DiPrete Engineering

Stormwater Management Report

Cranberry Highway

Located in Wareham, MA

Applicant: The Parikh Network

09-24-2021

Revised 03-08-2023

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Executive Summary

On behalf of the Client, we are submitting drainage calculations for the proposed development at 2404 Cranberry Highway. The site is located on Plan Book 63 Page 1009 Lot 2. The site exists today as mostly cleared as a result of the construction of the adjacent gas station. Prior to clearing, the site was mostly wooded with some areas of pavement and gravel. The client proposes to construct a new one-story drive though restaurant with associated parking and landscape improvements. The proposed building will be a Popeyes Louisiana Kitchen.

The post-development stormwater will be treated for water quality using Best Management Practices (BMPs). The Site has been designed to the Massachusetts Stormwater Management Standards (MASWMS). To treat and mitigate post-development flows on site, a series of deep sump and hooded catch basins, proprietary treatment devices, and underground infiltration systems will be utilized. The treatment train will remove TSS (total suspended solids) in accordance with the MASWMS. The infiltration systems are designed to control runoff for the 2 through 100-year storm events. The infiltration systems are also designed as water quality BMPs. These will remove 80% or more of TSS (total suspended solids) generated by the proposed impervious areas.

This report details how the site will show only negligible increases in stormwater runoff internal to the site from pre-development to post-development conditions. These minor increases will be further mitigated by existing BMPS/ appurtenances prior to discharging to public/downstream areas. The proposed development of this site is therefore considered to meet the intent of the Massachusetts Stormwater Management Standards (MASWMS) and the Town of Wareham Stormwater Management Bylaws. There will be no increases in peak or volume to areas under MassDOT jurisdiction.

Pre-development Conditions versus Post-development Conditions are summarized below:
Pre-development vs. Post-development Mitigated

Watershed 1: (DP-1)

Conditions – Peak Flow	2-Year	10-Year	25-Year	100-Year
Pre-dev Summation	0.24	0.48	0.68	1.10
Post-Dev Summation	0.24	0.48	0.68	1.10
Net Change	0.00	0.00	0.00	0.00

All flows in cubic feet per second (cfs)

Conditions – Volume	2-Year	10-Year	25-Year	100-Year
Pre-dev Summation	0.017	0.034	0.048	0.079
Post-Dev Summation	0.017	0.034	0.048	0.079
Net Change	0.000	0.000	0.000	0.000

All volumes in acre-feet (ac-ft)

Watershed 2: (DP-2)

Conditions – Peak Flow	2-Year	10-Year	25-Year	100-Year
Pre-dev Summation	0.00	0.00	0.02	0.23
Post-Dev Summation	0.00	0.01	0.05	0.25
Net Change	0.00	-0.01	-0.03	-0.02

All flows in cubic feet per second (cfs)

Conditions – Volume	2-Year	10-Year	25-Year	100-Year
Pre-dev Summation	0.000	0.001	0.010	0.054
Post-Dev Summation	0.000	0.003	0.008	0.023
Net Change	0.000	-0.002	0.002	0.031

All volumes in acre-feet (ac-ft)

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.

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 (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:

- [x] 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

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

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

Standard 3: Recharge

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

  ☐ Static ☒ Simple Dynamic ☐ Dynamic Field[1]

- ☒ Runoff from all impervious areas at the site discharging to the infiltration BMP.
- ☐ Runoff from all impervious areas at the site is *not* discharging to the infiltration BMP and calculations are provided showing that the drainage area contributing runoff to the infiltration BMPs is sufficient to generate the required recharge volume.
- ☒ Recharge BMPs have been sized to infiltrate the Required Recharge Volume.
- ☐ Recharge BMPs have been sized to infiltrate the Required Recharge Volume *only* to the maximum extent practicable for the following reason:
  - ☐ Site is comprised solely of C and D soils and/or bedrock at the land surface
  - ☐ M.G.L. c. 21E sites pursuant to 310 CMR 40.0000
  - ☐ Solid Waste Landfill pursuant to 310 CMR 19.000
  - ☐ Project is otherwise subject to Stormwater Management Standards only to the maximum extent practicable.
- ☒ Calculations showing that the infiltration BMPs will drain in 72 hours are provided.
- ☐ Property includes a M.G.L. c. 21E site or a solid waste landfill and a mounding analysis is included.

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

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist 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.

1.0 Project Description

The purpose of this report is to specify a Storm Water Management System for the proposed development at 2404 Cranberry Highway in Wareham Massachusetts. A Stormwater System Operations and Maintenance Plan (O&M) has been prepared by DiPrete Engineering as a separate document.

The proposed development is located on Plan Book 63 Page 1009 Lot 2 and totals 0.94 Acres in Wareham, Massachusetts. The site is located on Cranberry Highway near the intersection of Tow Road. The proposed development will include a new one story 2,535 sf building (Popeyes Louisiana Kitchen) with associated parking and landscape improvements. The site will be serviced by public water and sewer.

Stormwater treatment and mitigation will be provided by utilizing Best Management Practices (BMPs) as established by the Massachusetts Stormwater Handbook. BMPs will consist of 2 underground infiltration systems, 2 proprietary treatment devices and deep sump catch basins. The system has been designed to meet the Massachusetts Stormwater Management Standards (MASWMS) and the Town of Wareham Stormwater Management Bylaws.

2.0 Site Conditions

2.1 SOILS

There are the following soil types within the analyzed area of the Site as mapped by the NRCS USDA Soil Conservation service:

Soil Symbol	Description	Hydrologic Group
259B	Carver loamy coarse sand, 3 to 8 percent slopes	A
602B	Urban land, 0 to 8 percent slopes	

The onsite soils include Urban Land which does not have a Hydrologic Group. Other soils in and around the site include 259B – Carver loamy coarse sand, 3 to 8 percent slopes, which is Hydrologic Group A soil. Therefore, Hydrologic Group A has been used for modeling the site.

Site specific soil evaluations can be found in Appendix A2.1.

2.2 EXISTING SITE CONDITIONS

Currently the site is predominantly dirt and gravel with a portion of asphalt associated with the driveway to the newly constructed gas station adjacent to the site. Prior to clearing, the site was predominantly wooded. Stormwater runoff from the majority of the site flows overland and discharges to a low area to the northeast of Lot 2. Stormwater runoff from the paved section of the site flows overland to the existing catch basin for neighboring Lot 1, which is ultimately treated and infiltrated in an underground infiltration system on that site. As a conservative approach, the pre-development conditions of the site have been modeled prior to the site clearing using near map imagery.

Design Point 1 (DP-1) represents the existing drainage network that is directed to the stormwater system on Lot 1. Design Point 2 (DP-2) represents the existing low point on Lot 3. None of the stormwater discharging from the site to the existing low point on Lot 3 is currently treated or detained.

2.3 POST SITE CONDITIONS

The proposed drainage analysis uses stormwater management systems to control and treat runoff from the proposed development. The following BMP's are proposed and have been designed to include the following elements:

- Proprietary Separator: Downstream Defender (or Approved Equal)
    - 3rd party testing demonstrates over 80% removal efficiency of TSS;
    - Certification by New Jersey Corporation for Advanced Technology (NJCAT), the industry benchmark for pollutant removal testing;
    - 3rd party testing demonstrates over 80% removal efficiency of oils;
- Underground Infiltration System
    - Fully infiltrates the water quality storm event and all design storms up to and including the 100-year storm event

The above elements will used to meet the MASWMS.

3.0 Minimum Standards

3.1 Minimum Standard 1: No New Untreated Discharges

There are no new untreated discharges from the proposed development.

3.2 Minimum Standard 2: Peak Rate Attenuation

3.2.1 Method of Analysis

USDA Soil Conservation Service Method as defined by Technical Release No. 20 (TR-20) determines Stormwater runoff rate and volume. Type III rainfall distribution is utilized. Time of concentration is determined using Technical Release No 55 (TR-55) methodology, through the computer program *HydroCAD ver. 10.0* by HydroCAD Software Solutions LLC.

Infiltration rates have been determined based on onsite soil evaluations. The soil evaluations were used to develop a texture class. Infiltration rates are based on Rawl's Rates. See table 2.3.3 of the Massachusetts Stormwater Handbook.

Onsite soil evaluations revealed a shallow loamy sand layer at the surface underlain by sand throughout the site. An infiltration rate of 8.27 in/hr has been used under both existing and proposed conditions.

Drainage Network Design Parameters:

A. PIPES

- All drainage pipes are HDPE or equivalent unless otherwise noted.
- Manning's coefficient = 0.012 for HDPE Pipe
- Diameters & lengths as specified
- The 100-year design storm is utilized for the drainage pipe design and/ or overland flow design to ensure that the drainage system contains and channels water to the BMP areas as shown on the plans.
- The rational method has been used for the closed drainage system.

B. STRUCTURES

- Catch basins – Pre-cast concrete with 4' sump unless otherwise noted and inverts as specified
- Manholes – Pre-cast concrete with inverts as specified.

3.2.2 Design Storm

Analysis of 2-year, 10-year, 25-year and 100-year frequency storms are included. The following 24-hour rainfall intensities are obtained from the Cornell Extreme Precipitation in New York & New England (http://precip.eas.cornell.edu/). Note: For design storms where the Hydrology Handbook for Conservation Commissioners (Table F-1) lists a higher intensity than the Cornell data, that intensity has been adopted in lieu of the Cornell figure.

Plymouth County:

2 year =	3.40 inches
10 year =	4.99 inches
25 year =	6.24 inches
100 year=	8.76 inches

3.2.3 Design Point Breakdown

The site is analyzed as two watershed areas. In the pre-development stage there are 2 subcatchments. In the post-development stage, there are 4 subcatchments. A description of each watershed and associated subcatchments are summarized as follows, for cover types see color watershed maps located in back of this report. Numbers in parentheses ( ) indicate the HydroCAD Node Number.

Design Point 1:

Watershed #1 flows to Design Point 1 (DP-1). This watershed consists of the existing roadway on the south portion of the site that provides access to the adjacent gas station. The design point is the existing catch basin on site.

In pre-development conditions there is only one subcatchment tributary to Design Point 1.
Pre-01 (10) contains the existing roadway on the south portion of the site that provides access to the adjacent site. Stormwater travels via sheet flow to the Existing Catch Basin, Design Point 1 (11).

In post-development conditions there is only one subcatchment tributary to Design Point 1.
Post-01 (100) contains the existing roadway on the south portion of the site that provides access to the adjacent site. Stormwater travels via sheet flow to the Existing Catch Basin, Design Point 1 (101)

Below is a summary of the hydrologic parameters for the pre- and post-development subcatchments in Design Point-1.

	Area (acres)	CN	Tc (min)
Pre-01	0.162	76	6.0
Post-01	0.162	76	6.0

Design Point 2:

Watershed #2 flows to Design Point 2 (DP-2). This watershed consists of the majority of the site as shown on the Watershed Maps at the back of this report. The design point is the low point to the northeast of Lot 2.

In pre-development conditions there is only one subcatchment tributary to Design Point 2.
Pre-02 (20) contains most of the site. Stormwater travels via sheet flow to the Design Point 2 (21).

In post-development conditions there are 4 subcatchment tributaries to Design Point 2.
Post-02 (200) collects runoff from a portion of the proposed building and east parking/driving areas, and discharges to a proposed piped drainage network. This drainage network routes the stormwater through the bypass structure (201) to Underground Infiltration System A (202, 203) where it is infiltrated up to the 100-year storm event. If all systems were to fail, stormwater would ultimately flow overland to Design Point 2: Offsite North (213).

Post-03 (204) collects runoff from a portion of the proposed building and west parking/driving areas, and discharges to a proposed piped drainage network. This drainage network routes the stormwater through the bypass structure (205) to Underground Infiltration System B (206, 207) where it is infiltrated up to the 100-year storm event. If all systems were to fail, stormwater would ultimately flow overland to Design Point 2: Offsite North (213).

Post-04 (212) collects runoff from the undetained areas surrounding the parking lot. Stormwater travels via sheet flow to the Design Point 2 (213).

Below is a summary of the hydrologic parameters for the pre- and post-development subcatchments in Design Point-2.

	Area (acres)	CN	Tc (min)
Pre-02	0.921	31	18.5
Post-02	0.448	85	6.0
Post-03	0.298	81	6.0
Post-04	0.175	40	6.0

3.2.4 Outlet Protection

The proposed BMPs and drainage systems have been designed to minimize erosion from the proposed development. The lowest catch basin in each drainage network is used as an emergency overflow outlet. The peak elevations of each system will be below the rim of the lowest structure but under emergency situations these catch basins will serve as a relief point to overflow. These catch basins are located towards the edge of the parking lot in the instance that they overflow they will not impede on the building or pedestrian paths.

3.2.5 Standard 2 Conclusion

The tables below present summaries of both the pre-development flows vs. the mitigated post-development flows as well as the pre-development volumes vs the post-development volumes. The tables show negligible increased in the rate of runoff and volume for some storms included in the analysis but a decrease in stormwater volume for most storms associated with the off-site design point (DP-2).

Pre-development vs. Post-development Mitigated

Watershed 1: (DP-1)

Conditions – Peak Flow	2-Year	10-Year	25-Year	100-Year
Pre-dev Summation	0.24	0.48	0.68	1.10
Post-Dev Summation	0.24	0.48	0.68	1.10
Net Change	0.00	0.00	0.00	0.00

All flows in cubic feet per second (cfs)

Conditions – Volume	2-Year	10-Year	25-Year	100-Year
Pre-dev Summation	0.017	0.034	0.048	0.079
Post-Dev Summation	0.017	0.034	0.048	0.079
Net Change	0.000	0.000	0.000	0.000

All volumes in acre-feet (ac-ft)

Watershed 2: (DP-2)

Conditions – Peak Flow	2-Year	10-Year	25-Year	100-Year
Pre-dev Summation	0.00	0.00	0.02	0.23
Post-Dev Summation	0.00	0.01	0.05	0.25
Net Change	0.00	-0.01	-0.03	-0.02

All flows in cubic feet per second (cfs)

Conditions – Volume	2-Year	10-Year	25-Year	100-Year
Pre-dev Summation	0.000	0.001	0.010	0.054
Post-Dev Summation	0.000	0.003	0.008	0.023
Net Change	0.000	-0.002	0.002	0.031

All volumes in acre-feet (ac-ft)

As shown above, for design point 1, the peak flow and volume have stayed the same. The existing area will remain untouched or restored in kind. For design point 2 the runoff peak flow increases a negligible amount for the 10-100 storms but there is a decrease in stormwater volume following the proposed construction during the 25-100 storm events. All stormwater from the proposed pavement areas is directed to one of the proposed infiltration systems. The increases in peak flow rates are due to the increase in CN value from the woods to grass cover types and is considered negligible. Since design point 2 is a low-lying area, there will be some measure of natural infiltration. Such minor increases are therefore considered unlikely to have any impact on existing conditions since they will most likely be infiltrated. Any additional ponding on the site that could occur from these increases is therefore expected to remain on the site and have no impact on the surrounding properties.

3.3 Minimum Standard 3: Recharge

Recharge is analyzed per watershed based on impervious area coverage in accordance with Standard 3. Groundwater recharge is determined from the following equation:

Rv=F*impervious area

Where: Rv=Required Recharge Volume (ac-ft)

F= Target Depth Factor based on Hydrologic Soil Group Recharge (see table below)

I=Impervious Area (acres)

HSG	Target Depth Factor (F) (inch)
A	0.60
B	0.35
C	0.25
D	0.10

Due to the presence of Hydraulic Group A soils, the Target Depth Factor for this project is 0.60 inches for the Recharge Volume.

Given that:

- This site is required to meet the 1" rule for Water Quality Volume (see following section)
- For each treatment system, one practice is being used to meet both Standards 3 & 4

The Water Quality Volume (1") is larger than the Recharge Volume (0.6") for this project, therefore the infiltration BMPs have been sized to treat and recharge the Water Quality Volume.

The following recharge figures have been calculated using the Water Quality Volume (1"):

BMP	HSG	F	I (Acres)	R_v Required
A	A	*1.00*	0.334	0.028
B	A	*1.00*	0.211	0.018

Recharge volumes are met through the use of infiltration systems.

Each system has been assessed in accordance with the Massachusetts Stormwater Handbook Volume 3 Chapter 1.

<u>Underground Infiltration System A</u>

UIS-A has been sized using the Simple Dynamic method.

Required recharge volume: 0.028 acre-feet (see table above)

Infiltration rate (Rawls rate): 8.27 in/hr (see Appendix 2.1)

A HydroCAD model was calibrated using the impervious area and rainfall data to produce a runoff volume of 0.028 acre-feet. See Appendix 3.3 for detailed results.

As shown in the reported results, all stormwater to be recharged is directed to the water quality infiltration system, without overtopping the weir in the diversion manhole.

<u>Underground Infiltration System B</u>

UIS-B has been sized using the Simple Dynamic method.

Required recharge volume: 0.018 acre-feet (see table above)

Infiltration rate (Rawls rate): 8.27"/hr (see Appendix 2.1)

A HydroCAD model was calibrated using the impervious area and rainfall data to produce a runoff volume of 0.018 acre-feet. See Appendix 3.3 for detailed results.

As shown in the reported results, all stormwater to be recharged is directed to the water quality infiltration system, without overtopping the weir in the diversion manhole.

3.4 Minimum Standard 4: Water Quality

The proposed treatment train has been designed to meet or exceed water quality requirements per Standard 4.

The stormwater management system is required to provide a minimum of 80% TSS removal per Standard 4. See Appendix A3.4 for TSS Removal Calculation Worksheets.

For water quality volume requirements, per the Massachusetts Stormwater Handbook:

The required water quality volume equals 1.0 inch of runoff times the total impervious area of the post-development project site for a discharge –

- From a land use with a higher potential pollutant load
- Within an area with a rapid infiltration rate (greater than 2.4 inches per hour)
- Within a Zone II or Interim Wellhead Protection Area
- Near or to the following critical areas:
    - Outstanding Resource Waters
    - Special Resource Waters
    - Bathing beaches
    - Shellfish growing areas
    - Cold-water fisheries

For all other discharges the required water quality volume equals 0.5 inches of runoff times the total impervious area of the post-development site.

Since this site includes rapid infiltration rates it needs to meet the 1.0 inch rule.

For each treatment system, one practice is being used to meet both Standards 3 & 4. Therefore, the Water Quality Volume has been used to meet the recharge requirement (see previous section for more details).

The Water Quality Volume will be infiltrated using an infiltration system (ADS Stormtech Isolator Rows).

See Appendix 3.4 for TSS removal worksheet, demonstrating 80% TSS removal.

It should be noted that even though the ADS Stormtech Isolator Row has MASTEP verification of up to 83% TSS removal, a rate of 50% has been used in the worksheet to remain conservative.

The treatment train meets the standard regarding water quality volume required by Standard 4.

The provided water quality volume is based on the total storage of the BMP system beneath the elevation of the lowest outlet from the BMP system.

Drain Down

All infiltration BMPs are required to drain down within 72 hours of the storm event. Continuing the analysis methods per Section 3.3, the below equations have been used per the Stormwater Handbook Volume 3 Chapter 1. See hydrographs for the 100-year storm in Appendix A3.2.5.

Since the systems are used for compliance with Standards 3 & 4, the WQV has been used for drain down calculations:

$Time_{drawdown}$ = Rv/[(K)*(Bottom Area)] = 1,220 cuft / [(8.27”/hr/12”)*(666.38 sqft)] = 2.65 hours (UIS-A)

$Time_{drawdown}$ = Rv/[(K)*(Bottom Area)] = 785 cuft / [(8.27”/hr/12”)*(289.63 sqft)] = 3.93 hours (UIS-B)

3.4.1 Individual BMP Water Quality Requirements

Each BMP has been designed per the Massachusetts Stormwater Handbook to provide water quality treatment.

Proprietary Device

A proprietary device is proposed as part of the treatment train, as one of the pretreatment components.

Selection of an appropriate proprietary device has been made in accordance with DEP requirements:

- The proposed proprietary device (Downstream Defender) is in an offline configuration.
- Water quality volume to rate conversion calculations have been undertaken in accordance with the “*Standard Method to Convert Required Water Quality Volume to a Discharge Rate for Sizing Flow Based Manufactured Proprietary Stormwater Treatment Practices*” per the Massachusetts Department of Environmental Protection Wetlands Program.
- Calculations were based on the 1” rule for this site per the Massachusetts Stormwater Handbook.

See Appendix B for detailed calculations and Proprietary Unit selection.

3.4.2 TMDL

The proposed development site ultimately discharges stormwater to the Rose Brook Reservoir which has no listed impairments. Therefore, no TMDL applies to this site.

3.5 Minimum Standard 5: Land Uses with Higher Potential Pollutant Loads (LUHPPLs)

The site is not considered a LUHPPL.

3.6 Minimum Standard 6: Critical Areas

The site is not located within a critical resource area.

3.7 Minimum Standard 7: Redevelopments

The site is not classified as a redevelopment site.

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

See the plan set and Stormwater Pollution Prevention Plan (SWPPP) for this development prepared by DiPrete Engineering.

3.9 Minimum Standard 9: Operation and Maintenance Plan

See the Stormwater System Operations and Maintenance Plan prepared by DiPrete Engineering.

3.10 Minimum Standard 10: Prohibition of Illicit Discharges

There are no existing or proposed illicit discharges on site.

Appendix A

A2.1 Soil Evaluations

DiPrete Engineering

Soil Profile Description Form

DE Project Number 2932-003

Property Owner: Alpha Realty Holdings, LLC

Property Location: Cranberry Hwy. (Lot 2 of Plan Book 63, Page 1009) Wareham, MA

Date of Test Hole: July 26, 2021

Soil Evaluator: Chris Sutter   License Number: SE13767

Weather: Mostly Clear, 80's   Time: 8:00 am

TH 1 Horizon	Depth	Coarse Fragment % by Vol.		Soil Colors - Moist (Munsell)		Re-Dox	Soil Texture (USDA)	Soil Structure	Soil Consistence (Moist)	Infiltration Rate(in/hr) *
		Gravel	Cobbles & Stones	Matrix	Re-Dox Features	Depth, Percent				
Bw	0-18"	-	-	10YR 4/6	-	-	ls	1-gr	fri	NA
C1	18-42"	-	-	2.5Y 5/6	-	-	s	0-sg	L	NA
C2	42-132"	-	-	2.5Y 6/3	-	-	s	0-sg	L	NA

TH 2 Horizon	Depth	Coarse Fragment % by Vol.		Soil Colors - Moist (Munsell)		Re-Dox	Soil Texture (USDA)	Soil Structure	Soil Consistence (Moist)	Infiltration Rate(in/hr)*
		Gravel	Cobbles & Stones	Matrix	Re-Dox Features	Depth, Percent				
Bw	0-16"	-	-	10YR 4/6	-	-	ls	1-gr	fri	NA
C	16-132"	-	-	2.5Y 6/3	-	-	s	0-sg	L	NA

TH 1 Fill Depth NA Total Depth 132" Impervious/Limiting Layer Depth NA GW Seepage Depth NA SHWT 132"

TH 2 Fill Depth NA Total Depth 132" Impervious/Limiting Layer Depth NA GW Seepage Depth NA SHWT 132"

Comments:

DiPrete Engineering

Soil Profile Description Form

DE Project Number 2932-003

Property Owner: Alpha Realty Holdings, LLC
Property Location: Cranberry Hwy. (Lot 2 of Plan Book 63, Page 1009) Wareham, MA
Date of Test Hole: July 26, 2021
Soil Evaluator: Chris Sutter   License Number: SE13767
Weather: Mostly Clear, 80's   Time: 8:00 am

TH 3 Horizon	Depth	Coarse Fragment % by Vol.		Soil Colors - Moist (Munsell)		Re-Dox	Soil Texture (USDA)	Soil Structure	Soil Consistence (Moist)	Infiltration Rate(in/hr) *
		Gravel	Cobbles & Stones	Matrix	Re-Dox Features	Depth, Percent				
Bw	0-18"	-	-	10YR 4/6	-	-	ls	1-gr	fri	NA
C	18-138"	-	-	2.5Y 6/3	-	-	s	0-sg	L	NA

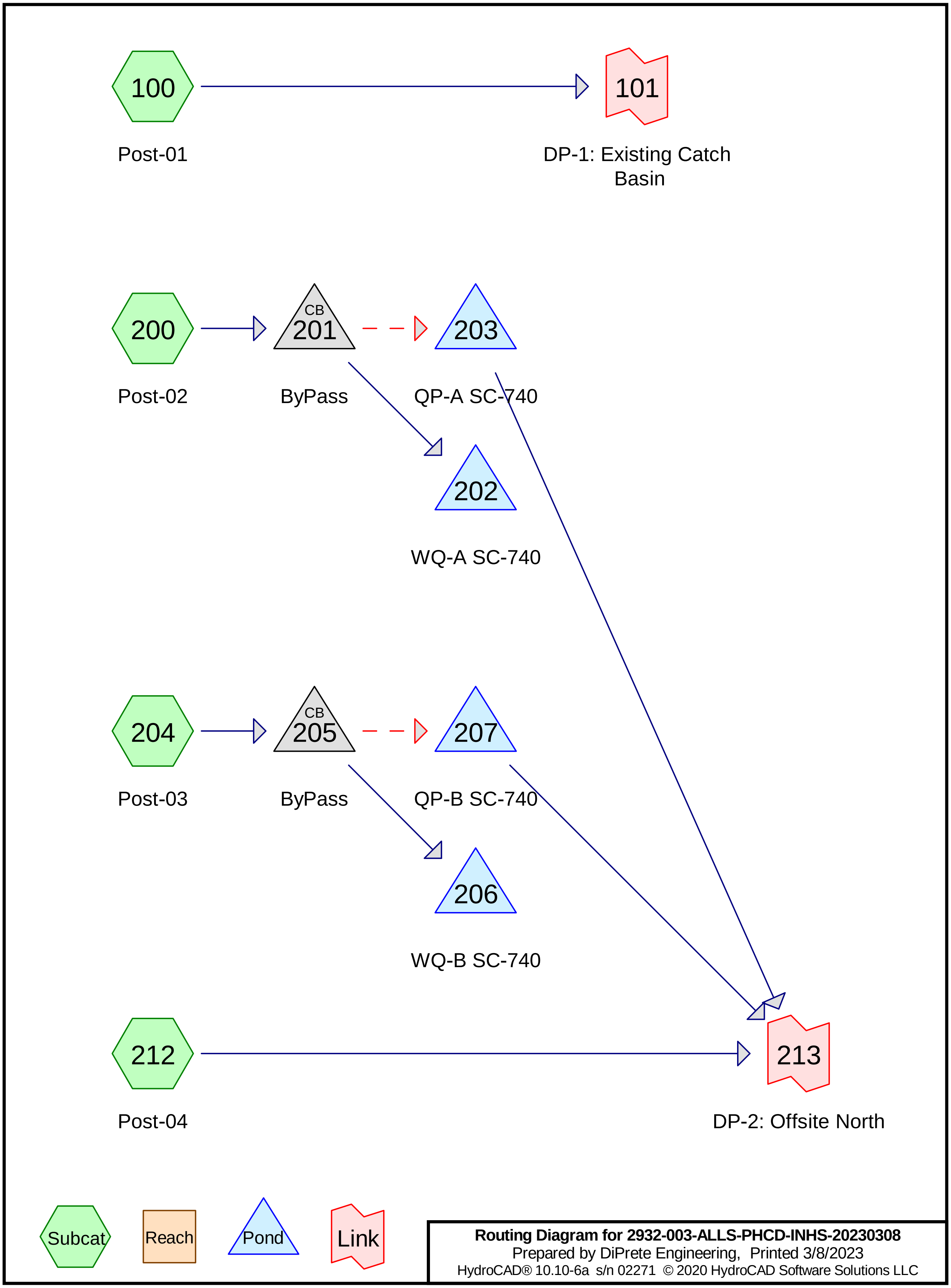
TH 4 Horizon	Depth	Coarse Fragment % by Vol.		Soil Colors - Moist (Munsell)		Re-Dox	Soil Texture (USDA)	Soil Structure	Soil Consistence (Moist)	Infiltration Rate(in/hr)*
		Gravel	Cobbles & Stones	Matrix	Re-Dox Features	Depth, Percent				
Bw	0-16"	-	-	10YR 4/6	-	-	ls	1-gr	fri	NA
C	16-138"	-	-	2.5Y 6/3	-	-	s	0-sg	L	NA

TH 3 Fill Depth NA Total Depth 138" Impervious/Limiting Layer Depth NA GW Seepage Depth NA SHWT 138"

TH 4 Fill Depth NA Total Depth 138" Impervious/Limiting Layer Depth NA GW Seepage Depth NA SHWT 138"

Comments:

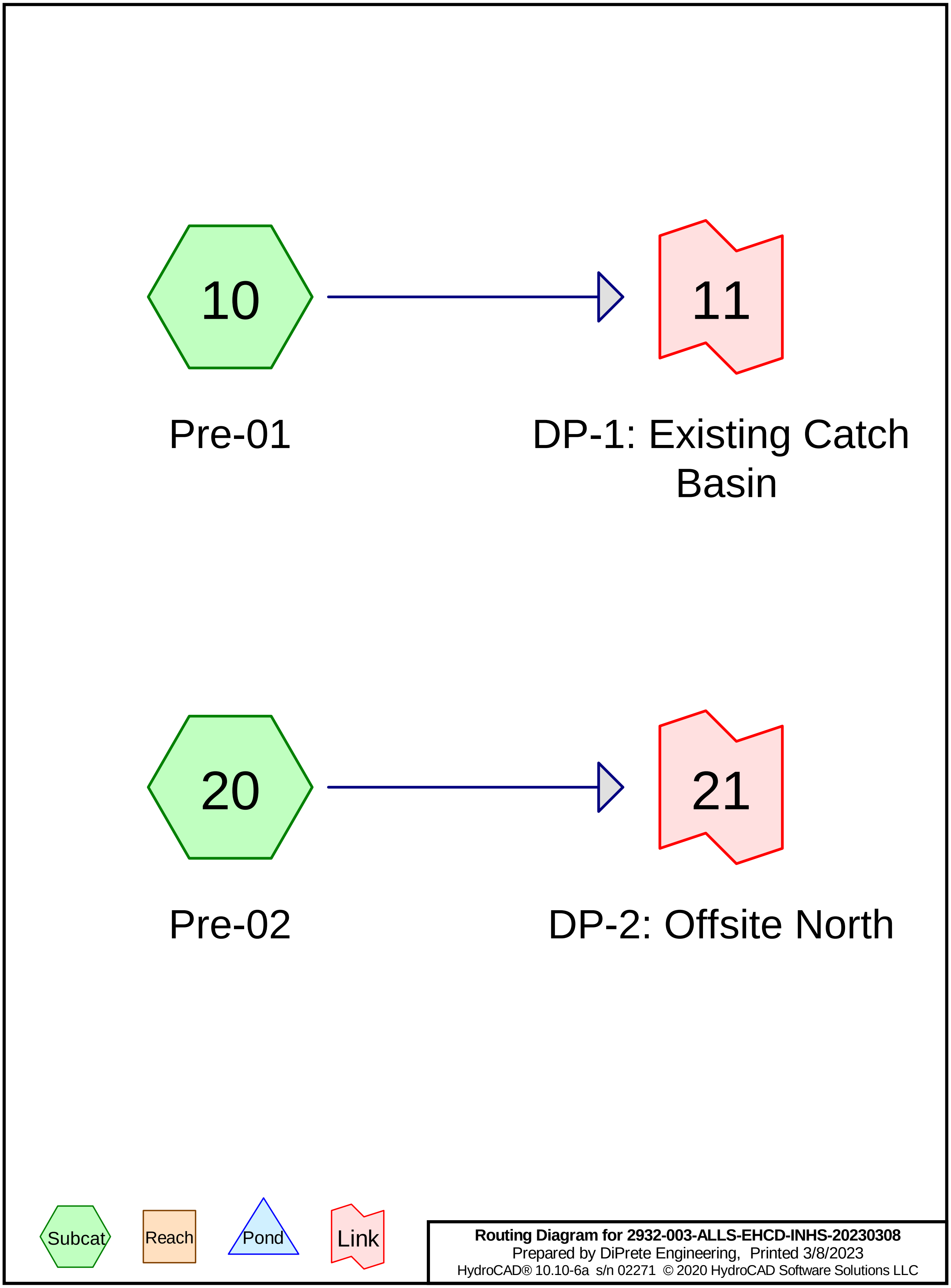
A3.2.1 HydroCAD Node Diagram



Routing Diagram for 2932-003-ALLS-PHCD-INHS-20230308
Prepared by DiPrete Engineering, Printed 3/8/2023
HydroCAD® 10.10-6a s/n 02271 © 2020 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.416	39	>75% Grass cover, Good, HSG A (100, 200, 204, 212)
0.661	98	Impervious, HSG A (100, 200, 204)
0.005	98	Offsite Impervious, HSG A (100, 200, 204, 212)
1.083	**75**	**TOTAL AREA**


10
11
Pre-01
DP-1: Existing Catch Basin
20
21
Pre-02
DP-2: Offsite North
Subcat
Reach
Pond
Link
Routing Diagram for 2932-003-ALLS-EHCD-INHS-20230308
Prepared by DiPrete Engineering, Printed 3/8/2023
HydroCAD® 10.10-6a s/n 02271 © 2020 HydroCAD Software Solutions LLC

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.145	39	>75% Grass cover, Good, HSG A (10, 20)
0.101	98	Impervious, HSG A (10, 20)
0.005	98	Offsite Impervious, HSG A (10, 20)
0.791	30	Woods, Good, HSG A (20)
0.041	32	Woods/grass comb., Good, HSG A (20)
1.083	**38**	**TOTAL AREA**

A3.2.2 HydroCAD 2-Year Storm Analysis

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 100: Post-01 Runoff Area=0.162 ac 62.43% Impervious Runoff Depth=1.29"
Tc=6.0 min CN=76 Runoff=0.24 cfs 0.017 af

Subcatchment 200: Post-02 Runoff Area=0.448 ac 78.19% Impervious Runoff Depth=1.93"
Tc=6.0 min CN=85 Runoff=1.01 cfs 0.072 af

Subcatchment 204: Post-03 Runoff Area=0.298 ac 71.49% Impervious Runoff Depth=1.63"
Tc=6.0 min CN=81 Runoff=0.57 cfs 0.040 af

Subcatchment 212: Post-04 Runoff Area=0.175 ac 1.29% Impervious Runoff Depth=0.01"
Tc=6.0 min CN=40 Runoff=0.00 cfs 0.000 af

Pond 201: ByPass Peak Elev=46.67' Inflow=1.01 cfs 0.072 af
Primary=0.84 cfs 0.064 af Secondary=0.25 cfs 0.008 af Outflow=1.01 cfs 0.072 af

Pond 202: WQ-A SC-740 Peak Elev=46.64' Storage=0.016 af Inflow=0.84 cfs 0.064 af
Outflow=0.13 cfs 0.064 af

Pond 203: QP-A SC-740 Peak Elev=45.01' Storage=0.000 af Inflow=0.25 cfs 0.008 af
Discarded=0.25 cfs 0.008 af Primary=0.00 cfs 0.000 af Outflow=0.25 cfs 0.008 af

Pond 205: ByPass Peak Elev=46.97' Inflow=0.57 cfs 0.040 af
Primary=0.57 cfs 0.035 af Secondary=0.26 cfs 0.005 af Outflow=0.57 cfs 0.040 af

Pond 206: WQ-B SC-740 Peak Elev=46.97' Storage=0.010 af Inflow=0.57 cfs 0.035 af
Outflow=0.06 cfs 0.035 af

Pond 207: QP-B SC-740 Peak Elev=44.51' Storage=0.000 af Inflow=0.26 cfs 0.005 af
Discarded=0.22 cfs 0.005 af Primary=0.00 cfs 0.000 af Outflow=0.22 cfs 0.005 af

Link 101: DP-1: Existing Catch Basin Inflow=0.24 cfs 0.017 af
Primary=0.24 cfs 0.017 af

Link 213: DP-2: Offsite North Inflow=0.00 cfs 0.000 af
Primary=0.00 cfs 0.000 af

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 10: Pre-01 Runoff Area=0.162 ac 62.45% Impervious Runoff Depth=1.29"
Tc=6.0 min CN=76 Runoff=0.24 cfs 0.017 af

Subcatchment 20: Pre-02 Runoff Area=0.921 ac 0.56% Impervious Runoff Depth=0.00"
Flow Length=296' Tc=18.5 min CN=31 Runoff=0.00 cfs 0.000 af

Link 11: DP-1: Existing Catch Basin Inflow=0.24 cfs 0.017 af
Primary=0.24 cfs 0.017 af

Link 21: DP-2: Offsite North Inflow=0.00 cfs 0.000 af
Primary=0.00 cfs 0.000 af

A3.2.3 HydroCAD 10-Year Storm Analysis

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 100: Post-01 Runoff Area=0.162 ac 62.43% Impervious Runoff Depth=2.53"
Tc=6.0 min CN=76 Runoff=0.48 cfs 0.034 af

Subcatchment 200: Post-02 Runoff Area=0.448 ac 78.19% Impervious Runoff Depth=3.36"
Tc=6.0 min CN=85 Runoff=1.75 cfs 0.125 af

Subcatchment 204: Post-03 Runoff Area=0.298 ac 71.49% Impervious Runoff Depth=2.98"
Tc=6.0 min CN=81 Runoff=1.04 cfs 0.074 af

Subcatchment 212: Post-04 Runoff Area=0.175 ac 1.29% Impervious Runoff Depth=0.23"
Tc=6.0 min CN=40 Runoff=0.01 cfs 0.003 af

Pond 201: ByPass Peak Elev=46.81' Inflow=1.75 cfs 0.125 af
Primary=0.73 cfs 0.089 af Secondary=1.24 cfs 0.036 af Outflow=1.75 cfs 0.125 af

Pond 202: WQ-A SC-740 Peak Elev=46.74' Storage=0.017 af Inflow=0.73 cfs 0.089 af
Outflow=0.13 cfs 0.089 af

Pond 203: QP-A SC-740 Peak Elev=46.00' Storage=0.019 af Inflow=1.24 cfs 0.036 af
Discarded=0.27 cfs 0.036 af Primary=0.00 cfs 0.000 af Outflow=0.27 cfs 0.036 af

Pond 205: ByPass Peak Elev=47.08' Inflow=1.04 cfs 0.074 af
Primary=0.65 cfs 0.048 af Secondary=1.03 cfs 0.026 af Outflow=1.04 cfs 0.074 af

Pond 206: WQ-B SC-740 Peak Elev=47.09' Storage=0.011 af Inflow=0.65 cfs 0.048 af
Outflow=0.06 cfs 0.048 af

Pond 207: QP-B SC-740 Peak Elev=45.26' Storage=0.011 af Inflow=1.03 cfs 0.026 af
Discarded=0.22 cfs 0.026 af Primary=0.00 cfs 0.000 af Outflow=0.22 cfs 0.026 af

Link 101: DP-1: Existing Catch Basin Inflow=0.48 cfs 0.034 af
Primary=0.48 cfs 0.034 af

Link 213: DP-2: Offsite North Inflow=0.01 cfs 0.003 af
Primary=0.01 cfs 0.003 af

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 10: Pre-01 Runoff Area=0.162 ac 62.45% Impervious Runoff Depth=2.53"
Tc=6.0 min CN=76 Runoff=0.48 cfs 0.034 af

Subcatchment 20: Pre-02 Runoff Area=0.921 ac 0.56% Impervious Runoff Depth=0.01"
Flow Length=296' Tc=18.5 min CN=31 Runoff=0.00 cfs 0.001 af

Link 11: DP-1: Existing Catch Basin Inflow=0.48 cfs 0.034 af
Primary=0.48 cfs 0.034 af

Link 21: DP-2: Offsite North Inflow=0.00 cfs 0.001 af
Primary=0.00 cfs 0.001 af

A3.2.4 HydroCAD 25-Year Storm Analysis

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 100: Post-01 Runoff Area=0.162 ac 62.43% Impervious Runoff Depth=3.59"
Tc=6.0 min CN=76 Runoff=0.68 cfs 0.048 af

Subcatchment 200: Post-02 Runoff Area=0.448 ac 78.19% Impervious Runoff Depth=4.53"
Tc=6.0 min CN=85 Runoff=2.33 cfs 0.169 af

Subcatchment 204: Post-03 Runoff Area=0.298 ac 71.49% Impervious Runoff Depth=4.10"
Tc=6.0 min CN=81 Runoff=1.42 cfs 0.102 af

Subcatchment 212: Post-04 Runoff Area=0.175 ac 1.29% Impervious Runoff Depth=0.58"
Tc=6.0 min CN=40 Runoff=0.05 cfs 0.008 af

Pond 201: ByPass Peak Elev=46.89' Inflow=2.33 cfs 0.169 af
Primary=0.72 cfs 0.107 af Secondary=1.98 cfs 0.062 af Outflow=2.33 cfs 0.169 af

Pond 202: WQ-A SC-740 Peak Elev=46.83' Storage=0.018 af Inflow=0.72 cfs 0.107 af
Outflow=0.13 cfs 0.107 af

Pond 203: QP-A SC-740 Peak Elev=46.76' Storage=0.037 af Inflow=1.98 cfs 0.062 af
Discarded=0.27 cfs 0.062 af Primary=0.00 cfs 0.000 af Outflow=0.27 cfs 0.062 af

Pond 205: ByPass Peak Elev=47.12' Inflow=1.42 cfs 0.102 af
Primary=0.51 cfs 0.057 af Secondary=1.37 cfs 0.045 af Outflow=1.42 cfs 0.102 af

Pond 206: WQ-B SC-740 Peak Elev=47.12' Storage=0.011 af Inflow=0.51 cfs 0.057 af
Outflow=0.06 cfs 0.057 af

Pond 207: QP-B SC-740 Peak Elev=45.85' Storage=0.023 af Inflow=1.37 cfs 0.045 af
Discarded=0.22 cfs 0.045 af Primary=0.00 cfs 0.000 af Outflow=0.22 cfs 0.045 af

Link 101: DP-1: Existing Catch Basin Inflow=0.68 cfs 0.048 af
Primary=0.68 cfs 0.048 af

Link 213: DP-2: Offsite North Inflow=0.05 cfs 0.008 af
Primary=0.05 cfs 0.008 af

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 10: Pre-01 Runoff Area=0.162 ac 62.45% Impervious Runoff Depth=3.59"
Tc=6.0 min CN=76 Runoff=0.68 cfs 0.048 af

Subcatchment 20: Pre-02 Runoff Area=0.921 ac 0.56% Impervious Runoff Depth=0.13"
Flow Length=296' Tc=18.5 min CN=31 Runoff=0.02 cfs 0.010 af

Link 11: DP-1: Existing Catch Basin Inflow=0.68 cfs 0.048 af
Primary=0.68 cfs 0.048 af

Link 21: DP-2: Offsite North Inflow=0.02 cfs 0.010 af
Primary=0.02 cfs 0.010 af

A3.2.5 HydroCAD 100-Year Storm Analysis

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 100: Post-01 Runoff Area=0.162 ac 62.43% Impervious Runoff Depth=5.85"
Tc=6.0 min CN=76 Runoff=1.10 cfs 0.079 af

Subcatchment 200: Post-02 Runoff Area=0.448 ac 78.19% Impervious Runoff Depth=6.95"
Tc=6.0 min CN=85 Runoff=3.50 cfs 0.259 af

Subcatchment 204: Post-03 Runoff Area=0.298 ac 71.49% Impervious Runoff Depth=6.46"
Tc=6.0 min CN=81 Runoff=2.21 cfs 0.161 af

Subcatchment 212: Post-04 Runoff Area=0.175 ac 1.29% Impervious Runoff Depth=1.60"
Tc=6.0 min CN=40 Runoff=0.25 cfs 0.023 af

Pond 201: ByPass Peak Elev=49.05' Inflow=3.50 cfs 0.259 af
Primary=0.58 cfs 0.135 af Secondary=3.22 cfs 0.124 af Outflow=3.50 cfs 0.259 af

Pond 202: WQ-A SC-740 Peak Elev=49.52' Storage=0.032 af Inflow=0.58 cfs 0.135 af
Outflow=0.13 cfs 0.135 af

Pond 203: QP-A SC-740 Peak Elev=49.07' Storage=0.068 af Inflow=3.22 cfs 0.124 af
Discarded=0.27 cfs 0.124 af Primary=0.00 cfs 0.000 af Outflow=0.27 cfs 0.124 af

Pond 205: ByPass Peak Elev=47.39' Inflow=2.21 cfs 0.161 af
Primary=0.29 cfs 0.070 af Secondary=2.16 cfs 0.091 af Outflow=2.21 cfs 0.161 af

Pond 206: WQ-B SC-740 Peak Elev=47.39' Storage=0.011 af Inflow=0.29 cfs 0.070 af
Outflow=0.06 cfs 0.070 af

Pond 207: QP-B SC-740 Peak Elev=47.39' Storage=0.050 af Inflow=2.16 cfs 0.091 af
Discarded=0.22 cfs 0.091 af Primary=0.00 cfs 0.000 af Outflow=0.22 cfs 0.091 af

Link 101: DP-1: Existing Catch Basin Inflow=1.10 cfs 0.079 af
Primary=1.10 cfs 0.079 af

Link 213: DP-2: Offsite North Inflow=0.25 cfs 0.023 af
Primary=0.25 cfs 0.023 af

Summary for Subcatchment 100: Post-01

Runoff = 1.10 cfs @ 12.09 hrs, Volume= 0.079 af, Depth= 5.85"
Routed to Link 101 : DP-1: Existing Catch Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.76"

Area (ac)	CN	Description
0.061	39	>75% Grass cover, Good, HSG A
0.101	98	Impervious, HSG A
0.000	98	Offsite Impervious, HSG A
0.162	76	Weighted Average
0.061	39	37.57% Pervious Area
0.101	98	62.43% Impervious Area

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

Summary for Subcatchment 200: Post-02

Runoff = 3.50 cfs @ 12.08 hrs, Volume= 0.259 af, Depth= 6.95"
Routed to Pond 201 : ByPass

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.76"

Area (ac)	CN	Description
0.098	39	>75% Grass cover, Good, HSG A
0.350	98	Impervious, HSG A
0.000	98	Offsite Impervious, HSG A
0.448	85	Weighted Average
0.098	39	21.81% Pervious Area
0.350	98	78.19% Impervious Area

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

Summary for Subcatchment 204: Post-03

Runoff = 2.21 cfs @ 12.09 hrs, Volume= 0.161 af, Depth= 6.46"
Routed to Pond 205 : ByPass

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.76"

Area (ac)	CN	Description
0.085	39	>75% Grass cover, Good, HSG A
0.210	98	Impervious, HSG A
0.003	98	Offsite Impervious, HSG A
0.298	81	Weighted Average
0.085	39	28.51% Pervious Area
0.213	98	71.49% Impervious Area

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

Summary for Subcatchment 212: Post-04

Runoff = 0.25 cfs @ 12.11 hrs, Volume= 0.023 af, Depth= 1.60"
Routed to Link 213 : DP-2: Offsite North

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.76"

Area (ac)	CN	Description
0.173	39	>75% Grass cover, Good, HSG A
0.002	98	Offsite Impervious, HSG A
0.175	40	Weighted Average
0.173	39	98.71% Pervious Area
0.002	98	1.29% Impervious Area

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

Summary for Pond 201: ByPass

Inflow Area = 0.448 ac, 78.19% Impervious, Inflow Depth = 6.95" for 100-Year event
Inflow = 3.50 cfs @ 12.08 hrs, Volume= 0.259 af
Outflow = 3.50 cfs @ 12.08 hrs, Volume= 0.259 af, Atten= 0%, Lag= 0.0 min
Primary = 0.58 cfs @ 12.24 hrs, Volume= 0.135 af
Routed to Pond 202 : WQ-A SC-740
Secondary = 3.22 cfs @ 12.09 hrs, Volume= 0.124 af
Routed to Pond 203 : QP-A SC-740

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 49.05' @ 12.75 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	45.60'	**6.00" Round WQ** L= 6.4' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 45.60' / 45.54' S= 0.0094 '/' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf
#2	Device 3	46.60'	**4.0' long ByPass Weir** 2 End Contraction(s)
#3	Secondary	45.68'	**15.00" Round QP** L= 7.5' CPP, square edge headwall, Ke= 0.500

Inlet / Outlet Invert= 45.68' / 45.61' S= 0.0093 '/' Cc= 0.900
n= 0.012, Flow Area= 1.23 sf

Primary OutFlow Max=0.55 cfs @ 12.24 hrs HW=47.70' TW=47.37' (Dynamic Tailwater)
↑—**1=WQ** (Inlet Controls 0.55 cfs @ 2.78 fps)

Secondary OutFlow Max=3.21 cfs @ 12.09 hrs HW=47.00' TW=46.61' (Dynamic Tailwater)
↑—**3=QP** (Passes 3.21 cfs of 3.66 cfs potential flow)
  ↑—**2=ByPass Weir** (Weir Controls 3.21 cfs @ 2.06 fps)

Summary for Pond 202: WQ-A SC-740

Inflow Area = 0.448 ac, 78.19% Impervious, Inflow Depth = 3.62" for 100-Year event
Inflow = 0.58 cfs @ 12.24 hrs, Volume= 0.135 af
Outflow = 0.13 cfs @ 12.62 hrs, Volume= 0.135 af, Atten= 78%, Lag= 22.6 min
Discarded = 0.13 cfs @ 12.62 hrs, Volume= 0.135 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 49.52' @ 12.66 hrs Surf.Area= 0.016 ac Storage= 0.032 af

Plug-Flow detention time= 62.5 min calculated for 0.135 af (100% of inflow)
Center-of-Mass det. time= 62.5 min (877.5 - 815.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	45.00'	0.015 af	**11.00'W x 60.58'L x 3.50'H Field A** 0.054 af Overall - 0.017 af Embedded = 0.037 af x 40.0% Voids
#2A	45.50'	0.017 af	**ADS_StormTech SC-740 +Cap** x 16 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 16 Chambers in 2 Rows
#3	48.50'	0.001 af	**4.00'D x 3.00'H Vertical Cone/Cylinder**
		0.032 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	45.00'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'

Discarded OutFlow Max=0.13 cfs @ 12.62 hrs HW=48.56' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.13 cfs)

Summary for Pond 203: QP-A SC-740

Inflow = 3.22 cfs @ 12.09 hrs, Volume= 0.124 af
Outflow = 0.27 cfs @ 12.60 hrs, Volume= 0.124 af, Atten= 92%, Lag= 30.7 min
Discarded = 0.27 cfs @ 12.60 hrs, Volume= 0.124 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Link 213 : DP-2: Offsite North

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Peak Elev= 49.07' @ 12.71 hrs Surf.Area= 0.032 ac Storage= 0.068 af

Plug-Flow detention time= 113.1 min calculated for 0.124 af (100% of inflow)
Center-of-Mass det. time= 113.1 min (870.5 - 757.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	45.00'	0.029 af	**20.50'W x 67.70'L x 3.50'H Field A** 0.112 af Overall - 0.038 af Embedded = 0.074 af x 40.0% Voids
#2A	45.50'	0.038 af	**ADS_StormTech SC-740 +Cap** x 36 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 36 Chambers in 4 Rows
#3	48.50'	0.001 af	**4.00'D x 3.00'H Vertical Cone/Cylinder**
		0.068 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	45.00'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'
#2	Primary	50.90'	**1.20" x 21.00" Horiz. Orifice/Grate X 10.00** C= 0.600 in 24.00" x 24.00" Grate (44% open area) Limited to weir flow at low heads

Discarded OutFlow Max=0.27 cfs @ 12.60 hrs HW=48.59' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.27 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=45.00' TW=0.00' (Dynamic Tailwater)
↑—**2=Orifice/Grate** (Controls 0.00 cfs)

Summary for Pond 205: ByPass

Inflow Area = 0.298 ac, 71.49% Impervious, Inflow Depth = 6.46" for 100-Year event
Inflow = 2.21 cfs @ 12.09 hrs, Volume= 0.161 af
Outflow = 2.21 cfs @ 12.09 hrs, Volume= 0.161 af, Atten= 0%, Lag= 0.0 min
Primary = 0.29 cfs @ 11.62 hrs, Volume= 0.070 af
Routed to Pond 206 : WQ-B SC-740
Secondary = 2.16 cfs @ 12.09 hrs, Volume= 0.091 af
Routed to Pond 207 : QP-B SC-740

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 47.39' @ 12.66 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	45.12'	**6.00" Round WQ** L= 7.5' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 45.12' / 45.04' S= 0.0107 '/' Cc= 0.900 n= 0.012, Flow Area= 0.20 sf
#2	Device 3	46.90'	**4.0' long ByPass Weir** 2 End Contraction(s)
#3	Secondary	45.19'	**12.00" Round QP** L= 8.9' CPP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 45.19' / 45.10' S= 0.0101 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf

Primary OutFlow Max=0.20 cfs @ 11.62 hrs HW=46.88' TW=46.83' (Dynamic Tailwater)
↑—**1=WQ** (Inlet Controls 0.20 cfs @ 1.02 fps)

Secondary OutFlow Max=2.16 cfs @ 12.09 hrs HW=47.20' TW=45.83' (Dynamic Tailwater)
↑—**3=QP** (Passes 2.16 cfs of 4.43 cfs potential flow)
  ↑—**2=ByPass Weir** (Weir Controls 2.16 cfs @ 1.80 fps)

Summary for Pond 206: WQ-B SC-740

Inflow Area = 0.298 ac, 71.49% Impervious, Inflow Depth = 2.82" for 100-Year event
Inflow = 0.29 cfs @ 11.62 hrs, Volume= 0.070 af
Outflow = 0.06 cfs @ 9.77 hrs, Volume= 0.070 af, Atten= 81%, Lag= 0.0 min
Discarded = 0.06 cfs @ 9.77 hrs, Volume= 0.070 af

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 47.39' @ 12.66 hrs Surf.Area= 0.007 ac Storage= 0.011 af

Plug-Flow detention time= 80.4 min calculated for 0.070 af (100% of inflow)
Center-of-Mass det. time= 80.4 min (937.8 - 857.4)

Volume	Invert	Avail.Storage	Storage Description
#1A	44.50'	0.007 af	**6.25'W x 46.34'L x 3.50'H Field A**
			0.023 af Overall - 0.006 af Embedded = 0.017 af x 40.0% Voids
#2A	45.00'	0.006 af	**ADS_StormTech SC-740 +Cap** x 6 Inside #1
			Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf
			Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap
		0.013 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	44.50'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'

Discarded OutFlow Max=0.06 cfs @ 9.77 hrs HW=44.54' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.06 cfs)

Summary for Pond 207: QP-B SC-740

Inflow = 2.16 cfs @ 12.09 hrs, Volume= 0.091 af
Outflow = 0.22 cfs @ 11.72 hrs, Volume= 0.091 af, Atten= 90%, Lag= 0.0 min
Discarded = 0.22 cfs @ 11.72 hrs, Volume= 0.091 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af
Routed to Link 213 : DP-2: Offsite North

Routing by Dyn-Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 47.39' @ 12.66 hrs Surf.Area= 0.027 ac Storage= 0.050 af

Plug-Flow detention time= 95.0 min calculated for 0.091 af (100% of inflow)
Center-of-Mass det. time= 94.9 min (845.7 - 750.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	44.50'	0.025 af	**25.25'W x 46.34'L x 3.50'H Field A** 0.094 af Overall - 0.032 af Embedded = 0.062 af x 40.0% Voids
#2A	45.00'	0.032 af	**ADS_StormTech SC-740 +Cap** x 30 Inside #1 Effective Size= 44.6"W x 30.0"H => 6.45 sf x 7.12'L = 45.9 cf Overall Size= 51.0"W x 30.0"H x 7.56'L with 0.44' Overlap 30 Chambers in 5 Rows
		0.057 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	44.50'	**8.270 in/hr Exfiltration over Surface area** Phase-In= 0.01'
#2	Primary	50.51'	**1.20" x 21.00" Horiz. Orifice/Grate X 10.00** C= 0.600 in 24.00" x 24.00" Grate (44% open area) Limited to weir flow at low heads

Discarded OutFlow Max=0.22 cfs @ 11.72 hrs HW=44.56' (Free Discharge)
↑—**1=Exfiltration** (Exfiltration Controls 0.22 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=44.50' TW=0.00' (Dynamic Tailwater)
↑—**2=Orifice/Grate** (Controls 0.00 cfs)

Summary for Link 101: DP-1: Existing Catch Basin

Inflow Area = 0.162 ac, 62.43% Impervious, Inflow Depth = 5.85" for 100-Year event
Inflow = 1.10 cfs @ 12.09 hrs, Volume= 0.079 af
Primary = 1.10 cfs @ 12.09 hrs, Volume= 0.079 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 213: DP-2: Offsite North

Inflow Area = 0.175 ac, 1.29% Impervious, Inflow Depth = 1.60" for 100-Year event
Inflow = 0.25 cfs @ 12.11 hrs, Volume= 0.023 af
Primary = 0.25 cfs @ 12.11 hrs, Volume= 0.023 af, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 10: Pre-01 Runoff Area=0.162 ac 62.45% Impervious Runoff Depth=5.85"
Tc=6.0 min CN=76 Runoff=1.10 cfs 0.079 af

Subcatchment 20: Pre-02 Runoff Area=0.921 ac 0.56% Impervious Runoff Depth=0.70"
Flow Length=296' Tc=18.5 min CN=31 Runoff=0.23 cfs 0.054 af

Link 11: DP-1: Existing Catch Basin Inflow=1.10 cfs 0.079 af
Primary=1.10 cfs 0.079 af

Link 21: DP-2: Offsite North Inflow=0.23 cfs 0.054 af
Primary=0.23 cfs 0.054 af

Summary for Subcatchment 10: Pre-01

Runoff = 1.10 cfs @ 12.09 hrs, Volume= 0.079 af, Depth= 5.85"
Routed to Link 11 : DP-1: Existing Catch Basin

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.76"

Area (ac)	CN	Description
0.061	39	>75% Grass cover, Good, HSG A
0.101	98	Impervious, HSG A
0.000	98	Offsite Impervious, HSG A
0.162	76	Weighted Average
0.061	39	37.55% Pervious Area
0.101	98	62.45% Impervious Area

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

Summary for Subcatchment 20: Pre-02

Runoff = 0.23 cfs @ 12.52 hrs, Volume= 0.054 af, Depth= 0.70"
Routed to Link 21 : DP-2: Offsite North

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=8.76"

Area (ac)	CN	Description
0.084	39	>75% Grass cover, Good, HSG A
0.000	98	Impervious, HSG A
0.005	98	Offsite Impervious, HSG A
0.791	30	Woods, Good, HSG A
0.041	32	Woods/grass comb., Good, HSG A
0.921	31	Weighted Average
0.916	31	99.44% Pervious Area
0.005	98	0.56% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
16.5	100	0.0360	0.10		**Sheet Flow, A** Woods: Light underbrush n= 0.400 P2= 3.40"
2.0	196	0.0100	1.61		**Shallow Concentrated Flow, B** Unpaved Kv= 16.1 fps
18.5	296	Total			

Summary for Link 11: DP-1: Existing Catch Basin

```
Inflow Area =      0.162 ac,  62.45% Impervious,  Inflow Depth =  5.85"    for  100-Year event
Inflow      =      1.10 cfs @   12.09 hrs,  Volume=          0.079 af
Primary     =      1.10 cfs @   12.09 hrs,  Volume=          0.079 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Link 21: DP-2: Offsite North

```
Inflow Area =      0.921 ac,   0.56% Impervious,  Inflow Depth =  0.70"    for  100-Year event
Inflow      =      0.23 cfs @   12.52 hrs,  Volume=          0.054 af
Primary     =      0.23 cfs @   12.52 hrs,  Volume=          0.054 af,  Atten= 0%,  Lag= 0.0 min
```

Primary outflow = Inflow, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

A3.3 HydroCAD Water Quality Storm Analysis

Time span=0.00-72.00 hrs, dt=0.01 hrs, 7201 points
Runoff by SCS TR-20 method, UH=SCS, Split Pervious/Imperv.
Reach routing by Dyn-Stor-Ind method - Pond routing by Dyn-Stor-Ind method

Subcatchment 100: Post-01 Runoff Area=0.162 ac 62.43% Impervious Runoff Depth=0.62"
Tc=6.0 min CN=39/98 Runoff=0.11 cfs 0.008 af

Subcatchment 200: Post-02 Runoff Area=0.448 ac 78.19% Impervious Runoff Depth=0.77"
Tc=6.0 min CN=39/98 Runoff=0.38 cfs 0.029 af

Subcatchment 204: Post-03 Runoff Area=0.298 ac 71.49% Impervious Runoff Depth=0.70"
Tc=6.0 min CN=39/98 Runoff=0.23 cfs 0.018 af

Subcatchment 212: Post-04 Runoff Area=0.175 ac 1.29% Impervious Runoff Depth=0.01"
Tc=6.0 min CN=39/98 Runoff=0.00 cfs 0.000 af

Pond 201: ByPass Peak Elev=46.08' Inflow=0.38 cfs 0.029 af
Primary=0.38 cfs 0.029 af Secondary=0.00 cfs 0.000 af Outflow=0.38 cfs 0.029 af

Pond 202: WQ-A SC-740 Peak Elev=45.59' Storage=0.004 af Inflow=0.38 cfs 0.029 af
Outflow=0.13 cfs 0.029 af

Pond 203: QP-A SC-740 Peak Elev=45.00' Storage=0.000 af 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 205: ByPass Peak Elev=45.49' Inflow=0.23 cfs 0.018 af
Primary=0.23 cfs 0.018 af Secondary=0.00 cfs 0.000 af Outflow=0.23 cfs 0.018 af

Pond 206: WQ-B SC-740 Peak Elev=45.48' Storage=0.004 af Inflow=0.23 cfs 0.018 af
Outflow=0.06 cfs 0.018 af

Pond 207: QP-B SC-740 Peak Elev=44.50' Storage=0.000 af 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

Link 101: DP-1: Existing Catch Basin Inflow=0.11 cfs 0.008 af
Primary=0.11 cfs 0.008 af

Link 213: DP-2: Offsite North Inflow=0.00 cfs 0.000 af
Primary=0.00 cfs 0.000 af

A3.4 TSS Removal Calculations Worksheets

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: UIS-A

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**0.25**	**1.00**	**0.25**	**0.75**
Extended Dry Detention Basin	**0.50**	**0.75**	**0.38**	**0.38**
Extended Dry Detention Basin	**0.50**	**0.38**	**0.19**	**0.19**
Infiltration Basin	**0.80**	**0.19**	**0.15**	**0.04**
	0.00	**0.04**	**0.00**	**0.04**

Total TSS Removal = 96%

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

Project: **2932-003 Popeyes Cranberry Highway**
Prepared By: **DiPrete Engineering**
Date: **3/8/2023**

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

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

INSTRUCTIONS:
1. In BMP Column, click on Blue Cell to Activate Drop Down Menu
2. Select BMP from Drop Down Menu
3. After BMP is selected, TSS Removal and other Columns are automatically completed.

Version 1, Automated: Mar. 4, 2008

Location: UIS-B

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[1]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**0.25**	**1.00**	**0.25**	**0.75**
Extended Dry Detention Basin	**0.50**	**0.75**	**0.38**	**0.38**
Extended Dry Detention Basin	**0.50**	**0.38**	**0.19**	**0.19**
Infiltration Basin	**0.80**	**0.19**	**0.15**	**0.04**
	0.00	**0.04**	**0.00**	**0.04**

Total TSS Removal = 96%

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

Project: **2932-003 Popeyes Cranberry Highway**
Prepared By: **DiPrete Engineering**
Date: **3/8/2023**

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

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

A4.1 Drainage Network Hydraulic Calculations

Draninage Inlet Area and Cover Types

C Values

Impervious	0.90
Grass	0.25
Woods	0.20

Inlet	Total Area	Impervious Area	Grass Area	Woods/Brush Area	C Value
1	0.179	0.167	0.012	0	0.86
6	0.15	0.111	0.039	0	0.73
7	0.055	0.034	0.021	0	0.65
8	0.129	0.065	0.064	0	0.58
12	0.132	0.109	0.023	0	0.79
17	0.024	0.024	0	0	0.90
18	0.035	0.035	0	0	0.90

DiPrete Engineering
Engineers • Planners • Surveyors

Project Name: Cranberry Highway UIS A — 25-Year Storm
Project Number: 2932-003 — Date: 1/16/2023

Pipe Analysis

Pipe ID	Pipe Length	Pipe Size	Pipe Slope	Flow Rate	Capacity Full	Velocity	Invert Down	Invert Up
	(ft)	(in)	(%)	(cfs)	(cfs)	(ft/s)	(Ft)	(ft)
3	12.00	15	1.00%	2.6	7.01	5.3	45.75	45.87
2	82.65	15	1.00%	1.5	7.01	4.5	45.87	46.70
1	42.37	15	1.00%	1.3	7.01	4.4	46.70	47.12
40	52.29	6	2.37%	0.2	0.94	3.7	47.00	48.24
6	18.04	12	4.00%	0.9	7.73	6.6	46.12	46.84
7	64.58	12	2.50%	0.3	6.11	4.0	46.12	47.74

DiPrete Engineering Engineers • Planners • Surveyors			Project Name:	Cranberry Highway UIS A				100-Year Storm
			Project Number:	2932-003				Date: 1/16/2023

Pipe Analysis

Pipe ID	Pipe Length	Pipe Size	Pipe Slope	Flow Rate	Capacity Full	Velocity	Invert Down	Invert Up
	(ft)	(in)	(%)	(cfs)	(cfs)	(ft/s)	(Ft)	(ft)
3	12.00	15	1.00%	3.4	7.01	5.7	45.75	45.87
2	82.65	15	1.00%	1.9	7.01	4.8	45.87	46.70
1	42.37	15	1.00%	1.7	7.01	4.7	46.70	47.12
40	52.29	6	2.37%	0.2	0.94	3.9	47.00	48.24
6	18.04	12	4.00%	1.2	7.73	7.1	46.12	46.84
7	64.58	12	2.50%	0.4	6.11	4.3	46.12	47.74

DiPrete Engineering
Engineers • Planners • Surveyors

Project Name: Cranberry Highway UIS A			100-Year Storm
Project Number: 2932-003			Date: 1/16/2023
HGL at Structure			
Structure	Rim Elevation	HGL Elevation	Rim-HGL
	(ft)	(ft)	(ft)
4	51.80	0.00	N/A
3	51.56	48.07	3.50
2	51.43	48.32	3.11
1	51.01	48.38	2.63
17	53.00	48.41	4.59
7	52.48	48.29	4.19

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Project Name: Cranberry Highway UIS A
Project Number: 2932-003

10-Year Storm
Date: 1/16/2023

Structure	Area	Inlet Time	Intensity	Runoff C	Q=Cia	Q Carry over	Q Captured	Q Bypassed	Bypass Structure	Inlet Type	Curb Opening	Curb Opening	Grate Length	Grate Width	Depth	Spread
	(sf)	(min)	(in/hr)	(C)	(cfs)	(cfs)	(cfs)	(cfs)			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
1	7,804	6	6.78	0.86	1.05	0	0.69	0.36	---	Grate inlet	---	---	2	2	0.136	6.797
6	6,538	6	6.775	0.73	0.75	0	0.53	0.22	---	Grate inlet	---	---	2	2	0.12	5.982
7	2,344	6	6.775	0.65	0.24	0	0.21	0.03	---	Grate inlet	---	---	2	2	0.078	3.898

DiPrete Engineering
Engineers • Planners • Surveyors

Project Name: Cranberry Highway UIS B — 25-Year Storm
Project Number: 2932-003 — Date: 1/16/2023

Pipe Analysis

Pipe ID	Pipe Length	Pipe Size	Pipe Slope	Flow Rate	Capacity Full	Velocity	Invert Down	Invert Up
	(ft)	(in)	(%)	(cfs)	(cfs)	(ft/s)	(Ft)	(ft)
9	8.51	15	1.00%	1.7	7.01	4.7	45.38	45.46
8	34.89	15	1.00%	0.6	7.01	3.5	45.46	45.81
16	104.06	15	1.00%	0.9	7.01	3.9	45.46	46.50
41	11.20	6	2.00%	0.3	0.86	3.8	47.00	47.22

DiPrete Engineering
Engineers • Planners • Surveyors

Project Name: Cranberry Highway UIS B | 100-Year Storm
Project Number: 2932-003 | Date: 1/16/2023

Pipe Analysis

Pipe ID	Pipe Length	Pipe Size	Pipe Slope	Flow Rate	Capacity Full	Velocity	Invert Down	Invert Up
	(ft)	(in)	(%)	(cfs)	(cfs)	(ft/s)	(Ft)	(ft)
9	8.51	15	1.00%	2.2	7.01	5.1	45.38	45.46
8	34.89	15	1.00%	0.8	7.01	3.8	45.46	45.81
16	104.06	15	1.00%	1.1	7.01	4.2	45.46	46.50
41	11.20	6	2.00%	0.3	0.86	4.1	47.00	47.22

DiPrete Engineering
Engineers • Planners • Surveyors

Project Name: Cranberry Highway UIS B		100-Year Storm	
Project Number: 2932-003		Date: 1/16/2023	
HGL at Structure			
Structure	Rim Elevation	HGL Elevation	Rim-HGL
	(ft)	(ft)	(ft)
12	52.01	0.00	N/A
11	52.12	47.40	4.72
10	51.66	47.47	4.19
14	50.52	47.49	3.03
20	52.96	47.54	5.42

DiPrete Engineering
Engineers • Planners • Surveyors

Project Name: Cranberry Highway UIS B
Project Number: 2932-003

10-Year Storm
Date: 1/16/2023

Structure	Area	Inlet Time	Intensity	Runoff C	Q=Cia	Q Carry over	Q Captured	Q Bypassed	Bypass Structure	Inlet Type	Curb Opening	Curb Opening	Grate Length	Grate Width	Depth	Spread
	(sf)	(min)	(in/hr)	(C)	(cfs)	(cfs)	(cfs)	(cfs)			(ft)	(ft)	(ft)	(ft)	(ft)	(ft)
8	5,618	6	6.78	0.58	0.51	0	0.40	0.12	---	Grate inlet	---	---	2	2	0.104	5.185
12	5,757	6	6.775	0.79	0.71	0	0.51	0.20	---	Grate inlet	---	---	2	2	0.118	5.875

Appendix B - Downstream Defender

Standard Method to Convert Required Water Quality Volume to a Discharge Rate for Sizing Flow Based Manufactured Proprietary Stormwater Treatment Practices

Massachusetts Department of Environmental Protection Wetlands Program

1-inch rule

UIS-A

$Q_1 = (qu)(A)(WQV)$ 1 ac = 0.0015625 sq mi

Q_1 = flow rate associated with first 1-inch of runoff

qu = the unit peak discharge, in csm/in

A = impervious surface drainage area (in square miles)

WQV = water quality volume in watershed inches (1 inch rule or 1/2-inch rule)

Tc	6	min	0.1 hr
qu	835	csm/in	Figure 2
A	0.334	ac	0.000522 sq mi
WQV	1.0		
Q_1 =	0.44	cfs	

Figure 4: for First 1-inch Runoff, Table of qu values for Ia/P Curve = 0.034, listed by tc, for Type III Storm Distribution

Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)
0.01	835	2.7	197	7.1	95
0.03	835	2.8	192	7.2	94
0.05	831	2.9	187	7.3	93
0.067	814	3	183	7.4	92
0.083	795	3.1	179	7.5	91
0.1	774	3.2	175	7.6	90
0.116	755	3.3	171	7.7	89
0.133	736	3.4	168	7.8	88
0.15	717	3.5	164	7.9	87
0.167	700	3.6	161	8	86
0.183	685	3.7	158	8.1	85
0.2	669	3.8	155	8.2	84
0.217	654	3.9	152	8.3	84
0.233	641	4	149	8.4	83
0.25	628	4.1	146	8.5	82
0.3	593	4.2	144	8.6	81
0.333	572	4.3	141	8.7	80
0.35	563	4.4	139	8.8	79
0.4	536	4.5	137	8.9	79
0.416	528	4.6	134	9	78
0.5	491	4.7	132	9.1	77
0.583	460	4.8	130	9.2	76
0.6	454	4.9	128	9.3	76
0.667	433	5	126	9.4	75
0.7	424	5.1	124	9.5	74
0.8	398	5.2	122	9.6	74
0.9	376	5.3	120	9.7	73
1	356	5.4	119	9.8	72
1.1	339	5.5	117	9.9	72
1.2	323	5.6	115	10	71
1.3	309	5.7	114		
1.4	296	5.8	112		
1.5	285	5.9	111		
1.6	274	6	109		
1.7	264	6.1	108		
1.8	255	6.2	106		
1.9	247	6.3	105		
2	239	6.4	104		
2.1	232	6.5	102		
2.2	225	6.6	101		
2.3	219	6.7	100		
2.4	213	6.8	99		
2.5	207	6.9	98		
2.6	202	7	96		

Standard Method to Convert Required Water Quality Volume to a Discharge Rate for Sizing Flow Based Manufactured Proprietary Stormwater Treatment Practices

Massachusetts Department of Environmental Protection Wetlands Program

1-inch rule **UIS-B**

$Q_1 = (qu)(A)(WQV)$ 1 ac = 0.0015625 sq mi

Q_1 = flow rate associated with first 1-inch of runoff

qu = the unit peak discharge, in csm/in

A = impervious surface drainage area (in square miles)

WQV = water quality volume in watershed inches (1 inch rule or 1/2-inch rule)

Tc	6	min	0.1	hr
qu	835	csm/in	Figure 2	
A	0.211	ac	0.00033	sq mi
WQV	1.0			
Q_1 =	0.28	cfs		

Figure 4: for First 1-inch Runoff, Table of qu values for Ia/P Curve = 0.034, listed by tc, for Type III Storm Distribution

Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)
0.01	835	2.7	197	7.1	95
0.03	835	2.8	192	7.2	94
0.05	831	2.9	187	7.3	93
0.067	814	3	183	7.4	92
0.083	795	3.1	179	7.5	91
0.1	774	3.2	175	7.6	90
0.116	755	3.3	171	7.7	89
0.133	736	3.4	168	7.8	88
0.15	717	3.5	164	7.9	87
0.167	700	3.6	161	8	86
0.183	685	3.7	158	8.1	85
0.2	669	3.8	155	8.2	84
0.217	654	3.9	152	8.3	84
0.233	641	4	149	8.4	83
0.25	628	4.1	146	8.5	82
0.3	593	4.2	144	8.6	81
0.333	572	4.3	141	8.7	80
0.35	563	4.4	139	8.8	79
0.4	536	4.5	137	8.9	79
0.416	528	4.6	134	9	78
0.5	491	4.7	132	9.1	77
0.583	460	4.8	130	9.2	76
0.6	454	4.9	128	9.3	76
0.667	433	5	126	9.4	75
0.7	424	5.1	124	9.5	74
0.8	398	5.2	122	9.6	74
0.9	376	5.3	120	9.7	73
1	356	5.4	119	9.8	72
1.1	339	5.5	117	9.9	72
1.2	323	5.6	115	10	71
1.3	309	5.7	114		
1.4	296	5.8	112		
1.5	285	5.9	111		
1.6	274	6	109		
1.7	264	6.1	108		
1.8	255	6.2	106		
1.9	247	6.3	105		
2	239	6.4	104		
2.1	232	6.5	102		
2.2	225	6.6	101		
2.3	219	6.7	100		
2.4	213	6.8	99		
2.5	207	6.9	98		
2.6	202	7	96		

Standard Method to Convert Required Water Quality Volume to a Discharge Rate for Sizing Flow Based Manufactured Proprietary Stormwater Treatment Practices

Massachusetts Department of Environmental Protection Wetlands Program

1-inch rule **UIS-C**

$Q_1 = (qu)(A)(WQV)$ 1 ac = 0.0015625 sq mi

Q_1 = flow rate associated with first 1-inch of runoff

qu = the unit peak discharge, in csm/in

A = impervious surface drainage area (in square miles)

WQV = water quality volume in watershed inches (1 inch rule or 1/2-inch rule)

Tc	6	min	0.1 hr
qu	835	csm/in	Figure 2
A	0.170	ac	0.000266 sq mi
WQV	1.0		
Q_1 =	0.22	cfs	

Figure 4: for First 1-inch Runoff, Table of qu values for Ia/P Curve = 0.034, listed by tc, for Type III Storm Distribution

Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)
0.01	835	2.7	197	7.1	95
0.03	835	2.8	192	7.2	94
0.05	831	2.9	187	7.3	93
0.067	814	3	183	7.4	92
0.083	795	3.1	179	7.5	91
0.1	774	3.2	175	7.6	90
0.116	755	3.3	171	7.7	89
0.133	736	3.4	168	7.8	88
0.15	717	3.5	164	7.9	87
0.167	700	3.6	161	8	86
0.183	685	3.7	158	8.1	85
0.2	669	3.8	155	8.2	84
0.217	654	3.9	152	8.3	84
0.233	641	4	149	8.4	83
0.25	628	4.1	146	8.5	82
0.3	593	4.2	144	8.6	81
0.333	572	4.3	141	8.7	80
0.35	563	4.4	139	8.8	79
0.4	536	4.5	137	8.9	79
0.416	528	4.6	134	9	78
0.5	491	4.7	132	9.1	77
0.583	460	4.8	130	9.2	76
0.6	454	4.9	128	9.3	76
0.667	433	5	126	9.4	75
0.7	424	5.1	124	9.5	74
0.8	398	5.2	122	9.6	74
0.9	376	5.3	120	9.7	73
1	356	5.4	119	9.8	72
1.1	339	5.5	117	9.9	72
1.2	323	5.6	115	10	71
1.3	309	5.7	114		
1.4	296	5.8	112		
1.5	285	5.9	111		
1.6	274	6	109		
1.7	264	6.1	108		
1.8	255	6.2	106		
1.9	247	6.3	105		
2	239	6.4	104		
2.1	232	6.5	102		
2.2	225	6.6	101		
2.3	219	6.7	100		
2.4	213	6.8	99		
2.5	207	6.9	98		
2.6	202	7	96		

Downstream Defender®

High-Level Treatment in a Small Footprint

Product Profile

The Downstream Defender® is an advanced vortex separator used to treat stormwater runoff in pretreatment or stand-alone applications. Its unique flow-modifying internal components distinguish the Downstream Defender® from conventional and simple swirl separators that typically bypass untreated peak flows to prevent washout of captured pollutants. Its wide treatment flow range, low headloss, small footprint and low-profile make it a compact and economical solution for capturing nonpoint source pollution.

Components

1. Inlet to Precast Vortex Chamber
2. Cylindrical Baffle
3. Center Shaft
4. Outlet Pipe
5. Sediment Storage Sump
6. Access Lid

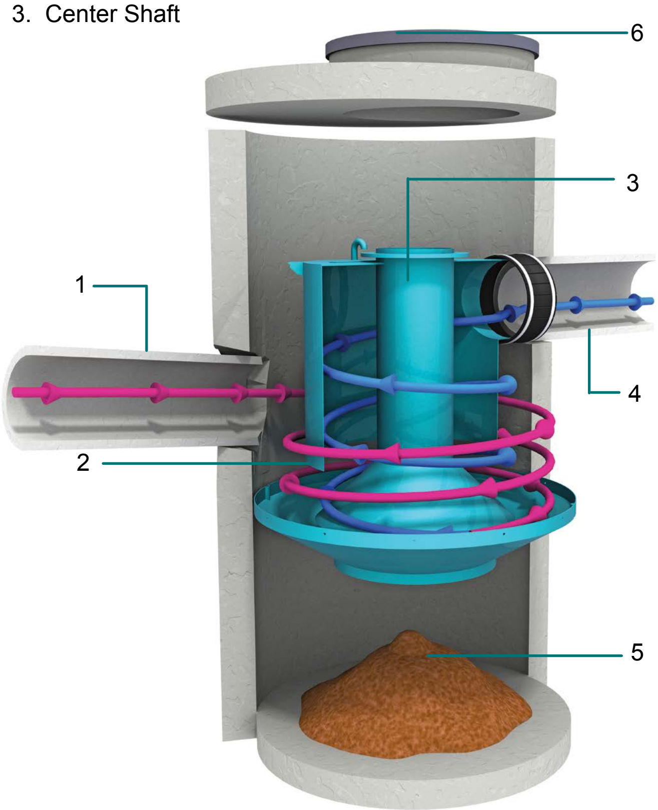

Fig.1 The Downstream Defender® has internal components designed to maximize pollutant capture and minimize pollutant washout.

Applications

- Removal of total suspended solids (TSS), floatable trash and petroleum products from stormwater runoff
- New construction or redevelopment of commercial and residential sites
- Pollutant hotspots such as maintenance yards, parking lots, gas stations, streets, highways, airports and transportation hubs
- Site constrained LID or green infrastructure based developments
- LEED® development projects

Advantages

- Special internal components maximize pollutant capture and minimize footprint, headloss and washout
- Captures and retains a wide range of TSS particles
- High peak treatment flow rates
- Treats the entire storm with no washout or untreated bypass flows
- Low maintenance requirements - no dredging required, and no screens or media to block
- Variable inlet/outlet angles for ease of site layout

How it Works

Advanced hydrodynamic vortex separation is a complex hydraulic process that augments gravity separation with low-energy rotary forces. The flow modifying internal components used in the Downstream Defender® harness the energy from vortex flow and maximize the time for separation to occur while deflecting high scour velocities (**Fig.1**).

Polluted stormwater is introduced tangentially into the side of the precast vortex chamber to establish rotational flow. A cylindrical baffle with an inner center shaft creates an outer (magenta arrow) and inner (blue arrow) spiraling column of flow and ensures maximum residence time for pollutant travel between the inlet and outlet.

Oil, trash and other floating pollutants are captured and stored on the surface of the outer spiraling column. Low energy vortex motion directs sediment into the protected sump region. Only after following a long three-dimensional flow path is the treated stormwater discharged from the outlet pipe. Maintenance ports at ground level provide access for easy inspection and clean-out.

Downstream Defender®

Drainage Profile

The Downstream Defender® is designed with a submerged tangential inlet to minimize turbulence within the device. Turbulence increases system headlosses and reduces performance by keeping pollutant particles in suspension.

The inlet elevation of the Downstream Defender® is located one inlet pipe diameter lower than the elevation of the outlet invert (**Fig.2**). This arrangement ensures that influent flows are introduced to the treatment chamber quiescently below the water surface elevation, minimizing turbulence.

The unique flow-modifying internal components also minimize hydraulic losses. There are no internal weirs or orifices; large clear openings ensure low headloss at peak flow rates with little risk of blockages that cause upstream flooding.

Inspection and Maintenance

Nobody maintains our systems better than we do. To ensure optimal, ongoing device performance, be sure to recommend Hydro International as a preferred service and maintenance provider to your clients.

Call **1 (800) 848-2706** to schedule an inspection and cleanout or learn more at **hydro-int.com/service**

Sizing & Design

The Downstream Defender® can be used to meet a wide range of stormwater treatment objectives. It is available in 5 precast models that fit easily into the drainage network (**Table 1**). Selection and layout of the appropriate Downstream Defender® model depends on site hydraulics, site constraints and local regulations. Both online (**Fig.3a)** and offline (**Fig.3b**) configurations are common.

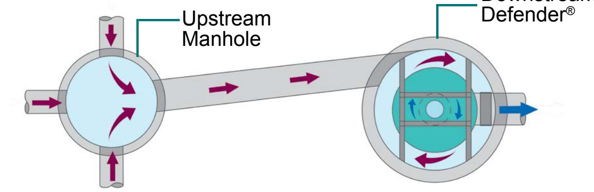

Fig.3a The Downstream Defender® in an online configuration.

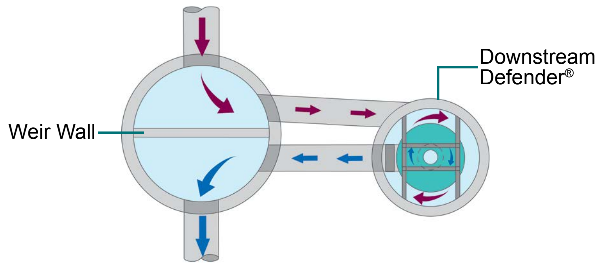

Fig.3b The Downstream Defender® in an offline configuration.

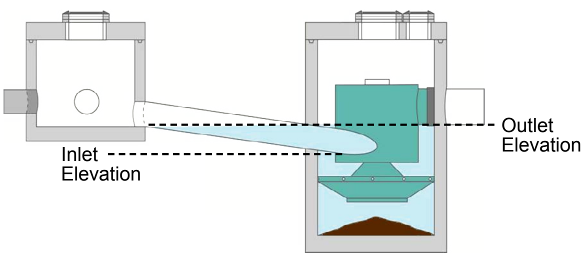

Fig.2 The Downstream Defender® has a submerged inlet that reduces headloss and improves efficiency of pollutant capture.

Free *Stormwater Sizing Tool*

This simple online tool will recommend the best separator, model size and online/offline arrangement based on site-specific data entered by the user.

Go to hydro-int.com/sizing to access the tool.

Table 1. Downstream Defender® Design Chart.

Model Number and Diameter		Peak Treatment Flow Rate		Maximum Pipe Diameter		Oil Storage Capacity		Sediment Storage Capacity		Minimum Distance from Outlet Invert to Top of Rim		Standard Height from Outlet Invert to Sump Floor	
(ft)	(m)	(cfs)	(L/s)	(in)	(mm)	(gal)	(L)	(yd³)	(m³)	(ft)	(m)	(ft)	(m)
4	1.2	3.0	85	12	300	70	265	0.70	0.53	2.8	0.85	4.1	1.25
6	1.8	8.0	227	18	450	216	818	2.10	1.61	3.2	0.98	5.9	1.80
8	2.4	15.0	425	24	600	540	2,044	4.65	3.56	4.2	1.28	7.7	2.35
10	3.0	25.0	708	30	750	1,050	3,975	8.70	6.65	5.0	1.52	9.4	2.85
12*	3.7	38.0	1,076	36	900	1,770	6,700	14.70	11.24	5.6	1.71	11.2	3.41

*Not available in all areas. Contact Hydro International for details.

Performance Verification of Oil and Grease Removal

The Downstream Defender® is a high efficiency advanced vortex separator used to intercept pollutants from urban runoff before they reach sensitive downstream waterways. Although the Downstream Defender® is primarily used to remove sediment from stormwater runoff, independent laboratory and field testing has shown that it is also very effective at capturing oils and grease. Tests conducted under simulated oil spill conditions showed that the Downstream Defender® maintains greater than 80% removal efficiency for a wide range of loading rates. Field testing on an urban mixed-use site showed effective control of oil and grease, limiting the average effluent concentration to 16 mg/L.

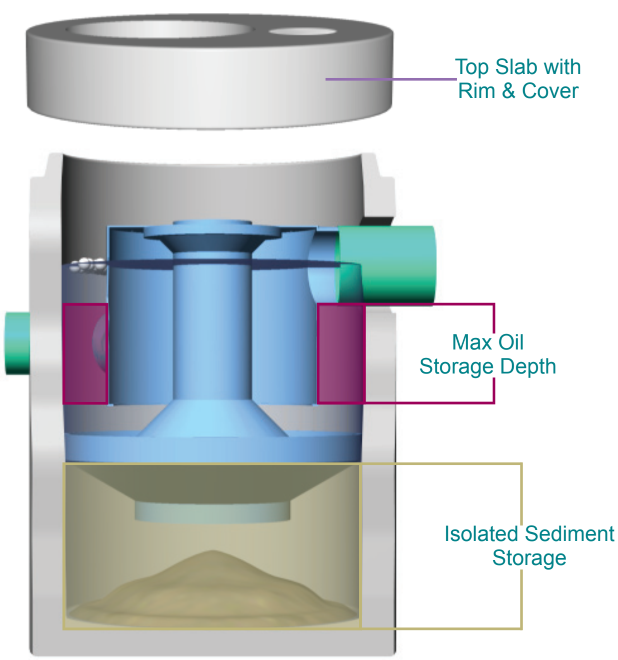

Fig.1 The pollutant storage zones of the Downstream Defender®.

Flow-modifying internal components (Fig.1) are not only critical for promoting separation of pollutants, they also ensure that the sediment and oil storage areas are protected, even at very high flow rates. The internal components keep pollutants such as sediment, oil, floating trash and debris from being washed out during the intense part of a storm. Without this protection, loss of pollutants would occur as they accumulate in the device between clean-outs.

Laboratory Oil Removal Efficiency Testing

An independent third-party laboratory study was conducted in 2000 by Coventry University's School of the Built Environment on a 4-ft Downstream Defender® (Pratt 2000)[1].

The test procedures were designed to simulate a spill event and to determine the efficiency at 6 constant flow rates, each having run durations of 20-27 minutes. The test pollutant was commercially available Shell motor oil. Five effluent samples were collected at each flow rate and analyzed with a Nicolet-250 Fourier Transfer InfraRed Spectrometer based upon ASTM D-3921-81.

Test results demonstrate greater than 80% removal efficiency for all tested flow rates (Fig.2). The results conclude that the Downstream Defender® is an effective device for removing oil in spill-like conditions.

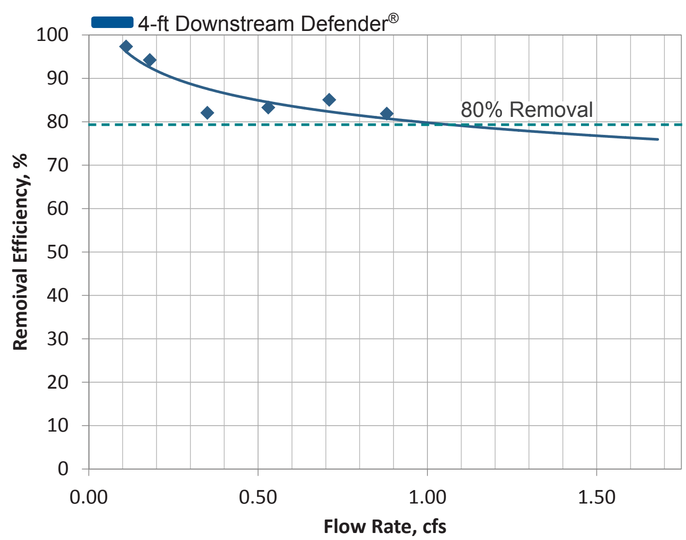

Fig.2 Measured oil removal efficiency of the 4-ft Downstream Defender®.

Effluent Control Field Monitoring

The National Hydraulic Research Institute of Malaysia (NAHRIM) led a field monitoring program in 2010 to evaluate water quality improvements of runoff from an urban, mixed-use site[2]. The field site, located in southern Malaysia, is known for high concentrations of oils, grease, trash and sediment. A variety of point and non-point source pollution is conveyed into a roadside open channel. The Downstream Defender® was retrofitted into the existing drainage network in an off-line configuration by installing a weir wall in the channel and diverting untreated flows into the unit (Fig.3).

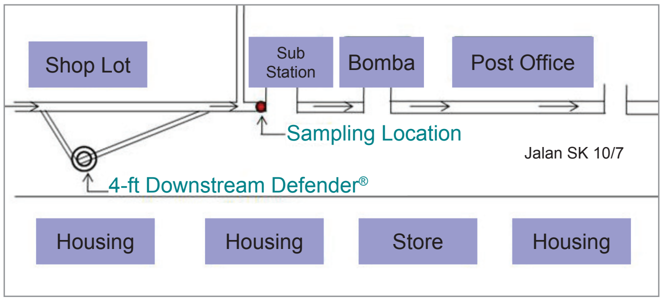

Fig.3 Schematic layout of Downstream Defender® installation showing sampling location.

Samples were collected prior to (Fig.4a) and following (Fig.4b) installation of a 4-ft diameter Downstream Defender® to determine its efficacy in removing and controlling oil and grease (O&G) found in a typical urban "hot spot". The post-installation effluent concentrations were compared with the pre-installation levels to ascertain device efficacy under varying influent concentrations typical of urban hot spots.

Fig.4(a) Pre-installation and (b) post-installation effluent in a storm trench where the 4-ft diameter Downstream Defender® was installed.

Eighteen "pre-installation and 12 "post-installation" samples were collected over the six-month monitoring period and analyzed for oil and grease by an independent accredited laboratory.

Field Monitoring Results

Post-installation conditions showed a significant drop in oil levels, with net O&G reduction > 89% when compared to pre-installation monitoring levels. More importantly, as shown in Fig.5, the average post-installation O&G effluent concentration was 16.2 mg/L, with a median of 13.0 mg/L. These results demonstrate consistent post-installation effluent O&G concentrations below 20 mg/L over the two-month monitoring period.

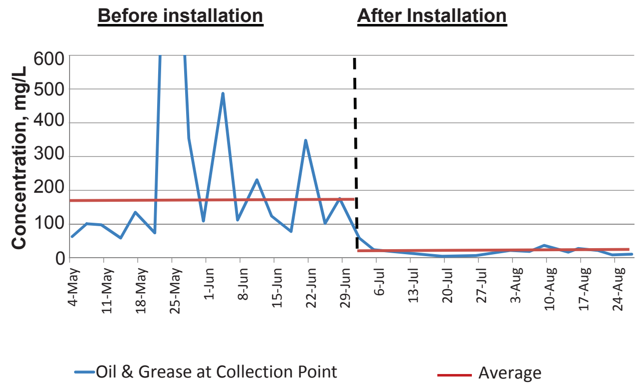

Fig.5 Oil & Grease concentrations before and after Downstream Defender® installation.

Downstream Defender® Sizing

There are 5 standard precast model sizes available, as shown in the table below. Treatment flow rates are based on test results using fine sediments. Listed oil storage capacities are the maximum volumes provided during operation. Larger oil storage volumes are possible. Contact Hydro International for more information.

Model Diameter	Oil Storage Volume	Max. Oil Clean Out Depth	Treatment Flow Rate for 80% TSS Removal of 106um Sediment	Peak Treatment Flow Rates
(ft)	(gal)	(in)	(cfs)	(cfs)
4	70	16	1.56	3.0
6	216	23	4.30	8.0
8	540	33	8.82	15.0
10	1,050	42	15.42	25.0
12	1,770	49	24.32	38.0

References

1. Pratt, C. et al. "Laboratory Tests Conducted in the School of The Built Environment, Coventry University, UK, on Downstream Defender for Hydro International plc., Clevedon, BS21 7RD". May - June 2000.

2. Research Centre For River Management, National Hydraulic Research Institute of Malaysia (NAHRIM). "Study On The Effectiveness Of The Downstream Defender, Serial no.: DD 2344". 20 November 2010.

State of New Jersey

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

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401-02B
Post Office Box 420
Trenton, New Jersey 08625-0420
609-633-7021 Fax: 609-777-0432
http://www.state.nj.us/dep/dwq/bnpc_home.htm

BOB MARTIN
Commissioner

RECEIVED
AUG 24 2015
HYDRO INTERNATIONAL

August 18, 2015

Lisa Lemont, CPSWQ
Business Development Manager
Hydro International (Stormwater)
94 Hutchins Drive
Portland, ME 04102

Re: Revised MTD Lab Certification for the Downstream Defender Stormwater Treatment Device By Hydro International

TSS Removal Rate 50%

Dear Ms. Lemont:

This letter supersedes the previous certification letter dated January 21, 2015. Hydro International requested a new verification for the Downstream Defender Stormwater Treatment Device from the New Jersey Corporation for Advanced Technology (NJCAT) based on enhanced Maximum Treatment Flow Rate (MTFR).

The Stormwater Management rules under N.J.A.C. 7:8-5.5(b) and 5.7(c) allow the use of manufactured treatment devices (MTDs) for compliance with the design and performance standards at N.J.A.C. 7:8-5 if the pollutant removal rates have been verified by the New Jersey Corporation for Advanced Technology (NJCAT) and have been certified by the New Jersey Department of Environmental Protection (NJDEP). Hydro International has requested a Laboratory Certification for the Downstream Defender Stormwater Treatment Device.

The projects falls under the "Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advance Technology" dated January 25, 2013. The applicable protocol is the "New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device" dated January 25, 2013.

NJCAT verification documents submitted to the NJDEP indicate that the requirements of the aforementioned protocol have been met or exceeded. The NJCAT letter also included a recommended certification TSS removal rate and the required maintenance plan. The NJCAT Verification Report with the Verification Appendix for this device is published online at http://www.njcat.org/verification-process/technology-verification-database.html.

The NJDEP certifies the use of the Downstream Defender Stormwater Treatment Device by Hydro International at a TSS removal rate of 50% when designed, operated and maintained in accordance with the information provided in the Verification Appendix.

Be advised a detailed maintenance plan is mandatory for any project with a Stormwater BMP subject to the Stormwater Management Rules, N.J.A.C. 7:8. The plan must include all of the items identified in the Stormwater Management Rules, N.J.A.C. 7:8-5.8. Such items include, but are not limited to, the list of inspection and maintenance equipment and tools, specific corrective and preventative maintenance tasks, indication of problems in the system, and training of maintenance personnel. Additional information can be found in Chapter 8: Maintenance of the New Jersey Stormwater Best Management Practices Manual.

If you have any questions regarding the above information, please contact Mr. Titus Magnanao of my office at (609) 633-7021.

Sincerely,

James J. Murphy, ~~Chief~~
Bureau of Nonpoint Pollution Control

C: Chron File
Richard Magee, NJCAT
Madhu Guru, DLUR
Ravi Patraju, NJDEP
Titus Magnanao, BNPC

Turning Water Around...®

August 25, 2014

Robert Cooper
Virginia Department of Environmental Quality
629 Main Street
Richmond, VA 23219

Re: MTD Registration with VDEQ for the Downstream Defender®

Dear Mr. Cooper:

Please accept the enclosed MTD Registration Document and binder of supporting documentation to register the Downstream Defender® as an approved BMP to remove up to 20% Total Phosphorus from stormwater runoff.

The Downstream Defender® is a vortex separator that has been used to remove sediment, trash and hydrocarbons from stormwater runoff for nearly 20 years. It has been independently tested in the laboratory and in the field and approved by nearly 50 state, county and city agencies across the US and Canada.

Please do not hesitate to contact me if you have any questions about the Downstream Defender® or the technical documentation contained within this submission. We truly appreciate the opportunity to market the Downstream Defender® in Virginia.

Kind regards,

Lisa Lemont, CPSWQ
Business Development Manager

LEGEND

WOODS - A SOILS	
WOODS - B SOILS	
WOODS - C SOILS	
WOODS - D SOILS	
GRASS - A SOILS	
GRASS - B SOILS	
GRASS - C SOILS	
GRASS - D SOILS	
GRAVEL - A SOILS	
GRAVEL - B SOILS	
GRAVEL - C SOILS	
GRAVEL - D SOILS	
IMPERVIOUS	
BRUSH - A SOILS	
BRUSH - B SOILS	
BRUSH - C SOILS	
BRUSH - D SOILS	
WATER	
COMBINATION - A SOILS	
COMBINATION - B SOILS	
COMBINATION - C SOILS	
COMBINATION - D SOILS	

LEGEND

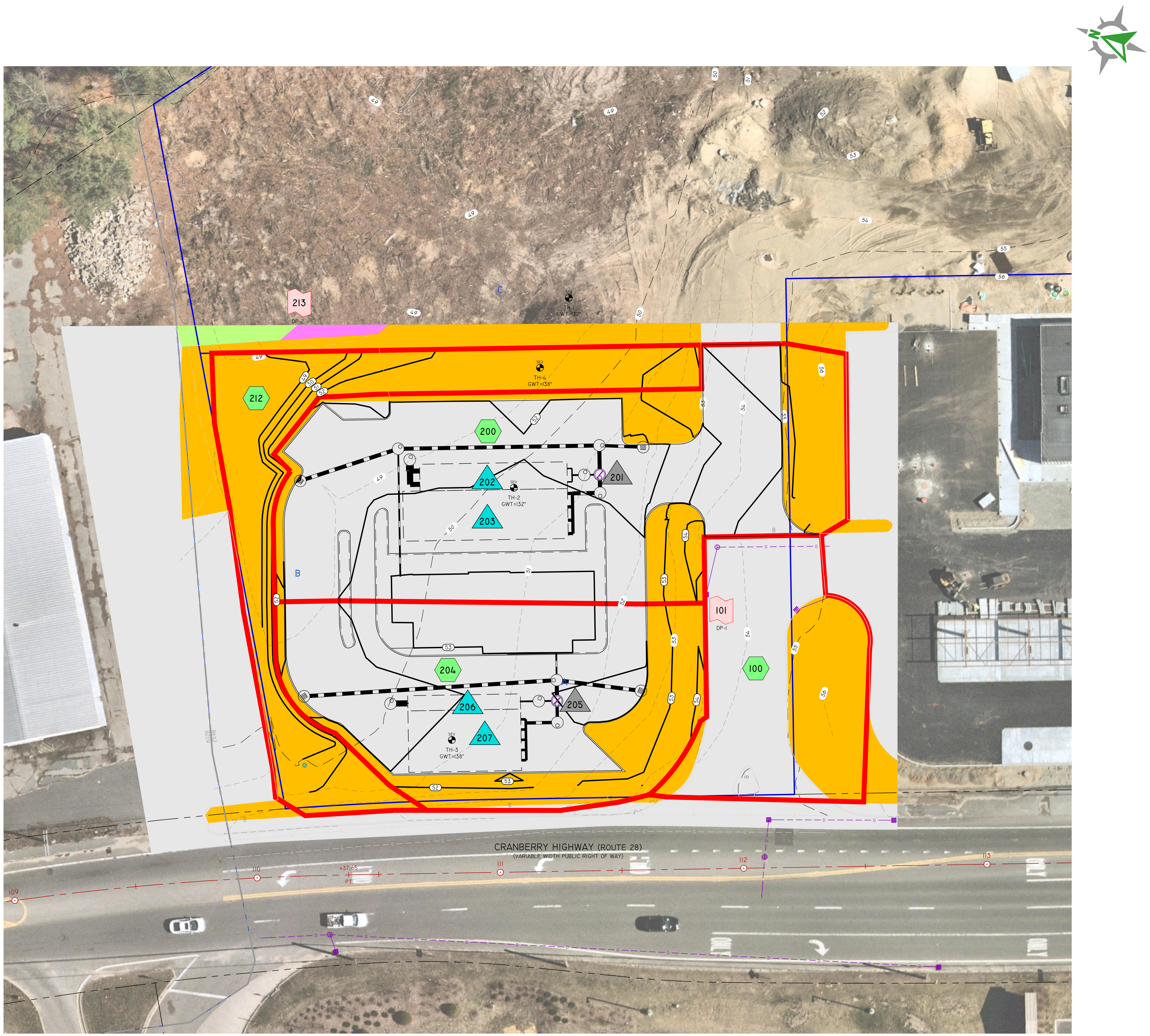
TC LINE WITH ELEVATIONS	37.5 A 32.5 B
SUBCATCHMENT AREA	
SOIL BOUNDARY	
REACH	
SUBCATCHMENT	100
DRAINAGE POND/BIO RETENTION/SAND FILTER/INFILTRATING SWALE	100
DRAINAGE STRUCTURE/POND WITH INSIGNIFICANT STORAGE	100
SWALE	100
DESIGN POINT	DP-1

SCALE: 1"=20'
0 10' 20' 40'

PRE-DEVELOPMENT WATERSHED MAP

CRANBERRY HIGHWAY

DiPrete Engineering
Two Stafford Court Cranston, RI 02920
tel 401-943-1000 fax 401-464-6006 www.diprete-eng.com



LEGEND

WOODS - A SOILS
WOODS - B SOILS
WOODS - C SOILS
WOODS - D SOILS
GRASS - A SOILS
GRASS - B SOILS
GRASS - C SOILS
GRASS - D SOILS
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GRAVEL - B SOILS
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IMPERVIOUS
BRUSH - A SOILS
BRUSH - B SOILS
BRUSH - C SOILS
BRUSH - D SOILS
WATER

LEGEND

TC LINE WITH ELEVATIONS
SUBCATCHMENT AREA
SOIL BOUNDARY
REACH
SUBCATCHMENT — 100
DRAINAGE POND/BIO RETENTION/SAND FILTER/INFILTRATING SWALE — 100
DRAINAGE STRUCTURE/POND WITH INSIGNIFICANT STORAGE — 100
SWALE — 100
DESIGN POINT — DP-1

SCALE: 1"=20'
0 10' 20' 40'

POST-DEVELOPMENT WATERSHED MAP
CRANBERRY HIGHWAY

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tel 401-943-1000 fax 401-464-6006 www.diprete-eng.com