

STORM WATER MANAGEMENT REPORT

**44 DUNHAM RIDGE
50 DUNHAM ROAD
BEVERLY, MA**

August 8, 2018

PREPARED FOR:
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1.0 Site Description

The project site is a 54 acre parcel of land located off the northeastern end of Dunham Road in Beverly, MA. The site currently contains one office building (50 Dunham Road), parking garage, outdoor parking areas and access roads. Two other buildings (48 and 52) are currently under construction. A large portion of the site is undisturbed woodland.

The site is bounded on the north by undeveloped land containing a large wetland, on the east by Norwood's Pond, a former gravel pit, and the North Shore Music Theatre, on the south by Dunham Road and Route 128, and on the west by a commercial property and residential properties.

1.1 Wetland Resource Areas

Wetland resource areas on the site include bordering vegetated wetlands along the northern boundary, along the southeasterly boundary, and surrounding a certified vernal at the western site boundary. The limits of the bordering vegetated wetland areas were flagged by Hancock Associates, Inc.

1.2 Natural Heritage and Endangered Species Program

Mapping of Priority Habitat of Rare Species and Estimated Habitats of Rare Wildlife is available on the MassGIS web site. According to the 2008 map there are no Priority Habitats of Rare Species or Estimated Habitats of Rare Wildlife located on or adjacent to the subject property.

The site contains 4 potential vernal pools and 2 certified vernal pools (nos. 3617 and 2977). Three additional vernal pools are located on the abutting property near the northeast corner of the site.

1.3 Bordering Land Subject to Flooding

The Federal Emergency Management Agency has delineated a Special Flood Hazard Area (Zone A) associated with Norwood's Pond along the eastern site boundary. The Zone A is shown graphically on Flood Insurance Rate Map (FIRM) 25009C0428F, effective date July 3, 2012. No based flood elevation has been defined.

1.4 Other Priority Resources

Mapping of Priority Resources is available on the MassGIS web site. According to this mapping the site does not lie within a Zone II groundwater protection area nor within a Zone A surface water supply protection area. Additionally, the site does not lie within an Area of Critical Environmental Concern (ACEC).

1.5 Soil Characteristics

Soil data for the site has been mapped by the Natural Resources Conservation Service (NRCS) and is available through the National Cooperative Soil Survey. The western portion of the development site contains a Chatfield-Hollis-Rock outcrop complex. Chatfield soil has a fine sandy loam surface soil with the underlying soils typically being gravelly fine sandy loam.

Bedrock is typically encountered between 3 and 5 feet below the surface. These soils are typically well-drained and have a moderately high saturated permeability.

Hollis soils typically have a thin (2") top layer of muck followed with a thin (3") layer of fine sandy loam. The lower layer is typically gravelly fine sandy loam. Bedrock is typically encountered between 2 and 5 feet below the surface. These soils are typically well-drained and have a moderately high saturated permeability.

2.0 Proposed Development

The project site is a 3.46 acre area located in the northwest corner of the 54-acre site. The proposed project is to construct a commercial building, associated parking and utilities, and a storm water management system.

The project does not propose to alter any bordering vegetated wetland areas. The limit of work will be approximately 25 feet from the wetland at its closest point and will be delineated with silt fence and Filtrexx Silt Soxx®.

3.0 Storm Water Management

The storm water management system at the site has been designed in conformance with the MA DEP Storm Water Management Policy and the requirements of the Beverly Conservation Commission. The following sections detail how the proposal satisfies the Storm Water Management Standards. The Storm Water Management Report Checklist is provided in Appendix A.

3.1 Standard 1

Standard 1 requires that no new untreated discharges to wetlands are created and that any new discharges would not result in erosion.

The storm water management system will discharge to a 10-foot wide level riprap pad to reduce flow velocities prior to discharge to the wetland. The peak flow from the 100 year storm event would be 3.66 cubic feet per second.

Criteria Satisfied

3.2 Standard 2

Standard 2 requires that post construction peak discharge rates do not exceed pre construction discharge rates. Hydrologic calculations were performed for the pre development and post development site conditions.

Table 1 is a Comparative Hydrologic Summary that compares the post development peak runoff flow rates at the point of analysis with the pre development site conditions. As the table indicates the post development runoff rates are below the predevelopment conditions in all storm events analyzed. Complete drainage calculations are provided in Appendix B.

Criteria Satisfied

TABLE 1
 Comparative Hydrologic Summary
Storm Water Management System
44 Dunham Road
 Beverly, MA
 August 8, 2018

2 Year Storm - 3.2 inches

Point of Analysis	Pre-Development	Post Development
	Peak Rate (c.f.s.)	Peak Rate (c.f.s.)
Off Site (North)	3.21	3.14

10 Year Storm - 4.6 inches

Point of Analysis	Pre-Development	Post Development
	Peak Rate (c.f.s.)	Peak Rate (c.f.s.)
Off Site (North)	6.80	4.45

25 Year Storm - 5.4 inches

Point of Analysis	Pre-Development	Post Development
	Peak Rate (c.f.s.)	Peak Rate (c.f.s.)
Off Site (North)	9.05	5.63

100 Year Storm - 6.5 inches

Point of Analysis	Pre-Development	Post Development
	Peak Rate (c.f.s.)	Peak Rate (c.f.s.)
Off Site (North)	12.27	9.14

3.3 Standard 3

Standard 3 requires that there not be a loss of annual groundwater recharge.

The total impervious area anticipated is 98,540 square feet. The detention basin is proposed to be located partially within an area containing bedrock. Blasting will be required to construct the basin. Approximately half of the detention basin will be constructed on top of the bedrock while the remaining half of the basin will be constructed on naturally occurring loamy sand. Therefore, exfiltration will occur during and after the storm events. However; the groundwater recharge calculations are based on a static analysis which simply compares the volume of recharge required to the storage volume. This method does not take into consideration that recharge will actively occur during the rainfall event.

Required recharge volume = $(98,540 \text{ s.f.} \times 0.25") / 12 = 2,095 \text{ cu-ft.}$

Detention Basin volume below outlet = 2,136 cu-ft.

Criteria Satisfied

3.4 Standard 4

Standard 4 requires the storm water management system to be designed to remove 80 percent of total suspended solids (TSS) from the storm water prior to discharge. This is achieved by implementing a series of Best Management Practices (BMPs) to treat the prescribed Water Quality Volume (WQV). These BMPs include deep sump catch basins and a Cultec infiltration system with separator rows. The initial water quality volume will be discharged to the separator rows for treatment will excess runoff being discharged to the standard Cultec chambers. TSS calculations were performed using the DEP TSS Removal Calculation Spreadsheet and are provided in Appendix C.

TSS Removal : 85%

Criteria Satisfied

3.5 Standard 5

Standard 5 regulates discharges from sites with higher potential pollutant loads. The area is not a Land Use with high Potential Pollutant Loads (LUHPPL).

3.6 Standard 6

Standard 6 regulates discharges to Outstanding Resource Waters (ORW). The site is not located within a Zone II for a public water supply, nor does runoff from the site discharge to an Outstanding Resource Water. Therefore, the design is in compliance with this standard.

3.7 Standard 7

Standard 7 requires that redevelopment project meet the Standards only to the extent practicable. The project is not a redevelopment project and therefore must fully comply with all of the standards.

3.8 Standard 8

Standard 8 requires a plan to control construction related impacts. Erosion control features are included to control construction related impacts. Current activities at the site are covered under a Storm Water Pollution Prevention Plan (SWPPP). This scope of work will also be covered under the SWPPP

3.9 Standard 9

Standard 9 requires a long term operation and maintenance plan to ensure that the storm water management system performs as designed. The current Storm Water Pollution Prevention Plan includes the required operation and maintenance plan.

3.10 Standard 10

Standard 10 prohibits any illicit discharges to the storm water management systems. There are no illicit discharges to the storm water management system proposed. A note requiring no illicit discharges is included in the current Storm Water Pollution Prevention Plan.

Appendix A
Storm Water Report Checklist



Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

- The Stormwater Checklist completed and stamped by a Registered Professional Engineer (see page 2) that certifies that the Stormwater Report contains all required submittals.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 8²
- 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.



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.

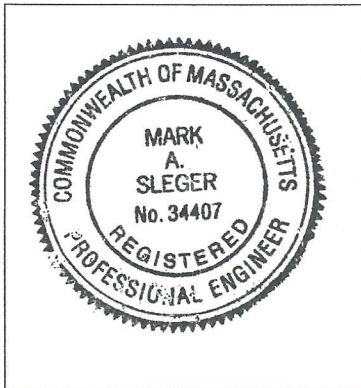
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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

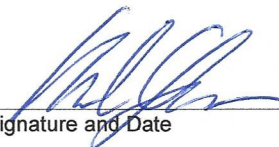
A complete checklist must include the Certification set forth below signed by the Registered Professional Engineer who prepared the Stormwater Report.

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



 8/8/2018
Signature and Date

Checklist

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

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



Checklist for Stormwater Report

Checklist (continued)

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

- No disturbance to any Wetland Resource Areas
- Site Design Practices (e.g. clustered development, reduced frontage setbacks)
- Reduced Impervious Area (Redevelopment Only)
- Minimizing disturbance to existing trees and shrubs
- LID Site Design Credit Requested:
 - Credit 1
 - Credit 2
 - Credit 3
- Use of "country drainage" versus curb and gutter conveyance and pipe
- Bioretention Cells (includes Rain Gardens)
- Constructed Stormwater Wetlands (includes Gravel Wetlands designs)
- Treebox Filter
- Water Quality Swale
- Grass Channel
- Green Roof
- Other (describe): _____

Standard 1: No New Untreated Discharges

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



Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

- Standard 2 waiver requested because the project is located in land subject to coastal storm flowage and stormwater discharge is to a wetland subject to coastal flooding.
- Evaluation provided to determine whether off-site flooding increases during the 100-year 24-hour storm.
- Calculations provided to show that post-development peak discharge rates do not exceed pre-development rates for the 2-year and 10-year 24-hour storms. If evaluation shows that off-site flooding increases during the 100-year 24-hour storm, calculations are also provided to show that post-development peak discharge rates do not exceed pre-development rates for the 100-year 24-hour storm.

Standard 3: Recharge

- Soil Analysis provided.
- Required Recharge Volume calculation provided.
- Required Recharge volume reduced through use of the LID site Design Credits.
- Sizing the infiltration, BMPs is based on the following method: Check the method used.
 - Static
 - Simple Dynamic
 - Dynamic Field¹
- 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.

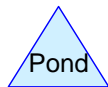
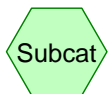
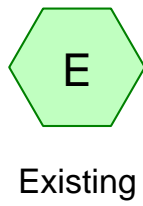
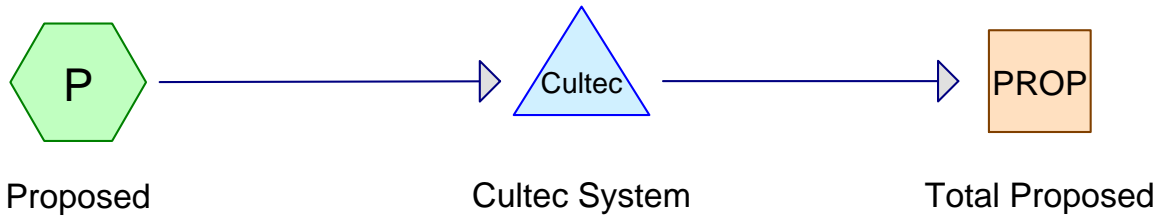
Standard 9: Operation and Maintenance Plan

- 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.

Appendix B
Drainage Calculations



44 Dunham Drainage

Prepared by ALAN Engineering, L.L.C.

HydroCAD® 10.00-16 s/n 04219 © 2015 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.964	74	>75% Grass cover, Good, HSG C (P)
2.262	98	Paved parking, HSG C (P)
3.456	73	Woods, Fair, HSG C (E)
0.230	70	Woods, Good, HSG C (P)
6.912	81	TOTAL AREA

44 Dunham Drainage

Prepared by ALAN Engineering, L.L.C.

HydroCAD® 10.00-16 s/n 04219 © 2015 HydroCAD Software Solutions LLC

44 Dunham Road Drainage Analysis
Type III 24-hr 2 Year Storm Rainfall=3.20"

Page 3

Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E: Existing

Runoff Area=150,540 sf 0.00% Impervious Runoff Depth>0.98"
Tc=10.0 min CN=73 Runoff=3.21 cfs 0.282 af

Subcatchment P: Proposed

Runoff Area=150,540 sf 65.46% Impervious Runoff Depth>2.29"
Tc=5.0 min CN=WQ Runoff=8.37 cfs 0.658 af

Reach PROP: Total Proposed

Inflow=3.14 cfs 0.511 af
Outflow=3.14 cfs 0.511 af

Pond Cultec: Cultec System

Peak Elev=92.22' Storage=9,326 cf Inflow=8.37 cfs 0.658 af
Discarded=0.05 cfs 0.091 af Primary=3.14 cfs 0.511 af Outflow=3.19 cfs 0.603 af

Total Runoff Area = 6.912 ac Runoff Volume = 0.941 af Average Runoff Depth = 1.63"
67.27% Pervious = 4.650 ac 32.73% Impervious = 2.262 ac

44 Dunham Drainage

Prepared by ALAN Engineering, L.L.C.

HydroCAD® 10.00-16 s/n 04219 © 2015 HydroCAD Software Solutions LLC

Summary for Subcatchment E: Existing

Runoff = 3.21 cfs @ 12.16 hrs, Volume= 0.282 af, Depth> 0.98"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Type III 24-hr 2 Year Storm Rainfall=3.20"

Area (sf)	CN	Description
150,540	73	Woods, Fair, HSG C
150,540		100.00% Pervious Area

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

Summary for Subcatchment P: Proposed

Runoff = 8.37 cfs @ 12.07 hrs, Volume= 0.658 af, Depth> 2.29"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
 Type III 24-hr 2 Year Storm Rainfall=3.20"

Area (sf)	CN	Description
98,540	98	Paved parking, HSG C
42,000	74	>75% Grass cover, Good, HSG C
10,000	70	Woods, Good, HSG C
150,540		Weighted Average
52,000		34.54% Pervious Area
98,540		65.46% Impervious Area

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

Summary for Reach PROP: Total Proposed

Inflow Area = 3.456 ac, 65.46% Impervious, Inflow Depth > 1.78" for 2 Year Storm event
 Inflow = 3.14 cfs @ 12.31 hrs, Volume= 0.511 af
 Outflow = 3.14 cfs @ 12.31 hrs, Volume= 0.511 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond Cultec: Cultec System

Inflow Area = 3.456 ac, 65.46% Impervious, Inflow Depth > 2.29" for 2 Year Storm event
 Inflow = 8.37 cfs @ 12.07 hrs, Volume= 0.658 af
 Outflow = 3.19 cfs @ 12.31 hrs, Volume= 0.603 af, Atten= 62%, Lag= 14.4 min
 Discarded = 0.05 cfs @ 5.00 hrs, Volume= 0.091 af
 Primary = 3.14 cfs @ 12.31 hrs, Volume= 0.511 af

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Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs / 5
 Peak Elev= 92.22' @ 12.31 hrs Surf.Area= 4,450 sf Storage= 9,326 cf

Plug-Flow detention time= 98.1 min calculated for 0.601 af (91% of inflow)
 Center-of-Mass det. time= 54.5 min (825.8 - 771.3)

Volume	Invert	Avail.Storage	Storage Description
#1A	88.00'	11,121 cf	52.75'W x 84.37'L x 8.00'H Field A 35,603 cf Overall - 7,801 cf Embedded = 27,801 cf x 40.0% Voids
#2A	91.00'	7,801 cf	Cultec R-902HD x 120 Inside #1 Effective Size= 69.8"W x 48.0"H => 17.65 sf x 3.67'L = 64.7 cf Overall Size= 78.0"W x 48.0"H x 4.10'L with 0.44' Overlap 6 Rows of 20 Chambers Cap Storage= +2.8 cf x 2 x 6 rows = 33.1 cf
		18,922 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	87.75'	18.0" Round 18" Culvert L= 25.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 87.75' / 87.50' S= 0.0100 '/ Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.77 sf
#2	Device 1	89.20'	6.0" Round 6" Culvert L= 5.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 89.20' / 89.20' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.20 sf
#3	Primary	91.00'	8.0" Round 8" Culvert L= 5.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 91.00' / 91.00' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.35 sf
#4	Device 1	94.00'	12.0" Round 12" Culvert L= 5.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 94.00' / 94.00' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#5	Discarded	88.00'	0.520 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.05 cfs @ 5.00 hrs HW=88.08' (Free Discharge)
 ↳ **5=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=3.14 cfs @ 12.31 hrs HW=92.22' (Free Discharge)
 ↳ **1=18" Culvert** (Passes 1.57 cfs of 16.40 cfs potential flow)
 ↳ **2=6" Culvert** (Inlet Controls 1.57 cfs @ 8.01 fps)
 ↳ **4=12" Culvert** (Controls 0.00 cfs)
 ↳ **3=8" Culvert** (Barrel Controls 1.56 cfs @ 4.48 fps)

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44 Dunham Road Drainage Analysis
Type III 24-hr 10 Year Storm Rainfall=4.60"

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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E: Existing

Runoff Area=150,540 sf 0.00% Impervious Runoff Depth>1.97"
Tc=10.0 min CN=73 Runoff=6.80 cfs 0.567 af

Subcatchment P: Proposed

Runoff Area=150,540 sf 65.46% Impervious Runoff Depth>3.54"
Tc=5.0 min CN=WQ Runoff=12.99 cfs 1.020 af

Reach PROP: Total Proposed

Inflow=4.45 cfs 0.866 af
Outflow=4.45 cfs 0.866 af

Pond Cultec: Cultec System

Peak Elev=93.59' Storage=13,574 cf Inflow=12.99 cfs 1.020 af
Discarded=0.05 cfs 0.096 af Primary=4.45 cfs 0.866 af Outflow=4.50 cfs 0.962 af

Total Runoff Area = 6.912 ac Runoff Volume = 1.587 af Average Runoff Depth = 2.75"
67.27% Pervious = 4.650 ac 32.73% Impervious = 2.262 ac

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Type III 24-hr 10 Year Storm Rainfall=4.60"

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Summary for Subcatchment E: Existing

Runoff = 6.80 cfs @ 12.15 hrs, Volume= 0.567 af, Depth> 1.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 Year Storm Rainfall=4.60"

Area (sf)	CN	Description
150,540	73	Woods, Fair, HSG C
150,540		100.00% Pervious Area

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

Summary for Subcatchment P: Proposed

Runoff = 12.99 cfs @ 12.07 hrs, Volume= 1.020 af, Depth> 3.54"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 10 Year Storm Rainfall=4.60"

Area (sf)	CN	Description
98,540	98	Paved parking, HSG C
42,000	74	>75% Grass cover, Good, HSG C
10,000	70	Woods, Good, HSG C
150,540		Weighted Average
52,000		34.54% Pervious Area
98,540		65.46% Impervious Area

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

Summary for Reach PROP: Total Proposed

Inflow Area = 3.456 ac, 65.46% Impervious, Inflow Depth > 3.01" for 10 Year Storm event
Inflow = 4.45 cfs @ 12.34 hrs, Volume= 0.866 af
Outflow = 4.45 cfs @ 12.34 hrs, Volume= 0.866 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond Cultec: Cultec System

Inflow Area = 3.456 ac, 65.46% Impervious, Inflow Depth > 3.54" for 10 Year Storm event
Inflow = 12.99 cfs @ 12.07 hrs, Volume= 1.020 af
Outflow = 4.50 cfs @ 12.34 hrs, Volume= 0.962 af, Atten= 65%, Lag= 16.3 min
Discarded = 0.05 cfs @ 3.35 hrs, Volume= 0.096 af
Primary = 4.45 cfs @ 12.34 hrs, Volume= 0.866 af

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44 Dunham Road Drainage Analysis
Type III 24-hr 10 Year Storm Rainfall=4.60"

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Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs / 5
Peak Elev= 93.59' @ 12.34 hrs Surf.Area= 4,450 sf Storage= 13,574 cf

Plug-Flow detention time= 83.9 min calculated for 0.960 af (94% of inflow)
Center-of-Mass det. time= 51.8 min (818.2 - 766.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	88.00'	11,121 cf	52.75'W x 84.37'L x 8.00'H Field A 35,603 cf Overall - 7,801 cf Embedded = 27,801 cf x 40.0% Voids
#2A	91.00'	7,801 cf	Cultec R-902HD x 120 Inside #1 Effective Size= 69.8"W x 48.0"H => 17.65 sf x 3.67'L = 64.7 cf Overall Size= 78.0"W x 48.0"H x 4.10'L with 0.44' Overlap 6 Rows of 20 Chambers Cap Storage= +2.8 cf x 2 x 6 rows = 33.1 cf
		18,922 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	87.75'	18.0" Round 18" Culvert L= 25.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 87.75' / 87.50' S= 0.0100 '/ Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.77 sf
#2	Device 1	89.20'	6.0" Round 6" Culvert L= 5.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 89.20' / 89.20' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.20 sf
#3	Primary	91.00'	8.0" Round 8" Culvert L= 5.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 91.00' / 91.00' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.35 sf
#4	Device 1	94.00'	12.0" Round 12" Culvert L= 5.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 94.00' / 94.00' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#5	Discarded	88.00'	0.520 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.05 cfs @ 3.35 hrs HW=88.08' (Free Discharge)
↳ **5=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=4.45 cfs @ 12.34 hrs HW=93.59' (Free Discharge)
↳ **1=18" Culvert** (Passes 1.92 cfs of 19.19 cfs potential flow)
↳ **2=6" Culvert** (Inlet Controls 1.92 cfs @ 9.80 fps)
↳ **4=12" Culvert** (Controls 0.00 cfs)
↳ **3=8" Culvert** (Inlet Controls 2.52 cfs @ 7.23 fps)

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Type III 24-hr 25 Year Storm Rainfall=5.40"

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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E: Existing

Runoff Area=150,540 sf 0.00% Impervious Runoff Depth>2.59"
Tc=10.0 min CN=73 Runoff=9.05 cfs 0.747 af

Subcatchment P: Proposed

Runoff Area=150,540 sf 65.46% Impervious Runoff Depth>4.28"
Tc=5.0 min CN=WQ Runoff=15.70 cfs 1.233 af

Reach PROP: Total Proposed

Inflow=5.63 cfs 1.076 af
Outflow=5.63 cfs 1.076 af

Pond Cultec: Cultec System

Peak Elev=94.48' Storage=16,022 cf Inflow=15.70 cfs 1.233 af
Discarded=0.05 cfs 0.098 af Primary=5.63 cfs 1.076 af Outflow=5.69 cfs 1.173 af

Total Runoff Area = 6.912 ac Runoff Volume = 1.980 af Average Runoff Depth = 3.44"
67.27% Pervious = 4.650 ac 32.73% Impervious = 2.262 ac

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Type III 24-hr 25 Year Storm Rainfall=5.40"

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Summary for Subcatchment E: Existing

Runoff = 9.05 cfs @ 12.15 hrs, Volume= 0.747 af, Depth> 2.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 Year Storm Rainfall=5.40"

Area (sf)	CN	Description
150,540	73	Woods, Fair, HSG C
150,540		100.00% Pervious Area

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

Summary for Subcatchment P: Proposed

Runoff = 15.70 cfs @ 12.07 hrs, Volume= 1.233 af, Depth> 4.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 25 Year Storm Rainfall=5.40"

Area (sf)	CN	Description
98,540	98	Paved parking, HSG C
42,000	74	>75% Grass cover, Good, HSG C
10,000	70	Woods, Good, HSG C
150,540		Weighted Average
52,000		34.54% Pervious Area
98,540		65.46% Impervious Area

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

Summary for Reach PROP: Total Proposed

Inflow Area = 3.456 ac, 65.46% Impervious, Inflow Depth > 3.73" for 25 Year Storm event
Inflow = 5.63 cfs @ 12.33 hrs, Volume= 1.076 af
Outflow = 5.63 cfs @ 12.33 hrs, Volume= 1.076 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond Cultec: Cultec System

Inflow Area = 3.456 ac, 65.46% Impervious, Inflow Depth > 4.28" for 25 Year Storm event
Inflow = 15.70 cfs @ 12.07 hrs, Volume= 1.233 af
Outflow = 5.69 cfs @ 12.33 hrs, Volume= 1.173 af, Atten= 64%, Lag= 15.2 min
Discarded = 0.05 cfs @ 2.80 hrs, Volume= 0.098 af
Primary = 5.63 cfs @ 12.33 hrs, Volume= 1.076 af

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44 Dunham Road Drainage Analysis
Type III 24-hr 25 Year Storm Rainfall=5.40"

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Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs / 5
Peak Elev= 94.48' @ 12.33 hrs Surf.Area= 4,450 sf Storage= 16,022 cf

Plug-Flow detention time= 78.9 min calculated for 1.171 af (95% of inflow)
Center-of-Mass det. time= 50.9 min (815.1 - 764.2)

Volume	Invert	Avail.Storage	Storage Description
#1A	88.00'	11,121 cf	52.75'W x 84.37'L x 8.00'H Field A 35,603 cf Overall - 7,801 cf Embedded = 27,801 cf x 40.0% Voids
#2A	91.00'	7,801 cf	Cultec R-902HD x 120 Inside #1 Effective Size= 69.8"W x 48.0"H => 17.65 sf x 3.67'L = 64.7 cf Overall Size= 78.0"W x 48.0"H x 4.10'L with 0.44' Overlap 6 Rows of 20 Chambers Cap Storage= +2.8 cf x 2 x 6 rows = 33.1 cf
		18,922 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	87.75'	18.0" Round 18" Culvert L= 25.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 87.75' / 87.50' S= 0.0100 '/ Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.77 sf
#2	Device 1	89.20'	6.0" Round 6" Culvert L= 5.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 89.20' / 89.20' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.20 sf
#3	Primary	91.00'	8.0" Round 8" Culvert L= 5.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 91.00' / 91.00' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.35 sf
#4	Device 1	94.00'	12.0" Round 12" Culvert L= 5.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 94.00' / 94.00' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#5	Discarded	88.00'	0.520 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.05 cfs @ 2.80 hrs HW=88.08' (Free Discharge)
↳ **5=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=5.62 cfs @ 12.33 hrs HW=94.47' (Free Discharge)
↳ **1=18" Culvert** (Passes 2.64 cfs of 20.79 cfs potential flow)
↳ **2=6" Culvert** (Inlet Controls 2.12 cfs @ 10.79 fps)
↳ **4=12" Culvert** (Barrel Controls 0.52 cfs @ 2.10 fps)
↳ **3=8" Culvert** (Inlet Controls 2.98 cfs @ 8.53 fps)

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44 Dunham Road Drainage Analysis
Type III 24-hr 100 Year Storm Rainfall=6.50"

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Time span=0.00-24.00 hrs, dt=0.05 hrs, 481 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-Q
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment E: Existing

Runoff Area=150,540 sf 0.00% Impervious Runoff Depth>3.50"
Tc=10.0 min CN=73 Runoff=12.27 cfs 1.008 af

Subcatchment P: Proposed

Runoff Area=150,540 sf 65.46% Impervious Runoff Depth>5.32"
Tc=5.0 min CN=WQ Runoff=19.47 cfs 1.531 af

Reach PROP: Total Proposed

Inflow=9.44 cfs 1.370 af
Outflow=9.44 cfs 1.370 af

Pond Cultec: Cultec System

Peak Elev=95.56' Storage=18,134 cf Inflow=19.47 cfs 1.531 af
Discarded=0.05 cfs 0.099 af Primary=9.44 cfs 1.370 af Outflow=9.49 cfs 1.469 af

Total Runoff Area = 6.912 ac Runoff Volume = 2.539 af Average Runoff Depth = 4.41"
67.27% Pervious = 4.650 ac 32.73% Impervious = 2.262 ac

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44 Dunham Road Drainage Analysis
Type III 24-hr 100 Year Storm Rainfall=6.50"

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Summary for Subcatchment E: Existing

Runoff = 12.27 cfs @ 12.14 hrs, Volume= 1.008 af, Depth> 3.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 Year Storm Rainfall=6.50"

Area (sf)	CN	Description
150,540	73	Woods, Fair, HSG C
150,540		100.00% Pervious Area

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

Summary for Subcatchment P: Proposed

Runoff = 19.47 cfs @ 12.07 hrs, Volume= 1.531 af, Depth> 5.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-Q, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs
Type III 24-hr 100 Year Storm Rainfall=6.50"

Area (sf)	CN	Description
98,540	98	Paved parking, HSG C
42,000	74	>75% Grass cover, Good, HSG C
10,000	70	Woods, Good, HSG C
150,540		Weighted Average
52,000		34.54% Pervious Area
98,540		65.46% Impervious Area

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

Summary for Reach PROP: Total Proposed

Inflow Area = 3.456 ac, 65.46% Impervious, Inflow Depth > 4.76" for 100 Year Storm event
Inflow = 9.44 cfs @ 12.22 hrs, Volume= 1.370 af
Outflow = 9.44 cfs @ 12.22 hrs, Volume= 1.370 af, Atten= 0%, Lag= 0.0 min

Routing by Stor-Ind+Trans method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs

Summary for Pond Cultec: Cultec System

Inflow Area = 3.456 ac, 65.46% Impervious, Inflow Depth > 5.32" for 100 Year Storm event
Inflow = 19.47 cfs @ 12.07 hrs, Volume= 1.531 af
Outflow = 9.49 cfs @ 12.22 hrs, Volume= 1.469 af, Atten= 51%, Lag= 9.1 min
Discarded = 0.05 cfs @ 2.25 hrs, Volume= 0.099 af
Primary = 9.44 cfs @ 12.22 hrs, Volume= 1.370 af

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Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.05 hrs / 5
 Peak Elev= 95.56' @ 12.22 hrs Surf.Area= 4,450 sf Storage= 18,134 cf

Plug-Flow detention time= 71.8 min calculated for 1.469 af (96% of inflow)
 Center-of-Mass det. time= 47.7 min (809.4 - 761.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	88.00'	11,121 cf	52.75'W x 84.37'L x 8.00'H Field A 35,603 cf Overall - 7,801 cf Embedded = 27,801 cf x 40.0% Voids
#2A	91.00'	7,801 cf	Cultec R-902HD x 120 Inside #1 Effective Size= 69.8"W x 48.0"H => 17.65 sf x 3.67'L = 64.7 cf Overall Size= 78.0"W x 48.0"H x 4.10'L with 0.44' Overlap 6 Rows of 20 Chambers Cap Storage= +2.8 cf x 2 x 6 rows = 33.1 cf
		18,922 cf	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Primary	87.75'	18.0" Round 18" Culvert L= 25.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 87.75' / 87.50' S= 0.0100 '/ Cc= 0.900 n= 0.010 PVC, smooth interior, Flow Area= 1.77 sf
#2	Device 1	89.20'	6.0" Round 6" Culvert L= 5.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 89.20' / 89.20' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.20 sf
#3	Primary	91.00'	8.0" Round 8" Culvert L= 5.0' CMP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 91.00' / 91.00' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.35 sf
#4	Device 1	94.00'	12.0" Round 12" Culvert L= 5.0' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 94.00' / 94.00' S= 0.0000 '/ Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 0.79 sf
#5	Discarded	88.00'	0.520 in/hr Exfiltration over Surface area

Discarded OutFlow Max=0.05 cfs @ 2.25 hrs HW=88.08' (Free Discharge)
 ↳ **5=Exfiltration** (Exfiltration Controls 0.05 cfs)

Primary OutFlow Max=9.30 cfs @ 12.22 hrs HW=95.52' (Free Discharge)
 ↳ **1=18" Culvert** (Passes 5.86 cfs of 22.54 cfs potential flow)
 ↳ **2=6" Culvert** (Inlet Controls 2.33 cfs @ 11.86 fps)
 ↳ **4=12" Culvert** (Barrel Controls 3.53 cfs @ 4.49 fps)
 ↳ **3=8" Culvert** (Inlet Controls 3.44 cfs @ 9.85 fps)

Appendix C

TSS Removal Calculations

TSS Removal Calculations

44 Dunham Ridge

Beverly, MA

8-Aug-18

Discharge Location: Detention Basin Outlet

**TSS Removal
Calculation Worksheet**

A BMP	B TSS Removal Rate	C Starting TSS Load*	D Amount Removed (B*C)	E Remaining Load (C-D)
Deep Sump Catch Basins	25%	1.00	0.25	0.75
Subsurface Infiltration System	80%	0.75	0.60	0.15
				0.15
				0.15
				0.15

Total TSS Removal = 85%

Project: 44 Dunham Ridge

Prepared By: MAS

Date: 8/8/2018

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