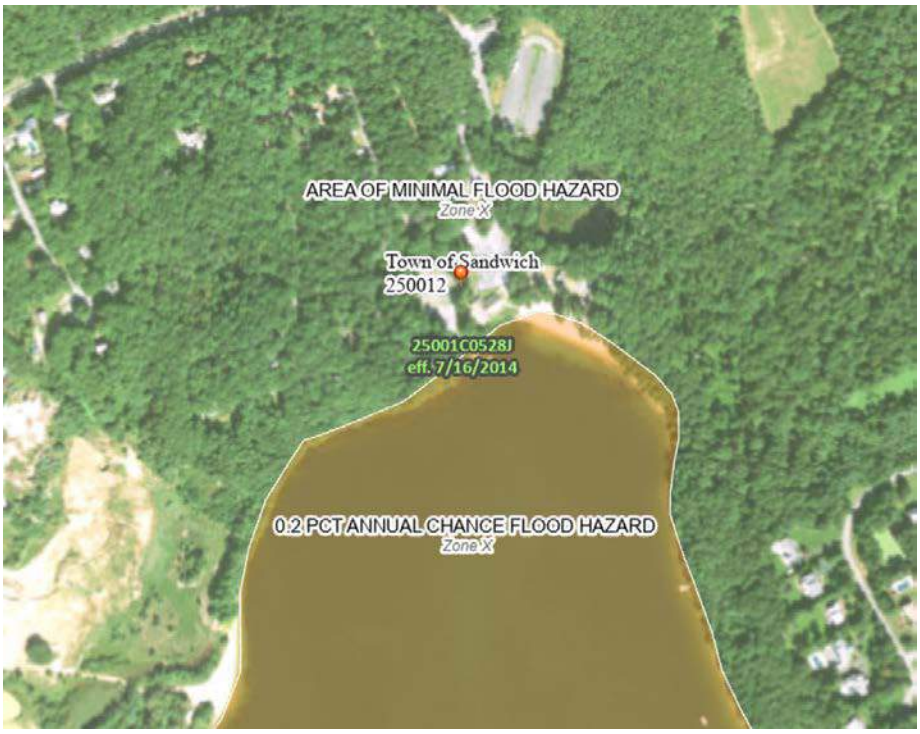


Figure 1. Excerpt from Federal Emergency Management Agency (FEMA) FIRMette for the subject site.

Figure 2. Rare species habitat (Source: MassMapper 2022).

HW followed wetland resource area identification and on-site delineation procedure guidelines described in the Massachusetts Department of Environmental Protection (MassDEP) handbook, entitled *Delineating Bordering Vegetated Wetlands Under the Massachusetts Wetlands Protection Act* (March, 1995), Massachusetts Wetlands Protection Act (M.G.L. Ch. 131 § 40), and its implementing Regulations (310 CMR 10.00), and the Town of Sandwich *Wetland Protection By-law* (Chapter 7) and associated Sandwich Conservation Commission Regulations.

Prior to conducting field delineations, HW reviewed existing source data, including USGS Geological Survey 7.5 minute topographic maps, Massachusetts Department of Environmental Protection (MassDEP) wetlands source data available through the Massachusetts Geographic Information System (MassGIS), USDA Natural Resources Conservation Service (NRCS) soils survey, U.S. Fish and Wildlife Service National Wetland Inventory (NWI) maps, and other source data to identify the presence of jurisdictional wetlands and waters of the United States within the site. This information was used to compile base mapping to assist in the understanding of the hydrologic variables, soils conditions, and vegetation communities (where applicable).

A brief description of the regulatory definitions and the observed resources areas is provided below.

Bank

Bank is defined at 310 CMR 10.54(2)(a) as:

> "…*the portion of land surface which normally abuts and confines a water body. It occurs between a water body and a vegetated bordering wetland and adjacent floodplain, or, in the absence of these, it occurs between a water body and an upland. A Bank may be partially or totally vegetated, or it may be comprised of exposed soil, gravel or stone. The upper boundary of a Bank is first observable break in the slope or the mean annual flood level, whichever is lower. The lower boundary of a Bank is the mean annual low flow level"* [310 CMR 10.54(2)(c)].

Bank is present around the perimeter of Peters Pond (**Photo 1**). HW used a combination of observed variables to determine the mean annual flood level/top of Bank, including water line markings and adventitious roots along the base of the existing woody vegetation growing on the Bank and changes in vegetative cover. Commonly observed vegetation along the Bank includes gray willow (*Salix cinerea*), arrowwood viburnum (*Viburnum dentatum*), multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), and purple loosestrife (*Lythrum salicaria*).

HW delineated the landward boundary of the Bank with a series of consecutively numbered blue flagging stations labeled MAHW 1 – MAHW 10. These flagging stations have been relabeled on the existing conditions plan as BANK, rather than MAHW.

The Sandwich Conservation Commission accepts and adopts defined pond elevations as found under Section 3610, Article III of the Town of Sandwich Zoning Bylaws, as stated in Regulation No. 1 of the Sandwich Conservation Commission Regulations. The pond elevation defined for

Peters Pond under Regulation No. 1 is stated as 71 feet (NGVD). HW uses this elevation, converted to 70.13 feet (NAVD 88), to show the upland edge of Peters Pond, which serves to define the upper boundary for the Bank and the associated 50-foot and 100-foot buffers, as locally regulated by the Town of Sandwich.

Photo 1. Looking northeast from the boat ramp at the Bank along the pond's perimeter.

Vegetated Wetland

The Sandwich Wetland Protection Bylaw (Section 7.10) lists vegetated wetland as a jurisdictional resource area, subject to the provisions of the bylaw and associated regulations. The site supports an isolated Vegetated Wetland area to the east of the recreation center's parking lot (**Photo 2**). The wetland is confined by steep rising slopes along its perimeter, particularly at the western and southern sides, located closest to the project site. The wetland is approximately 1.25 acres in size and sits at the bottom of a deep basin located approximately 250 feet landward of the pond and is characterized as a shrub swamp. Commonly observed vegetation in the shrub swamp wetland includes swamp loosestrife (*Decodon verticillatus*), red maple (*Acer rubrum*), arrowwood viburnum, sweet-pepperbush (*Clethra alnifolia*), highbush blueberry (*Vaccinium corymbosum*), gray willow, steeplebush (*Spiraea tomentosa*), woolgrass (*Scirpus cyperinus*), and soft rush (*Juncus effusus*).

HW delineated the boundary of the Vegetated Wetland with a series of consecutively numbered pink flagging stations labeled IVW 1 – IVW 9.

Photo 2. Looking south along the western edge of the shrub swamp wetland.

Invasive Species

Invasive or Likely Invasive species (as defined by the Massachusetts Invasive Plant Advisory Group) were present at the site. The forested hillside to the north and east of the tennis court area and the slopes adjacent to the driveway leading down to the boat ramp contained a high density of invasive plant species including multiflora rose, Asiatic bittersweet (*Celastrus orbiculatus*), shrub honeysuckle (*Lonicera sp.*), Japanese honeysuckle and border privet (*Ligustrum obtusifolium*). Additionally, the Bank along the pond edge contained significant densities of invasive gray willow. The Massachusetts Invasive Plant Advisory Group identifies invasive plant species as "non-native species that have spread into native or minimally managed plant systems in Massachusetts," and which "cause economic or environmental harm by developing self-sustaining populations and becoming dominant and/or disruptive to those systems." For future planning purposes, the Town may wish to develop a management plan for reducing or eliminating these plants at this site to allow for the establishment of naturally vegetated protective buffers to the wetland resource areas.

If you have any questions regarding our findings, or if HW may be of further assistance, please do not hesitate to contact me directly at bwollman@horsleywitten.com or at (508) 833-6600.

APPENDIX D – Soil Test Pit Logs

Commonwealth of Massachusetts

City/Town of Sandwich

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

C. On-Site Review

Deep Observation Hole Number: 1 (Hole #) | 1/24/23 (Date) | 855A (Time) | 35F Cloudy (Weather) | 41º41'41.33"N (Latitude) | 70º29'25.08"W (Longitude)

1. Land Use: Basketball court (e.g. woodland, agricultural field, vacant lot, etc.) | Pines (Vegetation) | No (Surface Stones (e.g. cobbles, stones, boulders, etc.)) | 3% (Slope (%))

Description of Location: Off east edge of basketball court

2. Soil Parent Material: Sandy and gravelly glaciofluvial | Outwash plains, terraces (Landform) | Backslope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances From:

Open Water Body	200 feet	Drainage Way	feet	Wetlands	feet		
Property Line	50+ feet	Drinking Water Well	feet	Other	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			
0-9	FILL	SL	10YR 3/4						M	Fr	
9-15	Ab	SL	10YR 3/2						M	Fr	
15-24	Bw	SL	10YR 3/3						M	Fr	
24-42	C1	LS	10YR 6/3						SG	Fr	
42-80	C2	G-CS	10YR 5/4				30		SG	Fr	
80-114	C3	MS	10YR 6/6						SG	Fr	

Additional Notes:

Commonwealth of Massachusetts

City/Town of Sandwich

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

C. On-Site Review

Deep Observation Hole Number: 1 (Hole #) | 1/24/23 (Date) | 1005A (Time) | 40F Sun (Weather) | 41º41'41.86"N (Latitude) | 70º29'24.32"W (Longitude)

1. Land Use: Parking lot (e.g. woodland, agricultural field, vacant lot, etc.) | Grass, cedars (Vegetation) | No (Surface Stones (e.g. cobbles, stones, boulders, etc.)) | 15% (Slope (%))

Description of Location: Off west edge of upper parking area

2. Soil Parent Material: Sandy and gravelly glaciofluvial | Outwash plains, terraces (Landform) | Backslope (Position on Landscape (SU, SH, BS, FS, TS))

3. Distances From:

Open Water Body	200+ feet	Drainage Way	feet	Wetlands	feet		
Property Line	50+ feet	Drinking Water Well	feet	Other	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			
0-15	FILL	SL	10YR 5/6						M	Fr	
15-20	Ab	SL	10YR 3/2						M	Fr	
20-24	Bw	SL	10YR 4/6						M	Fr	
24-33	C1	LS	10YR 4/6						SG	Fr	
33-108	C2	MS	10YR 6/4						SG	Fr	

Additional Notes:

APPENDIX E – Operation and Maintenance Guide

Stormwater Operations & Maintenance Guide

Oak Crest Cove Boat Ramp

Table of Contents

APPENDICES

1. INTRODUCTION

This document provides a general description along with the operation and maintenance requirements for the Oak Crest Cove Boat Ramp Stormwater Retrofit project at 34 Quaker Meetinghouse Road. The responsible parties are required to inspect and maintain all measures as outlined in this maintenance guide throughout the year. Site maintenance is divided into three categories as outlined below.

1. Green Stormwater Infrastructure
    - Structural Components
    - Structural Maintenance Schedule
    - Planting
    - Landscape Maintenance Schedule
    - Weed Guide

2. General Site Maintenance
    - Trash & Debris
    - Pet Waste
    - Pavement Sweeping
    - Contributing Drainage Areas
    - Snow Removal
    - De-icing

3. Long-Term Pollution Prevention Measures

2. RESPONSIBLE PARTIES AND BUDGET

The Oak Crest Cove Boat Ramp is located on Town of Sandwich property. The Town will provide staff, volunteers as possible, and funding for the long-term O&M at the site. The estimated average annual O&M budget for the proposed system is shown below:

- **Bioretentions (1):** **$2,000**
  ($2,000/Bio)
- **Porous Pavement (2):** **$3,000**
  ($1,500/cleaning)
- **Drainage Structures (RB 100 & DMH 100)** **$1,000**
  ($500/structure)

Owner contact information is provided below:

Owner: **Town of Sandwich**

Contact: **Department of Public Works**
Paul S. Tilton, Director
500 Route 130
Sandwich, MA 02563
ptilton@sandwichmass.org
508-833-8002

Contact: **Department of Recreation**
Tricia MacDonald, Director
34 Quaker Meetinghouse Road
Forestdale, MA 02644
tmacdonald@sandwichmass.org
508-888-4361

Owner - Signature:_____ Date:_____

Owner - Signature:_____ Date:_____

3. GREEN STORMWATER INFRASTRUCTURE

3.1. How Does Green Infrastructure Work?

Green Stormwater Infrastructure (GSI) is a nature-based approach to stormwater treatment and management. These stormwater practices or "treatment areas" are designed to mimic nature and use the natural filtration properties of soil and plants to remove pollutants from stormwater runoff prior to discharging to the municipal drainage system or waterbodies.

GSI relies on the following basic steps to function properly. Structural components of the practices facilitate the functioning of the steps. If one of these steps, or components, does not work properly, the entire system can be compromised and the GSI practice itself could be contributing to maintenance problems. This can lead to landscape nuisances, more frequent maintenance, and costly repairs/improvement. The steps are:

1. ***Collect*** (Inlets)
2. ***Move Water*** (Conveyance) if needed, can come after capturing sediment
3. ***Capture Sediment*** (Pretreatment)
4. ***Treat and Manage*** (Filter, Infiltrate or Store)
5. ***Overflow*** (Structures and Spillways)

3.2. What is required for Maintenance?

As these are nature-based systems that rely on plant upkeep, the maintenance for GSI typically falls under landscape and general site maintenance services. Proper operation and maintenance (O&M) are vital to its long-term viability. Regularly scheduled maintenance can prevent system failures due to sediment build-up, damage, or deterioration. The maintenance requirements outlined in this guide are critical to ensure proper treatment, maintain storage capacity and preserve the visual integrity.

General maintenance includes the following:

1. Removing sediment from the pretreatment practices used to capture sediment.
2. Maintaining the proper drainage function and pollutant removal capacity of the systems.
3. Maintaining healthy native trees, plants, and vegetative cover as well as the removal of unwanted weeds and invasive species.

It is recommended that all practices be maintained regularly as part of the routine landscape maintenance or at a minimum four times per year and after major rain events:

- **Early Spring**: during spring cleanup
- **Summer:** during lawn mowing and other routine site maintenance
- **Early Fall:** when leaves begin to fall
- **Late Fall/Early Winter:** after all the leaves have fallen during leaf removal
- **After major storm events**: 2" of rain or greater.

The following sections describe the general function and landscape maintenance of each practice on the site. Included in the appendices is a specific Inspection Report for the site (**Appendix A**) along with a plan showing the location of the items to be inspected and maintained (**Appendix B**).

3.3. What practices are used at this site?

The following practices are present at this site:

a. Bioretention Areas: A bioretention area is a stormwater management practice to manage and treat stormwater runoff using a conditioned planting soil bed or "filter" media and plants to filter runoff captured in a shallow depression. The method combines physical filtering and adsorption with bio-geochemical processes to remove pollutants.

b. Infiltration Basin: Infiltration basins are surface practices that are designed to capture, temporarily store, and infiltrate stormwater, allowing it to infiltrate into the underlying native soil.

c. Underground Infiltration: Recharge basins and perforated pipes are used for temporary underground storage of stormwater, allowing it to infiltrate into the underlying native soil.

d. Porous Pavement: Porous pavements are designed to capture and infiltrate runoff. The areas of porous pavement have been placed to ensure they do not collect runoff from the traditional impervious pavement, as this can clog the pervious pavement. Regular maintenance is critical to the success of this practice.

The maintenance for the green infrastructure is divided into two categories:

a. The **Structural Components** that make up the basic steps of a functioning system.

b. The **Plantings** that are the landscape and filtration element.

Each category is further described in the sections below.

4. STRUCTURAL COMPONENTS: BIORETENTION AREAS

Structural Components

1. ***Collect***: Stormwater runoff is directed to paved flume inlet where stormwater enters the sediment forebay.

2. ***Capture Sediment***: Sand and debris settle out within the sediment forebay.

3. ***Move Water:*** The stormwater discharges to the bioretention area via an overflow structure in the sediment forebay and a diversion structure upgradient of the bioretention area.

4. ***Treat and Manage***: Stormwater overtops the forebay overflow structure, flows through the diversion structure, and into the planted bioretention area. Plants slow the water down, and the soil media and plant roots filter the runoff, removing nutrients and bacteria. The treated water then infiltrates into the soil below or overflows as described below.

5. ***Overflow***: During rain events larger than 1 inch, much of the runoff will overtop the weir in the diversion structure, bypass the bioretention area, and connect into the underground infiltration components. Additionally, in the bioretention area, runoff greater than the water quality volume will overflow either into the outlet structure to the underground infiltration components or in extreme events, flow over the emergency spillway.

MAINTENANCE SCHEDULE: BIORETENTION AREAS

A site inspection of the bioretention components shall be conducted at least twice a year in the Spring and Fall, and after major storm events (2" of rain or greater). Debris and trash should be removed monthly (between April and November) and sediment removal should occur during the two site inspections and during the monthly debris and trash inspections as needed. See the calendar below and the Inspection Report in **Appendix A** for more information.

Bioretention General Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Site Inspection				**X**							**X**	
Debris & Trash Removal				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Sediment Removal				**X**	x	x	x	x	x	x	**X**	

should **also** be completed after major storm events

X required inspection

x as needed

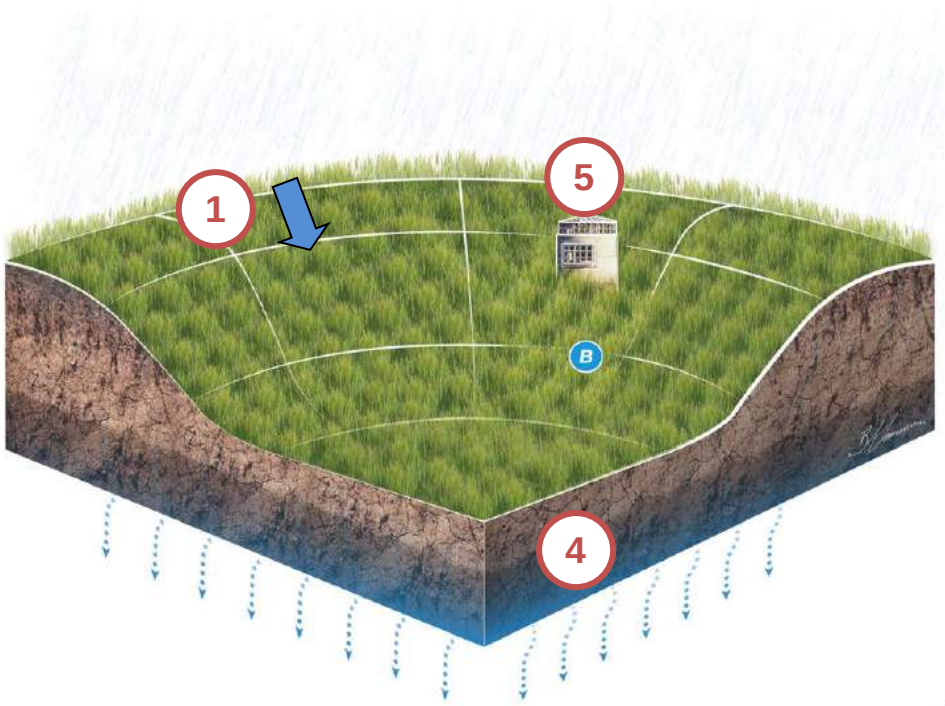
- When removing trash and debris during monthly inspections look for:
  - If sediment is > 3" in paver lined sediment forebays. Ensure sediment does not cause blockage of inlet weirs. If it is, remove sediment.
  - If standing water does not drain after 48 hours. See Inspection Report for action items.

- After rain event look for:
  - If standing water does not drain after 48 hours. See Inspection Report for action items.

Use a shovel to clear stone and sediment from the inlets.

See Plantings section for information on plantings maintenance of the bioretention area. Use the plantings maintenance calendar to combine maintenance efforts.

5. STRUCTURAL COMPONENTS: INFILTRATION BASIN



1. ***Collect***: Stormwater runoff is collected via overland flow from the wooded area.
2. ***Capture Sediment***: No forebay is needed since no impervious area runoff is directed to the basin unless prior pretreatment (by the bioretention system) has occurred.
3. ***Move Water:*** NA
4. ***Infiltrate***: Stormwater is infiltrated into the subsoils.
5. ***Overflow***: During larger rain events, the stormwater will fill up the basin and overflow into the underground infiltration system.
6. During larger rain events, the runoff will flow over the emergency spillway directed towards the courts.

MAINTENANCE SCHEDULE: INFILTRATION BASIN

A site inspection of the infiltration basin components shall be conducted at least twice a year in the Spring and Fall, and after major storm events (2" of rain or greater). Debris and trash should be removed monthly (between April and November) and sediment removal should occur during the two site inspections and during the monthly debris and trash inspections as needed. See the calendar below and the Inspection Report in **Appendix A** for more information.

Bioretention General Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Site Inspection				**X**							**X**	
Debris & Trash Removal				**X**	**X**	**X**	**X**	**X**	**X**	**X**	**X**	
Sediment Removal				**X**	x	x	x	x	x	x	**X**	

should **also** be completed after major storm events

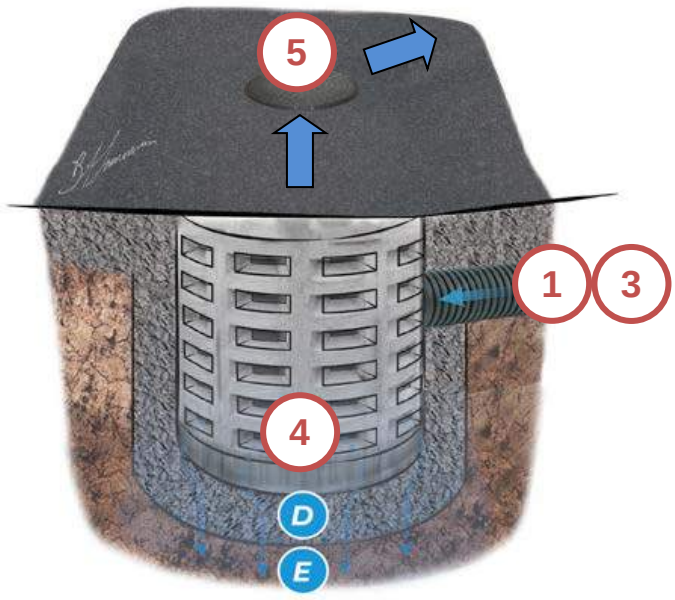
X required inspection

x as needed

- After rain event look for:
  - If standing water does not drain after 48 hours. See Inspection Report for action items.

See Plantings section for information on plantings maintenance of the infiltration basin. Use the plantings maintenance calendar to combine maintenance efforts.

6. STRUCTURAL COMPONENTS: UNDERGROUND INFILTRATION



Structural Components

1. ***Collect***: Stormwater runoff is collected in the perforated pipe via the upgradient drainage infrastructure (diversion structure, overflow structure, drain pipe).

2. ***Capture Sediment***: No sediment removal component is needed here since pretreatment is already provided by a sediment forebay and bioretention system before runoff is directed to the underground infiltration features (perforated pipe and recharge basin).

3. ***Move Water:*** The stormwater will flow through a perforated pipe and into the recharge basin.

4. ***Infiltrate***: Stormwater is infiltrated through the perforations in the pipe and recharge basin structure, as well as the surrounding stone.

5. ***Overflow***: During larger rain events, the stormwater will fill up the pipe and recharge basin and overflow out of the grate. Stormwater will continue down the boat ramp and into Peter's Pond.

MAINTENANCE SCHEDULE: UNDERGROUND INFILTRATION

A site inspection of the underground infiltration shall be conducted at least twice a year in the Spring and Fall, and after major storm events (2" of rain or greater). See the calendar below.

Pervious Pavement and Pavers General Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Site Inspection				**X**				**X**				
Debris & Trash Removal				**X**	x	x	x	x	x	x	**X**	
Sediment Removal				**X**	x	x	x	x	x	x	**X**	

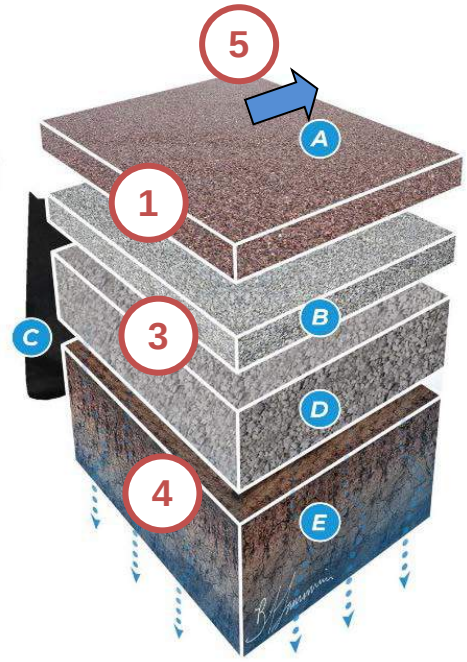
should **also** be completed after major storm events

X required inspection

x as needed

- When removing trash and debris during monthly inspections and after rain events look for standing water. If it does not drain after 48 hours. See Inspection Report for action items.

7. STRUCTURAL COMPONENTS: POROUS PAVEMENT



A Porous Pavement
B Choker Course
C Filter Fabric *(Sidewalls Only)*
D Filter Course
E Approved Subsoil

Structural Components

1. ***Collect***: Stormwater runoff is absorbed directly into the pervious surface when it rains.
2. ***Capture Sediment***: Porous pavements are designed for minimal run-on from permeable surfaces (like lawn areas) and no runoff from impervious pavement, so sediment should be minimal. Sediment trapped on the surface of the porous pavement should be vacuumed before the surface course clogs.
3. ***Move Water:*** The stormwater filters through the surface material and choker courses.
4. ***Treat and Manage***: The stormwater is treated as it flows through the filter course into the underlying native soils.
5. ***Overflow***: During larger rain events, once the porous pavement and gravel below are saturated, additional runoff will flow to the existing catch basin systems that discharge to Peter's Pond via the boat ramp and beach.

MAINTENANCE SCHEDULE: POROUS PAVEMENT

A site inspection of the porous pavement shall be conducted at least twice a year in the Spring and Fall, and after major storm events (2" of rain or greater). See the calendar below.

Pervious Pavement and Pavers General Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**July**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Site Inspection				**X**				**X**				
Debris & Trash Removal				**X**	x	x	x	x	x	x	**X**	
Sediment Removal	x	x	x	**X**	x	x	x	x	x	x	**X**	x

should **also** be completed after major storm events

X required inspection

x as needed

Frequent cleaning and maintenance are critical to prevent clogging of porous surfaces. To keep the surface clean, sweep the porous pavement using vacuum sweepers at least twice a year.

No sanding or de-icing is permitted. Full porous pavement replacement will be conducted every 10-20 years or as determined necessary due to field conditions.

8. PLANTINGS

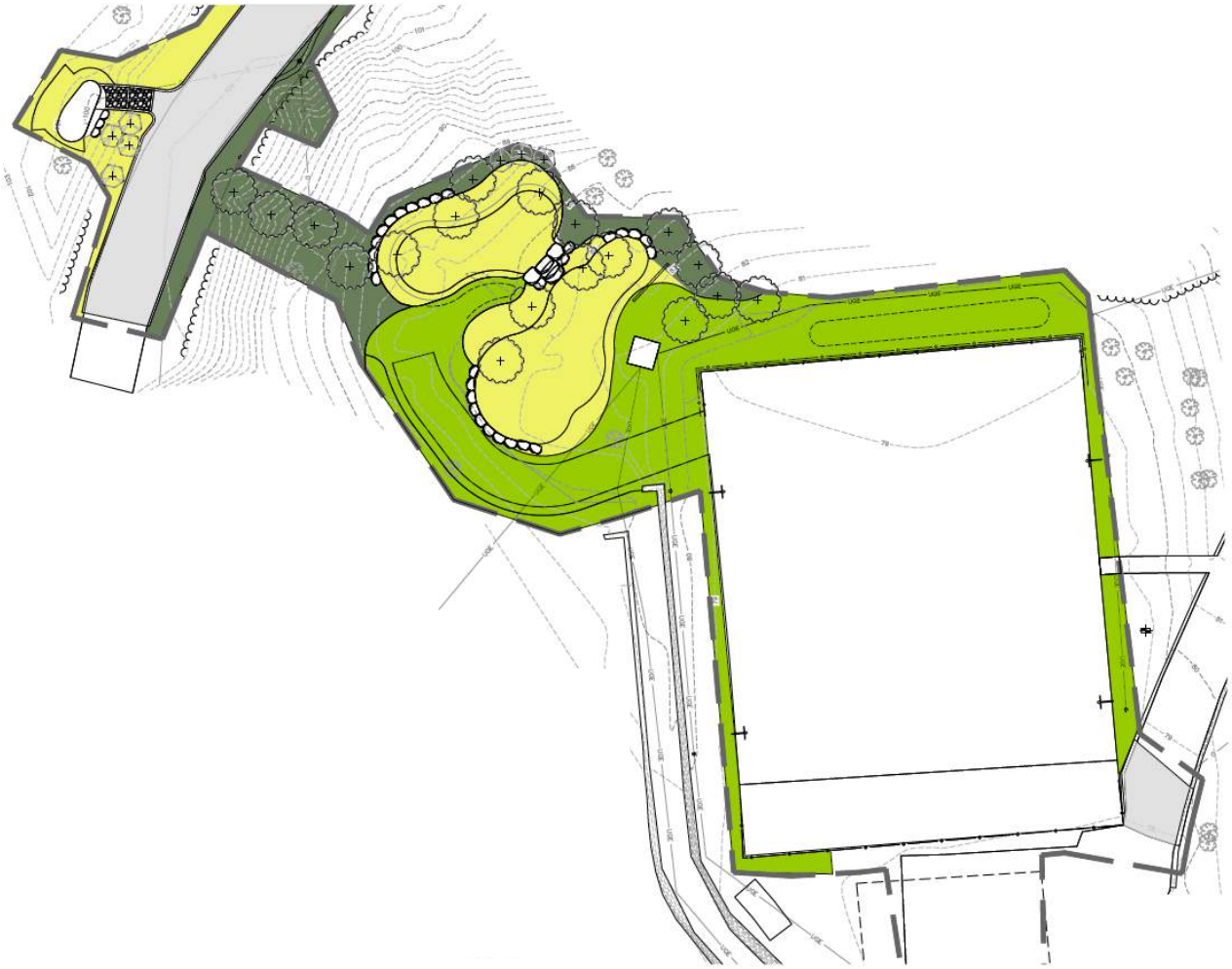
8.1. Plantings

The planting design for the site consists of three landscape maintenance areas. The “mow” area (consisting of turf that can be cut regularly with a mower or trimmer), the “no mow” areas (which can be cut back with shears one time per year or less), and natural areas (no cutting unless for invasives). The plantings maintenance checklist is included in **Appendix A**, and the full planting plan is available in **Appendix D**.

“Mow” Areas

No “Mow” Area

Natural Areas



PLANTINGS: "MOW" AREAS MAINTENANCE

There is an area of the site that is allowed to be maintained as "mowed" lawn as necessary. Landscape maintenance of "mowed" lawn areas includes the following:

Seeding

Loam and reseed bare spots with a seed mix that matches existing species.

Mowing/Weed Whacking

Cut only 1/3 of vegetation. Do not mow during drought periods or when excessively wet. Depending on height of grasses and the time of year, grass cuttings/stalks may need to be raked and removed from site.

Watering

Allowing the lawn areas to "brown" is desired. Water only during drought conditions or during reseeding establishment period.

Fertilizing

No fertilizer shall be used.

Weeding

Weeding should be limited to invasive and weedy species (see section 3.6 Weed Identification below and the Weed Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf). Non-chemical methods (hand pulling and hoeing) are required; chemical herbicides should be avoided. Properly remove and dispose of all invasive species off site as to prevent colonization elsewhere, this includes disposal on land beyond the project area.

Monitoring

During the establishment period, walk the mow areas monthly during the first year to look for invasive species, bare spots and identify potential pest or disease problems. Properly remove and dispose of all invasive species as to prevent colonization elsewhere, this includes disposal on land beyond the project area.

Debris & Trash

Remove and properly dispose litter from all areas prior to mowing.

PLANTINGS: NO "MOW" AREA MAINTENANCE (BIORETENTION AREAS)

By design, plants in bioretention areas are meant to flourish throughout the growing season leaving dry standing stalks during the dormant months. Plants do not require fertilizers or watering (except during drought or establishment period). This area, as well as the area surrounding the forebay, is designated as "no mow." Frequent mowing would eliminate selected meadow species, may promote the growth of undesirable plants, and require additional maintenance and watering. It is recommended this area be cut back no more than one time per year and only as necessary. Remove and replace vegetation as necessary, using the appropriate species as shown on the Planting Plan. The best time to plant is in early to mid-fall or early to mid-spring. Specific maintenance activities of the "no mow" area include:

Seeding

Loam and reseed bare spots with the specified seed mix as shown on the Planting Plan.

Cutting Back

Recommend cutting with shears a maximum of once a year in early spring. Otherwise, allow areas to grow to their natural heights (12" to 36") to maintain a meadow appearance. Do NOT cut area lower than 6" – maintain sporadic wooden stakes on site at 6" height to provide visual cues during cutting. Depending on height of grasses and the time of year, grass cuttings/stalks may need to be raked and removed from site so as not to clog the bioretention. Use a leaf blower as needed to assist in clean-up.

Pruning

Prune trees and shrubs to remove deadwood and low hanging branches.

Watering

Water only during drought conditions or during reseeding establishment period.

Fertilizing

No fertilizer shall be used.

Weeding

Weeding should be limited to invasive and weedy species (see section on Weed Identification below and the Weed Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf). Non-chemical methods (hand pulling and hoeing) are required; chemical herbicides should be avoided. Properly remove and dispose off site all invasive species as to prevent colonization elsewhere; this includes disposal on land beyond the project area.

Monitoring

During the establishment period, walk the "no mow" areas monthly without the intent to cut, but to look for invasive species, bare spots and identify potential pest or disease problems.

Debris & Trash

Remove and properly dispose of litter from all areas.

PLANTINGS: NATURAL AREAS MAINTENANCE

This area is intended to be kept as natural area and is not to be disturbed. Maintenance of natural areas includes the following:

Monitoring

Walk the areas to look for potential invasive species and identify potential disease.

Weeding

Weeding should be limited to invasive and weedy species (see section 3.6 Weed Identification below and the Weed Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf). Non-chemical methods (hand pulling and hoeing) are required; chemical herbicides should be avoided. Properly remove and dispose of all invasive species as to prevent colonization elsewhere; this includes disposal on land beyond the project area.

Watering

Water only during drought conditions or during the plant establishment period.

Debris & Trash

Remove and properly dispose litter from all natural areas.

PLANTINGS: REPLACEMENTS

The plants that thrive in bioretention areas are typically quite drought tolerant due to the filter profile having a top layer of planting soil and sandy soil media below. They need to be able to withstand periods of inundation after storm events; however, when it doesn't rain, there will be less water held naturally in the sand than in other soil types for the plants to use, so they need to tolerate dry periods as well.

Specifying plants native to the area increases the ecosystem benefits by helping to support native wildlife like pollinators.

If replacements are needed, use the planting plan as a guide (see **Appendix D**). However, if all the plants of a certain species have not done well in the bioretention area or other locations on the site, do not replace with that same species. Rather, replant with one or more of the other species that has thrived under the conditions or have a plant professional choose a different species based on current photos of the site.

Site specific considerations for plants in bioretention areas should be:

- Preferably native
- Drought tolerant
- Tolerant of inundation for 24 hours
- Size constraints:
    - taller perennials at the bottom of the bioretention
    - shorter perennials on the side slopes
- Shade tolerant
- Culturally important
- A mix of different types of plants that will create a resilient plant community: cold & warm season grasses, perennials, groundcovers in all areas.

PLANTINGS: MAINTENANCE SCHEDULE

By design, plants in the bioretention area are meant to help filter the stormwater as it passes through and flourish throughout the growing season. The plants do not require fertilizers or mulch, and, after establishment, only need water during periods of drought. Remove and replace vegetation as necessary, using the appropriate species as discussed in the no-mow section above. Weeding and monitoring for invasive species should occur quarterly during the growing season. An annual spring "clean up" includes cutting last season's growth of the perennials and pruning as needed. See the calendar below, the Plantings Maintenance Checklist in **Appendix A**, the Weed Identification section, and the Weed Identification Guide at https://web.uri.edu/riss/files/In-the-Weeds.pdf for more information.

Bioretention Landscape Maintenance Schedule												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Task	**Frequency & Time of the Year**											
Cutting				**X**								
Mowing				x	**X**	x	x	x	x	**X**	x	x
Weeding				**X**		**X**			**X**			**X**
Monitoring				**X**		**X**			**X**			**X**
Watering						x	x	x	x			
Seeding				x	x				x	x		
Plant Replacement				x	x				x	x		

"Mow" Areas
No "Mow" Areas
All areas

X required
x as needed

- Trash and debris are removed during monthly structural component inspections but can also be completed during landscape maintenance visits for weeding and monitoring.

Yellow Toadflax *(Linaris vulgaris)*

Redroot Pigweed- (*Amaranthus retroflexus)*

Smartweed *(Polygonum lapathifolium)*

Dandelion *(Taraxacum officinale)*

Fireweed *(Erechtites hieracifolia)*

Spotted Spurge (Euphorbia maculata)

Crabgrass *(Digitaria ischaemum)*

Crabgrass with seedheads

Ragweed (*Ambrosia artemisiifolia*)

Japanese Knotweed (Polygonum cuspidatum)

Ragweed (*Ambrosia artemisiifolia*)

Oriental Bittersweet (*Celastrus orbiculatus*)

Green Foxtail (Setaria viridis)

Norway Maple Tree Seedling (Acer platanoides)

Catalpa Tree Seedling (Catalpa speciosa)

Purple Loosestrife (*Lythrum salicaria*)

Field Bindweed (*Convolvulus arvensis*)

Black Swallow-wort (*Cynanchum louisea*)

9. GENERAL SITE MAINTENANCE

General site maintenance includes the following requirements:

Trash & Debris

Remove and properly dispose of all trash and debris.

Pet Waste

Visitors to the site are encouraged to pick up after their pets. Remove and properly dispose of all pet waste left behind. Pet waste should be picked up and disposed of properly to reduce bacteria and nutrient levels in stormwater.

Pavement Sweeping

Paved roadways should be mechanically swept, at a minimum of once per year in early spring, to remove accumulated sand and sediment debris. Porous pavement should be swept using a vacuum sweeper at least twice a year.

Snow Removal

Due to the potential for plant damage, snow piling and or removal is NOT recommended in the bioretention areas. Additionally, to prevent clogging of the porous pavement snow piling is NOT permitted on the porous pavement areas.

De-Icing

When de-icing compounds are necessary for areas draining to the green stormwater infrastructure, the least harmful chemicals should be used. Excessive salting should be avoided. Use of large amounts of sand should also be avoided, since it may obstruct the conveyance system. Ice removal is NOT permitted in the bioretention areas. For the porous pavement areas, avoid sanding or excessive salting.

10. LONG-TERM POLLUTION PREVENTION MEASURES

Long-term pollution prevention measures implemented at the site reduce pollutants in stormwater discharges. The following precautions will be employed on an on-going basis.

Spill Prevention & Control Measures

To minimize the risk of spills or other accidental exposure of materials and substances to stormwater runoff, the following material management is to be used when working on site.

- Any materials stored on-site will be stored in a neat, orderly manner in their appropriate containers.
- Products will be kept in their original containers with the original manufacturer's label.
- Substances will not be mixed with one another unless recommended by the manufacturer.
- Manufacturers' recommendations for proper use and disposal will be followed.
- The contractor's supervisor will be issued this Guide to ensure proper use and disposal of materials.

Materials or substances listed below may be present on-site for maintenance and care should be taken to avoid spills:

  - Petroleum Based Products

The following product-specific measures will be followed on-site:

- *Petroleum Products* - All on-site vehicles will be monitored for leaks and receive preventative maintenance to reduce the chance of leakage.
- *Grass Clipping, Leaf Litter and Plant Debris* – are to be removed from the property and not disposed on site.

APPENDIX A – Maintenance Checklists

- Bioretention Areas
- Infiltration Basin
- Underground Infiltration
- Porous Pavement
- Landscaping

Operation and Maintenance Checklist
Oak Crest Cove Boat Ramp

Date:

Time:

Inspector:

Maintenance Item	Description	Maintenance (Y/N)
1, 2 & 3. Inlet Flume, Sediment Forebay, and Forebay Overflow Structure		
Debris Cleanout	Remove all trash, leaf litter and debris from the inlet flume, forebay, and forebay overflow structure.	
Sediment/Organic Debris Removal	Check for clogging and sediment accumulation that impacts inflow and outflow. Remove and properly dispose of when sediment is >3" in the forebay. Remove/cut any vegetation that sprouts through voids in stone, pavement, or pavers.	
Erosion	Check for areas of erosion (gullies, animal burrowing, or overtopping). Repair as necessary and return to design grades.	
Actions to be taken:		
4. Bioretention Areas, Infiltration Basin, Perforated Pipe, Recharge Basin		
Debris Cleanout	Remove trash and debris from the surface.	
Erosion	Signs of erosion gullies, animal burrowing, or overtopping are observed. Repair as necessary.	
Sediment/Organic Debris Removal	Remove sediment accumulation and properly dispose when accumulation is greater than or equal to 3 inches.*	
Water Draining properly	If standing water is observed in bioretention areas or infiltration basin for more than 48 hours after a storm event, rototill or aerate the bottom 6 inches to break up any hard-packed sediment, and re-plant as needed. Check for leaf litter, debris, and sediment accumulation in overflow outlet structures that impact inflow to underground infiltration features. If accumulation present, schedule cleaning. Check for sediment accumulation and/or standing water that indicates clogging in the recharge basin and perforated pipe. If sediment or standing water is observed in the recharge basin for more than 48 hours after a storm event, clean out perforated pipe and recharge basin.	
Actions to be taken:		

Operation and Maintenance Checklist
Oak Crest Cove Boat Ramp

Maintenance Item	Description	Maintenance (Y/N)
5. Overflow Structures: Overflow Structures, Diversion Structure		
Debris Cleanout	Remove all trash, leaf litter and debris from the overflow structure.	
Sediment/Organic Debris Removal	Check for clogging and sediment accumulation that impacts inflow and outflow.	
Actions to be taken:		
Porous Pavement		
Debris Removal	Remove trash from paved and perimeter areas. Sweep surface.	
Vacuum	Vacuum surface to clean pores of debris and sediment with a commercial vacuum system.	
Structure	Repair cracking or other structural issues as found during inspection.	
Actions to be taken:		
General Site Maintenance		
Debris Removal	Remove trash from perimeter areas.	
Pet Waste Removal	Remove any pet waste from perimeter areas.	
Pavement Sweeping	Sweep road minimum once a year after spring thaw.	
Contributing drainage area	Confirm that contributing drainage area stabilized – stabilize as necessary.	
Snow Removal	Ensure snow piles do no block inlet structures and are not placed in the bioretention, infiltration basin, or on the porous pavement surfaces.	
De-Icing	Do not remove ice in the bioretention areas or infiltration basin. If needed on the porous pavement surfaces, use de-icing compounds with the least harmful chemicals. Avoid sanding the porous pavement or excessive salting.	
Actions to be taken:		

*Sediment shall be disposed of offsite in a pre-approved location.

Plantings Maintenance Checklist
Oak Crest Cove Boat Ramp

Location:

Date:

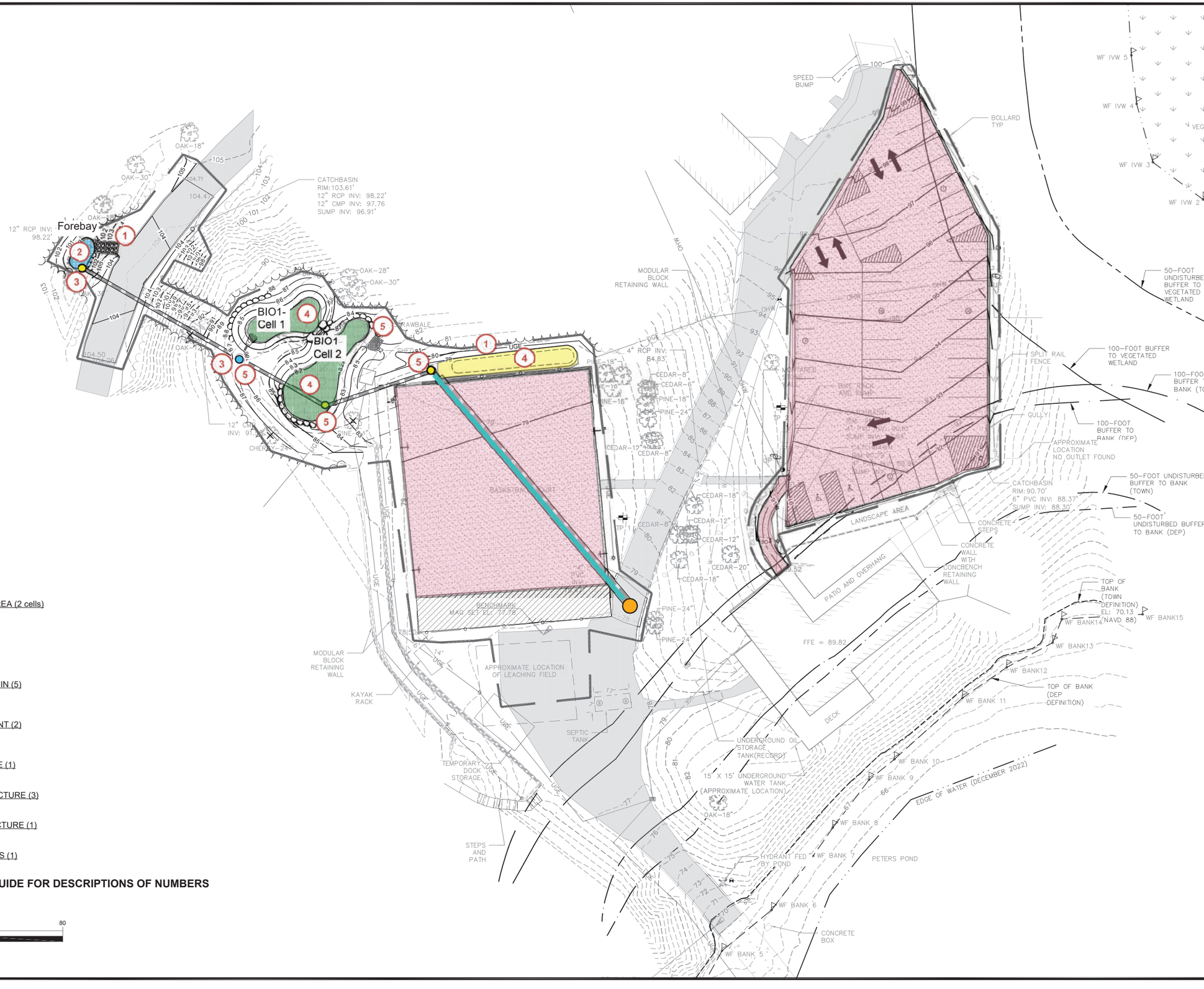
Inspector:

Task	Description	Complete (Y/N)
Cutting	• Cut with shears once a year in the early spring. • Do not cut lower than 6". • Blow out leaves and cuttings for easy removal. • Remove cuttings so the bioretention area does not clog.	
Mowing	• Mow twice a year or more frequently as needed with a mulching mower or weed whacker depending on the frequency of cutting. • Bag clippings as needed and dispose of off site. • Maintain a cutting height of 3" or greater. • Leave the grass taller in the warmer months. • Trim edges when necessary.	
Weeding	• Weeding should be limited to invasive and exotic species, which can overwhelm the desired plant community.* • Non-chemical methods including hand pulling and hoeing are recommended. • Chemical herbicides are not allowed.	
Monitoring	• Look for potential invasive species and identify potential disease. Remove and dispose of all invasive species.* (see weeding)	
Watering	• During establishment or drought conditions, plants should be watered a minimum of once every seven to ten days.	
Seeding	• Loam and re-seed bare spots with the specified seed mix as shown on the Planting Plan.	
Plant Replacement	• Replace/replant diseases, unhealthy or dead plans to maintain a healthy plant community	
Fertilizing	NONE	
Mulch	NONE	
Actions to be taken:		

*Invasive species shall be disposed of offsite in a pre-approved location. Species observed on site include multiflora rose, Asiatic bittersweet (*Celastrus orbiculatus*), shrub honeysuckle (*Lonicera sp.*), Japanese honeysuckle and border privet (*Ligustrum obtusifolium*).

"Mowed" Areas
No "Mow" Areas (Bioretention Areas)
All areas

APPENDIX B – Overall SCM Locations



LEGEND

- BIORETENTION AREA (2 cells)
- FOREBAY (1)
- INFILTRATION BASIN (5)
- POROUS PAVEMENT (2)
- PERFORATED PIPE (1)
- OVERFLOW STRUCTURE (3)
- DIVERSION STRUCTURE (1)
- RECHARGE BASINS (1)

***SEE STORMWATER O&M GUIDE FOR DESCRIPTIONS OF NUMBERS**

GRAPHIC SCALE

20 0 10 20 40 80

(in feet)

1 INCH = 20 FEET

Revisions

Rev.	Date	By	Appr.	Description
1				
2				
3				
4				
5				
6				
7				

Horsley Witten Group, Inc.
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Designed By: JLV | Drawn By: JLV | Checked By: MW

Date: SEPTEMBER 2023

Plan Set: CAPE COD BOAT RAMP STORMWATER RETROFIT PROJECT- PERMITTING PLANS

SANDWICH, MA

Plan Title: OVERALL SCM LOCATIONS

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Dated: MONTH 2010

Registration:

DRAFT NOT FOR CONSTRUCTION

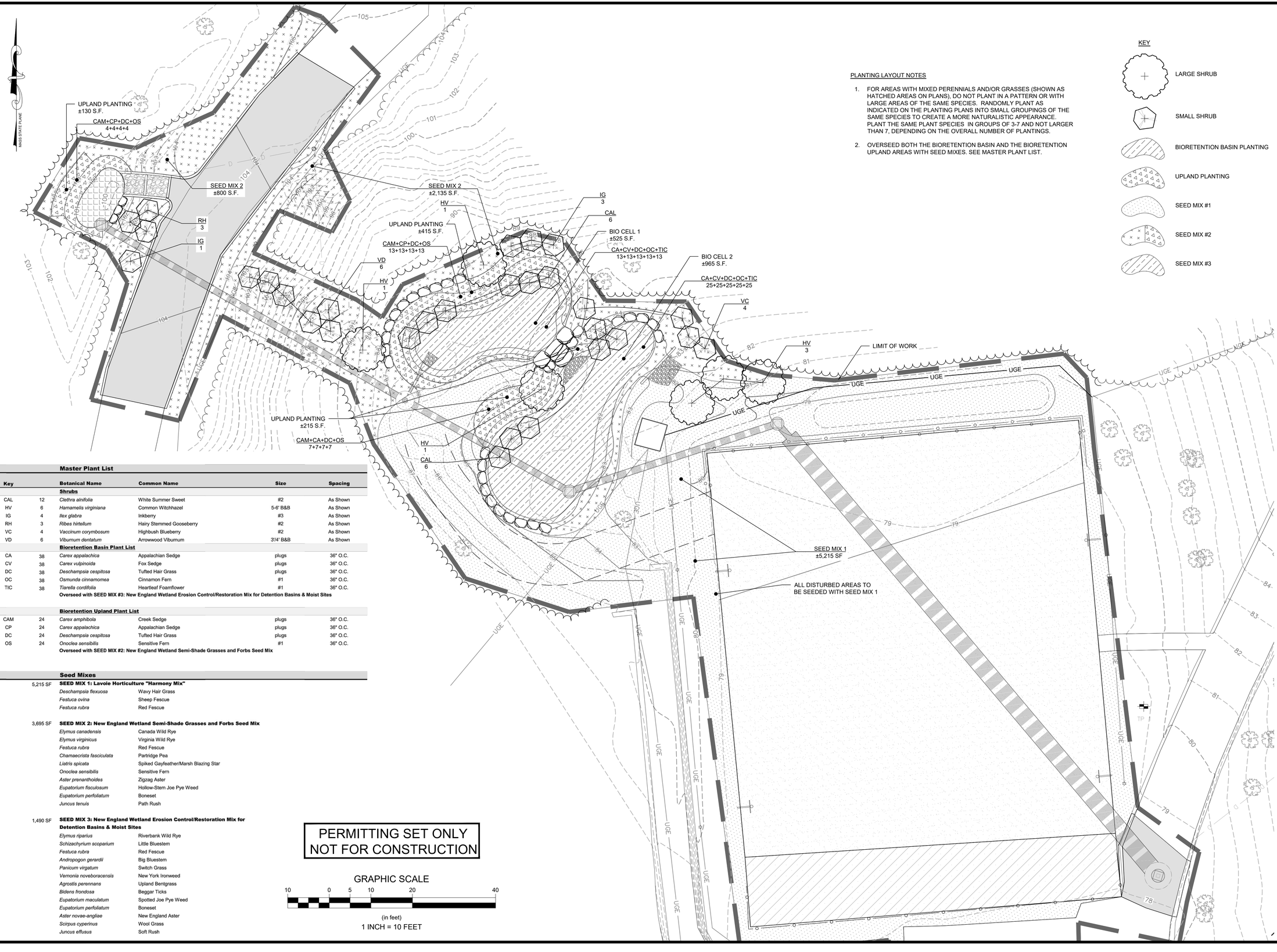
Project Number: 22032

Sheet : 4 of 8

Sheet Number: C - 4

last modified: 10/27/23 printed: 10/27/23 by jv H:\Projects\2022\22032 CC Boat Ramp SW Retrofits\Drawings\OAKCREST ST.dwg

APPENDIX C – Planting Plan



PLANTING LAYOUT NOTES

1. FOR AREAS WITH MIXED PERENNIALS AND/OR GRASSES (SHOWN AS HATCHED AREAS ON PLANS), DO NOT PLANT IN A PATTERN OR WITH LARGE AREAS OF THE SAME SPECIES. RANDOMLY PLANT AS INDICATED ON THE PLANTING PLANS INTO SMALL GROUPINGS OF THE SAME SPECIES TO CREATE A MORE NATURALISTIC APPEARANCE. PLANT THE SAME PLANT SPECIES IN GROUPS OF 3-7 AND NOT LARGER THAN 7, DEPENDING ON THE OVERALL NUMBER OF PLANTINGS.
2. OVERSEED BOTH THE BIORETENTION BASIN AND THE BIORETENTION UPLAND AREAS WITH SEED MIXES. SEE MASTER PLANT LIST.

KEY

- LARGE SHRUB
- SMALL SHRUB
- BIORETENTION BASIN PLANTING
- UPLAND PLANTING
- SEED MIX #1
- SEED MIX #2
- SEED MIX #3

Master Plant List

Key		Botanical Name	Common Name	Size	Spacing
		Shrubs			
CAL	12	*Clethra alnifolia*	White Summer Sweet	#2	As Shown
HV	6	*Hamamelis virginiana*	Common Witchhazel	5-6' B&B	As Shown
IG	4	*Ilex glabra*	Inkberry	#3	As Shown
RH	3	*Ribes hirtellum*	Hairy Stemmed Gooseberry	#2	As Shown
VC	4	*Vaccinum corymbosum*	Highbush Blueberry	#2	As Shown
VD	6	*Viburnum dentatum*	Arrowwood Viburnum	3'/4' B&B	As Shown
		Bioretention Basin Plant List			
CA	38	*Carex appalachica*	Appalachian Sedge	plugs	36" O.C.
CV	38	*Carex vulpinoida*	Fox Sedge	plugs	36" O.C.
DC	38	*Deschampsia cespitosa*	Tufted Hair Grass	plugs	36" O.C.
OC	38	*Osmunda cinnamomea*	Cinnamon Fern	#1	36" O.C.
TIC	38	*Tiarella cordifolia*	Heartleaf Foamflower	#1	36" O.C.
		Overseed with SEED MIX #3: New England Wetland Erosion Control/Restoration Mix for Detention Basins & Moist Sites			
		Bioretention Upland Plant List			
CAM	24	*Carex amphibola*	Creek Sedge	plugs	36" O.C.
CP	24	*Carex appalachica*	Appalachian Sedge	plugs	36" O.C.
DC	24	*Deschampsia cespitosa*	Tufted Hair Grass	plugs	36" O.C.
OS	24	*Onoclea sensibilis*	Sensitive Fern	#1	36" O.C.
		Overseed with SEED MIX #2: New England Wetland Semi-Shade Grasses and Forbs Seed Mix			

Seed Mixes

5,215 SF	**SEED MIX 1: Lavole Horticulture "Harmony Mix"**	
	Deschampsia flexuosa	Wavy Hair Grass
	Festuca ovina	Sheep Fescue
	Festuca rubra	Red Fescue
3,695 SF	**SEED MIX 2: New England Wetland Semi-Shade Grasses and Forbs Seed Mix**	
	Elymus canadensis	Canada Wild Rye
	Elymus virginicus	Virginia Wild Rye
	Festuca rubra	Red Fescue
	Chamaecrista fasciculata	Partridge Pea
	Liatris spicata	Spiked Gayfeather/Marsh Blazing Star
	Onoclea sensibilis	Sensitive Fern
	Aster prenantholdes	Zigzag Aster
	Eupatorium fisculosum	Hollow-Stem Joe Pye Weed
	Eupatorium perfoliatum	Boneset
	Juncus tenuis	Path Rush
1,490 SF	**SEED MIX 3: New England Wetland Erosion Control/Restoration Mix for Detention Basins & Moist Sites**	
	Elymus riparius	Riverbank Wild Rye
	Schizachyrium scoparium	Little Bluestem
	Festuca rubra	Red Fescue
	Andropogon gerardii	Big Bluestem
	Panicum virgatum	Switch Grass
	Vernonia noveboracensis	New York Ironweed
	Agrostis perennans	Upland Bentgrass
	Bidens frondosa	Beggar Ticks
	Eupatorium maculatum	Spotted Joe Pye Weed
	Eupatorium perfoliatum	Boneset
	Aster novae-angliae	New England Aster
	Scirpus cyperinus	Wool Grass
	Juncus effusus	Soft Rush

PERMITTING SET ONLY
NOT FOR CONSTRUCTION

GRAPHIC SCALE

10 0 5 10 20 40

(in feet)
1 INCH = 10 FEET

Revisions

Rev.	Date	By	Appr.	Description

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Designed By: KAK/EE
Date: NOVEMBER 2023

Plan Set: CAPE COD BOAT RAMP STORMWATER RETROFIT PROJECT- PERMITTING PLANS
OAK CREST COVE
SANDWICH, MA

Plan Title: PLANTING PLAN

Prepared For:
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Registration:

COMMONWEALTH OF MASSACHUSETTS
ERIN R. KUCK
NO. 1525
REGISTERED LANDSCAPE ARCHITECT
11/3/23

Project Number: 22032
Sheet : 7 of 8
Sheet Number: C - 7

last modified: 11/06/23 printed: 11/06/23 by kk H:\Projects\2022\22032 CC Boat Ramp SW Retrofits\Drawings\OAKCREST\22032 OAKCREST LA.dwg

APPENDIX F – Pollutant Controls During Construction

POLLUTANT CONTROLS DURING CONSTRUCTION

1.1 Structural Practices

The following are the structural practices that will be implemented as part of the construction activity.

- Visibility Fence/Sediment Silt Sock Barrier will be installed prior to commencement of construction. The visibility fence will keep construction equipment within the limit of work, and the silt sock will be used on the downgradient portions of the limit of work to allow water to flow through it while keeping sediment on site. The Town will be informed upon their installation so that they may inspect these barriers prior to construction. Portions of these barriers will be replaced and/or repaired as necessary. Barriers will be installed parallel to land slope at the perimeter of the work site, as shown on the Plans. Details are provided in the Plans.

- Silt Sacks (or approved equivalent) will be installed at catch basins and following construction of the proposed overflow structures to prevent sedimentation during construction. The silt sack will be emptied/replaced and disposed of off-site if damage is observed.

- Sediment Traps/Basins. The bioretention area(s) will be graded to within one foot of design elevations until site is fully stabilized to capture sediment during construction. Heavy equipment will not be allowed to operate on the surface location where the systems are planned because soil compaction can adversely impact their long-term performance. Light earth-moving equipment will be used for excavation and construction of the systems. All excavated materials from the area will be removed and disposed of in an approved location. Additional sediment traps should be installed as shown on the plans and in additional locations as needed during construction. All sediment traps/basins will be inspected at least once every seven calendar days and immediately after storm events by the Construction Manager.

- Construction Entrance will be installed following pavement removal. All construction vehicles must use this access point to ensure sediment is not tracked off site.

- Slope Stabilization will occur immediately upon obtaining final grades as shown on the project site plans. Areas that fail to stabilize will be re-graded to final grade and stabilized as necessary. The amount of land disturbed will be minimized to reduce potential for erosion and sedimentation. Stabilization measures shall be initiated within 14 days following the end of construction at each portion of the site and as soon as practicable.

- Pipe Slope Drain will be installed to convey runoff from the existing catch basin/culvert infrastructure at the top of the steep slope and direct it to the sediment trap at the bottom of the slope. The purpose of this is to protect the slope and downgradient stormwater management elements, other site features, and Peter's Pond from erosion and sediment build up during construction.

The entire stormwater management system including pipes, structures, bioretention areas, and infiltration features will be inspected upon completion of construction. Sediment will be removed from all elements of the stormwater management system. All control measures must be installed and maintained in accordance with manufacturer's specifications, good engineering practices, and in accordance with this report (every seven calendar days and after storm events). If inspections show that a control has failed or been installed incorrectly, the Operator must replace or modify it within 24 hours.

1.2 Stabilization Practices

The amount of land disturbed during construction will be minimized to reduce the potential for erosion and sedimentation. Prompt surface stabilization will be provided to control erosion in areas where disturbances cannot be avoided during construction. Stabilization measures shall be initiated within 14 days following the end of construction at each portion of the site. Exceptions to this requirement are allowable when snow cover prevents the initiation of stabilization within 14 days, in which case such measures shall be undertaken as soon as possible.

Stabilization measures that will be, or may be, used during construction are described below:

- Temporary Seeding – Temporary seeding of disturbed surfaces with fast-growing grasses (annual rye) to provide greater resistance to stormwater runoff and/or wind erosion for areas where construction has temporarily ceased.
- Permanent Seeding – Permanent seeding of surfaces with vegetation, including but not limited to grass, trees, bushes, and shrubs, to stabilize the soil. Establishing a permanent and sustainable ground cover at a site stabilizes the soil while reducing the sediment content in runoff.
- Permanent Planting –establish all planting as required at the completion of the project.
- Erosion Control Blankets - install erosion control blankets along all slopes greater than 3:1.
- Mulching – materials, including but not limited to hay, grass, woodchips, straw, and gravel will be placed on the soil surface to cover and hold in place disturbed soils.

Temporary seeding or other soil stabilization measures will be provided where construction activities have ceased at the site. Topsoil stockpiles will be temporarily seeded or covered to prevent erosion and will be surrounded with silt fence or silt sock. When the site's final grade has been established, permanent vegetation will be planted on the disturbed areas. The vegetation will consist of grass, shrubs, bushes, and trees in the locations indicated on the plans.

1.3 Other Types of Controls

Additional controls/practices will be undertaken to reduce pollution in stormwater runoff flows which include, but are not limited to, control of off-site mud tracking from construction site, dust suppression, proper sanitary waste disposal, earthwork procedures timed and conducted in manners aimed to minimize erosion and sedimentation, snow removal plans, proper management of waste materials, proper management of hazardous waste, proper material stockpiling, and spill prevention and control measures.

- Dust Suppression – Water sprays shall be used to control dust during extended dry periods during construction.

- Earthwork – The exposure of disturbed surfaces to stormwater and potential stormwater erosion will be minimized by well-organized earthwork procedures. Stabilization procedures shall be undertaken in accordance with this report. Grubbing during wet seasons will be avoided if feasible.

- Snow Removal Plan – Plowed snow collected from the roadway and parking areas will be deposited onto free draining, pervious surfaces, away from the sites drainage conveyance structures to maximize infiltration.

- Waste Materials – Dumpsters rented from a licensed solid waste management company will be used to store solid waste and debris that cannot be recycled, reused or salvaged. The dumpsters will meet all local and state solid waste management regulations. Dumpsters will be covered when refuse is not being directly deposited or withdrawn from them. Potentially hazardous wastes will be separated from normal wastes, including segregation of storage areas and proper labeling of containers. Removal of all waste from the site will be performed by licensed contractors in accordance with applicable regulatory requirements and disposed of at either local or regional approved facilities. Waste materials will not be buried on-site. All site personnel will be instructed regarding the correct procedures for waste disposal. Notices stating these procedures will be posted at the site. Solvents and flushing materials used during construction and pre-operational cleaning will be provided, handled, managed, and removed by the contractor for appropriate off-site disposal.

- Hazardous Waste Materials – Any disposal of hazardous materials will be completed using the required paperwork. Copies will be provided to the Engineer and to the city.

- Spill Prevention and Control Measures – To minimize the risk of spills or other accidental exposure of materials and substances to stormwater runoff, the following material management practices will be used throughout the project:

    - An effort will be made to store only enough products required to do the job.

- All materials stored on-site will be stored in a neat, orderly manner in their appropriate containers and, if possible, under a roof or other enclosure.
- Products will be kept in their original containers with the original manufacturer's label.
- Substances will not be mixed with one another unless recommended by the manufacturer.
- Whenever possible, the maximum amount of a product will be used before disposing of the container.
- Manufacturers' recommendations for proper use and disposal will be followed.
- The site superintendent will conduct daily inspections to ensure proper use and disposal of materials.

To reduce the risk associated with hazardous materials used on the site, the following practices will be used:

- Products will be kept in original containers unless they are not resealable.
- Original labels and material safety data sheets will be retained and kept on-site; they contain important product information.
- If surplus product must be disposed of, manufacturers' or local and state recommended methods for proper disposal will be followed.

- Materials List - Materials or substances listed below are expected to be present on-site during construction:

- Concrete	- Fertilizers
- Asphalt	- Petroleum Based Products
- Paints (enamel and latex)	- Cleaning Solvents
- Metal Studs	- Wood
- Concrete	- Tar
- Sealants	- Adhesives

The following product-specific practices will be followed on-site:

Petroleum Products - All on-site vehicles will be monitored for leaks and receive preventative maintenance to reduce the chance of leakage. Petroleum products will be stored in tightly sealed containers which area clearly labeled. Any asphalt substances used on-site will be applied according to the manufacturers' recommendations.

Paints – All containers will be tightly sealed and stored indoors when not required for use. Excess paint will not be discharged to the storm sewer system but will be properly disposed of according to the manufacturers' instructions or state and local regulations.

Concrete Trucks – Concrete trucks will not be allowed to wash out or discharge surplus concrete or drum wash water on the site.

In addition to the good housekeeping and material management practices discussed in the previous sections of this plan, the following practices will be followed for spill prevention and cleanup:

- Manufacturers' recommended methods for spill cleanup will be clearly posted, and site personnel will be made aware of the procedures and location of the information and cleanup supplies.
- Materials and equipment necessary for spill cleanup will be kept in the material storage area on-site. Equipment and materials will include, but not be limited to, brooms, dust pans, mops, rags, gloves, goggles, speedi-dry, sand, sawdust, and plastic and metal trash containers specifically for this purpose.
- All spills will be cleaned up immediately after discovery. Spills large enough to reach the storm water system will be reported to the National Response Center at 1-800-424-8802.
- The spill area will be kept well ventilated and personnel will wear appropriate protective clothing to prevent injury from contact with a hazardous substance.
- Spills of toxic or hazardous material will be reported to the appropriate state or local government agency, regardless of the size.
- The site superintendent responsible for the day-to-day site operations will be the spill prevention and clean-up coordinator. He will designate at least three other site personnel who will receive spill prevention and cleanup training. These individuals will each become responsible for a particular phase of prevention and cleanup. The names of responsible spill personnel will be posted in the material storage area and in the on-site office trailer.

APPENDIX G – Site Plans