ENVIRONMENTAL SERVICES

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ENGINEERING SERVICES

STORMWATER REPORT

NOBLE ENERGY
PROPOSED TRAVEL CENTER
#195, 197, 201, & 201A CHARLTON ROAD (ROUTE 20)
STURBRIDGE, MA

MARCH 26, 2021

PREPARED FOR:

NOBLE ENERGY REAL ESTATE HOLDINGS, LLC.
131 BUCKINGHAM STREET, SUITE 301
HARTFORD, CT 06106

PREPARED BY:

CMG ENVIRONMENTAL, INC.
CMG ID 2020-127

67 HALL ROAD
STURBRIDGE, MA 01566
PHONE (774) 241-0901
FAX (774) 241-0906

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Proposed Travel Center
Charlton Road, Sturbridge, MA
March 26, 2021

Introduction

The project Applicant, *Noble Energy Real Estate Holdings, LLC,* retained *CMG Engineering* to prepare this engineering analysis of pre- and post-development drainage runoff conditions for a proposed **8,437 s.f. Travel Center and 16,640 s.f. Electric Vehicle Discovery Center.** The proposed site improvements are located on four separate properties, with a total area of 7.27 Acres, identified as #195, 197, 201, and 201A Charlton Road (Site).

The site is currently occupied by a towing company with a paved impound lot, an abandoned tavern, and multiple paved and gravel areas within the Commercial II (C2) zoning district. The existing buildings are serviced by municipal water and sewer located within the Charlton Road (Route 20) right-of-way.

Two (2) existing stormwater conveyance swales are located either within or directly near the property boundaries and were evaluated as potential wetland resource areas. One of the swales is located near the northeastern corner of the property within the Charlton Road right-of-way, and is a part of the Massachusetts DOT stormwater management system for Route 20. The other swale is partially located on the property along the southwest property line. The applicant filed a Request for Determination of Applicability (RDA) with the Sturbridge Conservation Commission (SCC) to determine if these drainage swales were considered jurisdictional resource areas. The SCC issued a negative determination based on evidence provided by EcoTec. A copy of the SCC's December 3, 2020 negative determination is included as **Appendix B**.

The proposed project is considered redevelopment as it will decrease the previously developed Site's impervious areas including the two (2) new buildings, two (2) fueling canopies, electric vehicle charging canopy, associated pavement, utilities, and stormwater management system.

A copy of the "MA-DEP Checklist for Stormwater Report" is included as **Appendix A**.

Hydrology

Computer Model: HydroCAD 10.0 © 2015 Applied Microcomputer Systems, drainage modeling software;

Hydrologic Methodology: TR-55 Methodology is used for analysis of peak flow and drywell sizing.

Surface Runoff Conditions

Rainfall Intensity: NOAA Extreme Precipitation Values – Northeast Regional Climate Center
2-Year Storm = 3.15 in.
10-Year Storm = 4.68 in
25-Year Storm = 5.86 in.
100-Year Storm = 8.28 in.

Watershed Areas: Watershed areas are calculated using AutoCAD software based on the subcatchment areas delineated on topographic mapping included as "Pre-Development Drainage" and "Post-Development Drainage". The areas shown, times of concentration and runoff coefficients are all consistent with the TR-55 drainage calculation method.

FEMA Flood Mapping: Site is not in the 100-year flood plain based on Flood Insurance Rate Map (FIRM) Town of Sturbridge, Worcester County Massachusetts (All Jurisdictions) Map Number 25027C0927E & 25027C0931E, Effective Date July 04, 2011 (see **Appendix B).**

Soils & Topography:

The soils within the southwestern portion of the Site consists of Ridgebury Fine Sandy Loam (71B) with 3~8% slopes classified as Hydrologic Soil Group "D". The soils along the front portion of the Site consists of Woodbridge Fine Sandy Loam (310B) with 3~8% slopes classified as Hydrologic Soil Group "C/D". A small portion in the rear portion of the Site consists of Paxton Fine Sandy Loam (307C) with 8-15% slopes classified as Hydrologic Soil Group "C".

A copy of the *National Resources Conservation Service* (NRCS) Soils Map, listed area soil types are included as **Appendix C.**

On-Site Soil Testing:

November 18, 2020 Soil Testing – Avizinis Environmental Services, Inc. (Edward J. Avizinis, CPSS, PWS)

On November 18, 2020 Avizinis Environmental Services, Inc. completed four (4) on-site soil test pits within the proposed project area. The purpose of these test pits was to verify the ESHGW and soil conditions within the proposed stormwater management areas.

Depth to Groundwater:

Estimated seasonal high groundwater (ESHGW) elevations based on soil mottling are as follows:

TH - 1	**TH - 2**	**TH - 3**	**TH - 4**
ESHGW = 40"	**ESHGW=36"**	**ESHGW = 33"**	**ESHGW = 21"**

Soil Conditions:

Test pits TH – 1 and TH - 2 were excavated in the northeastern corner of the Site to approximately 9 ft. below grade and are located in the vicinity of the proposed diesel fueling canopy. Soil testing results are consistent with the NRCS mapping for Woodbridge fine sandy loam with an ESHGW located approximately 3 ft. below ground surface.

Test pit TH - 3 was excavated in the vicinity of the proposed E.V. charging canopy to approximately 9 ft. below grade. Soil testing results were also consistent with the NRCS mapping for Woodbridge fine sandy loam, however ESHGW depths were shallower on this portion of the Site at 33" below ground surface.

Test pit TH – 4 was excavated along the western property behind the existing office building. The test pit was excavated to approximately 8.5' below grade. Soils were consistent with NRCS mapping for Ridgebury fine sandy loam with shallower ESHGW at 21" below ground surface.

Copies of Site Soil Investigation Data are also included in **Appendix C**.

Soil Permeability (k):
Based upon on-site classification by a State of Massachusetts Licensed Soil Evaluator Edward Avizinis, CPSS, PWS, Site subsurface soils within the development area are classified as a "sandy loam" and are consistent with the SCS soil mapping (Type "C" & "D" Soils)

Design permeability (k) values of Type "C" & Type "D" Soils:

***k* = 0.27 in / hr** (Rawls Rate: Type "C" Soils)

***k* = 0.09 in / hr** (Rawls Rate: Type "D" Soils)

Please note, no on-site stormwater infiltration BMP's are proposed for the above-mentioned site improvements. Site constraints including shallow groundwater, "D-Type" soils, and subsurface contamination from the previously sited truck stop will prohibit stormwater infiltration on the site.

Existing Conditions:

The existing site currently consists of four (4) separate commercial properties located at #195, 197, 201, and 201A Charlton Road with a cumulative area of 7.275 Acres. A former truck stop and manufactured office building is located on 201 and 201A Charlton Road. Currently, the truck stop is used by a towing company. The majority of these two parcels' ground cover consists of pavement, gravel, concrete and roof areas. An existing drainage swale is located along the rear property line of #201A which conveys off-site stormwater runoff around the Site to the Route 20 drainage system.

An abandoned tavern and remnants of the parking area associated with a previously demolished motel are located on #195 & 197 Charlton Road. There are two (2) separate stormwater outfall locations for the entire 7.275 Acre Site:

Outfall 1S – 2' x 3' Box Culvert In addition to on-site stormwater runoff, the site also conveys approximately 18 acres of off-site stormwater runoff before being captured via the Route 20 drainage system. Stormwater runoff from 195 and 197 Charlton Road, and approximately 5 acres of off-site drainage, is collected by two (2) on-site catch basins and one catch basin located within the Route 20 right-of-way. These catch basins convey water via subsurface drainage to a quad-grate concrete drainage structure within the Route 20 right-of-way. The structure outlets all stormwater via a 2' x 3' box culvert across Route 20 and eventually outlets to Hobbs Brook due North of the Site.

Outfall 2S – Route 20 Drop Inlet The remaining 13 acres of off-site stormwater runoff is collected via an existing drainage swale along the rear property line of 201A Charlton Road. 8" PVC underdrains within the existing swale are connected to four (4) on-site catch basins along the rear property line and are conveyed to the subsurface on-site drainage system. Three (3) additional on-site catch basins and two (2) catch basins within the Route 20 right-of-way capture and convey the on-site stormwater runoff located on 201 and 201A Charlton Road. The subsurface drainage system conveys all stormwater to an off-site concrete drop inlet located near the NW corner of #201 Charlton Road.

Proposed Conditions:

The project Applicant is proposing to construct an 8,437 s.f. Travel Center with Drive-Thru coffee shop, ten (10) gasoline fuel pump islands, four (4) high speed diesel fueling positions, ten (10) electric vehicle charging stations, and associated parking spaces and utilities on the two properties knows as #195 and 197 Charlton Road. An Electric Vehicle Discovery Center with office and restaurant spaces, associated parking, and utilities is proposed on the properties known as #201 and 201A Charlton Road. The project will decrease Site impervious area and

portions of the Site are considered a Land Use with High Potential Pollutant Load (LUHPPL) under the Massachusetts Stormwater Management Standards.
Therefore, we are proposing the following Stormwater Management System for the Site in order to meet the MA-DEP Stormwater Management Standards for a redevelopment project.

Outfall 1S – Route 20 Culvert Subcatchment 1A consists of the gasoline and diesel fueling areas and a portion of the travel center parking spaces. This subcatchment falls within the LUHPPL category and is most suspectable to contamination associated with vehicle fueling operations. Runoff from this area is directed to four (4) deep sump catch basins and then conveyed to one of two oil/grit separators. A 3,000-gallon oil grit separator will handle stormwater flows from the diesel fueling canopy while a 5,000-gallon oil grit separator will handle stormwater flows from the larger gasoline fueling canopy. The stormwater flows are then conveyed to a Hydrostorm (HS-6) water quality unit to adequately treat for oil, TSS, metals, and nutrients. The Hydrostorm unit then discharges to the existing quad grate concrete structure and box culvert. The design submission prepared by Hydroworks for the proposed HS-6 unit is included in **Appendix G**.

Subcatchment 1B consists of the site access driveway, E.V. charging canopy area, and travel center drive-through. Stormwater along the impervious areas is conveyed to eight (8) deep sump catch basins and are then conveyed to the same HS-6 water quality unit as Subcatchment 1A.

Subcatchment 1C consists of the front landscape area along the Route 20 right-of-way. Stormwater runoff from the front landscape area will flow directly into the existing drainage structures within the Route 20 right-of-way. Once inside the Route 20 drainage system, stormwater flows will be conveyed to the quad grate concrete structure and eventually discharged via the 2’ x 3’ box culvert.

Subcatchment 3 consists of approximately 5 Acres of off-site stormwater runoff as well as the roof runoff from the proposed travel center, E.V. charging canopy, and gasoline fueling canopy. The off-site drainage is captured via a proposed swale along the rear property line of #197 Charlton Road. An inlet control structure collects and conveys the stormwater runoff to an independent subsurface drain line which does not receive on-site runoff from the proposed paved or landscaped areas. This drain line discharges directly to the existing quad grate concrete structure and does not connect to a treatment unit. The proposed roof drains for the travel center and canopies are connected to this drain line as they do not require treatment from the Hydro storm water quality unit.

Outfall 2S – Route 20 Drop Inlet Subcatchment 2A consists of the proposed E.V. Discovery Center’s paved and grass parking areas. Stormwater runoff from the proposed paved and grass parking areas will be captured via two (2) catch basins and discharged to a Hydrostorm (HS-4) water quality unit. The water quality unit then outlets via a subsurface drain line to a proposed rain garden along the #201 Charlton Road frontage. Due to poor site soils and shallow eshgw, the proposed rain garden will filter to an 8” perforated underdrain and connected to a concrete outlet control structure. The outlet control structure then discharges stormwater to the existing drainage manhole located in the NW corner of #201 Charlton Road. The design submission prepared by Hydroworks for the proposed HS-4 unit is included in **Appendix G.**

Subcatchment 2B& 4 consists of the rear portion of #201A Charlton Road used to convey off-site stormwater runoff. Off-site stormwater runoff is captured via the existing swale located along the rear property line of #201A Charlton Road. The applicant is proposing drainage improvements along the rear property line at #201A Charlton Road, to better handle off-site stormwater runoff entering the Site. Four (4) Nyloplast lawn drains will be installed along the property line and connected to the existing 8”

pvc underdrains located within the existing off-site swale. The lawn drains will then convey water via an independent 12" HDPE drain line to the existing manhole located in the NW corner of #201 Charlton Road.

Subcatchment 2C consists of the front landscape area located along Route 20. The landscape area discharges directly to the proposed rain garden via overland flow. The rain garden then outlets to the existing drainage manhole in the NW corner of #201 Charlton Road.

Roof runoff from the proposed 16,640 s.f. E.V. Discovery Center (Subcatchment BLD2) will directly discharge to the same existing manhole. The manhole discharges all stormwater runoff to the existing concrete drop inlet within the Route 20 right-of-way.

Proposed Stormwater Management System:

Filling Station / Convenience Store w/ Drive Thru

- Double and single grate – deep sump hooded catch basins collect runoff for site's impervious and landscaped areas.
- Nyloplast Lawn Drains, a deep sump catch basin, and swales will capture and convey the 18 acres of off-site stormwater runoff and will remain separate from the on-site stormwater runoff from paved and landscaped areas.
- An in-line 3,000-gallon oil grit separator treats stormwater runoff for diesel fueling area.
- An in-line 5,000-gallon oil grit separator treats stormwater runoff for the gasoline fueling area.
- One (1) Hydrostorm (HS-6) water quality unit treats stormwater runoff for the proposed travel center paved areas and site access driveway.
- One (1) Hydrostorm (HS-4) water quality unit treats stormwater runoff for the proposed E.V. discovery center's paved and grass parking area.
- Site Long-term Operation and Maintenance plan is provided for the Site.

MA-DEP STORMWATER MANAGEMENT STANDARDS

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

Proposed Full Compliance:

- **Combination of on-site stormwater BMPs including deep sump catch basins with hoods, oil-grit separators, and two (2) water quality units provide treatment for all on-site stormwater prior to discharge to Outfall 1S and Outfall 2S.**

STANDARD 2: (Peak rate control and flood prevention):
Stormwater management systems must be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates. This Standard may be waived for land subject to coastal storm flowage.

Proposed Full Compliance:

- **No proposed increase to post-development Site peak runoff and Site is not in the 100-year flood plain.**

STANDARD 3: (Recharge to Groundwater):

Loss of annual recharge to ground water shall be eliminated or minimized through the use of infiltration measures including environmentally sensitive site design, low impact development techniques, best management practices, and good operation and maintenance. At a minimum, the annual recharge from the post-development conditions based on soil type. This Standard is met when the storm water management system is design to infiltrate the required recharge volume as determined in accordance with the Massachusetts Storm water Handbook.

Proposed Full Compliance:

- **Due to contaminated soils, Type "D" soils, and high seasonal groundwater, there are no infiltration BMP's proposed for the stormwater management system. CMG believes the project is in full compliance to the maximum extent practicable for Standard 3 as the project is considered a redevelopment and results in a reduction of impervious area (48,152 s.f.) which in its self promotes additional recharge over the existing conditions.**
- **The existing truck stop (#201 & 201A Charlton Road) contains groundwater contamination due to the previously sited LUHPPPL. Infiltration practices in this area were restricted to avoid further conveyance of pollutants into the groundwater.**

STANDARD 4: (TSS Removal):

Stormwater management systems must be designed to remove 80% of the average annual post construction load of Total Suspended Solids (TSS).

Proposed Full Compliance:

- **Outfall 1S –will achieve 89% TSS removal through a combination of; deep sump catch basins, oil/ grit separators, and a Hydrostorm (HS-6) water quality unit.**
- **Outfall 2S – will achieve 89% TSS removal through a combination of; deep sump catch basins and a Hydrostorm (HS-4) water quality unit.**
- **A "Long Term Operation and Maintenance Plan" is being provided as Appendix H.**

STANDARD 5: (Higher Potential Pollutant Loads (LUHPPL)):

For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Storm water Handbook to eliminate or reduce the discharge of storm water runoff from such land uses to the maximum extent practicable. If through source control and/or pollution prevention, all land uses with higher potential pollutant loads cannot be completely protected from exposure to rain, snow, snow melt, or storm water runoff, the proponent shall use the specific storm water BMP's determined by the Department to be suitable for such use as provided in the Massachusetts Storm water Handbook.

Proposed Full Compliance:

- **The stormwater management design incorporates increased stormwater volumes (1") as required in LUHPPL areas by incorporating the following.**
- **The site will utilize deep sump hooded catch basins, a 3,000-gallon oil grit separator, a 5,000-gallon oil grit separator, and a two Hydrostorm water quality units to achieve TSS removal and provide oil storage in the case of a spill.**
- **Long Term Pollution Prevention Plan is included in Stormwater Management Report, Appendix H.**

STANDARD 6: (Critical Areas)
Storm water discharges to a Zone II or Interim Wellhead Protection Area of a public water supply and storm water discharges near or any other critical area require the use of the specific storm water best management practices determined by the Department to be suitable for managing discharges to such area as provided in the Massachusetts Storm water Handbook.

Proposed Full Compliance:

- **The site does not appear to lie within a Zone II, Interim Wellhead Protection Area, or any other critical area.**

STANDARD 7: (Redevelopment)

"A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable; Standard 2, Standard 3, and the pretreatment and structural best management practice requirements of Standards 4, 5, and 6. Existing stormwater discharges shall comply with Standard 1 only to the maximum extent practicable. A redevelopment project shall also comply with all other requirements of the Stormwater Management Standards and improve existing conditions."

Proposed Full Compliance:

- **Site is considered redevelopment and will meet all applicable Stormwater Management Standards. Standard 3 has been met to the maximum extent practicable and all other standards have been met.**

STANDARD 8: (Erosion, Sediment Control):
A plan to control construction related impacts including erosion sedimentation and other pollution prevention sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) must be implemented.

Proposed Full Compliance:

- **The "Erosion and Sedimentation Control Plan" Sheet C-5 and "Erosion and Sediment Control Details" Sheet C-5.1 are incorporated into the Plan Set.**
- **Project will disturb > 1 Acre, therefore an EPA–NPDES Stormwater General Permit is required prior to construction and will be accompanied with a comprehensive SWPP Plan.**

STANDARD 9: (Operation and Maintenance):
A long-term operation and maintenance plan must be developed and implemented to ensure that storm water management systems function as designed.

Proposed Full Compliance:

- **Long Term Operation and Maintenance Plan is included in Stormwater Management Report, Appendix I.**

STANDARD 10: (Illicit Discharges):
All illicit discharges to the stormwater management system are prohibited.

Proposed Full Compliance:

- A signed "illicit discharge compliance statement" will be provided as part of the final "Storm water Management System Long-Term Operation & Maintenance Plan".

A copy of the "MA-DEP Checklist for Stormwater Report" is included as **Appendix A**.

Table No. 1 provides a summary of off-site Pre- and Post-Development peak runoff flow rates and volumes**.**

Table No. 2 provides a summary of the subcatchment drainage area calculations.

Table No. 3 provides the TSS Removal calculations for the proposed structural BMPs.

Appendix D & E includes the complete Pre-Development and Post-Development *HydroCAD* drainage calculation reports and **Figures D-1 and D-2 "Pre- "and "Post-Development Drainage Areas" plans**.

Appendix F provides additional stormwater calculations.

Appendix G provides the Manufacturer's Design Report for the two Hydrostorm Water Quality Units.

Appendix H provides a DRAFT "Long Term Stormwater Operation & Maintenance Plan"

The complete Site Plans for the **"Noble Energy - Proposed Travel Center #195, 197, 201, 201A Charlton Road, Sturbridge, MA" prepared by CMG Engineering, dated 3/26/2021** (or latest version) provide details of the complete storm water management system design**.**

Please note these plans are subject to review and approval by two (2) separate Town Boards including: the Sturbridge Zoning Board of Appeals & Planning Board.

TABLE 1

PRE- VS. POST-DEVELOPMENT STORMWATER RUNOFF SUMMARY

3/25/2021

TABLE NO. 1

PRE VS. POST-DEVELOPMENT
STORMWATER RUNOFF AND VOLUME SUMMARY
#195, 197, 201, 201A CHARLTON ROAD
STURBRIDGE, MA

Pre-Site Development (Fig D1) Conditions					
		2-Year	**10-Year**	**25-Year**	**100-Year**
1S - ROUTE 20 CULVERT	***Peak Flow (cfs)***	***16.39***	***28.44***	***38.18***	***58.77***
2S - ROUTE 20 DROP INLET	***Peak Flow (cfs)***	***11.65***	***24.53***	***35.45***	***59.03***

Post-Site Development (Fig D2) Conditions					
		2-Year	***10-Year***	***25-Year***	***100-Year***
1S - ROUTE 20 CULVERT	***Peak Flow (cfs)***	***15.29***	***27.29***	***37.02***	***57.56***
2S - ROUTE 20 DROP INLET	***Peak Flow (cfs)***	***11.15***	***24.07***	***35.03***	***58.75***
	Proposed Reduction	**-1.60**	**-1.61**	**-1.58**	**-1.49**

TABLE 2

SUBCATCHMENT DRAINAGE AREA CALCULATIONS

TABLE NO. 2

DRAINAGE AREA CALCULATIONS
#195, 197, 201, 201A CHARLTON ROAD - STURBRIDGE, MA
PROPOSED NOBLE TRAVEL CENTER

PRE-DEVELOPMENT DRAINAGE AREAS (s.f.)

Area	Ex. Building	Bit. Drive/Walks	Gravel Parking	Grass/Landscape	Woods	Total
1	5,684	134,029		65,198	10,832	215,743
2	8,622	78,159		14,328		101,109
3				3,610	222,651	226,261
4				2,523	551,881	554,404
	Ex. Building	Bit. Drive/Walks	Gravel Parking	Grass/Landscape	Woods	Total
	14,306	212,188	0	85,659	785,364	**1,097,517 s.f.**
					Tot.=	**25.20** Ac

Total Impervious= 226,494 s.f.

POST-DEVELOPMENT DRAINAGE AREAS (s.f.)

Area	Prop. Building	Bit. Drive/Walks	Gravel Parking	Grass/Landscape	Woods	Total
1A		74,059		27,547		101,606
1B		42,596		43,655		86,251
1C				4,976		4,976
2A		31,489		24,774		56,263
2B				27,477		27,477
2C				10,081		10,081
BLD1	8,438					8,438
BLD2	9,465					9,465
CAN1	1,800					1,800
CAN2	7,795					7,795
CAN3	2,700					2,700
3				3,610	222,651	226,261
4				2,523	551,881	554,404
	Prop. Building	Bit. Drive/Walks		Grass/Landscape		Total
	30,198	148,144	0	144,643	774,532	**1,097,517 s.f.**
					Tot.=	**25.20** Ac

Total Impervious= 178,342 s.f.

Note:

[1] All Drainage Areas are calculated using AutoCAD Land Development Software based on Pre- & Post Development Drainage Plans prepared by CMG Engineering revised 11/6/2020

Appendix A

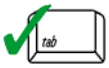
MA-DEP Stormwater Checklist

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

Checklist for Stormwater Report

A. Introduction

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



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

The Stormwater Report must include:

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

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

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

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

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

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

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

Checklist for Stormwater Report

B. Stormwater Checklist and Certification

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

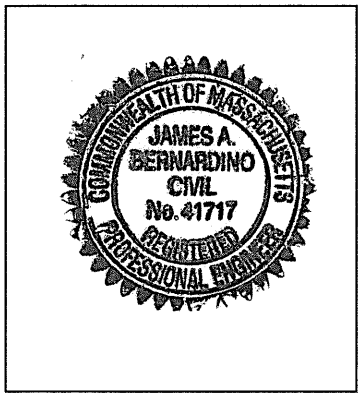
Note: Because stormwater requirements vary from project to project, it is possible that a complete Stormwater Report may not include information on some of the subjects specified in the Checklist. If it is determined that a specific item does not apply to the project under review, please note that the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

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

Registered Professional Engineer's Certification

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

Registered Professional Engineer Block and Signature



Signature and Date

Checklist

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

☐ New development

☒ Redevelopment

☐ Mix of New Development and Redevelopment

Checklist for Stormwater Report

Checklist (continued)

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

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

Standard 1: No New Untreated Discharges

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

Checklist for Stormwater Report

Checklist (continued)

Standard 2: Peak Rate Attenuation

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

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

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

Standard 3: Recharge

☒ Soil Analysis provided.

☐ Required Recharge Volume calculation provided.

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

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

☐ Static ☐ Simple Dynamic ☐ Dynamic Field[1]

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

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

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

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

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

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

☐ Solid Waste Landfill pursuant to 310 CMR 19.000

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 3: Recharge (continued)

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

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

Standard 4: Water Quality

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

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

Standard 4: Water Quality (continued)

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

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

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

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

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

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

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

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

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

☐ All exposure has been eliminated.

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

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

Standard 6: Critical Areas

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

☐ Limited Project

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

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

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

☐ Bike Path and/or Foot Path

☒ Redevelopment Project

☐ Redevelopment portion of mix of new and redevelopment.

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

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

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

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

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

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

Checklist for Stormwater Report

Checklist (continued)

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

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

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

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

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

Standard 9: Operation and Maintenance Plan

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

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

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

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

Standard 10: Prohibition of Illicit Discharges

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

☐ An Illicit Discharge Compliance Statement is attached;

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

Appendix B

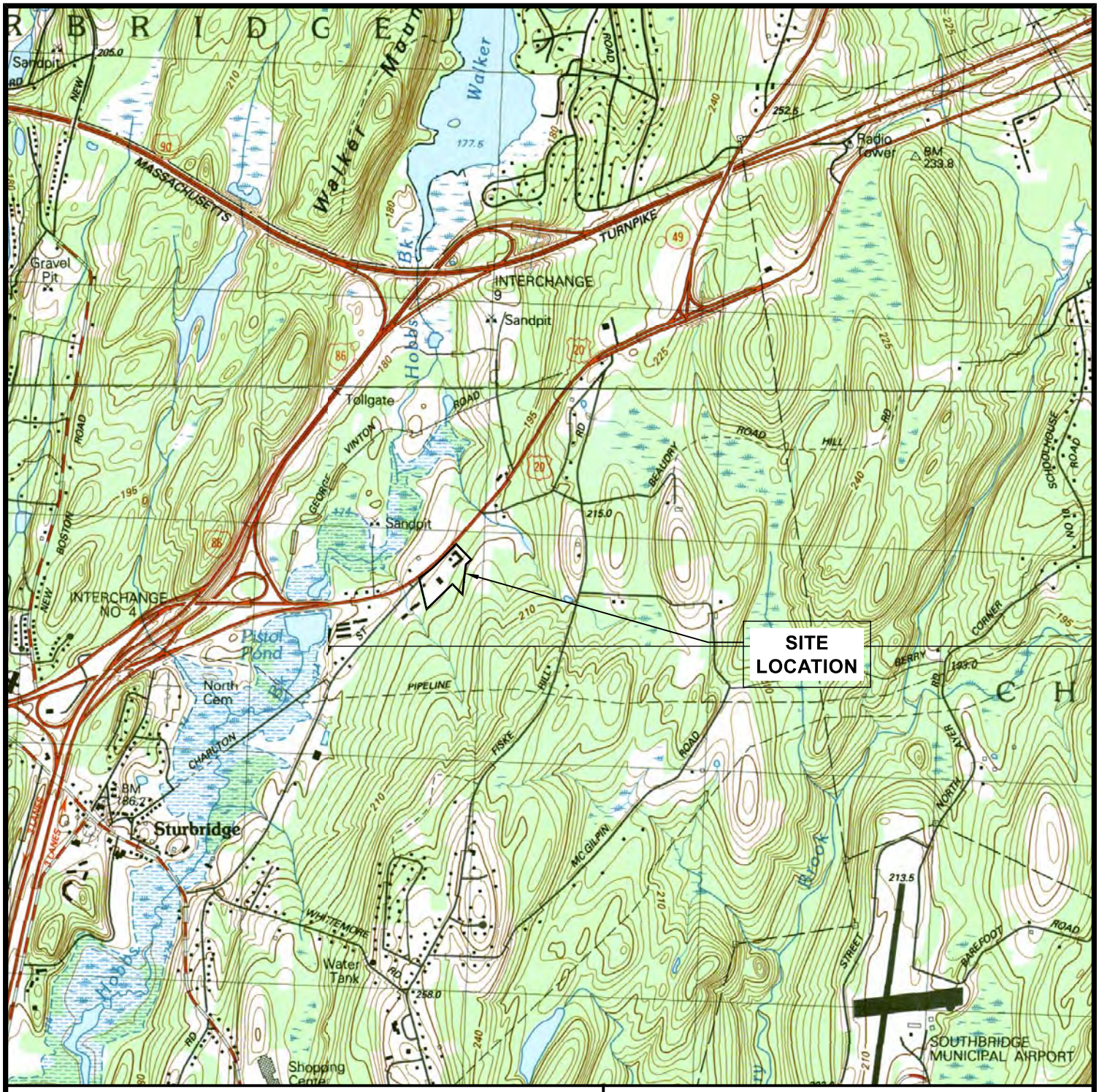
USGS Site Location Map

FEMA Flood Plain Mapping

&

Sturbridge Conservation Commission Negative Determination of Applicability Letter,

Dated December 3, 2020



TOWN LOCATION - STURBRIDGE, MA

FIGURE 1: SITE LOCATION

#195, 197, 201, & 201A CHARLTON ROAD
STURBRIDGE, MA 01566
CMG ID 2020-127

SCALE 1:2,000

2000 FT 0 2000 FT

ENVIRONMENTAL SERVICES CMG EST. 2002 ENGINEERING SERVICES

67 HALL ROAD. STURBRIDGE MA 01566

National Flood Hazard Layer FIRMette

FEMA

72°4'6"W 42°7'20"N

0 250 500 1,000 1,500 2,000 Feet

1:6,000

72°3'28"W 42°6'54"N

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS
- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD
- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS
- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES
- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES
- 20.2 Cross Sections with 1% Annual Chance
- 17.5 Water Surface Elevation
- Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS
- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 12/10/2020 at 3:52 PM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

Town of Sturbridge

Conservation Commission

December 3, 2020

Noble Energy Real Estate Holdings
131 Buckingham Street, Suite 301
Hartford, CT 06106

Re: 195, 197, 201, 201A Charlton Road, Sturbridge, MA 01566
Request for Determination of Applicability

To Whom It May Concern,

The Sturbridge Conservation Commission (SCC) has received your Request for Determination of Applicability for the above referenced property. At the December 1, 2020 Sturbridge Conservation Commission meeting, the SCC discussed the application and site and determined that the areas described in the request are not areas subject to the MA Wetland Protection Act (WPA) or within the Buffer Zone. They also determined that the areas described in the request do not appear to be subject to the Sturbridge Wetland Bylaw (SWB). Please see the attached Determination of Applicability.

As discussed, stormwater currently exits this site and has been found to be connected to the MA DOT stormwater system associated with Charlton Rd. (Rt. 20). At this time, it is uncertain if this system discharges to a wetland resource area which may be subject to protection under the WPA or the SWB. Changes/increases of stormwater flow, which discharges into a wetland resource area, would appear to be a regulated activity pursuant to the WPA and the SWB. It is our understanding that the project team will provide additional information on this as they work to develop plans for the site re-development. Please provide such information to the SCC when it is available.

Thank you and please feel free to contact the Conservation Commission with any additional question or comments.

Sincerely,

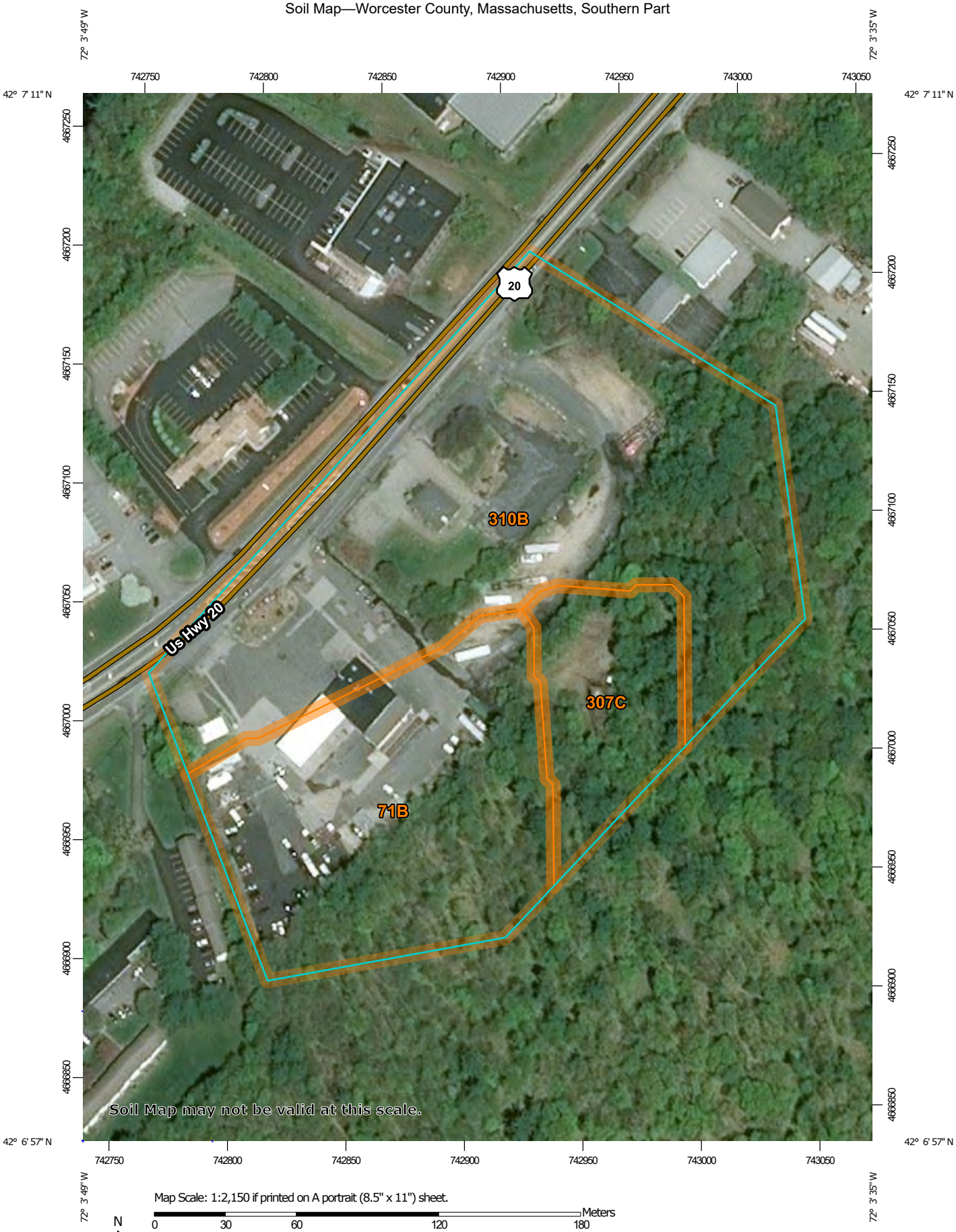
Rebecca Gendreau
Conservation Agent

CC: Scott Connor, Representative for the Estate of Philip Connor, Property Owner
Scott Morrison, EcoTec, Inc.
DEP Central Region, Wetland Section

Attachment: Determination of Applicability

Appendix C

NCRS Soil Mapping
&
On-Site Soil Testing Logs



Map Scale: 1:2,150 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 30 60 120 180

Feet: 0 100 200 400 600

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

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

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

Water Features
- Streams and Canals

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

Background
- Aerial Photography

MAP INFORMATION

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

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

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

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

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

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

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

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

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

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

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
71B	Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony	4.0	31.3%
307C	Paxton fine sandy loam, 8 to 15 percent slopes, extremely stony	1.5	11.5%
310B	Woodbridge fine sandy loam, 3 to 8 percent slopes	7.2	57.2%
Totals for Area of Interest		**12.7**	**100.0%**

Worcester County, Massachusetts, Southern Part

71B—Ridgebury fine sandy loam, 3 to 8 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2w69c
Elevation: 0 to 1,290 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Ridgebury, extremely stony, and similar soils: 80 percent
Minor components: 20 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Ridgebury, Extremely Stony

Setting

Landform: Depressions, drumlins, drainageways, hills, ground moraines
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 1 inches: moderately decomposed plant material
A - 1 to 6 inches: fine sandy loam
Bw - 6 to 10 inches: sandy loam
Bg - 10 to 19 inches: gravelly sandy loam
Cd - 19 to 66 inches: gravelly sandy loam

Properties and qualities

Slope: 3 to 8 percent
Surface area covered with cobbles, stones or boulders: 9.0 percent
Depth to restrictive feature: 15 to 35 inches to densic material
Drainage class: Poorly drained
Runoff class: Very high
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 0 to 6 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water capacity: Low (about 3.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: D
Ecological site: F144AY009CT - Wet Till Depressions
Hydric soil rating: Yes

Minor Components

Woodbridge, extremely stony

Percent of map unit: 10 percent
Landform: Drumlins, hills, ground moraines
Landform position (two-dimensional): Footslope, summit, backslope
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Convex
Across-slope shape: Linear
Hydric soil rating: No

Whitman, extremely stony

Percent of map unit: 8 percent
Landform: Depressions
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Paxton, extremely stony

Percent of map unit: 2 percent
Landform: Drumlins, hills, ground moraines
Landform position (two-dimensional): Shoulder, summit, backslope
Landform position (three-dimensional): Crest, side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Hydric soil rating: No

Data Source Information

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

Worcester County, Massachusetts, Southern Part

307C—Paxton fine sandy loam, 8 to 15 percent slopes, extremely stony

Map Unit Setting

National map unit symbol: 2w676
Elevation: 0 to 1,490 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: Not prime farmland

Map Unit Composition

Paxton, extremely stony, and similar soils: 85 percent
Minor components: 15 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Paxton, Extremely Stony

Setting

Landform: Ground moraines, drumlins, hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Oe - 0 to 2 inches: moderately decomposed plant material
A - 2 to 10 inches: fine sandy loam
Bw1 - 10 to 17 inches: fine sandy loam
Bw2 - 17 to 28 inches: fine sandy loam
Cd - 28 to 67 inches: gravelly fine sandy loam

Properties and qualities

Slope: 8 to 15 percent
Surface area covered with cobbles, stones or boulders: 9.0 percent
Depth to restrictive feature: 20 to 43 inches to densic material
Drainage class: Well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 37 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water capacity: Low (about 4.7 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 7s
Hydrologic Soil Group: C
Ecological site: F144AY007CT - Well Drained Dense Till Uplands
Hydric soil rating: No

Minor Components

Charlton, extremely stony

Percent of map unit: 8 percent
Landform: Hills
Landform position (two-dimensional): Backslope
Landform position (three-dimensional): Side slope
Down-slope shape: Convex
Across-slope shape: Convex
Hydric soil rating: No

Woodbridge, extremely stony

Percent of map unit: 6 percent
Landform: Ground moraines, drumlins, hills
Landform position (two-dimensional): Backslope, footslope
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Hydric soil rating: No

Ridgebury, extremely stony

Percent of map unit: 1 percent
Landform: Drainageways, hills, ground moraines, depressions, drumlins
Landform position (two-dimensional): Toeslope, footslope
Landform position (three-dimensional): Base slope, head slope
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Data Source Information

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

Worcester County, Massachusetts, Southern Part

310B—Woodbridge fine sandy loam, 3 to 8 percent slopes

Map Unit Setting

National map unit symbol: 2t2ql
Elevation: 0 to 1,470 feet
Mean annual precipitation: 36 to 71 inches
Mean annual air temperature: 39 to 55 degrees F
Frost-free period: 140 to 240 days
Farmland classification: All areas are prime farmland

Map Unit Composition

Woodbridge, fine sandy loam, and similar soils: 82 percent
Minor components: 18 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Woodbridge, Fine Sandy Loam

Setting

Landform: Hills, drumlins, ground moraines
Landform position (two-dimensional): Backslope, footslope, summit
Landform position (three-dimensional): Side slope
Down-slope shape: Concave
Across-slope shape: Linear
Parent material: Coarse-loamy lodgment till derived from gneiss, granite, and/or schist

Typical profile

Ap - 0 to 7 inches: fine sandy loam
Bw1 - 7 to 18 inches: fine sandy loam
Bw2 - 18 to 30 inches: fine sandy loam
Cd - 30 to 65 inches: gravelly fine sandy loam

Properties and qualities

Slope: 3 to 8 percent
Depth to restrictive feature: 20 to 39 inches to densic material
Drainage class: Moderately well drained
Runoff class: Medium
Capacity of the most limiting layer to transmit water (Ksat): Very low to moderately low (0.00 to 0.14 in/hr)
Depth to water table: About 18 to 30 inches
Frequency of flooding: None
Frequency of ponding: None
Maximum salinity: Nonsaline (0.0 to 1.9 mmhos/cm)
Available water capacity: Low (about 3.6 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2w
Hydrologic Soil Group: C/D

Ecological site: F144AY037MA - Moist Dense Till Uplands
Hydric soil rating: No

Minor Components

Paxton

Percent of map unit: 10 percent
Landform: Drumlins, hills, ground moraines
Landform position (two-dimensional): Backslope, summit, shoulder
Landform position (three-dimensional): Side slope, crest, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex
Hydric soil rating: No

Ridgebury

Percent of map unit: 8 percent
Landform: Drainageways, hills, ground moraines, depressions
Landform position (two-dimensional): Backslope, footslope, toeslope
Landform position (three-dimensional): Head slope, base slope, dip
Down-slope shape: Concave
Across-slope shape: Concave
Hydric soil rating: Yes

Data Source Information

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

AVIZINIS
ENVIRONMENTAL
SERVICES INC

SOIL EVALUATION REPORT

SITE LOCATION:
195, 197, 201 & 201A
Charlton Road
Sturbridge, Massachusetts

PREPARED FOR:
CMG Environmental, Inc.
67 Hall Rd, Sturbridge, MA 01566

PREPARED (NOVEMBER 20, 2020) BY:

Edward J. Avizinis, CPSS, PWS | President

CPSS
Certified Professional Soil Scientist
EDWARD J. AVIZINIS
343219

PWS
EDWARD J. AVIZINIS
2746
PROFESSIONAL WETLAND SCIENTIST

INTRODUCTION

Avizinis Environmental Services, Inc., (AES), has completed the requested soil evaluations for stormwater mitigation system design purposes at the above referenced address. These evaluations were performed in accordance with the Massachusetts Stormwater Handbook, Volume 3, Chapter 1 by a Title 5 certified soil evaluator, Edward J. Avizinis (SE#14250). Four soil evaluations were performed as directed by you and as indicated on the provided preliminary site plan for the property. Site work was performed and completed on November 18, 2020.

EXISTING CONDITIONS

The properties are located along the south side of Route 20 in Sturbridge, Massachusetts. These parcels are historically developed and are comprised almost entirely of impervious surface with some degree of fill material across the entire site. The USDA – NRCS Soil Survey Map for this region lists a number of soil series across the parcels. The majority of the area is mapped as variations of the Paxton, and Woodbridge soils. These are characterized as glacial till deposited soils that are generally indicative of upland areas. The subsoil is generally considered a densic layer comprised of fine sandy loam. The AES findings were consistent with the soils map for the property.

The southwest corner of the property is mapped by the NRCS as the Ridgebury soil series. This is similarly a fine sandy loam soil however is indicative of wetland areas. This map unit exists in the vicinity of test hole 4.

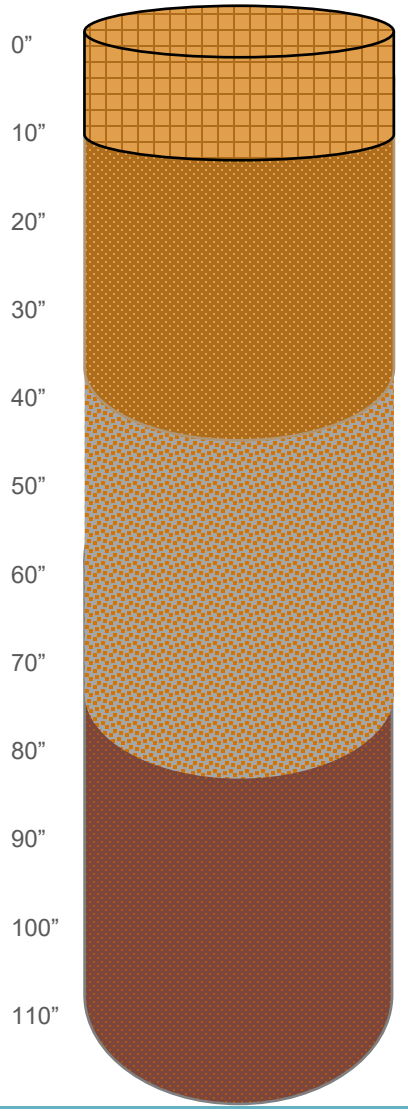
SOIL DATA

Please see the test hole data for TH1 – TH4 on the following pages. In addition, I have located the test holes with a Spectra SP20 decimetric GPS unit and applied the data to an aerial photograph of the subject lots for reference. Although this is not a professional survey, this data can be provided to you to incorporate into your preliminary planning.

SOIL DATA

Test Hole 1

Depth	Horizon	Color	Texture	Redoximorphic Features
0 – 10”	HTM	2.5Y 3/3	Loamy Sand	-
10 – 40”	Bw	10YR 4/4	Loamy Sand	-
40 – 78”	2Cd1	2.5Y 4/3	Fine Sandy Loam	Prominent medium
78 – 110”	2Cd2	2.5Y 4/2	Fine Sandy Loam	Prominent medium



Results

Total Depth = 110”

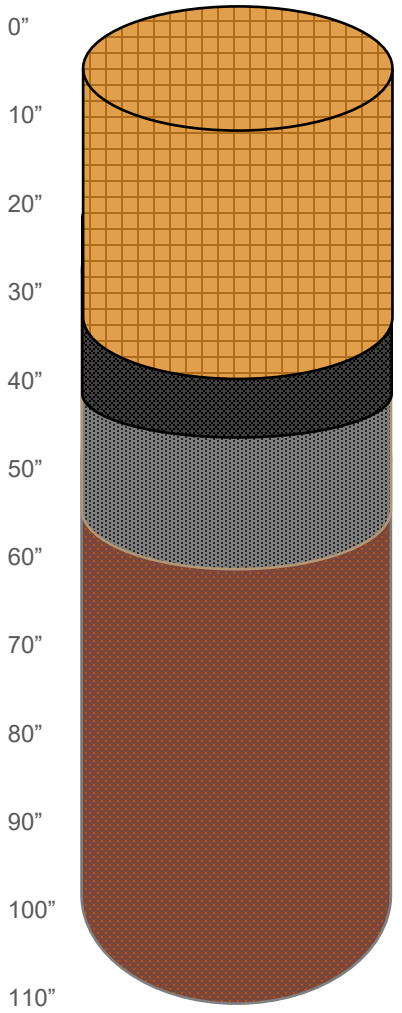
Depth to Restrictive Layer = N/A

Depth to Groundwater Seep = 78”

Estimated Seasonally High Water Table = 40”

Test Hole 2

Depth	Horizon	Color	Texture	Redoximorphic Features
0 – 36”	HTM	2.5Y 4/3	Loamy Sand	-
36 – 43”	Ap	10YR 3/1	Silt Loam	Prominent medium
43 – 58”	Bg	2.5Y 5/2	Silt Loam	Prominent medium
58 – 106”	2Cd	2.5Y 4/2	Fine Sandy Loam	Prominent medium



Results

Total Depth = 106”

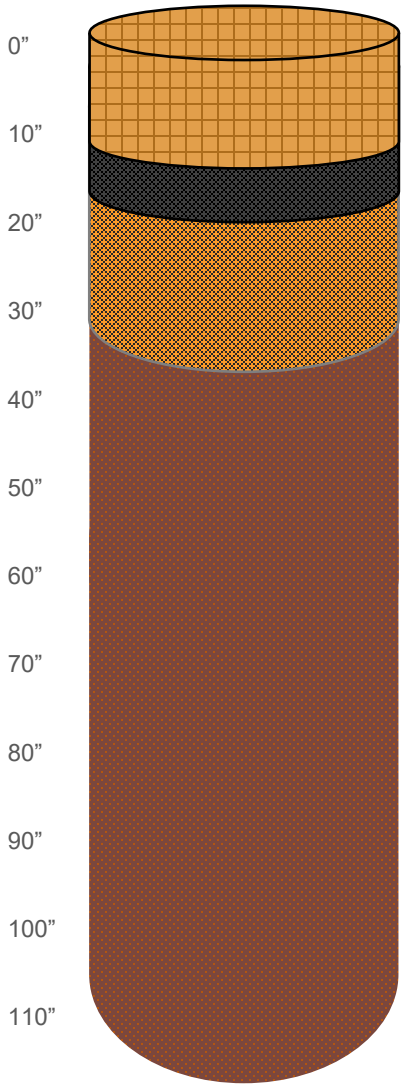
Depth to Restrictive Layer = N/A

Depth to Groundwater Seep = 76”

Estimated Seasonally High Water Table = 36”

Test Hole 3

Depth	Horizon	Color	Texture	Redoximorphic Features
0 – 12”	HTM	2.5Y 3/3	Extremely Gravelly Loamy Sand	-
12 – 17”	Ap	10YR 3/1	Sandy Loam	-
17 – 33”	Bw	10YR 5/4	Sandy Loam	-
33 – 109”	2Cd	2.5Y 4/2	Fine Sandy Loam	Prominent medium



Results

Total Depth = 109”

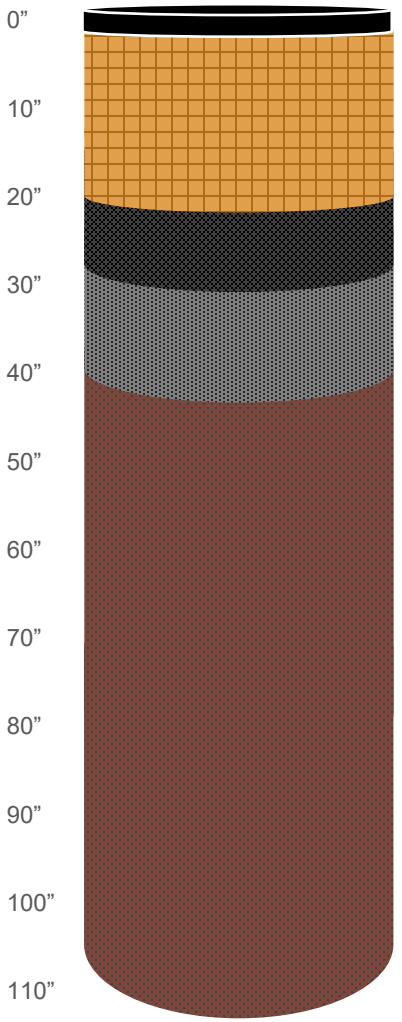
Depth to Restrictive Layer = N/A

Depth to Groundwater Seep = 105”

Estimated Seasonally High Water Table = 33”

Test Hole 4

Depth	Horizon	Color	Texture	Redoximorphic Features
0 – 2”	M	-	pavement	-
2 – 20”	HTM	10YR 4/4	Loamy Sand	-
20 – 28”	A	10YR 2/1	Silt Loam	Prominent small
28 – 40”	Bg	10YR 5/1	Sandy Loam	Prominent medium
40 – 108”	2Cd	2.5Y 4/1	Very Fine Sandy Loam	Prominent medium



Results

Total Depth = 108”

Depth to Restrictive Layer = N/A

Depth to Groundwater Seep = 102”

Estimated Seasonally High Water Table = 21”

SITE MAPS

AVIZINIS
ENVIRONMENTAL
SERVICES INC

Site Location
195, 197, 201 & 201A Charlton Road
Sturbridge, Massachusetts

LEGEND

- Property Line (Approximated)

General Notes:
1. This map should not be interpreted as a survey quality graphic. It is designed for preliminary planning purposes only. AES recommends consultation with a Professional Land Surveyor for accurate site feature locations.
2. Property lines as depicted on this map have been approximated from plat maps available from the town assessor's online database.
3. 2019 Aerial photograph base map acquired from the Massachusetts OLIVER database.

200 100 0 200 400 600
Feet

AVIZINIS
ENVIRONMENTAL
SERVICES INC

Soil Evaluation Location Map
195, 197, 201 & 201A Charlton Road
Sturbridge, Massachusetts

LEGEND

- Property Line (Approximated)
- -Benchmark Point
- -Soil Evaluation Location

General Notes:

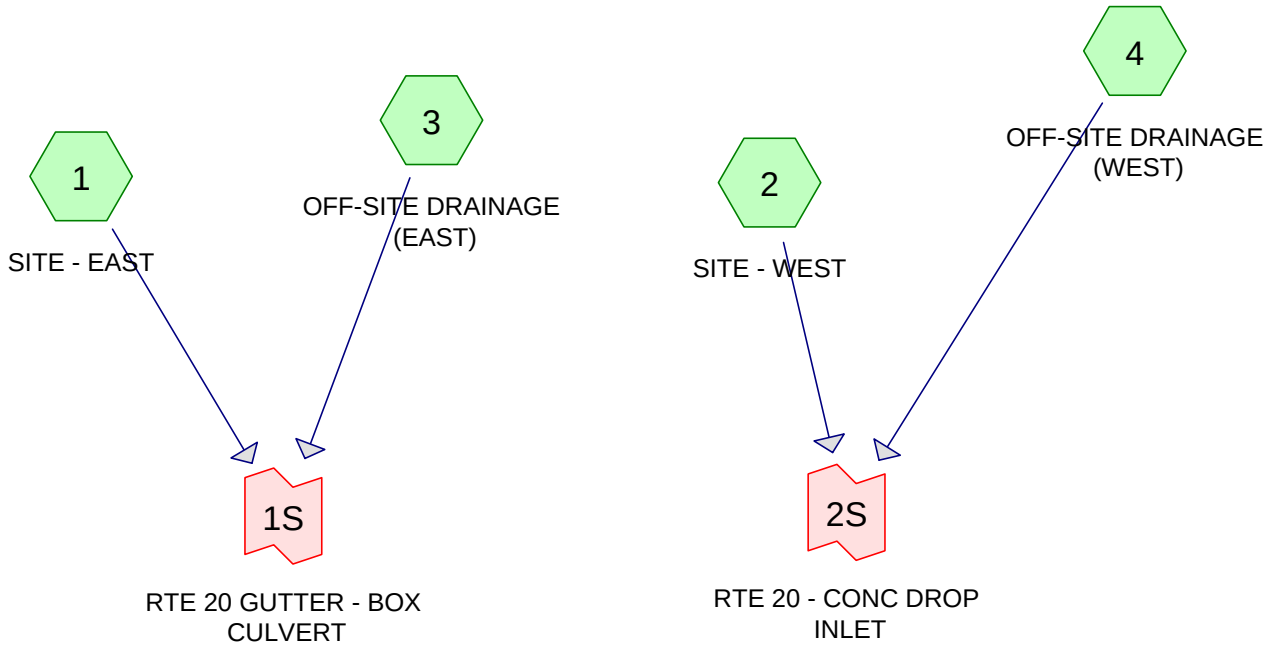
1. This map should not be interpreted as a survey quality graphic. It is designed for preliminary planning purposes only. AES recommends consultation with a Professional Land Surveyor for accurate site feature locations.
2. Property lines as depicted on this map have been approximated from plat maps available from the town assessor's online database.
3. 2019 Aerial photograph base map acquired from the Massachusetts OLIVER database.
4. Soil evaluations performed by Edward J. Avizinis, CPSS, PWS (SE#14250) on November 18, 2020.

200 100 0 200 400 600

Feet

Appendix D

Pre-Development Drainage Calculations



Subcat Reach Pond Link

Routing Diagram for jab 2020.10.27-Noble_SturbridgeMA-EXISTING
Prepared by CMG, Printed 3/25/2021

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	2-Year Storm	Type III 24-hr		Default	24.00	1	3.15	2
2	10-Year Storm	Type III 24-hr		Default	24.00	1	4.68	2
3	25-Year Storm	Type III 24-hr		Default	24.00	1	5.86	2
4	100-Year Storm	Type III 24-hr		Default	24.00	1	8.28	2

Summary for Subcatchment 1: SITE - EAST

Runoff = 13.70 cfs @ 12.09 hrs, Volume= 44,863 cf, Depth= 2.50"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

	Area (sf)	CN	Description
*	5,684	98	Existing Roof
*	134,029	98	Existing Pavement
	65,198	89	<50% Grass cover, Poor, HSG D
	10,832	70	Woods, Good, HSG C
	215,743	94	Weighted Average
	76,030		35.24% Pervious Area
	139,713		64.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	463	0.0250	1.21		**Lag/CN Method,**

Summary for Subcatchment 2: SITE - WEST

Runoff = 6.69 cfs @ 12.08 hrs, Volume= 21,873 cf, Depth= 2.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

	Area (sf)	CN	Description
*	8,622	98	Ex. Building Roof
*	78,159	98	Ex. Pavement
	14,328	80	>75% Grass cover, Good, HSG D
	101,109	95	Weighted Average
	14,328		14.17% Pervious Area
	86,781		85.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3: OFF-SITE DRAINAGE (EAST)

Runoff = 3.77 cfs @ 12.19 hrs, Volume= 15,993 cf, Depth= 0.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
18,284	77	Woods, Good, HSG D
204,367	70	Woods, Good, HSG C
3,610	84	50-75% Grass cover, Fair, HSG D
226,261	71	Weighted Average
226,261		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	813	0.0810	1.10		**Lag/CN Method, OFF-SITE RUNOFF (EASTERN AREA)**

Summary for Subcatchment 4: OFF-SITE DRAINAGE (WEST)

Runoff = 8.85 cfs @ 12.30 hrs, Volume= 43,935 cf, Depth= 0.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
314,430	70	Woods, Good, HSG C
237,451	77	Woods, Good, HSG D
2,523	79	50-75% Grass cover, Fair, HSG C
554,404	73	Weighted Average
554,404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,432	0.0680	1.20		**Lag/CN Method, OFF-SITE RUNOFF (WESTERN AREA)**

Summary for Link 1S: RTE 20 GUTTER - BOX CULVERT

Inflow Area = 442,004 sf, 31.61% Impervious, Inflow Depth = 1.65" for 2-Year Storm event
Inflow = 16.39 cfs @ 12.10 hrs, Volume= 60,855 cf
Primary = 16.39 cfs @ 12.10 hrs, Volume= 60,855 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Link 2S: RTE 20 - CONC DROP INLET

Inflow Area = 655,513 sf, 13.24% Impervious, Inflow Depth = 1.20" for 2-Year Storm event
Inflow = 11.65 cfs @ 12.27 hrs, Volume= 65,809 cf
Primary = 11.65 cfs @ 12.27 hrs, Volume= 65,809 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Subcatchment 1: SITE - EAST

Runoff = 21.35 cfs @ 12.09 hrs, Volume= 71,780 cf, Depth= 3.99"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

	Area (sf)	CN	Description
*	5,684	98	Existing Roof
*	134,029	98	Existing Pavement
	65,198	89	<50% Grass cover, Poor, HSG D
	10,832	70	Woods, Good, HSG C
	215,743	94	Weighted Average
	76,030		35.24% Pervious Area
	139,713		64.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	463	0.0250	1.21		**Lag/CN Method,**

Summary for Subcatchment 2: SITE - WEST

Runoff = 10.30 cfs @ 12.08 hrs, Volume= 34,569 cf, Depth= 4.10"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

	Area (sf)	CN	Description
*	8,622	98	Ex. Building Roof
*	78,159	98	Ex. Pavement
	14,328	80	>75% Grass cover, Good, HSG D
	101,109	95	Weighted Average
	14,328		14.17% Pervious Area
	86,781		85.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3: OFF-SITE DRAINAGE (EAST)

Runoff = 9.10 cfs @ 12.18 hrs, Volume= 35,405 cf, Depth= 1.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
18,284	77	Woods, Good, HSG D
204,367	70	Woods, Good, HSG C
3,610	84	50-75% Grass cover, Fair, HSG D
226,261	71	Weighted Average
226,261		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	813	0.0810	1.10		**Lag/CN Method, OFF-SITE RUNOFF (EASTERN AREA)**

Summary for Subcatchment 4: OFF-SITE DRAINAGE (WEST)

Runoff = 20.16 cfs @ 12.29 hrs, Volume= 93,900 cf, Depth= 2.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
314,430	70	Woods, Good, HSG C
237,451	77	Woods, Good, HSG D
2,523	79	50-75% Grass cover, Fair, HSG C
554,404	73	Weighted Average
554,404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,432	0.0680	1.20		**Lag/CN Method, OFF-SITE RUNOFF (WESTERN AREA)**

Summary for Link 1S: RTE 20 GUTTER - BOX CULVERT

Inflow Area = 442,004 sf, 31.61% Impervious, Inflow Depth = 2.91" for 10-Year Storm event
Inflow = 28.44 cfs @ 12.10 hrs, Volume= 107,185 cf
Primary = 28.44 cfs @ 12.10 hrs, Volume= 107,185 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Link 2S: RTE 20 - CONC DROP INLET

Inflow Area = 655,513 sf, 13.24% Impervious, Inflow Depth = 2.35" for 10-Year Storm event
Inflow = 24.53 cfs @ 12.26 hrs, Volume= 128,469 cf
Primary = 24.53 cfs @ 12.26 hrs, Volume= 128,469 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Subcatchment 1: SITE - EAST

Runoff = 27.18 cfs @ 12.09 hrs, Volume= 92,733 cf, Depth= 5.16"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

	Area (sf)	CN	Description
*	5,684	98	Existing Roof
*	134,029	98	Existing Pavement
	65,198	89	<50% Grass cover, Poor, HSG D
	10,832	70	Woods, Good, HSG C
	215,743	94	Weighted Average
	76,030		35.24% Pervious Area
	139,713		64.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	463	0.0250	1.21		**Lag/CN Method,**

Summary for Subcatchment 2: SITE - WEST

Runoff = 13.05 cfs @ 12.08 hrs, Volume= 44,425 cf, Depth= 5.27"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

	Area (sf)	CN	Description
*	8,622	98	Ex. Building Roof
*	78,159	98	Ex. Pavement
	14,328	80	>75% Grass cover, Good, HSG D
	101,109	95	Weighted Average
	14,328		14.17% Pervious Area
	86,781		85.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3: OFF-SITE DRAINAGE (EAST)

Runoff = 13.73 cfs @ 12.17 hrs, Volume= 52,537 cf, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
18,284	77	Woods, Good, HSG D
204,367	70	Woods, Good, HSG C
3,610	84	50-75% Grass cover, Fair, HSG D
226,261	71	Weighted Average
226,261		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	813	0.0810	1.10		**Lag/CN Method, OFF-SITE RUNOFF (EASTERN AREA)**

Summary for Subcatchment 4: OFF-SITE DRAINAGE (WEST)

Runoff = 29.82 cfs @ 12.28 hrs, Volume= 137,346 cf, Depth= 2.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
314,430	70	Woods, Good, HSG C
237,451	77	Woods, Good, HSG D
2,523	79	50-75% Grass cover, Fair, HSG C
554,404	73	Weighted Average
554,404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,432	0.0680	1.20		**Lag/CN Method, OFF-SITE RUNOFF (WESTERN AREA)**

Summary for Link 1S: RTE 20 GUTTER - BOX CULVERT

Inflow Area = 442,004 sf, 31.61% Impervious, Inflow Depth = 3.94" for 25-Year Storm event
Inflow = 38.18 cfs @ 12.11 hrs, Volume= 145,271 cf
Primary = 38.18 cfs @ 12.11 hrs, Volume= 145,271 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Link 2S: RTE 20 - CONC DROP INLET

Inflow Area = 655,513 sf, 13.24% Impervious, Inflow Depth = 3.33" for 25-Year Storm event
Inflow = 35.45 cfs @ 12.25 hrs, Volume= 181,771 cf
Primary = 35.45 cfs @ 12.25 hrs, Volume= 181,771 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Subcatchment 1: SITE - EAST

Runoff = 39.04 cfs @ 12.09 hrs, Volume= 135,925 cf, Depth= 7.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

	Area (sf)	CN	Description
*	5,684	98	Existing Roof
*	134,029	98	Existing Pavement
	65,198	89	<50% Grass cover, Poor, HSG D
	10,832	70	Woods, Good, HSG C
	215,743	94	Weighted Average
	76,030		35.24% Pervious Area
	139,713		64.76% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.4	463	0.0250	1.21		**Lag/CN Method,**

Summary for Subcatchment 2: SITE - WEST

Runoff = 18.66 cfs @ 12.08 hrs, Volume= 64,712 cf, Depth= 7.68"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

	Area (sf)	CN	Description
*	8,622	98	Ex. Building Roof
*	78,159	98	Ex. Pavement
	14,328	80	>75% Grass cover, Good, HSG D
	101,109	95	Weighted Average
	14,328		14.17% Pervious Area
	86,781		85.83% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3: OFF-SITE DRAINAGE (EAST)

Runoff = 23.92 cfs @ 12.17 hrs, Volume= 90,944 cf, Depth= 4.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
18,284	77	Woods, Good, HSG D
204,367	70	Woods, Good, HSG C
3,610	84	50-75% Grass cover, Fair, HSG D
226,261	71	Weighted Average
226,261		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	813	0.0810	1.10		**Lag/CN Method, OFF-SITE RUNOFF (EASTERN AREA)**

Summary for Subcatchment 4: OFF-SITE DRAINAGE (WEST)

Runoff = 50.84 cfs @ 12.27 hrs, Volume= 233,720 cf, Depth= 5.06"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
314,430	70	Woods, Good, HSG C
237,451	77	Woods, Good, HSG D
2,523	79	50-75% Grass cover, Fair, HSG C
554,404	73	Weighted Average
554,404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,432	0.0680	1.20		**Lag/CN Method, OFF-SITE RUNOFF (WESTERN AREA)**

Summary for Link 1S: RTE 20 GUTTER - BOX CULVERT

Inflow Area = 442,004 sf, 31.61% Impervious, Inflow Depth = 6.16" for 100-Year Storm event
Inflow = 58.77 cfs @ 12.11 hrs, Volume= 226,869 cf
Primary = 58.77 cfs @ 12.11 hrs, Volume= 226,869 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

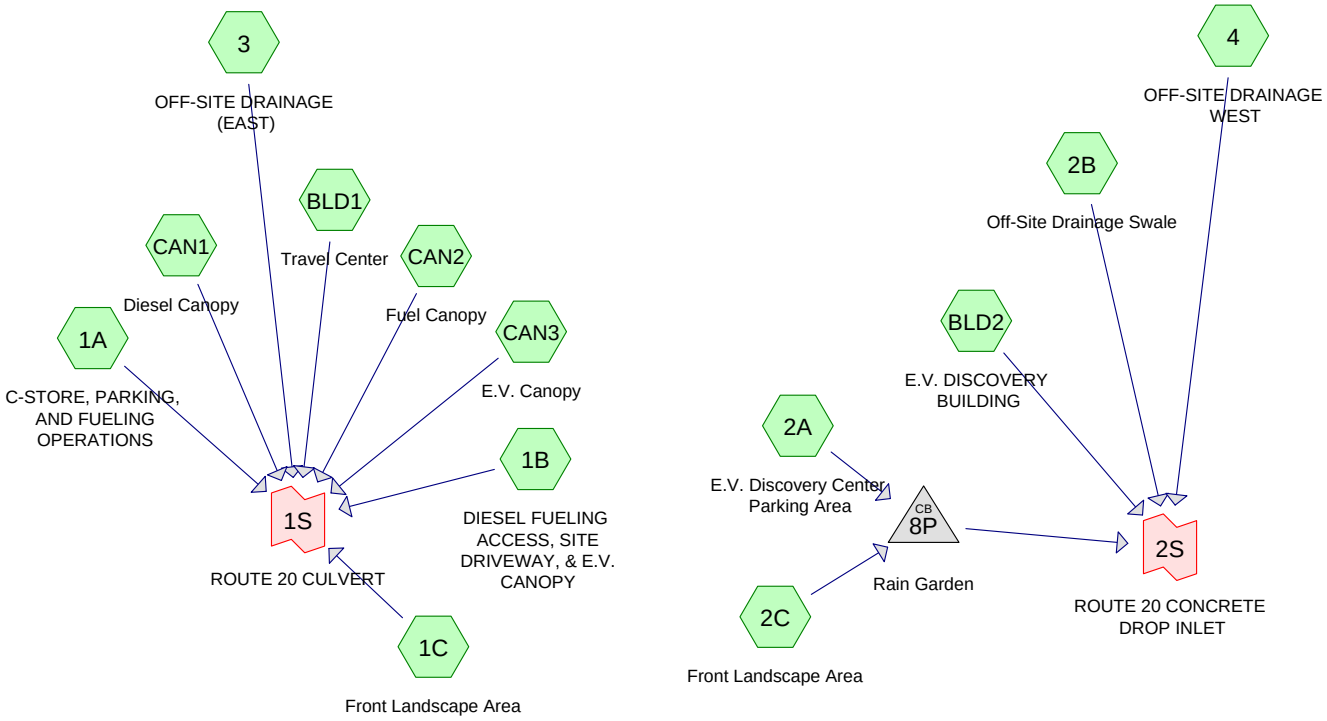
Summary for Link 2S: RTE 20 - CONC DROP INLET

Inflow Area = 655,513 sf, 13.24% Impervious, Inflow Depth = 5.46" for 100-Year Storm event
Inflow = 59.03 cfs @ 12.25 hrs, Volume= 298,432 cf
Primary = 59.03 cfs @ 12.25 hrs, Volume= 298,432 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Appendix E

Post-Development Drainage Calculations



Subcat Reach Pond Link

Routing Diagram for 2020.11.6-Noble_SturbridgeMA-PROPOSED_REV1
Prepared by CMG, Printed 3/25/2021

Summary for Subcatchment 1A: C-STORE, PARKING, AND FUELING OPERATIONS

Runoff = 6.35 cfs @ 12.09 hrs, Volume= 20,302 cf, Depth= 2.40"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
74,059	98	Paved parking, HSG D
27,547	80	>75% Grass cover, Good, HSG D
101,606	93	Weighted Average
27,547		27.11% Pervious Area
74,059		72.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 1B: DIESEL FUELING ACCESS, SITE DRIVEWAY, & E.V. CANOPY

Runoff = 4.70 cfs @ 12.09 hrs, Volume= 14,634 cf, Depth= 2.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
42,596	98	Paved parking, HSG D
43,655	80	>75% Grass cover, Good, HSG D
86,251	89	Weighted Average
43,655		50.61% Pervious Area
42,596		49.39% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 1C: Front Landscape Area

Runoff = 0.18 cfs @ 12.09 hrs, Volume= 565 cf, Depth= 1.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
4,976	80	>75% Grass cover, Good, HSG D
4,976		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2A: E.V. Discovery Center Parking Area

Runoff = 3.18 cfs @ 12.09 hrs, Volume= 9,951 cf, Depth= 2.12"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
31,489	98	Paved parking, HSG D
24,774	80	>75% Grass cover, Good, HSG D
56,263	90	Weighted Average
24,774		44.03% Pervious Area
31,489		55.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2B: Off-Site Drainage Swale

Runoff = 0.99 cfs @ 12.10 hrs, Volume= 3,122 cf, Depth= 1.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
27,474	80	>75% Grass cover, Good, HSG D
27,474		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	235	0.0250	0.62		**Lag/CN Method,**

Summary for Subcatchment 2C: Front Landscape Area

Runoff = 0.37 cfs @ 12.09 hrs, Volume= 1,146 cf, Depth= 1.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
10,081	80	>75% Grass cover, Good, HSG D
10,081		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3: OFF-SITE DRAINAGE (EAST)

Runoff = 3.77 cfs @ 12.19 hrs, Volume= 15,993 cf, Depth= 0.85"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
18,284	77	Woods, Good, HSG D
204,367	70	Woods, Good, HSG C
3,610	84	50-75% Grass cover, Fair, HSG D
226,261	71	Weighted Average
226,261		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	813	0.0810	1.10		**Lag/CN Method, OFF-SITE RUNOFF (EASTERN AREA)**

Summary for Subcatchment 4: OFF-SITE DRAINAGE WEST

Runoff = 8.85 cfs @ 12.30 hrs, Volume= 43,935 cf, Depth= 0.95"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
314,430	70	Woods, Good, HSG C
237,451	77	Woods, Good, HSG D
2,523	79	50-75% Grass cover, Fair, HSG C
554,404	73	Weighted Average
554,404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,432	0.0680	1.20		**Lag/CN Method, OFF-SITE RUNOFF (WESTERN AREA)**

Summary for Subcatchment BLD1: Travel Center

Runoff = 0.59 cfs @ 12.08 hrs, Volume= 2,052 cf, Depth= 2.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
8,438	98	Roofs, HSG D
8,438		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment BLD2: E.V. DISCOVERY BUILDING

Runoff = 0.66 cfs @ 12.08 hrs, Volume= 2,301 cf, Depth= 2.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
9,465	98	Unconnected roofs, HSG D
9,465		100.00% Impervious Area
9,465		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN1: Diesel Canopy

Runoff = 0.13 cfs @ 12.08 hrs, Volume= 438 cf, Depth= 2.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
1,800	98	Roofs, HSG D
1,800		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN2: Fuel Canopy

Runoff = 0.55 cfs @ 12.08 hrs, Volume= 1,895 cf, Depth= 2.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
7,795	98	Roofs, HSG D
7,795		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN3: E.V. Canopy

Runoff = 0.19 cfs @ 12.08 hrs, Volume= 656 cf, Depth= 2.92"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Storm Rainfall=3.15"

Area (sf)	CN	Description
2,700	98	Roofs, HSG D
2,700		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond 8P: Rain Garden

Inflow Area = 66,344 sf, 47.46% Impervious, Inflow Depth = 2.01" for 2-Year Storm event
Inflow = 3.55 cfs @ 12.09 hrs, Volume= 11,096 cf
Outflow = 3.55 cfs @ 12.09 hrs, Volume= 11,096 cf, Atten= 0%, Lag= 0.0 min
Primary = 3.55 cfs @ 12.09 hrs, Volume= 11,096 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 617.20' @ 12.09 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	614.50'	**12.0" Round Culvert** L= 45.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 614.50' / 613.55' S= 0.0211 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	617.00'	**48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	617.25'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir**

Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=3.54 cfs @ 12.09 hrs HW=617.20' TW=0.00' (Dynamic Tailwater)
- **1=Culvert** (Passes 3.54 cfs of 4.42 cfs potential flow)
  - **2=Orifice/Grate** (Weir Controls 3.54 cfs @ 1.44 fps)
- **3=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

Summary for Link 1S: ROUTE 20 CULVERT

Inflow Area = 439,827 sf, 31.24% Impervious, Inflow Depth = 1.54" for 2-Year Storm event
Inflow = 15.29 cfs @ 12.10 hrs, Volume= 56,535 cf
Primary = 15.29 cfs @ 12.10 hrs, Volume= 56,535 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Link 2S: ROUTE 20 CONCRETE DROP INLET

Inflow Area = 657,687 sf, 6.23% Impervious, Inflow Depth = 1.10" for 2-Year Storm event
Inflow = 11.15 cfs @ 12.28 hrs, Volume= 60,455 cf
Primary = 11.15 cfs @ 12.28 hrs, Volume= 60,455 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Subcatchment 1A: C-STORE, PARKING, AND FUELING OPERATIONS

Runoff = 10.03 cfs @ 12.08 hrs, Volume= 32,887 cf, Depth= 3.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
74,059	98	Paved parking, HSG D
27,547	80	>75% Grass cover, Good, HSG D
101,606	93	Weighted Average
27,547		27.11% Pervious Area
74,059		72.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 1B: DIESEL FUELING ACCESS, SITE DRIVEWAY, & E.V. CANOPY

Runoff = 7.85 cfs @ 12.09 hrs, Volume= 24,915 cf, Depth= 3.47"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
42,596	98	Paved parking, HSG D
43,655	80	>75% Grass cover, Good, HSG D
86,251	89	Weighted Average
43,655		50.61% Pervious Area
42,596		49.39% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 1C: Front Landscape Area

Runoff = 0.35 cfs @ 12.09 hrs, Volume= 1,085 cf, Depth= 2.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
4,976	80	>75% Grass cover, Good, HSG D
4,976		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2A: E.V. Discovery Center Parking Area

Runoff = 5.23 cfs @ 12.09 hrs, Volume= 16,731 cf, Depth= 3.57"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
31,489	98	Paved parking, HSG D
24,774	80	>75% Grass cover, Good, HSG D
56,263	90	Weighted Average
24,774		44.03% Pervious Area
31,489		55.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2B: Off-Site Drainage Swale

Runoff = 1.92 cfs @ 12.09 hrs, Volume= 5,988 cf, Depth= 2.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
27,474	80	>75% Grass cover, Good, HSG D
27,474		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	235	0.0250	0.62		**Lag/CN Method,**

Summary for Subcatchment 2C: Front Landscape Area

Runoff = 0.71 cfs @ 12.09 hrs, Volume= 2,197 cf, Depth= 2.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
10,081	80	>75% Grass cover, Good, HSG D
10,081		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3: OFF-SITE DRAINAGE (EAST)

Runoff = 9.10 cfs @ 12.18 hrs, Volume= 35,405 cf, Depth= 1.88"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
18,284	77	Woods, Good, HSG D
204,367	70	Woods, Good, HSG C
3,610	84	50-75% Grass cover, Fair, HSG D
226,261	71	Weighted Average
226,261		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	813	0.0810	1.10		**Lag/CN Method, OFF-SITE RUNOFF (EASTERN AREA)**

Summary for Subcatchment 4: OFF-SITE DRAINAGE WEST

Runoff = 20.16 cfs @ 12.29 hrs, Volume= 93,900 cf, Depth= 2.03"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
314,430	70	Woods, Good, HSG C
237,451	77	Woods, Good, HSG D
2,523	79	50-75% Grass cover, Fair, HSG C
554,404	73	Weighted Average
554,404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,432	0.0680	1.20		**Lag/CN Method, OFF-SITE RUNOFF (WESTERN AREA)**

Summary for Subcatchment BLD1: Travel Center

Runoff = 0.89 cfs @ 12.08 hrs, Volume= 3,125 cf, Depth= 4.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
8,438	98	Roofs, HSG D
8,438		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment BLD2: E.V. DISCOVERY BUILDING

Runoff = 0.99 cfs @ 12.08 hrs, Volume= 3,505 cf, Depth= 4.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
9,465	98	Unconnected roofs, HSG D
9,465		100.00% Impervious Area
9,465		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN1: Diesel Canopy

Runoff = 0.19 cfs @ 12.08 hrs, Volume= 667 cf, Depth= 4.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
1,800	98	Roofs, HSG D
1,800		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN2: Fuel Canopy

Runoff = 0.82 cfs @ 12.08 hrs, Volume= 2,887 cf, Depth= 4.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
7,795	98	Roofs, HSG D
7,795		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN3: E.V. Canopy

Runoff = 0.28 cfs @ 12.08 hrs, Volume= 1,000 cf, Depth= 4.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Storm Rainfall=4.68"

Area (sf)	CN	Description
2,700	98	Roofs, HSG D
2,700		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond 8P: Rain Garden

Inflow Area = 66,344 sf, 47.46% Impervious, Inflow Depth = 3.42" for 10-Year Storm event
Inflow = 5.94 cfs @ 12.09 hrs, Volume= 18,928 cf
Outflow = 5.94 cfs @ 12.09 hrs, Volume= 18,928 cf, Atten= 0%, Lag= 0.0 min
Primary = 5.94 cfs @ 12.09 hrs, Volume= 18,928 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 617.39' @ 12.09 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	614.50'	**12.0" Round Culvert** L= 45.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 614.50' / 613.55' S= 0.0211 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	617.00'	**48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	617.25'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir**

Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=5.93 cfs @ 12.09 hrs HW=617.39' TW=0.00' (Dynamic Tailwater)
- **1=Culvert** (Inlet Controls 4.62 cfs @ 5.88 fps)
  - **2=Orifice/Grate** (Passes 4.62 cfs of 10.04 cfs potential flow)
- **3=Broad-Crested Rectangular Weir** (Weir Controls 1.32 cfs @ 0.93 fps)

Summary for Link 1S: ROUTE 20 CULVERT

Inflow Area = 439,827 sf, 31.24% Impervious, Inflow Depth = 2.78" for 10-Year Storm event
Inflow = 27.29 cfs @ 12.10 hrs, Volume= 101,968 cf
Primary = 27.29 cfs @ 12.10 hrs, Volume= 101,968 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Link 2S: ROUTE 20 CONCRETE DROP INLET

Inflow Area = 657,687 sf, 6.23% Impervious, Inflow Depth = 2.23" for 10-Year Storm event
Inflow = 24.07 cfs @ 12.27 hrs, Volume= 122,322 cf
Primary = 24.07 cfs @ 12.27 hrs, Volume= 122,322 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Subcatchment 1A: C-STORE, PARKING, AND FUELING OPERATIONS

Runoff = 12.83 cfs @ 12.08 hrs, Volume= 42,712 cf, Depth= 5.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
74,059	98	Paved parking, HSG D
27,547	80	>75% Grass cover, Good, HSG D
101,606	93	Weighted Average
27,547		27.11% Pervious Area
74,059		72.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 1B: DIESEL FUELING ACCESS, SITE DRIVEWAY, & E.V. CANOPY

Runoff = 10.27 cfs @ 12.08 hrs, Volume= 33,062 cf, Depth= 4.60"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
42,596	98	Paved parking, HSG D
43,655	80	>75% Grass cover, Good, HSG D
86,251	89	Weighted Average
43,655		50.61% Pervious Area
42,596		49.39% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 1C: Front Landscape Area

Runoff = 0.49 cfs @ 12.09 hrs, Volume= 1,516 cf, Depth= 3.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
4,976	80	>75% Grass cover, Good, HSG D
4,976		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2A: E.V. Discovery Center Parking Area

Runoff = 6.81 cfs @ 12.08 hrs, Volume= 22,081 cf, Depth= 4.71"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
31,489	98	Paved parking, HSG D
24,774	80	>75% Grass cover, Good, HSG D
56,263	90	Weighted Average
24,774		44.03% Pervious Area
31,489		55.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2B: Off-Site Drainage Swale

Runoff = 2.67 cfs @ 12.09 hrs, Volume= 8,369 cf, Depth= 3.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
27,474	80	>75% Grass cover, Good, HSG D
27,474		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	235	0.0250	0.62		**Lag/CN Method,**

Summary for Subcatchment 2C: Front Landscape Area

Runoff = 0.99 cfs @ 12.09 hrs, Volume= 3,071 cf, Depth= 3.66"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
10,081	80	>75% Grass cover, Good, HSG D
10,081		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3: OFF-SITE DRAINAGE (EAST)

Runoff = 13.73 cfs @ 12.17 hrs, Volume= 52,537 cf, Depth= 2.79"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
18,284	77	Woods, Good, HSG D
204,367	70	Woods, Good, HSG C
3,610	84	50-75% Grass cover, Fair, HSG D
226,261	71	Weighted Average
226,261		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	813	0.0810	1.10		**Lag/CN Method, OFF-SITE RUNOFF (EASTERN AREA)**

Summary for Subcatchment 4: OFF-SITE DRAINAGE WEST

Runoff = 29.82 cfs @ 12.28 hrs, Volume= 137,346 cf, Depth= 2.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
314,430	70	Woods, Good, HSG C
237,451	77	Woods, Good, HSG D
2,523	79	50-75% Grass cover, Fair, HSG C
554,404	73	Weighted Average
554,404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,432	0.0680	1.20		**Lag/CN Method, OFF-SITE RUNOFF (WESTERN AREA)**

Summary for Subcatchment BLD1: Travel Center

Runoff = 1.11 cfs @ 12.08 hrs, Volume= 3,953 cf, Depth= 5.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
8,438	98	Roofs, HSG D
8,438		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment BLD2: E.V. DISCOVERY BUILDING

Runoff = 1.25 cfs @ 12.08 hrs, Volume= 4,434 cf, Depth= 5.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
9,465	98	Unconnected roofs, HSG D
9,465		100.00% Impervious Area
9,465		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN1: Diesel Canopy

Runoff = 0.24 cfs @ 12.08 hrs, Volume= 843 cf, Depth= 5.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
1,800	98	Roofs, HSG D
1,800		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN2: Fuel Canopy

Runoff = 1.03 cfs @ 12.08 hrs, Volume= 3,652 cf, Depth= 5.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
7,795	98	Roofs, HSG D
7,795		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN3: E.V. Canopy

Runoff = 0.36 cfs @ 12.08 hrs, Volume= 1,265 cf, Depth= 5.62"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Storm Rainfall=5.86"

Area (sf)	CN	Description
2,700	98	Roofs, HSG D
2,700		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond 8P: Rain Garden

Inflow Area = 66,344 sf, 47.46% Impervious, Inflow Depth = 4.55" for 25-Year Storm event
Inflow = 7.80 cfs @ 12.09 hrs, Volume= 25,152 cf
Outflow = 7.80 cfs @ 12.09 hrs, Volume= 25,152 cf, Atten= 0%, Lag= 0.0 min
Primary = 7.80 cfs @ 12.09 hrs, Volume= 25,152 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 617.50' @ 12.09 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	614.50'	**12.0" Round Culvert** L= 45.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 614.50' / 613.55' S= 0.0211 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	617.00'	**48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	617.25'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir**

Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=7.78 cfs @ 12.09 hrs HW=617.50' TW=0.00' (Dynamic Tailwater)
- **1=Culvert** (Inlet Controls 4.72 cfs @ 6.01 fps)
  - **2=Orifice/Grate** (Passes 4.72 cfs of 14.37 cfs potential flow)
- **3=Broad-Crested Rectangular Weir** (Weir Controls 3.06 cfs @ 1.24 fps)

Summary for Link 1S: ROUTE 20 CULVERT

Inflow Area = 439,827 sf, 31.24% Impervious, Inflow Depth = 3.81" for 25-Year Storm event
Inflow = 37.02 cfs @ 12.10 hrs, Volume= 139,541 cf
Primary = 37.02 cfs @ 12.10 hrs, Volume= 139,541 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Link 2S: ROUTE 20 CONCRETE DROP INLET

Inflow Area = 657,687 sf, 6.23% Impervious, Inflow Depth = 3.20" for 25-Year Storm event
Inflow = 35.03 cfs @ 12.26 hrs, Volume= 175,301 cf
Primary = 35.03 cfs @ 12.26 hrs, Volume= 175,301 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Subcatchment 1A: C-STORE, PARKING, AND FUELING OPERATIONS

Runoff = 18.52 cfs @ 12.08 hrs, Volume= 63,000 cf, Depth= 7.44"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
74,059	98	Paved parking, HSG D
27,547	80	>75% Grass cover, Good, HSG D
101,606	93	Weighted Average
27,547		27.11% Pervious Area
74,059		72.89% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 1B: DIESEL FUELING ACCESS, SITE DRIVEWAY, & E.V. CANOPY

Runoff = 15.18 cfs @ 12.08 hrs, Volume= 50,038 cf, Depth= 6.96"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
42,596	98	Paved parking, HSG D
43,655	80	>75% Grass cover, Good, HSG D
86,251	89	Weighted Average
43,655		50.61% Pervious Area
42,596		49.39% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 1C: Front Landscape Area

Runoff = 0.77 cfs @ 12.09 hrs, Volume= 2,442 cf, Depth= 5.89"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
4,976	80	>75% Grass cover, Good, HSG D
4,976		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2A: E.V. Discovery Center Parking Area

Runoff = 10.00 cfs @ 12.08 hrs, Volume= 33,201 cf, Depth= 7.08"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
31,489	98	Paved parking, HSG D
24,774	80	>75% Grass cover, Good, HSG D
56,263	90	Weighted Average
24,774		44.03% Pervious Area
31,489		55.97% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, DIRECT**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 2B: Off-Site Drainage Swale

Runoff = 4.23 cfs @ 12.09 hrs, Volume= 13,481 cf, Depth= 5.89"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
27,474	80	>75% Grass cover, Good, HSG D
27,474		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.3	235	0.0250	0.62		**Lag/CN Method,**

Summary for Subcatchment 2C: Front Landscape Area

Runoff = 1.57 cfs @ 12.09 hrs, Volume= 4,946 cf, Depth= 5.89"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
10,081	80	>75% Grass cover, Good, HSG D
10,081		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment 3: OFF-SITE DRAINAGE (EAST)

Runoff = 23.92 cfs @ 12.17 hrs, Volume= 90,944 cf, Depth= 4.82"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
18,284	77	Woods, Good, HSG D
204,367	70	Woods, Good, HSG C
3,610	84	50-75% Grass cover, Fair, HSG D
226,261	71	Weighted Average
226,261		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
12.3	813	0.0810	1.10		**Lag/CN Method, OFF-SITE RUNOFF (EASTERN AREA)**

Summary for Subcatchment 4: OFF-SITE DRAINAGE WEST

Runoff = 50.84 cfs @ 12.27 hrs, Volume= 233,720 cf, Depth= 5.06"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
314,430	70	Woods, Good, HSG C
237,451	77	Woods, Good, HSG D
2,523	79	50-75% Grass cover, Fair, HSG C
554,404	73	Weighted Average
554,404		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
20.0	1,432	0.0680	1.20		**Lag/CN Method, OFF-SITE RUNOFF (WESTERN AREA)**

Summary for Subcatchment BLD1: Travel Center

Runoff = 1.57 cfs @ 12.08 hrs, Volume= 5,653 cf, Depth= 8.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
8,438	98	Roofs, HSG D
8,438		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment BLD2: E.V. DISCOVERY BUILDING

Runoff = 1.77 cfs @ 12.08 hrs, Volume= 6,342 cf, Depth= 8.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
9,465	98	Unconnected roofs, HSG D
9,465		100.00% Impervious Area
9,465		100.00% Unconnected

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN1: Diesel Canopy

Runoff = 0.34 cfs @ 12.08 hrs, Volume= 1,206 cf, Depth= 8.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
1,800	98	Roofs, HSG D
1,800		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN2: Fuel Canopy

Runoff = 1.45 cfs @ 12.08 hrs, Volume= 5,223 cf, Depth= 8.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
7,795	98	Roofs, HSG D
7,795		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Subcatchment CAN3: E.V. Canopy

Runoff = 0.50 cfs @ 12.08 hrs, Volume= 1,809 cf, Depth= 8.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Storm Rainfall=8.28"

Area (sf)	CN	Description
2,700	98	Roofs, HSG D
2,700		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
5.0					**Direct Entry, Direct**
5.0	0	Total, Increased to minimum Tc = 6.0 min			

Summary for Pond 8P: Rain Garden

Inflow Area = 66,344 sf, 47.46% Impervious, Inflow Depth = 6.90" for 100-Year Storm event
Inflow = 11.57 cfs @ 12.08 hrs, Volume= 38,148 cf
Outflow = 11.57 cfs @ 12.08 hrs, Volume= 38,148 cf, Atten= 0%, Lag= 0.0 min
Primary = 11.57 cfs @ 12.08 hrs, Volume= 38,148 cf

Routing by Dyn-Stor-Ind method, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs / 4
Peak Elev= 617.66' @ 12.08 hrs

Device	Routing	Invert	Outlet Devices
#1	Primary	614.50'	**12.0" Round Culvert** L= 45.0' CPP, projecting, no headwall, Ke= 0.900 Inlet / Outlet Invert= 614.50' / 613.55' S= 0.0211 '/' Cc= 0.900 n= 0.012, Flow Area= 0.79 sf
#2	Device 1	617.00'	**48.0" Horiz. Orifice/Grate** C= 0.600 Limited to weir flow at low heads
#3	Primary	617.25'	**10.0' long x 10.0' breadth Broad-Crested Rectangular Weir**

Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60
Coef. (English) 2.49 2.56 2.70 2.69 2.68 2.69 2.67 2.64

Primary OutFlow Max=11.55 cfs @ 12.08 hrs HW=617.66' TW=0.00' (Dynamic Tailwater)
- **1=Culvert** (Inlet Controls 4.87 cfs @ 6.20 fps)
  - **2=Orifice/Grate** (Passes 4.87 cfs of 21.93 cfs potential flow)
- **3=Broad-Crested Rectangular Weir** (Weir Controls 6.68 cfs @ 1.64 fps)

Summary for Link 1S: ROUTE 20 CULVERT

Inflow Area = 439,827 sf, 31.24% Impervious, Inflow Depth = 6.01" for 100-Year Storm event
Inflow = 57.56 cfs @ 12.10 hrs, Volume= 220,315 cf
Primary = 57.56 cfs @ 12.10 hrs, Volume= 220,315 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Summary for Link 2S: ROUTE 20 CONCRETE DROP INLET

Inflow Area = 657,687 sf, 6.23% Impervious, Inflow Depth = 5.32" for 100-Year Storm event
Inflow = 58.75 cfs @ 12.25 hrs, Volume= 291,690 cf
Primary = 58.75 cfs @ 12.25 hrs, Volume= 291,690 cf, Atten= 0%, Lag= 0.0 min

Primary outflow = Inflow, Time Span= 0.00-48.00 hrs, dt= 0.01 hrs

Appendix F

Additional Stormwater Design
Drainage Calculations

TABLE NO. 3
STORMWATER MANAGEMENT CALCULATIONS
CHARLTON ROAD - STURBRIDGE, MA
PROPOSED TRAVEL CENTER

STANDARD 3 - RECHARGE
Exempt - Addressed to the maximum extant practicable
Reduction in Impervious Area = 48,152 s.f.

STANDARD 4
WATER QUALITY VOLUME (WQv)

EXISTING Impervious Area =	226,494	s.f.
PROPOSED Paved Parking Area =	148,144	s.f.
PROPOSED Building & Canopy Roof Area =	30,198	s.f.
Total Area =	178,342	s.f.
Proposed Impervious =	178,342	s.f.

Impervious Area (s.f.)	**WQv = Rv (cf)**	**(LUHPPL = 1 in. Runoff)**
178,342	**14,862**	**c.f.** Required WQv (Imp. Area X 1 in.)

PROPOSED WQv TREATMENT	WQF	
Hydrostorm HS-6	2.75 cfs*	(See Appendix 4 of Hydroworks Submission)
Hydrostorm HS-4	0.86 cfs*	(See Appendix 4 of Hydroworks Submission)

***See Flow Rate Calculations, prepared by Hydroworks included as Appendix G**

PRE-TREATMENT - Total Suspended Solids (TSS) Removal

SUBCATCHMENT 1A & 1B

Redevelopment Area TSS Removal Calculation		**TSS Removal**	**TSS Remaining**	
1. Deep Sump Drain Manhole	25%	0.25	**0.75**	
2. Hydroworks HS-6	82%	0.82	**0.14**	
		TSS Removal Efficiency =		**0.87 > 80%***

SUBCATCHMENT 2A

Redevelopment Area TSS Removal Calculation		**TSS Removal**	**TSS Remaining**	
1. Deep Sump Hooded Catch Basins	25%	0.25	**0.75**	
2. Hydroworks HS-4	89%	0.89	**0.08**	
		TSS Removal Efficiency =		**0.92 > 80%***

RATIONAL METHOD PIPE DESIGN WORKSHEET
NOBLE ENERGY
PROPOSED TRAVEL CENTER
STURBRIDGE, MA

LOCATION	PIPE SEGMENT		INCREMENTAL AREA						FLOW TIME (min.)			25-Yr	25-Yr	DESIGN CONDITIONS					Design (25-Yr)		Inverts		Remarks
	From	To	DESIGNATION	A (Acres)	Total A	C	C*A	Sum (C*A)	To Inlet	In Chan.	Tot.	I (in/hr)	Q (cfs)	Pipe Diam (in.)	Length (ft)	Slope (%)	Q-full (cfs)	V-Full (fps)	Depth Peak (in.)	V-Peak (fps)	Up	Down	
Diesel Fuel Canopy to DMH-25																							
DBL GRATE	CB-2	O/G-1		0.58		0.77	**0.44**		5		5	6.0	2.66	12	12	0.008	**3.53**	4.50	9.0	3.38	617.5	617.40	CB-2 Rim =620.75
	O/G-1	DMH-3			0.58			**0.44**	5		5	6.0	2.66	12	60	0.019	**5.31**	6.76	6.0	3.38	617.15	616.02	O/G-1 Rim =621.25
	CAN-1	DMH-3		0.04		0.90	**0.04**		5		5	6.0	0.22	4	27	0.035	**0.39**	4.42	2.3	2.56	619.44	618.50	
	DMH-3	DMH-5			0.62			**0.48**	5		5	6.0	2.88	12	70	0.020	**5.41**	6.89	6.4	3.67	615.92	614.55	DMH-3 Rim =621.25
	CB-4	DMH-5		0.29		0.68	**0.20**		5		5	6.0	1.17	12	29	0.005	**2.78**	3.54	5.1	1.49	614.70	614.55	CB-4 Rim =618.20
	DMH-5	DMH-7			0.904			**0.68**	5		5	6.0	**4.05**	15	93	0.005	**4.99**	4.06	12.2	3.30	614.45	613.98	DMH-5 Rim=618.88
	CB-6	DMH-7		0.267		0.86	**0.23**		5		5	6.0	1.38	12	77	0.010	**3.87**	4.93	4.3	1.75	617.00	616.23	CB-6 Rim =621.00
	DMH-7	DMH-10			1.171			**0.90**	5		5	6.0	5.43	15	120	0.006	**5.65**	4.61	14.4	4.42	613.88	613.10	DMH-10 Rim =619.50
	CB-8	O/G-2		0.153		0.85	**0.13**		5		5	6.0	0.78	8	93	0.005	**0.93**	2.67	6.7	2.23	616.65	616.18	CB-8 Rim =620.15
	CB-10	O/G-2		0.158		0.90	**0.14**		5		5	6.0	0.85	8	93	0.005	**0.92**	2.64	7.4	2.45	616.64	616.18	CB-10 Rim =619.00
	O/G-2	DMH-10			0.311			**0.27**	5		5	6.0	1.63	12	10	0.010	**3.87**	4.93	5.1	2.08	615.93	615.83	O/G-2 Rim =620.5
	DMH-10	DMH-25			1.482			**1.18**	5		5	6.0	7.06	18	140	0.005	**7.77**	4.40	16.4	4.00	613.00	612.35	DMH-10 Rim =619.50
CB-11 to DMH-25																							
	CB-11	DMH-13		0.247		0.72	**0.18**		5		5	6.0	1.07	12	174	0.005	**2.74**	3.48	4.7	1.36	618.65	617.78	CB-11 Rim=622.15
	CB-12	DMH-13		0.390		0.74	**0.29**		5		5	6.0	1.73	12	52	0.005	**2.74**	3.48	7.6	2.20	617.5	617.24	CB-12 Rim=621.00
	DMH-13	DMH-17			0.637			**0.47**	5		5	6.0	2.80	12	78	0.006	**2.91**	3.70	11.6	3.56	617.14	616.7	DMH-13 Rim=622.03
	CB-14	DMH-16		0.166		0.90	**0.15**		5		5	6.0	**0.90**	8	16	0.009	**1.23**	3.52	5.8	2.57	620.28	620.14	CB-14 Rim=623.48
	CB-15	DMH-16		0.277		0.46	**0.13**		5		5	6.0	0.76	8	17	0.009	**1.27**	3.65	4.8	2.19	620.3	620.14	CB-15 Rim=623.5
	DMH-16	DMH-17			1.080			**0.28**	5		5	6.0	1.66	12	25	0.006	**3.00**	3.82	6.7	2.12	620.04	619.89	DMH-16 Rim=622.85
	DMH-17	DMH-20			1.080			**0.74**	5		5	6.0	4.46	15	93	0.009	**6.82**	5.56	9.8	3.64	616.6	615.72	DMH-17 Rim=622.85
	CB-18	DMH-20		0.078		0.62	**0.05**		5		5	6.0	0.29	8	9	0.014	**1.58**	4.52	1.5	0.84	617.88	617.75	CB-18 Rim=621.13
	CB-19	DMH-20		0.134		0.62	**0.08**		5		5	6.0	0.50	8	16	0.011	**1.39**	3.99	2.9	1.42	617.93	617.75	CB-19 Rim=621.13
	DMH-20	DMH-24			1.293			**0.87**	5		5	6.0	**5.25**	15	98	0.010	**7.01**	5.72	11.2	4.28	615.62	614.64	DMH-20 Rim=621.02+/-
	CB-22	DMH-24		0.440		0.74	**0.33**		5		5	6.0	1.97	12	15	0.015	**4.68**	5.97	5.0	2.51	614.50	614.28	CB-22 Rim=617.0+/-
	CB-23	DMH-24		0.361		0.78	**0.28**		5		5	6.0	1.69	12	53	0.004	**2.49**	3.17	8.2	2.16	614.50	614.28	CB-23 Rim=617.0+/-
	DMH-24	DMH-25			2.094			**1.48**	5		5	6.0	8.91	18	36	0.008	**10.06**	5.69	15.9	5.04	614.18	613.90	DMH-24 Rim =617.73
DMH-25 to DMH-31																							
	DMH-25	WQ-1			3.577			**2.66**	5		5	6.0	**15.97**	18	21	0.021	**16.69**	9.45	17.2	9.04	612.05	611.60	DMH-25 Rim=617.73
	WQ-1	DMH-31			3.577			**2.66**	5		5	6.0	**15.97**	18	15	0.023	**17.42**	9.86	16.5	9.04	611.35	611.00	WQ-1 Rim=619.00
CB-25 to FES-1																							
DBL GRATE	CB-25	DMH-27		0.805		0.67	**0.54**		5		5	6.0	**3.23**	12	29	0.052	**8.80**	11.21	4.4	4.12	618.50	617.00	CB-25 Rim=622
	CB-26	DMH-27		0.516		0.49	**0.25**		5		5	6.0	**1.51**	8	101	0.019	**1.82**	5.23	6.6	4.33	618.95	617.00	CB-26 Rim=622.45
	DMH-27	WQ-2			1.320			**0.79**	5		5	6.0	**4.74**	15	50	0.006	**5.43**	4.43	13.1	3.87	616.90	616.60	DMH-27 Rim=620.7
	WQ-2	FES-1			1.320			**0.79**	5		5	6.0	**4.74**	15	70	0.005	**4.96**	4.04	14.3	3.87	616.35	616.00	WQ-2 Rim=622.90
	FES-1	OCS-2		0.266		0.20	**0.05**	**0.84**	5		5	6.0	**5.06**	8	162	0.006	**1.03**	2.95	39.3	14.50	616.00	615.00	SWALE - NO PIPE
	OCS-2	DMH-E			1.586			**0.84**	5		5	6.0	**5.06**	12	45	0.021	**5.62**	7.16	10.8	6.45	614.50	613.55	OCS-2 Rim=617
OFF-SITE DRAINAGE STRUCTURES																							
	LD-1	FES-2		1.997		0.20	**0.40**		12.3		12	4.6	**1.84**	12	180	0.011	**4.08**	5.19	5.4	2.34	621.00	619.00	LD-1 Rim=623.75
	OCS-1	CB-28		3.789		0.20	**0.76**		12.3		12	4.6	**3.49**	8	37	0.083	**3.77**	10.81	7.4	9.99	626.46	623.40	OCS-1 Rim=633.00
	CB-28	DMH-27			3.789			**0.76**	12.3		12	4.6	**3.49**	12	62	0.041	**7.84**	9.99	5.3	4.44	621.65	619.10	CB-28 Rim=626.00
	DMH-27	DMH-29			3.789			**0.76**	12.3		12	4.6	**3.49**	12	62	0.048	**8.51**	10.84	4.9	4.44	619.85	616.85	DMH-27 Rim=624.25
	BLD-1	DMH-28		0.194		0.90	**0.17**		5		5	6.0	**1.05**	6	55	0.045	**1.30**	6.62	4.8	5.33	619.50	617.00	
	CAN-2	DMH-28		0.179		0.90	**0.16**		5		5	6.0	**0.97**	8	69	0.007	**1.12**	3.20	6.9	2.77	617.50	617.00	
	DMH-28	DMH-29			6.159			**0.34**	5		5	6.0	**2.01**	12	85	0.005	**2.65**	3.38	9.1	2.56	616.90	616.50	DMH-28 Rim=622.30
	DMH-29	DMH-30			6.159			**1.49**	12.3		12	4.6	**6.87**	15	114	0.021	**10.11**	8.24	10.2	5.60	614.15	611.78	DMH-29 Rim=621.00

RATIONAL METHOD PIPE DESIGN WORKSHEET
NOBLE ENERGY
PROPOSED TRAVEL CENTER
STURBRIDGE, MA

LOCATION	PIPE SEGMENT		INCREMENTAL AREA						FLOW TIME (min.)			25-Yr	25-Yr	DESIGN CONDITIONS						Design (25-Yr)		Inverts		Remarks
	From	To	DESIGNATION	A (Acres)	Total A	C	C*A	Sum (C*A)	To Inlet	In Chan.	Tot.	I (in/hr)	Q (cfs)	Pipe Diam (in.)	Length (ft)	Slope (%)	Q-full (cfs)	V-Full (fps)	Depth Peak (in.)	V-Peak (fps)	Up	Down	
	DMH-30	DMH-31			9.736			**1.49**	12.3		12	4.6	**6.87**	15	27	0.025	**11.13**	9.07	9.3	5.60	611.68	611.00	DMH-30 Rim=617.73
	DMH-31	Ex quad CB			9.736			**4.15**	5		5	6.0	**24.92**	24	10	0.040	**49.12**	15.64	12.2	7.94	610.90	610.50	DMH-31 Rim=616.78

Notes:

1) Runoff Coefficient C-Values used; Impervious(Pavement) C=0.90 Grass/OpenSpace C=0.20, Residential Suburban C=.25~.40, Mannings "n" HDPE n=0.012, RCP n=0.013
2) Rainfall Intensity I (in/hr) values taken from Figure 10-4 Intensity-Duration-Frequency Curve for Boston, Massachusetts, Mass Highway Design Manual.
3) Five (5) minute minimum flow time used for minimum time of concentration (Tc) to CB inlet to system
4) Massachusetts Cascade Grate Inlet Capacity = 1.26 cfs @ 100% efficiency, Standard Grate = 0.95 cfs est.
5) Blue Highlight denotes calculated peak flow (cfs) to CB Inlet

Drainage Structure	Contributing Area Impervious	Grass/Lawn	Total s.f.	Ac.	Runoff Coefficient C
LD-1		87,001	87,001	1.997	0.20
CB-2	20,364	4,765	25,129	0.577	0.77
CB-4	8,596	3,833	12,429	0.285	0.68
CB-6	10,947	698	11,645	0.267	0.86
CB-8	6,169	515	6,684	0.153	0.85
CB-10	6,883	-	6,883	0.158	0.90
CB-11	8,007	2,751	10,758	0.247	0.72
CB-12	13,083	3,920	17,003	0.390	0.74
CB-14	7,237	-	7,237	0.166	0.90
CB-15	4,479	7,586	12,065	0.277	0.46
CB-18	2,058	1,354	3,412	0.078	0.62
CB-19	3,483	2,358	5,841	0.134	0.62
CB-22	14,928	4,258	19,186	0.440	0.74
CB-23	13,064	2,658	15,722	0.361	0.78
CB-25	23,489	11,563	35,052	0.805	0.67
CB-26	9,254	13,211	22,465	0.516	0.49
CB-28		87,904	87,904	2.018	0.20
LD-34		74,187	74,187	1.703	0.20
LD-35/36		143,923	143,923	3.304	0.20
LD-37		172,421	172,421	3.958	0.20
CAN-1	1,800	-	1,800	0.041	0.90
CAN-2	7,795	-	7,795	0.179	0.90
CAN-3	2,700	-	2,700	0.062	0.90
BLD-1	8,438	-	8,438	0.194	0.90
BLD-2	8,702	-	8,702	0.200	0.90
FES-1	-	11,574	11,574	0.266	0.20
OCS-1	-	165,065	165,065	3.789	0.20

Appendix G

Hydrostorm HS-4 & Hydrostorm HS-6
Manufacturer's Design Reports

Technical Design Submission

Travel Center
201 Charlton Road
Sturbridge, MA

Revised
3/10/2021

Hydroworks, LLC

Hydroworks Technical Submission for Travel Center

Hydroworks is pleased to make a submission regarding the stormwater treatment structures for the Travel Center project at 201 Charlton Road in Sturbridge, MA. We propose the use of one (1) HS 6 and one (1) HS 4 hydrodynamic separator for this project. Sizing calculations were based on an annual TSS removal objective of 80% for a modified NJDEP particle size distribution and treatment of the MassDEP water quality flow (WQF).

Hydroworks HS Operation

The Hydroworks HydroStorm separator is a vortex separator with a high flow bypass. Accordingly, high flows do not scour out the fines that are settled in the low flow path since they are bypassed downstream without entering the lower chamber as shown in Figure 1.

The HS separator consists of 4 areas:

1. A pre-treatment area designed to remove coarse solids
2. An inner chamber where water enters the treatment chamber and oil is trapped
3. A lower chamber where fine solids are removed
4. A high flow bypass to convey higher flows directly downstream

Under normal or low flows, water enters a pre-treatment area with a horizontal grate. The area underneath the grate is submerged with openings to the main treatment area of the separator. Coarse solids fall through the grate and are either trapped in the pretreatment area or conveyed into the main treatment area depending on the flow rate (Figure 1A). Fines are transported into the main treatment area. Openings and weirs in the pretreatment area allow entry of water and solids into the main treatment area and cause water to rotate in the main treatment area creating a vortex motion. Water in the main treatment area is forced to rise along the walls of the separator to discharge from the treatment area to the downstream pipe.

The vortex motion forces solids and floatables to the middle of the inner chamber. Floatables are trapped since the inlet to the treatment area is submerged. The design maximizes the retention of settled solids since solids are forced to the center of the inner chamber by the vortex motion of water while water must flow up the walls of the separator to discharge into the downstream pipe.

A set of high flow weirs near the outlet pipe create a high flow bypass over both the pretreatment area and main treatment chamber. The rate of flow into the treatment area is regulated by the number and size of openings into the treatment chamber and the height of by-pass weirs. High flows flow over the weirs directly to the outlet pipe preventing the scour and resuspension of any fines collected in the treatment chamber.

A central tube is located in the structure to provide access for cleaning. The arrangement of the inlet area and bypass weirs near the outlet pipe facilitate the use of multiple inlet pipes. Figure 1B is a profile view of the HydroStorm separator showing the flow patterns for low and high flows.

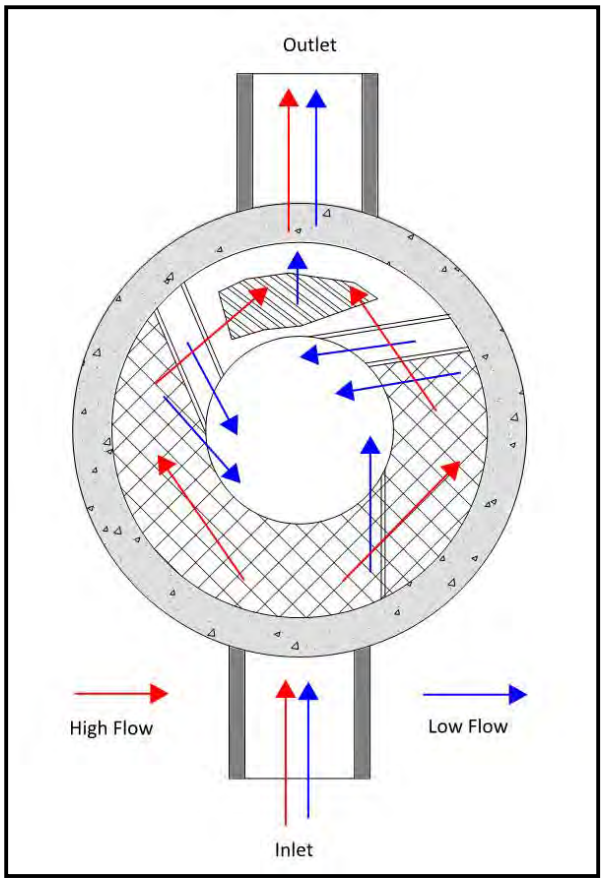


Figure 1A Hydroworks HydroStorm Operation – Plan View

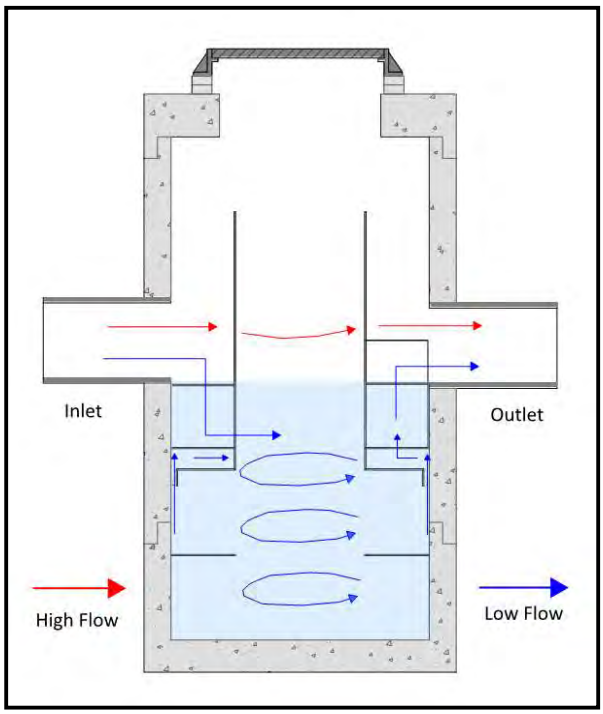


Figure 1B Hydroworks HydroStorm Operation – Profile View

The HSi is an inlet version of the HydroStorm (HS) separator (Figure 2). There is a catch-basin grate on top of the HSi. Water flows directly into the HSi from above through the catch-basin grate on top of the structure. The grate is oversized to allow maintenance of the entire structure. A funnel sits under the grate on the top cap and directs the water to the inlet side of the separator.

Water continues moving through the separator similar to a standard unit once the water falls on the upstream side of the by-pass weirs.

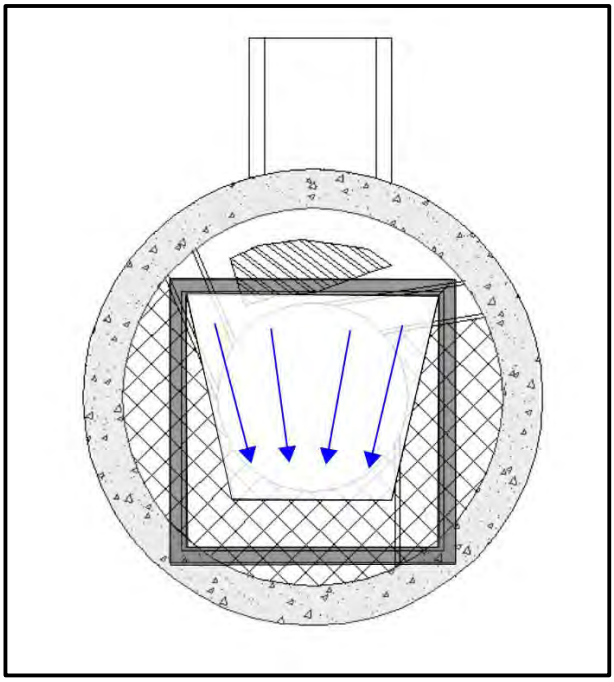


Figure 2. Hydroworks HSi Flow Path

The HSi provides the same separate flow paths for low and high flow as the other HydroStorm models. The funnel is removed for inspection and cleaning providing the exact same access for operations and maintenance as the standard HydroStorm models.

Construction Materials

The inner chamber and outlet baffle are made out of a copolymer plastic. The shell of the structure is pre-cast concrete. Pre-cast concrete is readily accepted by all municipalities since it has the following advantages:

- long service life
- ease of installation (less dependent on backfill (contractor proficiency) for structural integrity)
- concrete structures are designed for both anti-buoyancy and traffic loading without any field requirements (such as structural loading slabs in traffic areas and anti-buoyancy slabs to prevent groundwater uplift).
- low maintenance requirements

Hydroworks HS Separator Dimensions and Capacities

The HS separator is manufactured in a variety of sizes from 4 ft inside diameter to 12 ft inside diameter as shown in Table 1. Larger sizes may not be available in all areas. Please check with Hydroworks to ensure availability of the larger model sizes.

Table 1. Hydroworks HS Separator Dimensions*

Model	Structure Inside Diam. (SID) (ft)	Structure Depth (ft)*	Sediment/ Sinking Trash Volume (ft^3)	Oil/Floating Trash Volume (gal)	Permanent Pool Wet Volume (gal)
HS 4	4	4	30	95	375
HS 5	5	5	60	165	730
HS 6	6	6	110	270	1265
HS 7	7	6.5	160	410	1870
HS 8	8	7	220	615	2630
HS 10	10	9	465	1130	5285
HS 12	12	11	835	1875	9035

*Dimensions vary with project requirements

The volumes provided in Table 1 for oil and sediment are to full capacity and not indicative of recommended depths/volumes for maintenance.

ConnDOT treatment flow rates are derived from surface area and volumetric scaling of NJDEP ratings to Connecticut standards (100 micron particles). The treatment flow rates by ConnDOT calculations are 3.12 cfs for the HS 6 and 1.14 cfs for the HS 4.

Headloss

Any water quality system implemented in a storm drain network will create headloss in the system. In general, depending on the configuration of the by-pass, systems designed to treat high flows or all of the flow will have a higher headloss impact on the storm drain network than systems that by-pass high flows.

The headloss created by the HS separator was measured in an independent laboratory (Alden Research Laboratory) for a full-scale HS 4. The K value ($h = K\ v2/(2g)$) for headloss calculations was determined to be 1.04 as shown in Figure 3.

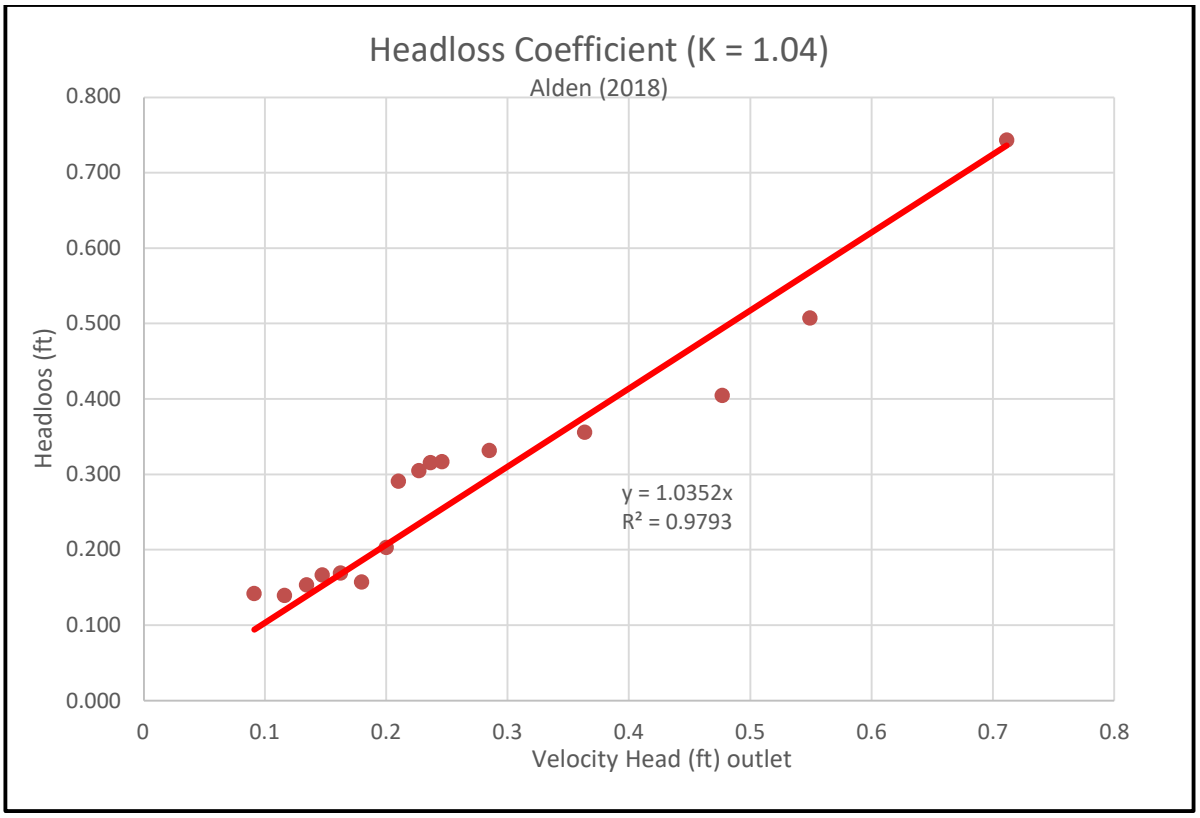


Figure 3. HydroStorm Headloss K Factor (1.04)

Site Drainage

Drainage areas for TSS removal modeling were delineated from the Grading and Drainage Plan Sheets #1 and #2 dated 2/26/2021 (Figure 4). The impervious areas used to calculate WQF were provided by CMG Environmental. Table 2 provides the design information for the recommended separators.

Table 2. Travel Center Water Quality Separator Parameters

Location	Area (ac)	Impervious (%)	Time of Concentration (hr)	MassDEP WQF (cfs)*	Recommended Unit
WQ-1	4.15	60.5	0.17	2.75	HS 6
WQ-3	1.04	68.0	0.10	0.86	HS 4

*Based on 1" of runoff

The ConnDOT separator ratings for the HydroStorm HS 6 and HS 4 are 3.12 cfs and 1.14 cfs respectively. These ratings exceed the required MassDEP water quality flows of 2.75 cfs and 0.86 cfs to the respective separators. The recommended HS 6 and HS 4 units therefore provide the appropriate water quality treatment on this project.

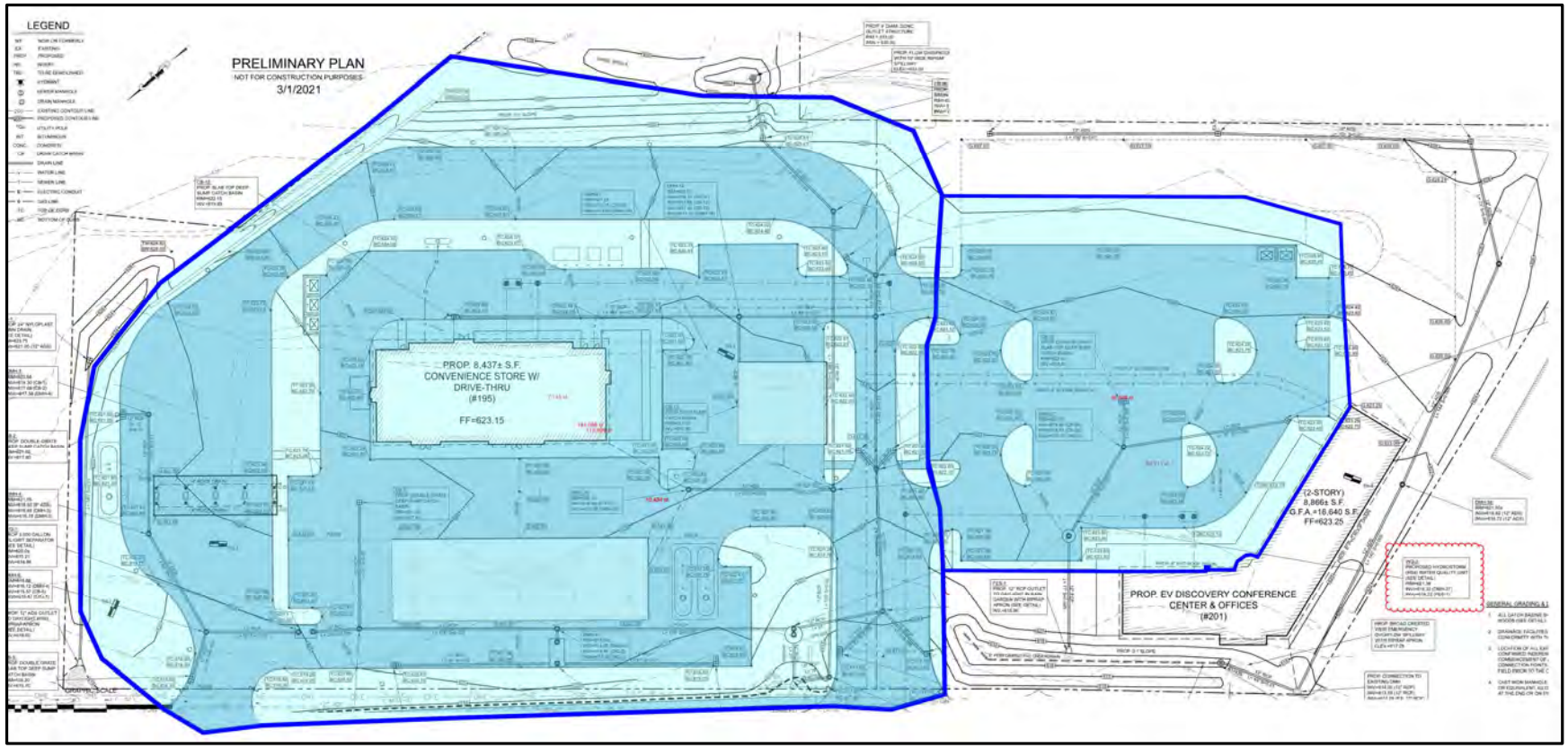


Figure 4. Travel Center Separator Drainage Areas

TSS Removal Calculations for the Specified System

Hydroworks sizes separators based on continuous modeling of rainfall, runoff, TSS buildup, TSS washoff, TSS settling and TSS transport through the system.

The continuous simulation model is based on SWMM 4.4. The model uses the buildup and washoff models directly from SWMM. Settling was calculated based on independent laboratory TSS removal results (Alden, 2008) for dynamic (flowing water) timesteps. During periods with no flow (quiescent) settling is calculated based on Cheng's Equation. These calculations require a user input particle size distribution. We have used the modified NJDEP particle size distribution shown in Table 3 for this project.

Table 3. Travel Center TSS Particle Size Distribution	
Particle Size (um)	% by Mass
20	25
50	10
75	15
100	15
150	15
250	10
500	5
1000	5

TSS removal calculations in the sizing program are based on the HydroStorm being a completely mixed reactor vessel. The removal calculations solve a first order differential equation for the concentration of solids in the tank at any time. The first order differential equation is for continuity of mass.

$C'V = QC_i - QC_t - r_cV$

C' = the change in concentration of solids in the tank with time
Q = flow rate through the tank
C_i = solids concentration in the influent to the tank
C_t = solids concentration in the tank
V = tank volume
r_c = reduction in solids in the tank (TSS Removal)

Continuous simulation requires historical rainfall data. Forty-five years of rainfall data (1957-2001) from Worchester, MA were used to analyze the Travel Center project.

Continuous simulation provides the most accurate way of estimating performance possible since it takes into account:

- The effect of flow rate (detention time) on settling
- Back to back storms
- Pollutant buildup and washoff

- Inter-event settling.

Hydroworks has developed a sizing methodology based on the Peclet Number to estimate TSS removal for particle size distributions that are different from the NJDEP distribution that was tested.

The independent laboratory testing (Alden Research Laboratory, 2018) results for TSS removal for the HydroStorm using the NJDEP particle size distribution is provided in Figure 5. Figure 6 shows the NJDEP particle size distribution tested by Alden on the HS 4.

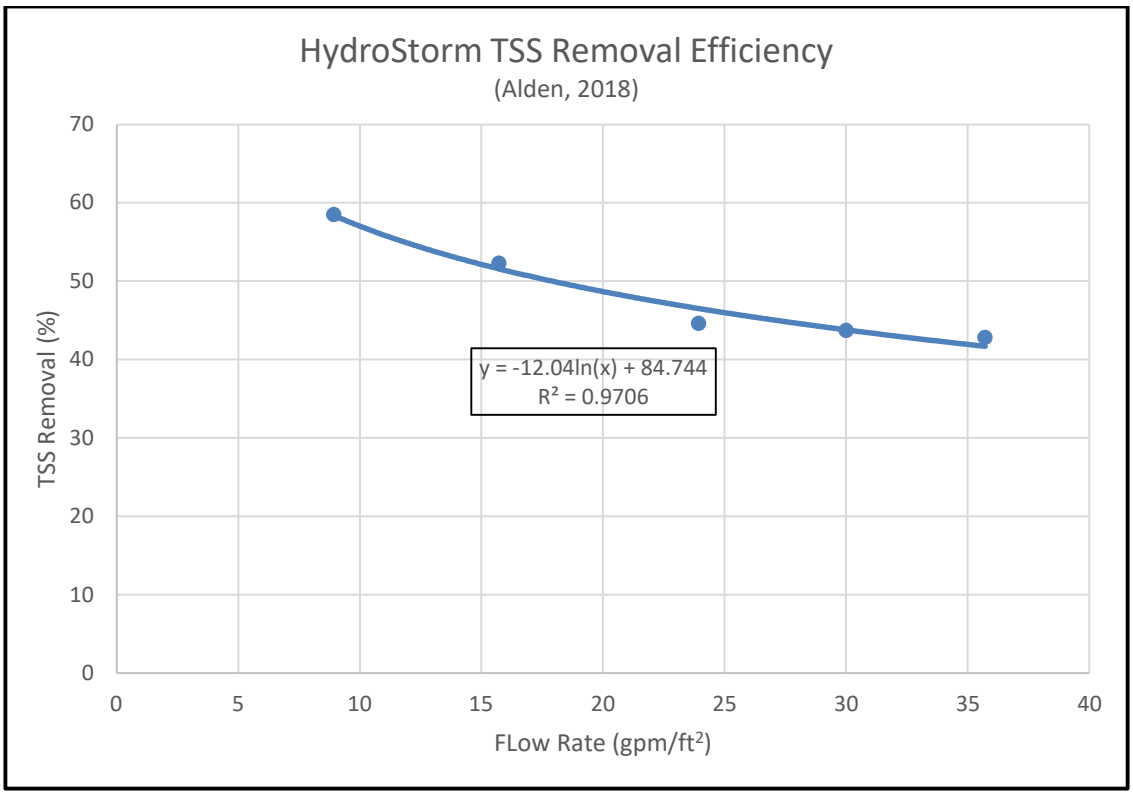


Figure 5. Independent Laboratory Results (Alden, 2018)

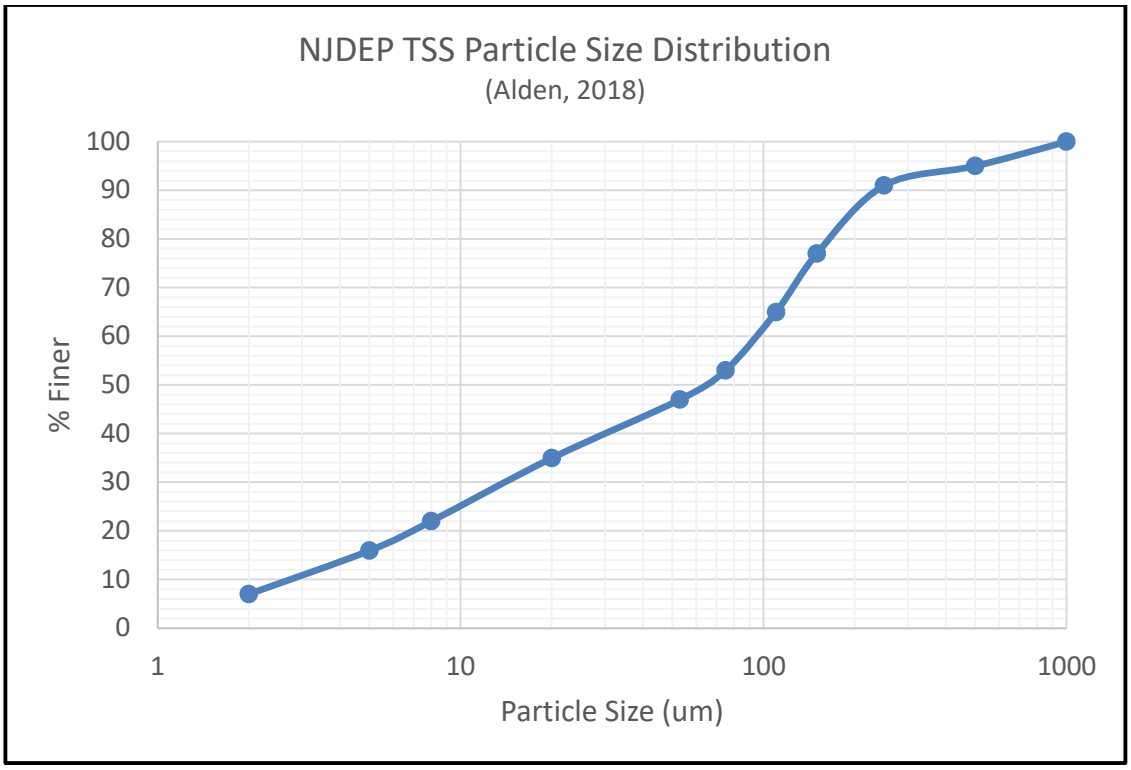


Figure 6. Independent Testing Particle Size Distribution (Alden, 2018)

Hydroworks uses the Peclet Number to calculate TSS removal based on the independent laboratory testing. The Peclet number has been used as a dimensionless scaling number for sediment deposition in lakes (Dhamotharan, et. Al. 1981). Others have suggested its use for scaling of TSS removal results for hydrodynamic separators (Dhanak, 2008, Gulliver, Guo and Wu, 2008).

The Peclet number is the ratio of convection (convective settling) to diffusion (turbulence keeping particles in suspension). The Peclet number (Equation 1) varies with the size of separator, particle size of TSS, and flow rate.

$$Pe = Vs\ h\ d\ /Q \qquad \text{Equation 1}$$

Where Pe = Peclet number
Vs = settling velocity
h = depth of separator sump
d = separator diameter
Q = flow rate

A particle will be removed in the separator if the Peclet number is equal to, or greater than, the Peclet number calculated for removal of that particle based on the independent laboratory results. Based on the NJDEP PSD in Figure 6, the TSS removal in Figure 5, and the dimensions of the tested HS 4, critical Peclet Numbers can be calculated for each particle size in Figure 6 (critical Peclet number is the Peclet Number above which the particle is removed). A critical Peclet Number curve was then developed and input to the model (Figure 7).

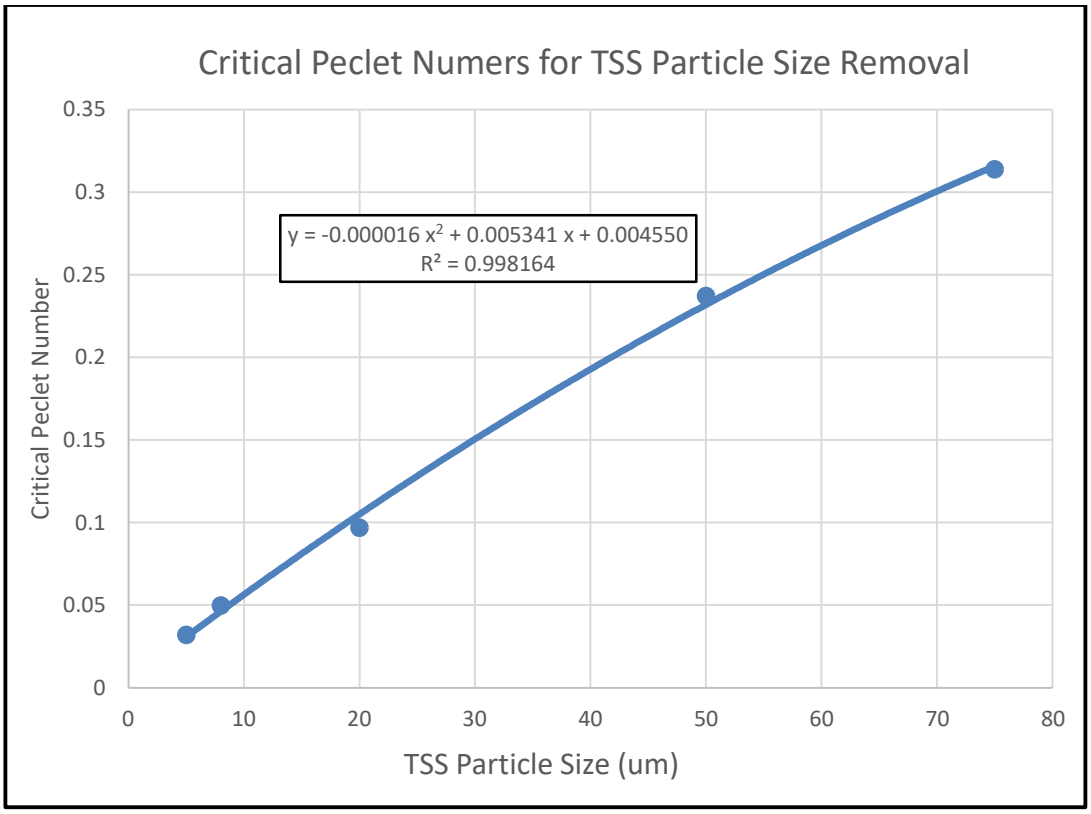


Figure 7. Critical Peclet Number Curve

At each timestep the Peclet Number is calculated for every flow and every Hydroworks separator for each particle size in the design particle size distribution. The calculated Peclet Number is then compared to the Critical Peclet Number to determine if the particle is removed at that timestep or not (removed if the calculated Peclet Number is greater than the Critical Peclet Number and not removed if less than the Critical Peclet Number). These calculations are done for the entire rainfall record to determine an overall TSS removal percentage.

Hydroworks added a Peclet routine to the USEPA SWMM model to determine TSS removal based on the Peclet number calibrated to the independent laboratory testing completed by Alden Research Laboratory (Figure 7). Figure 8 shows the calibrated model results compared to the independent laboratory testing results from Alden Labs for a HydroStorm HS4 based on the NJDEP particle size distribution used by Alden for testing purposes.

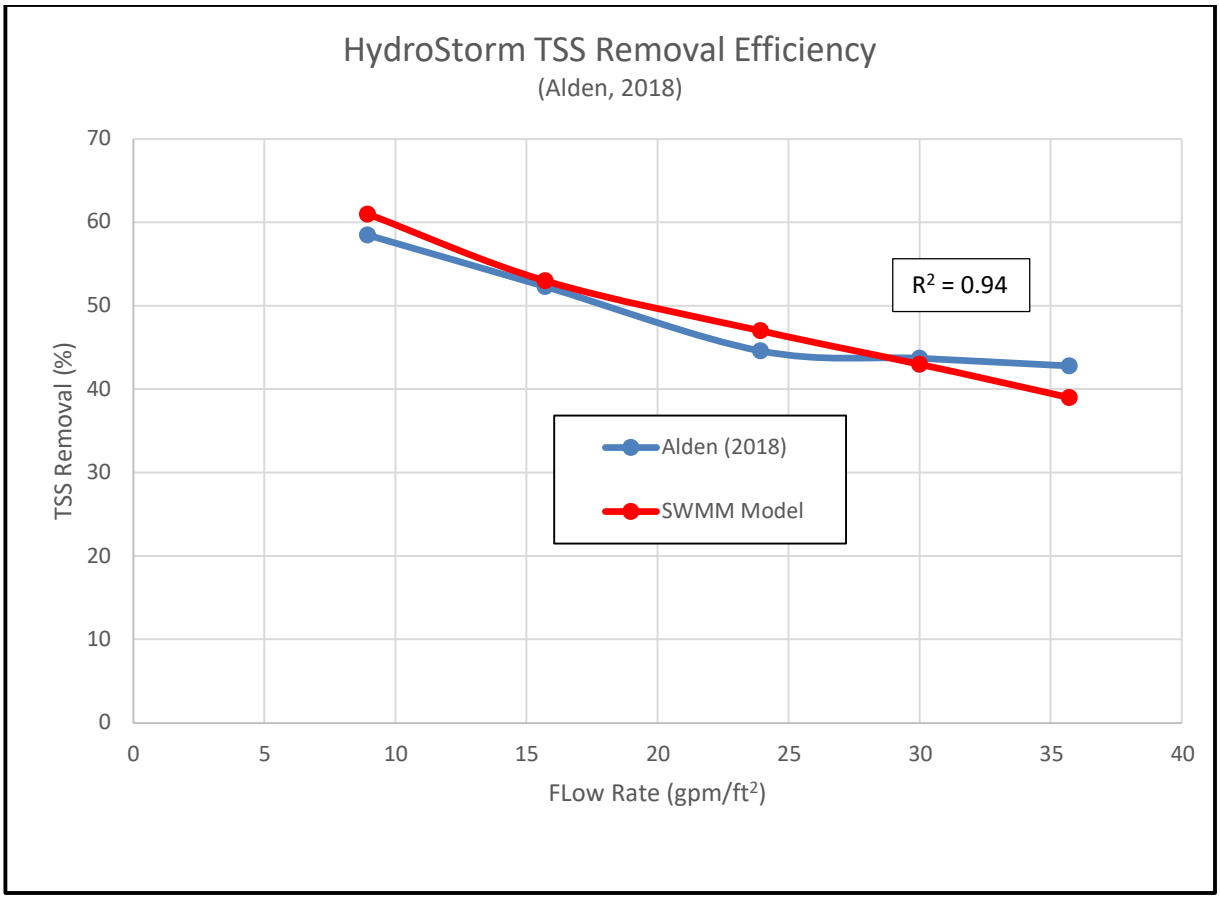


Figure 8. Independent Laboratory TSS Removal Performance versus Peclet Sizing Model

The use of the Peclet Number allows Hydroworks to size the HydroStorm based on any particle size and design storm or local hydrology

Sizing Recommendations

Water Quality Flow (WQF) Rate

The MassDEP WQF is calculated based on 1" of runoff from the impervious area. The calculated WQF to the recommended HS 6 and HS 4 separators is 2.75 cfs and 0.86 cfs respectively (Table 2). Since the water quality flow ratings for the HS 6 and HS 4 (3.12 cfs and 1.14 cfs) both exceed their respective MassDEP WQF by ConnDOT standards, the recommended separators meet the water quality flow requirements for this site.

TSS Removal

The sizing simulation results (Figures 9 and 10) indicate that both the HS 6 and HS 4 achieve greater than 80% annual TSS removal based on the particle size distribution given in Table 3. Detailed simulation results are provided in Appendix 3.

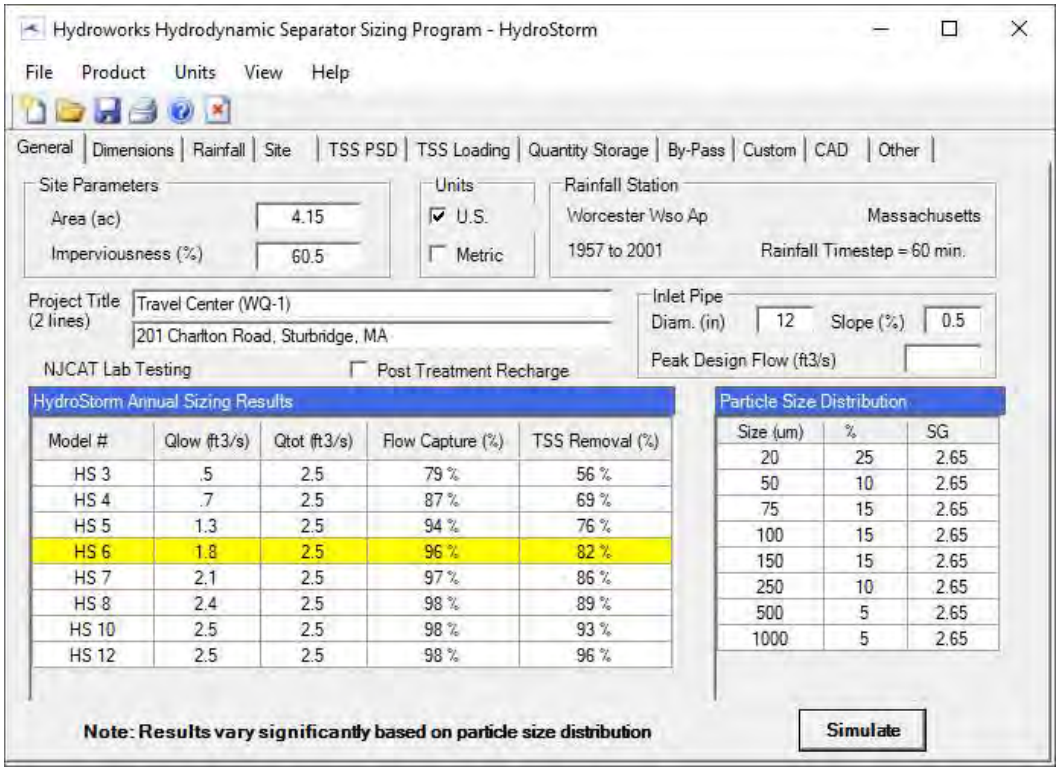


Figure 9. Travel Center Annual TSS Removal (WQ-1)

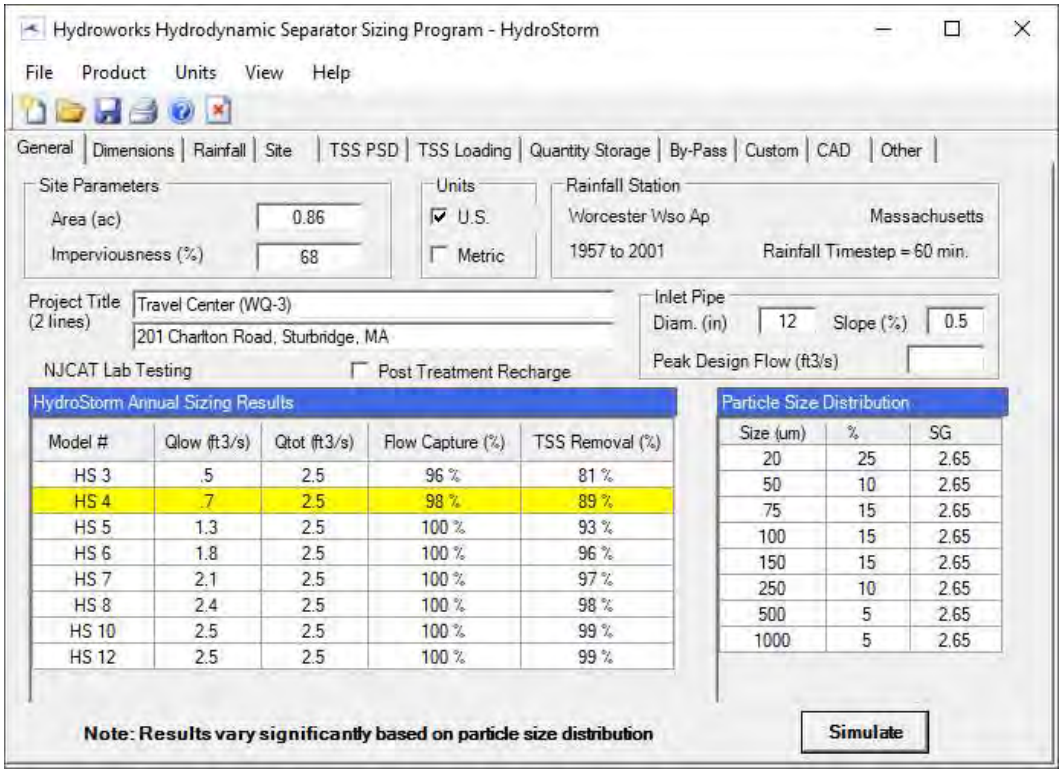


Figure 10. Travel Center Annual TSS Removal (WQ-3)

Approvals

HydroStorm has received verification from the New Jersey Center for Advanced Technology (NJCAT, 2018) (TARP Tier 1 Approval).

HydroStorm is certified by the New Jersey Department of Environmental Protection (NJDEP, 2018)

HydroStorm is ETV Canada verified to the 2013 Procedure for Laboratory Testing of Oil/Grit Separators developed by ETV Canada (TRCA, 2013).

HydroStorm has received Environmental Technology Verification based on ISO 14034:2016

HydroStorm is approved by the Virginia Department of Environmental Quality and is listed on the Virginia BMP Clearinghouse (VDEQ, 2018)

Local Production

Hydroworks units are made locally by Sani-Tank Inc, United Concrete Products Inc, and CSI Concrete Systems Inc. Most of the internal components for HydroStorm are made in Groveland, MA. HydroStorm was independently tested by Alden Labs in Holden, MA. Therefore, the use of HydroStorm supports the local MA economy.

Summary

We propose the use of one (1) HydroStorm HS 6 separator and one (1) HS 4 separator for the Travel Center project in Sturbridge, MA. The proposed HydroStorm separators will provide 80% annual TSS removal and treat the required MassDEP water quality flow rates at the site.

APPENDIX 1

Approvals

State of New Jersey

PHILIP D. MURPHY
Governor

SHEILA Y. OLIVER
Lt. Governor

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Mail Code – 401-02B
Division of Water Quality
Bureau of Nonpoint Pollution Control
P.O. Box 420 – 401 E. State St.
Trenton, NJ 08625-0420
Phone: (609) 633-7021 / Fax: (609) 777-0432
http://www.state.nj.us/dep/dwq/bnpc_home.htm

CATHERINE R. McCABE
Acting Commissioner

March 27, 2018

Graham Bryant, M.Sc., P.E.
President
Hydroworks, LLC
136 Central Avenue
Clark, NJ 07066

Re: MTD Lab Certification
HydroStorm Hydrodynamic Separator by Hydroworks, LLC
Online Installation

TSS Removal Rate 50%

Dear Mr. Bryant:

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). Hydroworks, LLC has requested an MTD Laboratory Certification for the Hydroworks HydroStorm Hydrodynamic Separator.

The project 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 (dated February 2018) for this device is published online at http://www.njcat.org/verification-process/technology-verification-database.html.

The NJDEP certifies the use of the HydroStorm by Hydroworks, LLC at a TSS removal rate of 50% when designed, operated, and maintained in accordance with the information provided in the Verification Appendix and the following conditions:

1. The maximum treatment flow rate (MTFR) for the manufactured treatment device (MTD) is calculated using the New Jersey Water Quality Design Storm (1.25 inches in 2 hrs) in N.J.A.C. 7:8-5.5.

2. The HydroStorm shall be installed using the same configuration reviewed by NJCAT and shall be sized in accordance with the criteria specified in item 6 below.

3. This HydroStorm cannot be used in series with another MTD or a media filter (such as a sand filter) to achieve an enhanced removal rate for total suspended solids (TSS) removal under N.J.A.C. 7:8-5.5.

4. Additional design criteria for MTDs can be found in Chapter 9.6 of the New Jersey Stormwater Best Management Practices (NJ Stormwater BMP) Manual, which can be found online at www.njstormwater.org.

5. The maintenance plan for a site using this device shall incorporate, at a minimum, the maintenance requirements for the Hydrostorm. A copy of the maintenance plan is attached to this certification. However, it is recommended to review the maintenance website at http://www.hydroworks.com/hydrostormo&m.pdf for any changes to the maintenance requirements.

6. Sizing Requirement:

   The example below demonstrates the sizing procedure for the Hydrostorm:

   Example: A 0.25-acre impervious site is to be treated to 50% TSS removal using a HydroStorm. The impervious site runoff (Q) based on the New Jersey Water Quality Design Storm was determined to be 0.79 cfs.

   Maximum Treatment Flow Rate (MTFR) Evaluation:

   The site runoff (Q) was based on the following:
   time of concentration = 10 minutes
   i = 3.2 in/hr (page 5-8, Fig. 5-3 of the NJ Stormwater BMP Manual)
   c = 0.99 (runoff coefficient for impervious)
   Q = ciA = 0.99 x 3.2 x 0.25 = 0.79 cfs

   Given the site runoff is 0.79 cfs and based on Table 1 below, the HydroStorm Model HS4 with a MTFR of 0.88 cfs could be used for this site to remove 50% of the TSS from the impervious area without exceeding the MTFR.

   The sizing table corresponding to the available system models is noted below. Additional specifications regarding each model can be found in the Verification Appendix under Table A-1.

Table 1 HydroStorm Sizing Information

HydroStorm Model	NJDEP 50% TSS Maximum Treatment Flow Rate (cfs)	Treatment Area (ft^2)	Hydraulic Loading Rate (gpm/ft^2)	50% Maximum Sediment Storage (ft^3)
HS3	0.50	7.1	31.4	3.6
HS4	0.88	12.6	31.4	6.3
HS5	1.37	19.6	31.4	9.8
HS6	1.98	28.3	31.4	14.2
HS7	2.69	38.5	31.4	19.3
HS8	3.52	50.3	31.4	25.2
HS9	4.45	63.6	31.4	31.8
HS10	5.49	78.5	31.4	39.3
HS11	6.65	95.0	31.4	47.5
HS12	7.91	113.0	31.4	56.5

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 and Retrofit of Stormwater Management Measures.

If you have any questions regarding the above information, please contact Brian Salvo or Nick Grotts of my office at (609) 633-7021.

Sincerely,

James J. Murphy, Chief
Bureau of Nonpoint Pollution Control

Attachment: Maintenance Plan

cc: Chron File
Richard Magee, NJCAT
Vince Mazzei, NJDEP - DLUR
Ravi Patraju, NJDEP - BES
Gabriel Mahon, NJDEP - BNPC
Brian Salvo, NJDEP – BNPC
Nick Grotts, NJDEP – BNPC

Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030-0000

January 25, 2018

Jim Murphy, Chief
NJDEP
Bureau of Non-Point Pollution Control
Division of Water Quality
Mail Code 401-02B, PO Box 420
Trenton, NJ 08625-0420

Dear Mr. Murphy,

Based on my review, evaluation and assessment of the testing conducted on the Hydroworks HydroStorm (Model HS 4) hydrodynamic separator at the Alden Research Laboratory, Inc. (Alden), Holden, Massachusetts, under the direct supervision of Alden's senior stormwater engineer, James Mailloux, the test protocol requirements contained in the *"New Jersey Laboratory Testing Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device (January 25, 2013)"* (NJDEP HDS Protocol) were met or exceeded. Specifically

Test Sediment Feed

The mean PSD of the test sediments comply with the PSD criteria established by the NJDEP HDS protocol. The removal efficiency test sediment PSD analysis was plotted against the NJDEP removal efficiency test PSD specification. The test sediment was shown to be slightly finer than the sediment blend specified by the protocol (<75μ); the test sediment d_{50} was 67 microns. The scour test sediment PSD analysis was plotted against the NJDEP scour test PSD specification and shown to meet the protocol specifications.

Removal Efficiency Testing

In accordance with the NJDEP HDS Protocol, removal efficiency testing was executed on the HydroStorm (HS 4), a 4-ft. diameter commercially available unit, to establish the ability of the HydroStorm to remove the specified test sediment at 25%, 50%, 75%, 100% and 125% of the

target MTFR. The HS 4 demonstrated 50.1% annualized weighted solids removal as defined in the NJDEP HDS Protocol. The flow rates, feed rates and influent concentration all met the NJDEP HDS test protocol's coefficient of variance requirements and the background concentration for all five test runs never exceeded 20 mg/L (maximum of 8.9 mg/L).

Scour Testing

To demonstrate the ability of the HydroStorm to be used as an online treatment device, scour testing was conducted at 228% of the MTFR which exceeds the 200% MTFR required by the NJDEP HDS Protocol. The scour test was conducted with the 50% capacity (6") false floor installed. An additional 4" of the 50-1000-micron test sediment was preloaded on top of the false floor, resulting in the unit being preloaded to the 83% storage capacity of 10".

The average flow rate during the online scour test was 2.01 cfs (903 gpm), which represents 228% of the MTFR (MTFR = 0.88 cfs). Background concentrations were <3.1 mg/L throughout the scour testing, which complies with the 20 mg/L maximum background concentration specified by the test protocol. Unadjusted effluent concentrations ranged from 10.9 mg/L to 30.3 mg/L, with an average concentration of 16.8 mg/L. When adjusted for background concentrations, the average effluent concentration was 14.6 mg/L. These results confirm that the HS 4 did not scour at 200% MTFR and meets the criteria for online use.

Maintenance Frequency

The predicted maintenance frequency for all HydroStorm models is 50 months.

Sincerely,

Richard S. Magee, Sc.D., P.E., BCEE

38

ALDEN

Solving flow problems since 1894

January 24, 2018

Dr. Richard Magee, P.E., BCEE
Executive Director
New Jersey Corporation for Advanced Technology
Center for Environmental Systems
Stevens Institute of Technology
One Castle Point
Hoboken, NJ 07030

Conflict of Interest Statement

Alden Research Laboratory (ALDEN) is a non-biased independent testing entity which receives compensation for testing services rendered. ALDEN does not have any vested interest in the products it tests or their affiliated companies. There is no financial, personal or professional conflict of interest between ALDEN and Hydroworks, LLC.

Protocol Compliance Statement

Alden performed design research testing, as well as verification testing on the Hydroworks HydroStorm 4 (HS 4) separator. All submitted data was collected on the selected final design, as discussed in the report. The Technical Report and all required supporting documentation has been submitted as required by the protocol.

Testing performed by ALDEN on the Hydroworks HydroStorm HS 4 unit met or exceeded the requirements as stated in the "New Jersey Department of Environmental Protection Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device", (January 25, 2013), with the following exception:

The reported 25% MTFR test flow was higher than the +10% allowance as per the protocol. However, the higher test flow also results in a higher treatment velocity, which is conservative for removal of sediment particles.

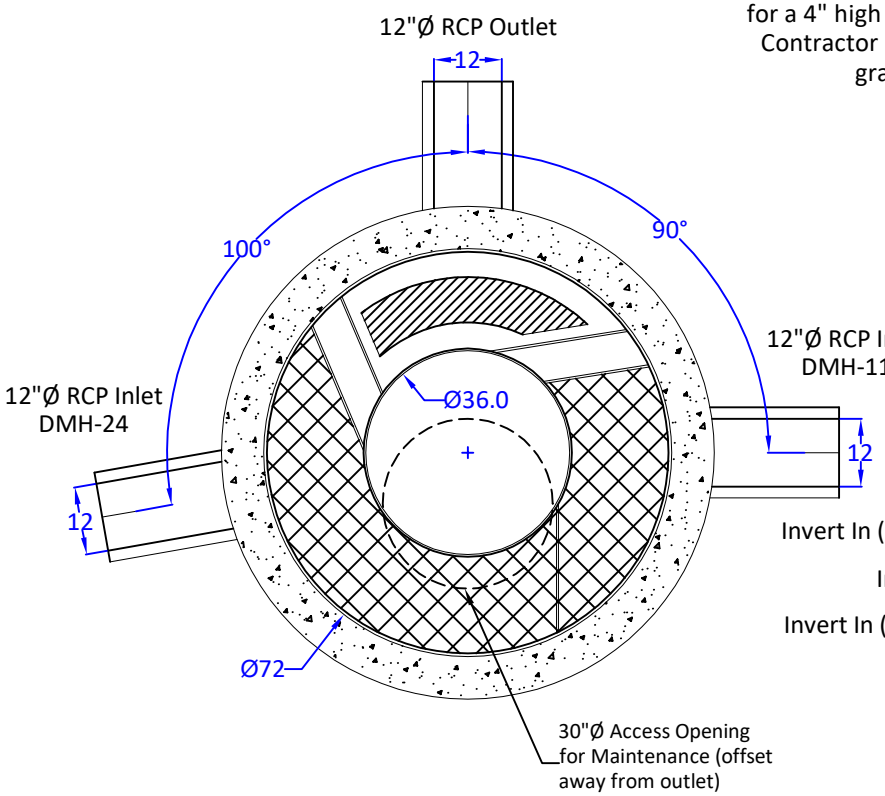
James T. Mailloux

Senior Engineer
Alden Research Laboratory
jmailloux@aldenlab.com

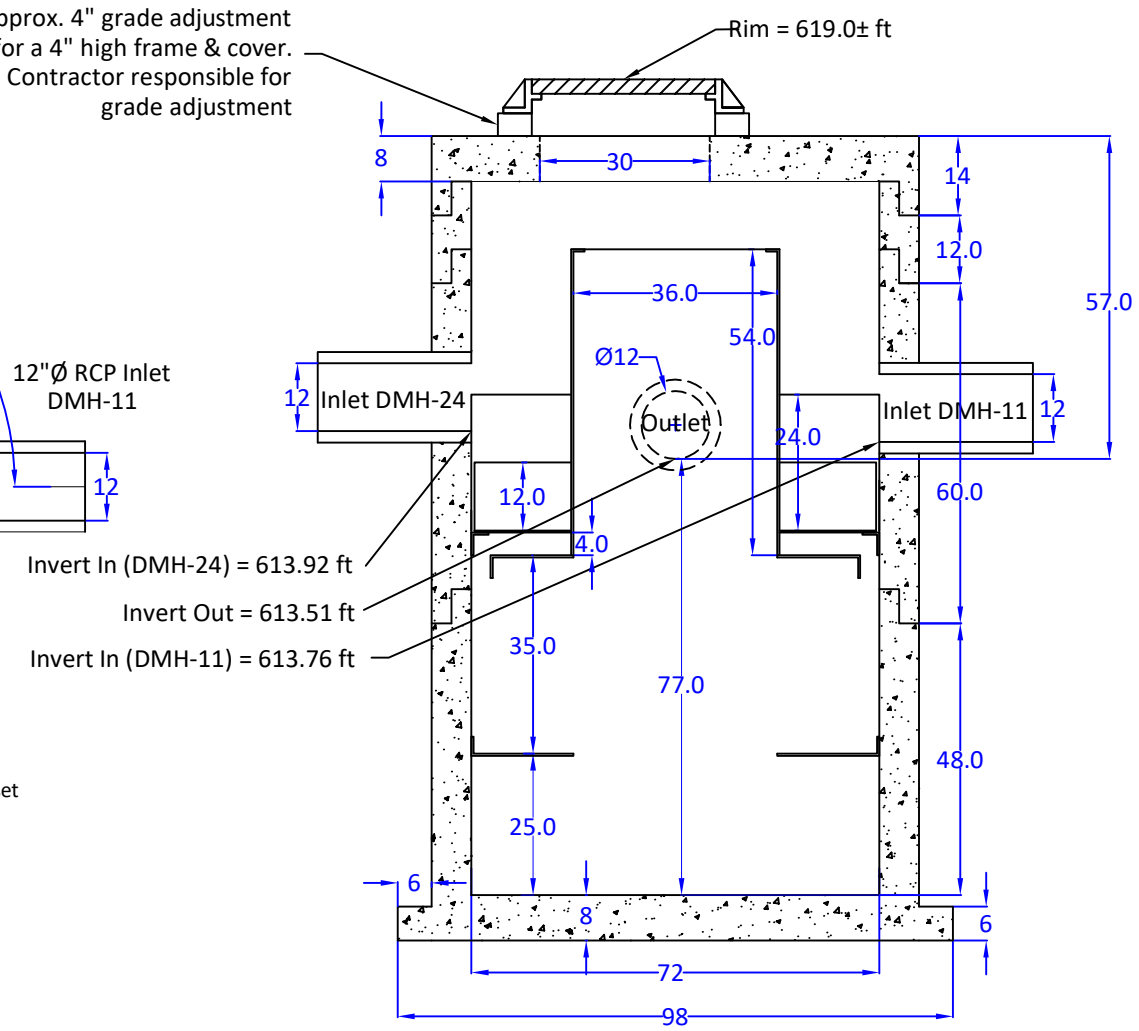
(508) 829-6000 x6446

APPENDIX 2

CAD Drawings



Plan



Profile

Permanent pool = 1350 gallon storage

Alternate equals must be NJDEP certified to the 2013 NJDEP separator protocol based on testing data from an independent laboratory

Vendor testing and/or field testing is not acceptable to demonstrate an alternate equal due to the lack of repeatability

HydroStorm
U.S. Patent
#10,710,907
www.hydroworks.com
888-290-7900

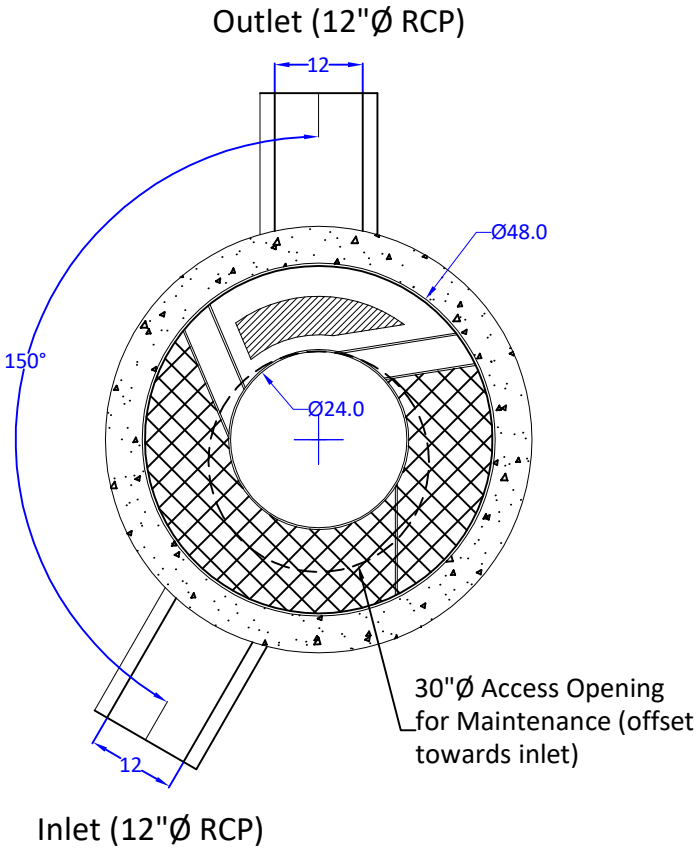
Hydroworks HS6 (72"Ø)

PROJECT: 201 Charlton Road (WQ-1)

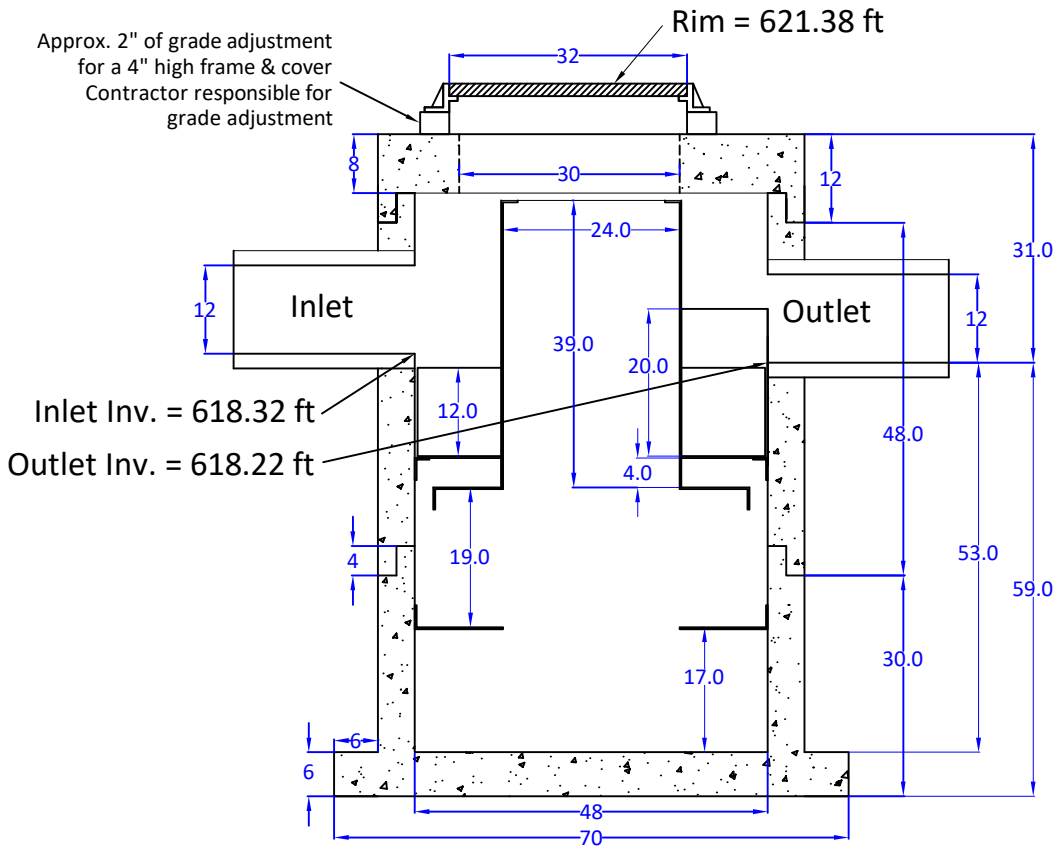
LOCATION: Sturbridge, MA

REVISION DATE: 3/10/2021

Hydroworks



Plan



Profile

Permanent pool = 415 gallon storage

Alternate equals must be NJDEP certified to the 2013 NJDEP separator protocol based on testing data from an independent laboratory

Vendor testing and/or field testing is not acceptable to demonstrate an alternate equal due to the lack of repeatability

HydroStorm
U.S. Patent #10,710,907
www.hydroworks.com
888-290-7900

Hydroworks HS4 (48"Ø)

PROJECT: 201 Charlton Road (WQ-3)

LOCATION: Sturbridge, MA

REVISION DATE: 3/10/2021

Hydroworks

APPENDIX 3

TSS Removal Calculations

Hydroworks Sizing Summary

Travel Center (WQ-1)
201 Charlton Road, Sturbridge, MA

03-10-2021

Recommended Size: HydroStorm HS 6

A HydroStorm HS 6 is recommended to provide 80 % annual TSS removal based on a drainage area of 4.15 (ac) with an imperviousness of 60.5 % and Worcester Wso Ap, Massachusetts rainfall for the User defined particle size distribution.

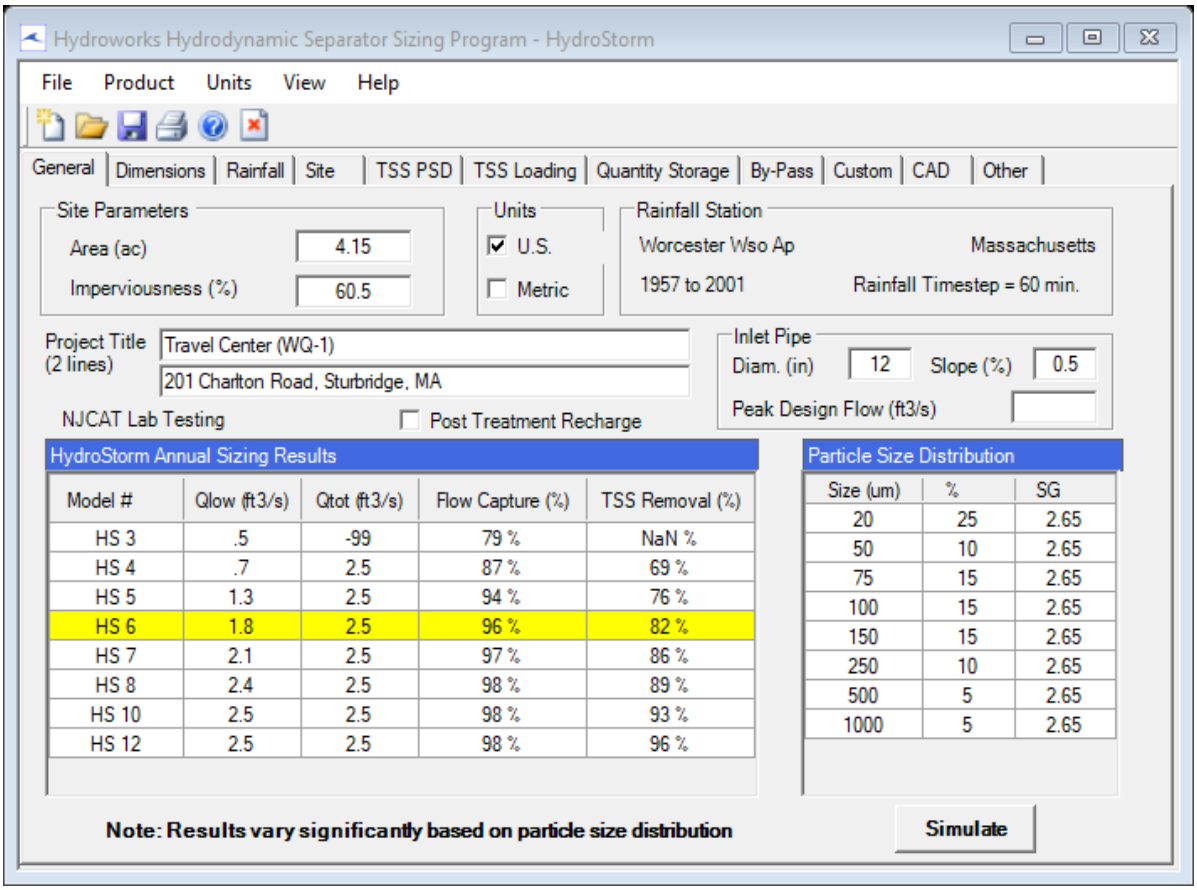
The recommended HydroStorm HS 6 treats 96 % of the annual runoff and provides 82 % annual TSS removal for the Worcester Wso Ap rainfall records and User defined particle size distribution.

The HydroStorm has a headloss coefficient (K) of 1.04. Since a peak flow was not specified, headloss was calculated using the full pipe flow of -99 (ft3/s) for the given 12 (in) pipe diameter at .5% slope. The headloss was calculated to be 2 (in) based on a flow depth of 12 (in) (full pipe flow).

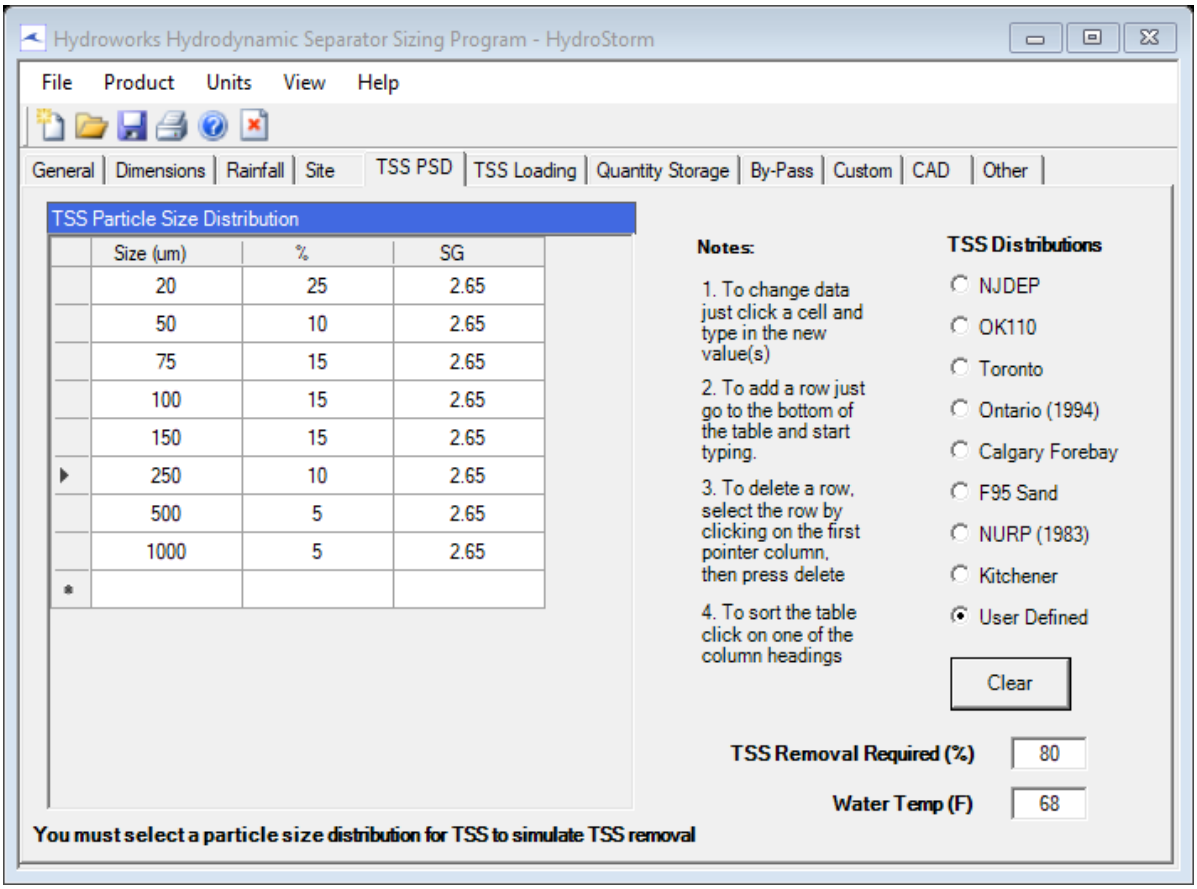
This summary report provides the main parameters that were used for sizing. These parameters are shown on the summary tables and graphs provided in this report.

If you have any questions regarding this sizing summary please do not hesitate to contact Hydroworks at 888-290-7900 or email us at support@hydroworks.com.

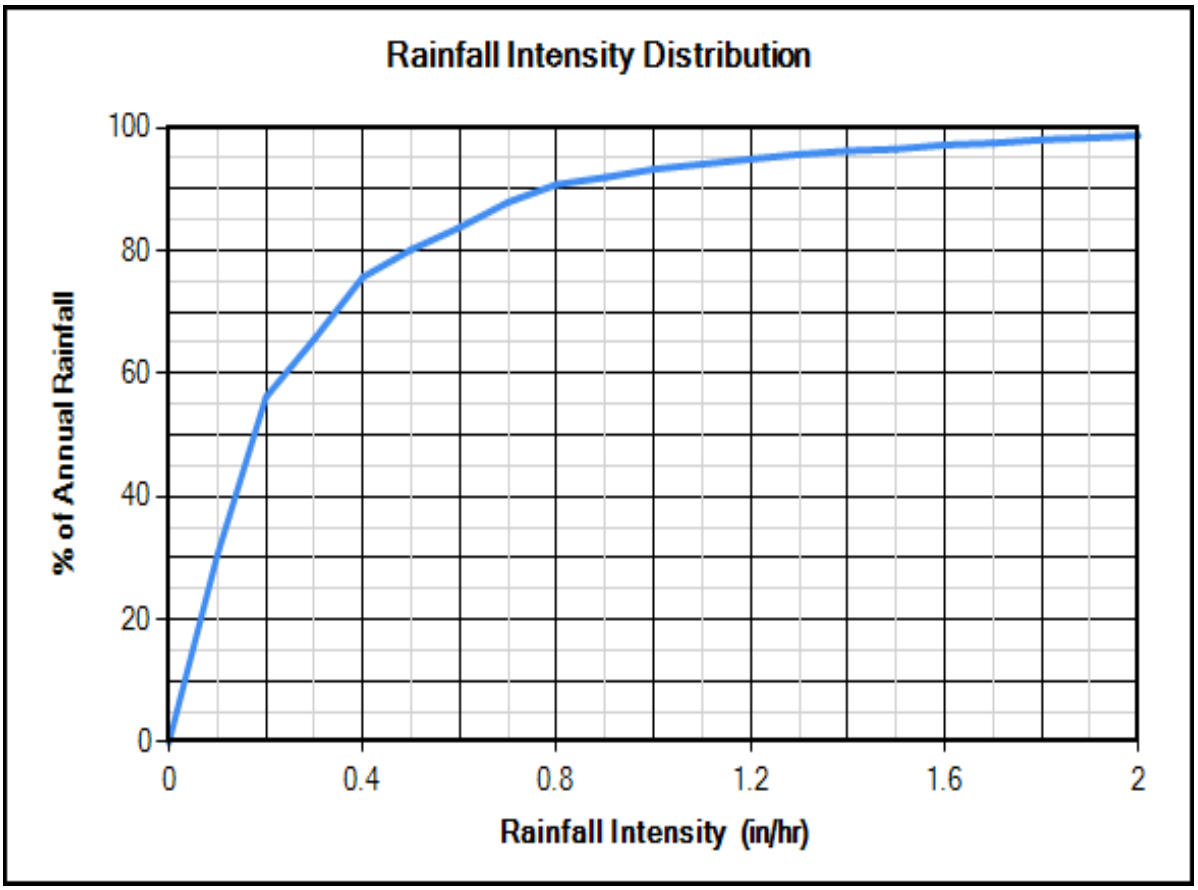
TSS Removal Sizing Summary



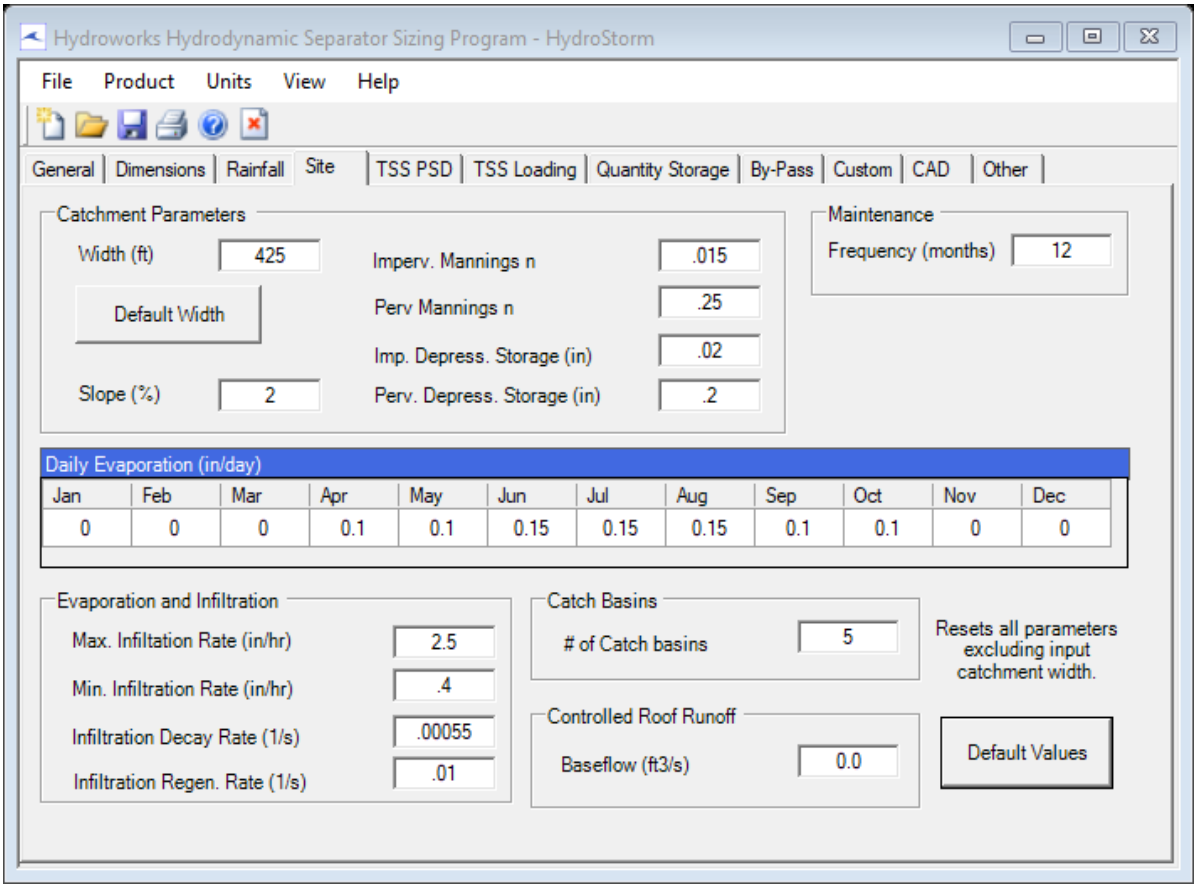
TSS Particle Size Distribution



Rainfall Station - Worcester Wso Ap, Massachusetts(1957 to 2001)



Site Physical Characteristics



Dimensions And Capacities

Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units View Help

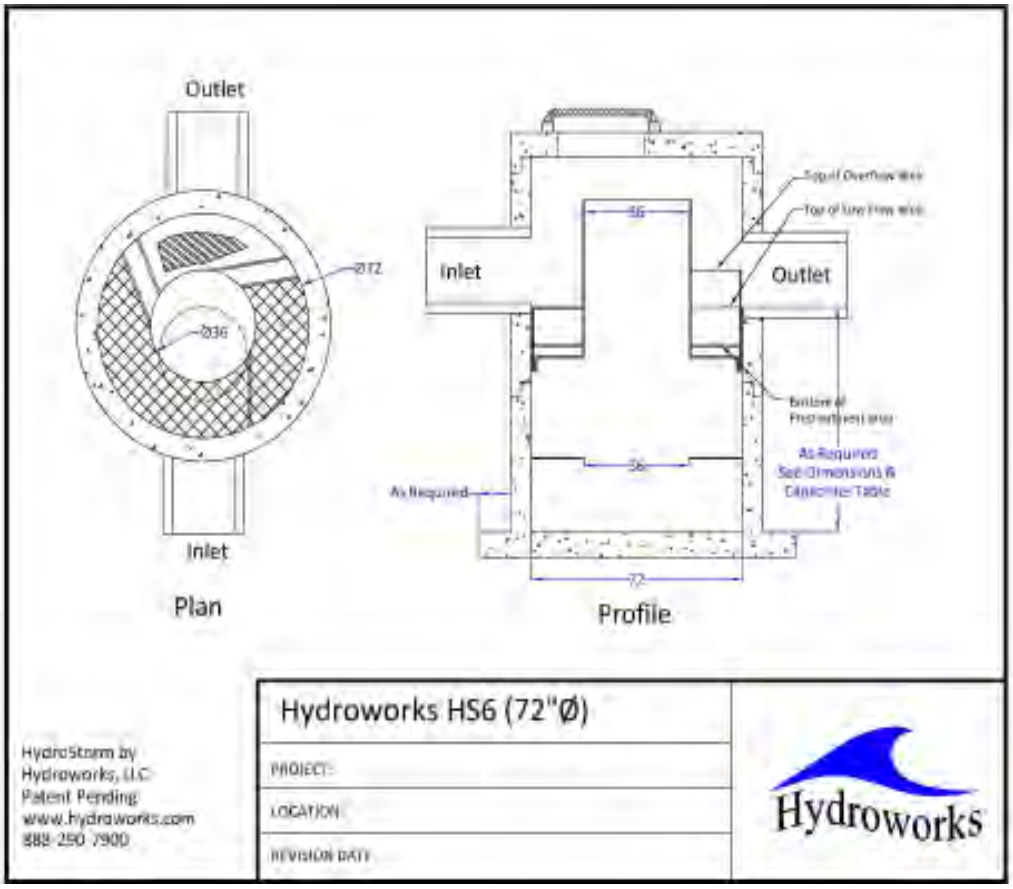
General | Dimensions | Rainfall | Site | TSS PSD | TSS Loading | Quantity Storage | By-Pass | Custom | CAD | Other

Dimensions and Capacities

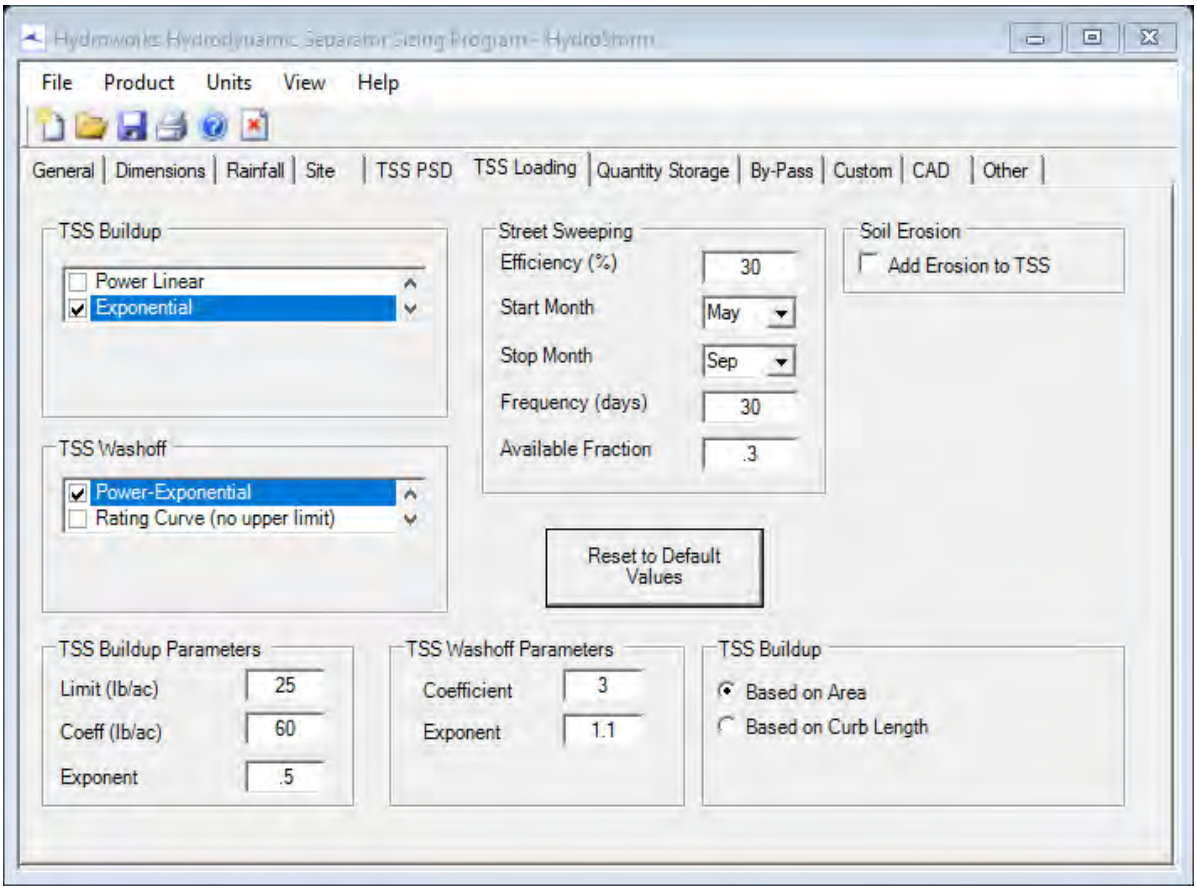
Model	Diam. (ft)	Depth (ft)	Float. Vol. (gal)	Sediment Vol. (ft3)	Total Vol. (gal)
HS 3	3	3.5	49	15	185
HS 4	4	4	101	30	376
HS 5	5	5	170	64	734
HS 6	6	6	275	113	1269
HS 7	7	6.5	416	164	1871
HS 8	8	7	622	222	2632
HS 10	10	9	1143	465	5288
HS 12	12	11	1893	839	9306
HS 3	3	3.5	49	15	185

Depth = Depth from outlet invert to inside bottom of tank

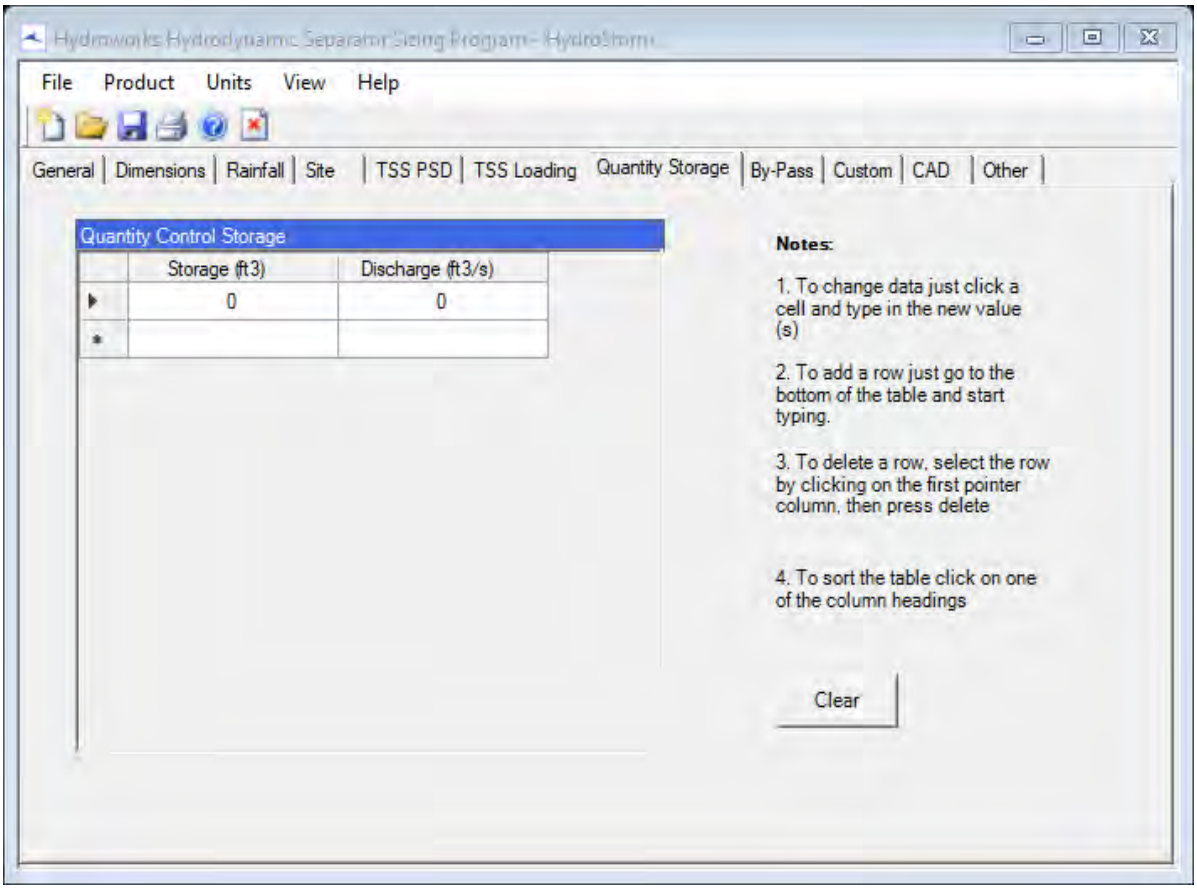
Generic HS 6 CAD Drawing



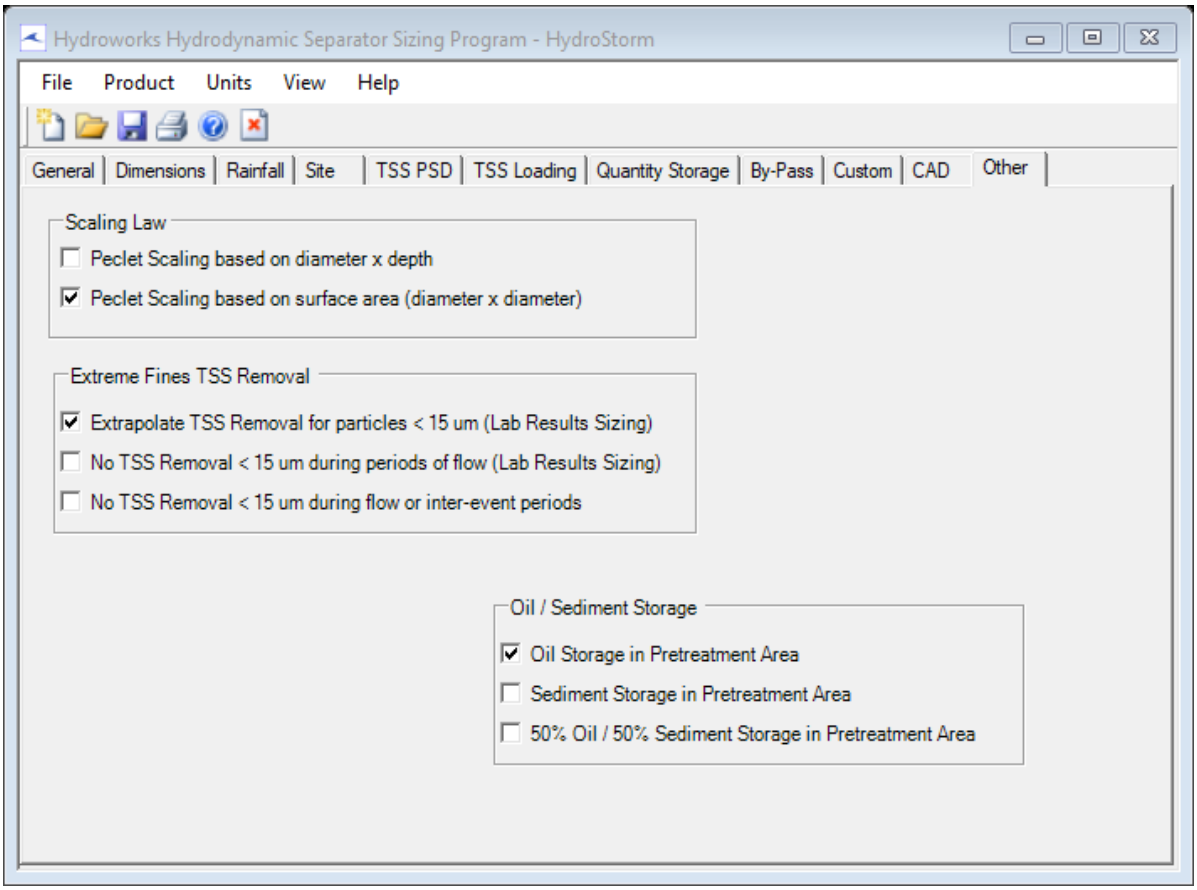
TSS Buildup And Washoff



Upstream Quantity Storage



Other Parameters



Hydroworks Sizing Program - Version 5.0

Hydroworks Sizing Summary

Travel Center (WQ-3)
201 Charlton Road, Sturbridge, MA

03-10-2021

Recommended Size: HydroStorm HS 4

A HydroStorm HS 4 is recommended to provide 88 % annual TSS removal based on a drainage area of 0.86 (ac) with an imperviousness of 68 % and Worcester Wso Ap, Massachusetts rainfall for the User defined particle size distribution.

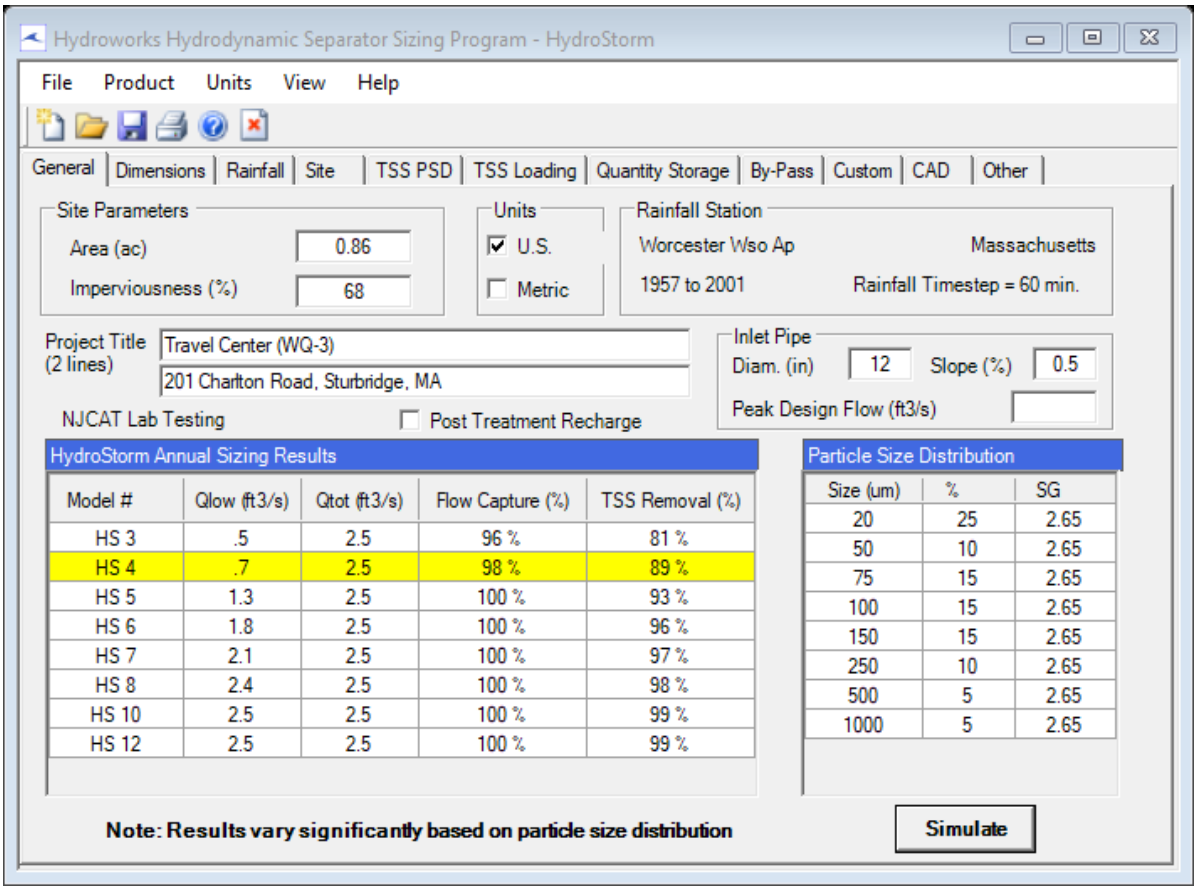
The recommended HydroStorm HS 4 treats 98 % of the annual runoff and provides 89 % annual TSS removal for the Worcester Wso Ap rainfall records and User defined particle size distribution.

The HydroStorm has a headloss coefficient (K) of 1.04. Since a peak flow was not specified, headloss was calculated using the full pipe flow of 2.52 (ft3/s) for the given 12 (in) pipe diameter at .5% slope. The headloss was calculated to be 2 (in) based on a flow depth of 12 (in) (full pipe flow).

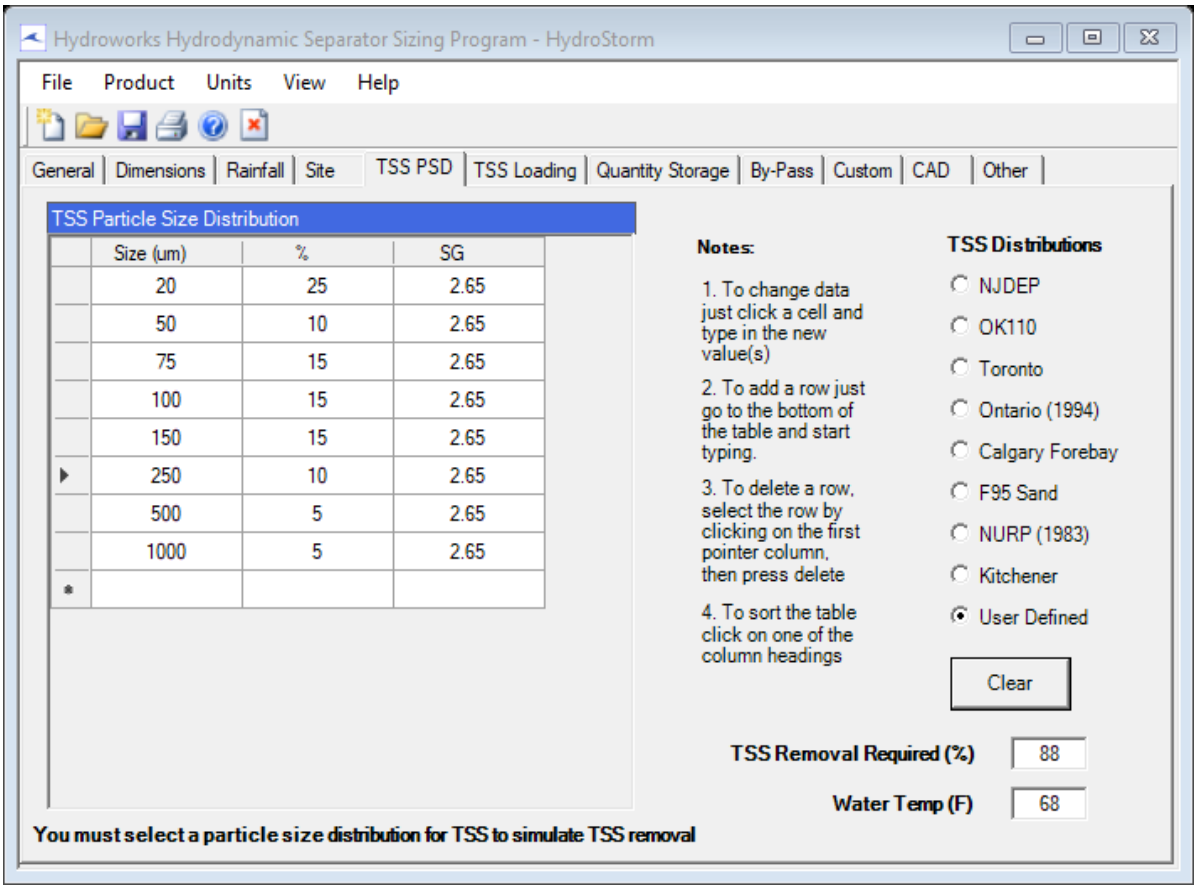
This summary report provides the main parameters that were used for sizing. These parameters are shown on the summary tables and graphs provided in this report.

If you have any questions regarding this sizing summary please do not hesitate to contact Hydroworks at 888-290-7900 or email us at support@hydroworks.com.

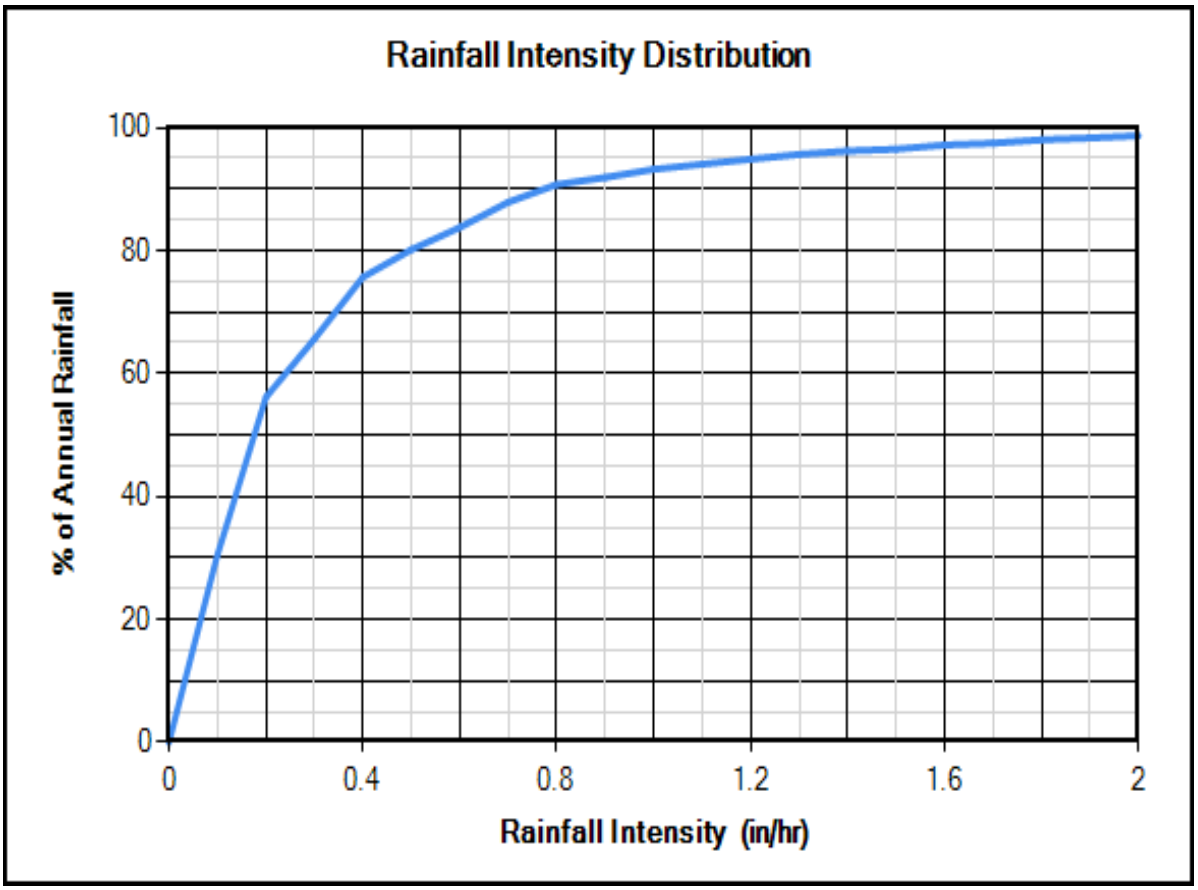
TSS Removal Sizing Summary



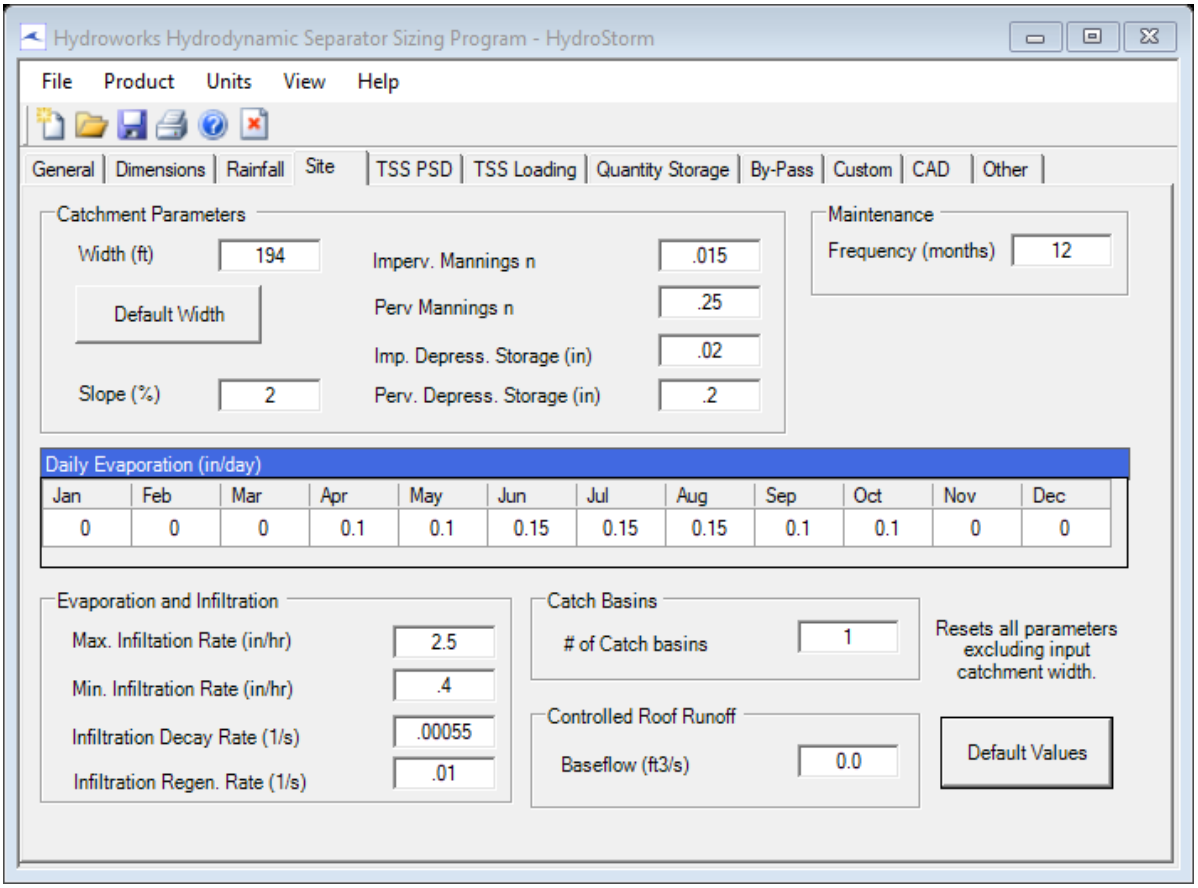
TSS Particle Size Distribution



Rainfall Station - Worcester Wso Ap, Massachusetts(1957 to 2001)



Site Physical Characteristics



Dimensions And Capacities

Hydroworks Hydrodynamic Separator Sizing Program - HydroStorm

File Product Units View Help

General | Dimensions | Rainfall | Site | TSS PSD | TSS Loading | Quantity Storage | By-Pass | Custom | CAD | Other

Dimensions and Capacities

Model	Diam. (ft)	Depth (ft)	Float. Vol. (gal)	Sediment Vol. (ft3)	Total Vol. (gal)
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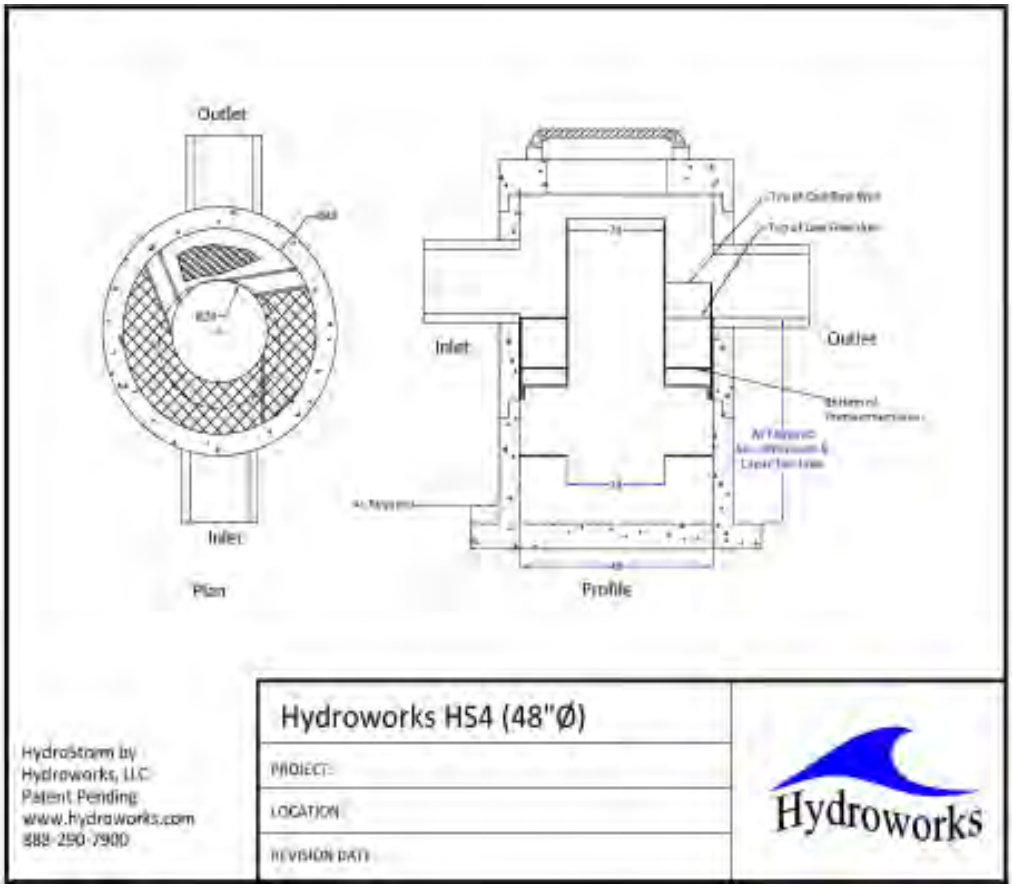
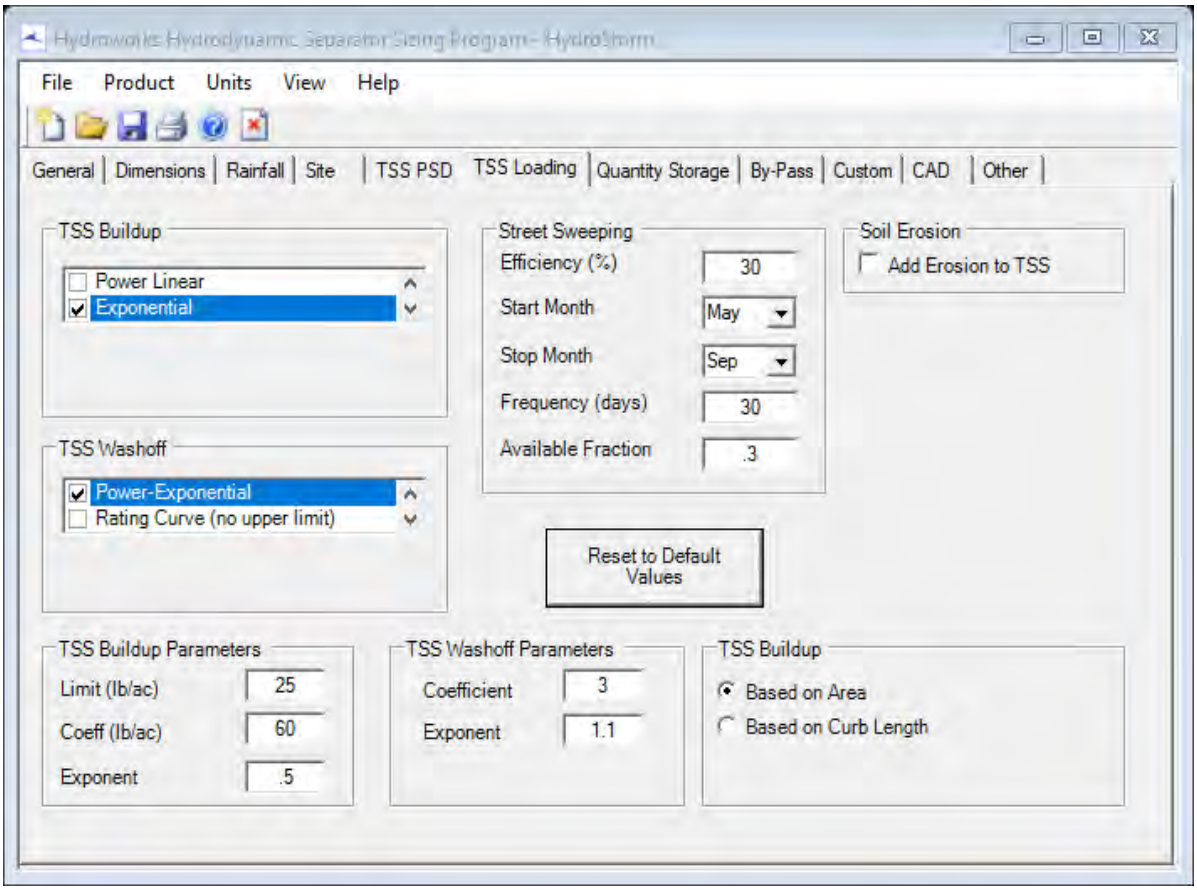
HS 3	3	3.5	49	15	185

Depth = Depth from outlet invert to inside bottom of tank

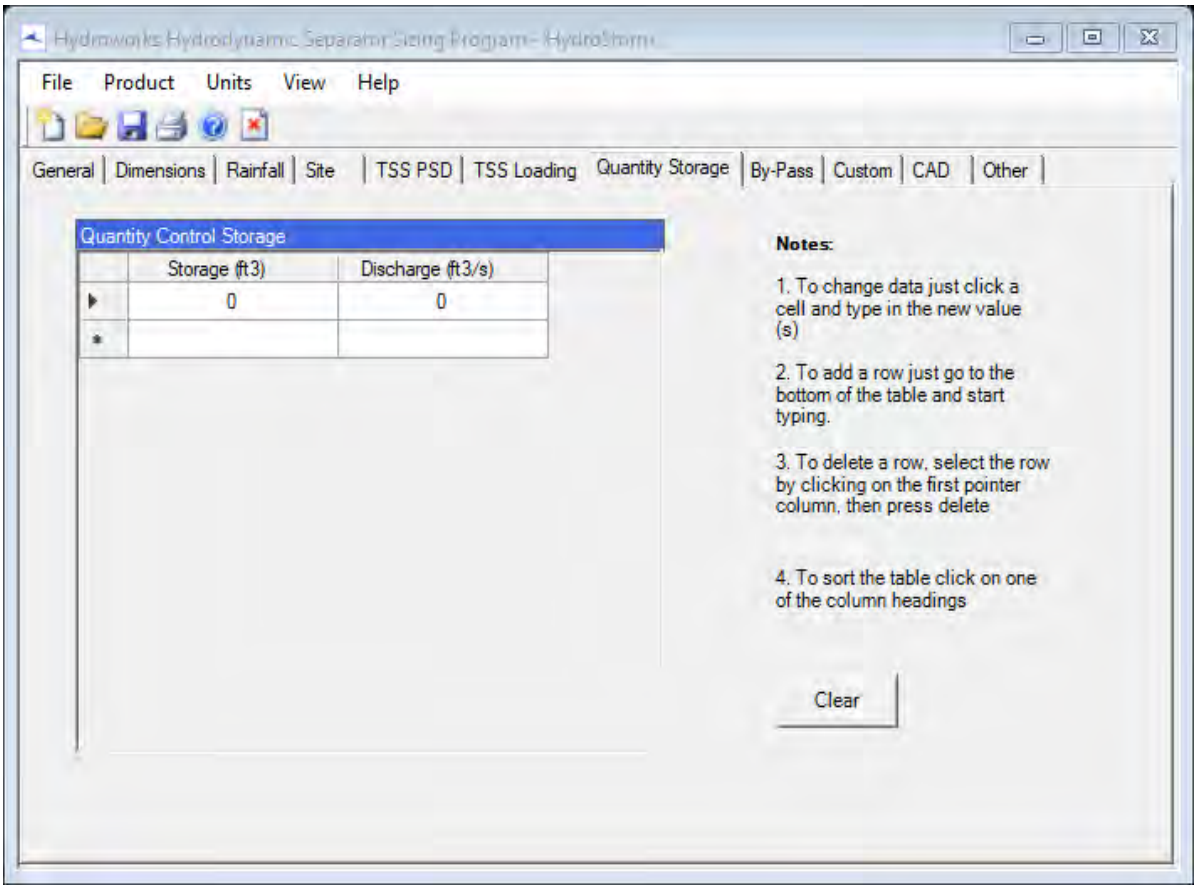
Generic HS 4 CAD Drawing



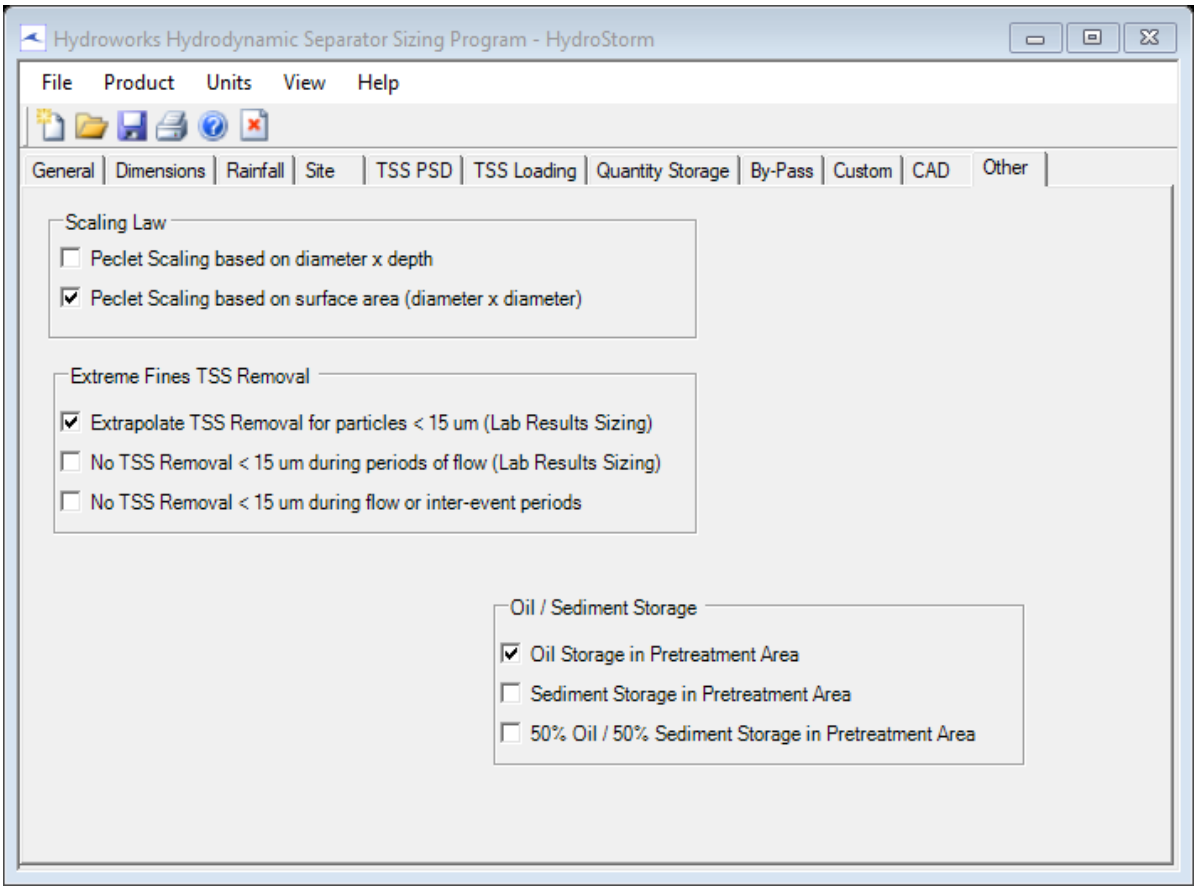
TSS Buildup And Washoff



Upstream Quantity Storage



Other Parameters



Hydroworks Sizing Program - Version 5.0

APPENDIX 4

MassDEP WQF Calculations

WQ-1

Water Quality Flow (cfs)	
State	MA
Rain (in)	1
SCS Type	III
Area (ac)	4.15
Imp (%)	60.5
P (in)	1
Rv	0.59
Q (in)	1.00
CN	98
Ia	0.041
Ia/P	0.034
tc	0.17
qu	700
WQF (cfs)	2.75

For the State of MA the runoff (Q) is calculated from the impervious area as either 1" or 0.5" over the impervious area. We have assumed 1" of runoff for this project.

Therefore Q = 1" and IA = 2.51 ac = 0.003922 mi^2

For 1" of runoff MassDEP requires that Ia/P be 0.034.

Assuming a time of concentration of 6 min, qu becomes 700

The water quality flow is therefore:

WQF = qu A Q

WQF = 700 x 0.003922 x 1

WQF = 2.75 cfs

WQ-3

Water Quality Flow (cfs)	
State	MA
Rain (in)	1
SCS Type	III
Area (ac)	1.04
Imp (%)	68.0
P (in)	1
Rv	0.66
Q (in)	1.00
CN	98
Ia	0.041
Ia/P	0.034
tc	0.10
qu	774
WQF (cfs)	0.86

For the State of MA the runoff (Q) is calculated from the impervious area as either 1" or 0.5" over the impervious area. We have assumed 1" of runoff for this project.

Therefore Q = 1" and IA = 0.71 ac = 0.001105 mi^2

For 1" of runoff MassDEP requires that Ia/P be 0.034.

Assuming a time of concentration of 6 min, qu becomes 774

The water quality flow is therefore:

WQF = qu A Q

WQF = 774 x 0.001105 x 1

WQF = 0.86 cfs

Appendix H

Stormwater Management System
Long-Term Operation & Maintenance (O&M) Plan

STORM WATER MANAGEMENT SYSTEM
LONG-TERM OPERATION & MAINTENANCE PLAN

March 26, 2021

Noble Energy
Proposed Travel Center
#195, 197, 201, & 201A Charlton Road (Route 20)
Sturbridge, MA

Prepared For:
Noble Energy Real Estate Holdings, LLC.
131 Buckingham Street, Suite 301
Hartford, CT 06106

Prepared By:
CMG Environmental, Inc.
67 Hall Road
Sturbridge, MA 01566
Phone: (774) 241-0901

CMG ID 2020-127

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TABLES

ATTACHMENTS

Long Term Operation & Maintenance Plan
Site Stormwater Management System
#195, 197, 201, & 201A CHARLTON ROAD
Proposed Travel Center
STURBRIDGE, MA

Operation and Maintenance (O&M) Plan

The purpose of this Storm Water Management System Operation and Maintenance Plan is to prevent erosion, sedimentation, pollution or other deterioration of the storm water management system and resource areas located on and adjacent to the site property located at **#195, 197, 201, & 201A Charlton Road in Sturbridge, MA** (the "Site"). The storm water management system shall be maintained properly to assure its continued performance.

Responsible Party:

Noble Energy Real Estate Holdings, LLC.
131 Buckingham Street, Suite 301
Hartford, CT 06106
p. (860) 462-0527

Storm water Management System Owner: **(same as above)**

Site subject to Wetlands Protection Act: **NO**

The "Responsible Party" Shall:

- Prepare and submit an **"Operation and Maintenance (O & M) Compliance Statement" (see Attachment #1)** upon completion of site construction activities.
- Implement the routine and non-routine operation, maintenance, and inspection tasks in accordance with the procedures specified in this document to ensure that all storm water management systems function as designed;
- Maintain a log of all operation and maintenance (O & M) activities for the last five (5) years, including inspections, repairs, replacement and disposal (for disposal, the log shall indicate the type of material and disposal location);
- Make this log available to **Town of Sturbridge** official representatives upon request;
- Agree to notify in writing all "future property owners" of the presence of the storm water management system and the requirement for proper operation and maintenance.

"Noble Energy Real Estate Holdings, LLC." maintains a contract with the following companies:

Landscaping & Pavement Maintenance: _____

Snow Removal & Plowing: _____

Storm Water System Maintenance: _____

Table No. 1
#195, 197, 201, & 201A CHARLTON ROAD, STURBRIDGE, MA
Proposed Travel Center

STORMWATER SYSTEM INSPECTION AND MAINTENANCE SCHEDULE		
Best Management Practice (BMP)	**Inspection Frequency**	**Maintenance Frequency**
STRUCTURAL BMPs		
CATCH BASIN DEEP SUMP W/ HOOD	Four (4) Times / Year	Remove Sediment Four (4) Times / Year or if Sediment Depth Reaches 50% of Sump (End of Foliage & Snow Removal Seasons)
TWO (2) OIL/ GRIT SEPARATORS 3,000 & 5,000 Gal. Capacity	Monthly	Bi-annual Twice per Year Or Following a Spill Event
HYDROSTORM WATER QUALITY UNITS (HS-4 and HS-6)	Four (4) Times / Year	Per Manufacturer's Recommendations (See Attached Hydrostorm Operation and Maintenance Manual)
RAIN GARDEN	Monthly	Bi-Annual (Spring and Fall) Remove/ Replace Dead Vegetation Mulch and Prune
12" & 15" OUTLET PIPES Rip-Rap Apron	Four (4) Times / Year	Remove Sediment Four (4) Times / Year (Including End of Foliage & Snow Removal Seasons)
NON-STRUCTURAL STORMWATER CONTROLS		
SPILL KIT	Four (4) Times / Year	Replenish Spill Kit as Needed
Landscaping	Four (4) Times / Year	Seasonally As Needed
Roadway / Driveway Sweeping	Two (2) Times /Year	Seasonally As Needed
Snow Removal	Seasonally As Needed	In Accordance with M.G.L. Title XIV. Public Ways and Works; Chapter 85

STRUCTURAL STORMWATER BMP MAINTENANCE:
Deep Sump Catch Basin(s):

- Inspect or clean catch basin(s) at least four (4) times per year, including the end of the foliage and snow removal seasons.
- Inspection shall occur by probing the structure with a rod to determine the depth of accumulated sediment.
- Sediments must be removed four (4) times per year or whenever the depth of sediment is greater than or equal to one half of the depth from the bottom of the invert of the lowest pipe in the basin. At a minimum, cleaning shall occur twice a year during the spring and fall.
- The structure will be cleaned of water and sand/debris with the use of a vacuum truck. Material removed from the structure will be disposed of legally off-site by the vendor.
- Unless there is evidence that they have been contaminated by a spill or other means, catch basin cleanings may be taken to a landfill or other facility permitted by MassDEP to accept solid waste.

Two (2) 3,000- & 5,000-Gallon Oil / Grit Separators Maintenance

- Separator shall be inspected on a monthly basis for proper operation.
- Typical maintenance (removal of accumulated oil/grease, floatables, and sediment) shall be conducted twice / year or following a spill event with the use of a vacuum truck.
- Material removed from the structures will be disposed of legally off-site by the vendor.

Hydrostorm Water Quality Units (HS-4 & HS-6)

- Per manufacturer's recommendations, see Attachment #2: Hydroworks Hydrostorm Operation and Maintenance Manual

Rain Garden

- Inspect Rain Garden inlets twice per year for signs of accumulation of sediment or debris. Any debris or sediment that could potentially clog the system shall be removed as necessary.
- Inspection shall also involve visual observations of failure apparent in the area surrounding the gardens perimeter and outlet structure.
- Inspect soil and repair eroded areas monthly. Re-mulch void areas as needed. Remove trash and debris from garden monthly.
- Remove and replace dead vegetation twice per year (spring and fall).

Rip-rap Apron Outlets

- Inspect regularly, especially after large rainfall events;
- Note and repair any erosion & sediment buildup at the Rip-Rap outlet protection.

NON- STRUCTURAL STORM WATER MANAGEMENT CONTROLS:

Non-Structural Control Measures & Stormwater Treatment

- **SPILL KIT** - a minimum of one (1) 55-gallon overpack drum, spill response equipment, and oil absorbents need to be located on-site in an accessible location within the building.

Landscape & Pavement Maintenance:

- **No debris, refuse or other materials,** including but not limited to landscaping debris, leaves, shrubs and tree trimmings, logs, bricks, stone or trash shall be deposited within the vegetated wetland.
- The use of pesticides, herbicides, and fertilizers on the site shall be minimized to the extent practicable and shall be applied in accordance with manufacture recommendations by experienced and if applicable, licensed personnel.
- Pavement areas will be swept seasonally as necessary to remove accumulated winter sand and salt and fall leaves, and shall be swept as required to remove litter. Collected material will be properly disposed of off-site.

Trash Removal

- Inspect on-site area for litter and trash as needed. Any accumulated trash, litter, and discarded materials in this area will be removed and will be disposed of at a suitable location on a weekly basis.

HAZARDOUS WASTE / OIL SPILL RESPONSE PROCEDURE

Initial Notification. In the event of a spill of hazardous waste or oil the facility manager or supervisor will be notified immediately by telephone.

Assessment – Initial Containment. The supervisor or manager will assess the incident and initiate control measures. The supervisor will first contact the **Town of Sturbridge Fire Department** and then notify the **Town of Sturbridge Police Department**. The Fire Department is ultimately responsible for matters of public health and safety and should be notified immediately.

Fire Department Telephone: 911 (Emergency); (508) 347-2525 (Non-Emergency)

Police Department Telephone: 911 (Emergency); 508-347-2525 (Non-Emergency)

Further Notification. Based on the assessment by the Fire Chief, additional notification to a clean up contractor may be made. The Massachusetts Department of Environmental Protection and the EPA may be notified depending upon the nature and severity of the spill. The Fire Chief will be responsible for determining the level of clean up and notification required.

SNOW MANAGEMENT PLAN:

- No snow storage shall be located within or "deposited" within wetland resource areas on or off-site.

- No salt shall be used to treat unpaved areas during snow and ice conditions. The storage of all "de-icing" chemicals and treatment products is to be inside the building.

- If Site snow storage interferes with driveway maneuvers or sight distances (i.e. blocking of travel aisles, sight distance, or parking) the snow pile will be either removed or reduced legally in a legal manner by the snow plow vendor within 24-hours.

- Pavement areas will be swept seasonally as necessary to remove accumulated winter sand and salt and fall leaves, and shall be swept as required to remove litter. Collected material will be properly disposed of off-site.

INSPECTIONS / RECORDKEEPING:

Routine Inspections:
Routine inspections and maintenance to be conducted with the frequency described in this Operation and Maintenance Plan. All repairs and maintenance activities regarding the stormwater management system should be recorded and provided to the Sturbridge Planning Board upon request. An example inspection form is provided in **Attachment #2**.

Recordkeeping
Records of all drainage system inspections and maintenance shall be kept on file for a period of at least **five (5) years.**

PUBLIC SAFETY FEATURES:

- All cast iron storm water structure grates and covers shall be kept in good condition and kept closed at all times. Any damaged or broken structures will be replaced immediately upon discovery;

Attachment #1

Illicit Discharge Compliance Statement

Illicit Discharge Compliance Statement
Site Storm Water Management System
#195, 107, 201, & 201A CHARLTON ROAD
PROPOSED TRAVEL CENTER
STURBRIDGE, MA

Responsible Party:
Noble Energy Real Estate Holdings, LLC
131 Buckingham Street, Suite 301
Hartford, CT 06106
p. (860) 462-0527

Storm Water Management System Owner: (same as above)

Site subject to Wetlands Protection Act: NO

The above listed "responsible party" is responsible for implementation of this "Long-Term Operation and Maintenance Plan" and certifies that:

- The site has been inspected for erosion and appropriate steps have been taken to permanently stabilize any eroded areas;
- All aspects of storm water BMPs have been inspected for damage, wear and malfunction, and appropriate steps have been taken to repair or replace the system or portions of the system so that the storm water at the site may be managed in accordance with:
    - MA-DEP Stormwater Management Standards, revise date January 2, 2008;
- There is no record or knowledge of illicit discharges to the on-site stormwater management system;
- All "future property owners" must be notified of their continuing legal responsibility to operate and maintain the Site Stormwater Management System.
- The "Long-Term Operation and Maintenance Plan" for the storm water BMPs is being implemented.

Signature of Responsible Party:

_____ _____
Noble Energy Real Estate Holdings, LLC. Date

Attachment #2

Hydroworks Hydrostorm
Operations & Maintenance Manual

Hydroworks® HydroStorm

Operations & Maintenance Manual

Version 1.0

Please call Hydroworks at 888-290-7900 or email us at support@hydroworks.com if you have any questions regarding the Inspection Checklist. Please fax a copy of the completed checklist to Hydroworks at 888-783-7271 for our records.

Introduction

The HydroStorm is a state of the art hydrodynamic separator. Hydrodynamic separators remove solids, debris and lighter than water (oil, trash, floating debris) pollutants from stormwater. Hydrodynamic separators and other water quality measures are mandated by regulatory agencies (Town/City, State, Federal Government) to protect storm water quality from pollution generated by urban development (traffic, people) as part of new development permitting requirements.

As storm water treatment structures fill up with pollutants they become less and less effective in removing new pollution. Therefore, it is important that storm water treatment structures be maintained on a regular basis to ensure that they are operating at optimum performance. The HydroStorm is no different in this regard and this manual has been assembled to provide the owner/operator with the necessary information to inspect and coordinate maintenance of their HydroStorm.

Hydroworks® HydroStorm Operation

The Hydroworks HydroStorm (HS) separator is a unique hydrodynamic by-pass separator. It incorporates a protected submerged pretreatment zone to collect larger solids, a treatment tank to remove finer solids, and a dual set of weirs to create a high flow bypass. High flows are conveyed directly to the outlet and do not enter the treatment area, however, the submerged pretreatment area still allows removal of coarse solids during high flows.

Under normal or low flows, water enters an inlet area with a horizontal grate. The area underneath the grate is submerged with openings to the main treatment area of the separator. Coarse solids fall through the grate and are either trapped in the pretreatment area or conveyed into the main treatment area depending on the flow rate. Fines are transported into the main treatment area. Openings and weirs in the pretreatment area allow entry of water and solids into the main treatment area and cause water to rotate in the main treatment area creating a vortex motion. Water in the main treatment area is forced to rise along the walls of the separator to discharge from the treatment area to the downstream pipe.

The vortex motion forces solids and floatables to the middle of the inner chamber. Floatables are trapped since the inlet to the treatment area is submerged. The design maximizes the retention of settled solids since solids are forced to the center of the inner chamber by the vortex motion of water while water must flow up the walls of the separator to discharge into the downstream pipe.

A set of high flow weirs near the outlet pipe create a high flow bypass over both the pretreatment area and main treatment chamber. The rate of flow into the treatment area is regulated by the number and size of openings into the treatment chamber and the height of by-pass weirs. High flows flow over the weirs directly to the outlet pipe preventing the scour and resuspension of any fines collected in the treatment chamber.

A central access tube is located in the structure to provide access for cleaning. The arrangement of the inlet area and bypass weirs near the outlet pipe facilitate the use of multiple inlet pipes.

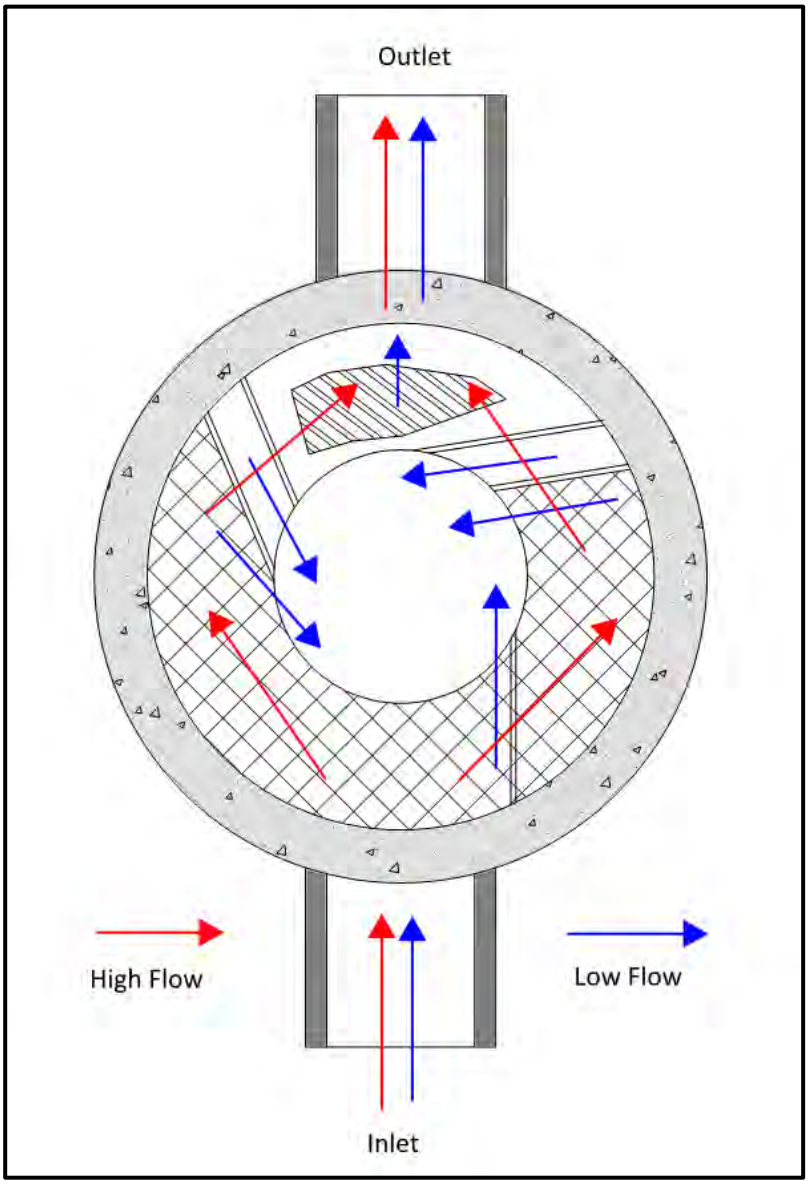

Figure 1. Hydroworks HydroStorm Operation – Plan View

Figure 2 is a profile view of the HydroStorm separator showing the flow patterns for low and high flows.

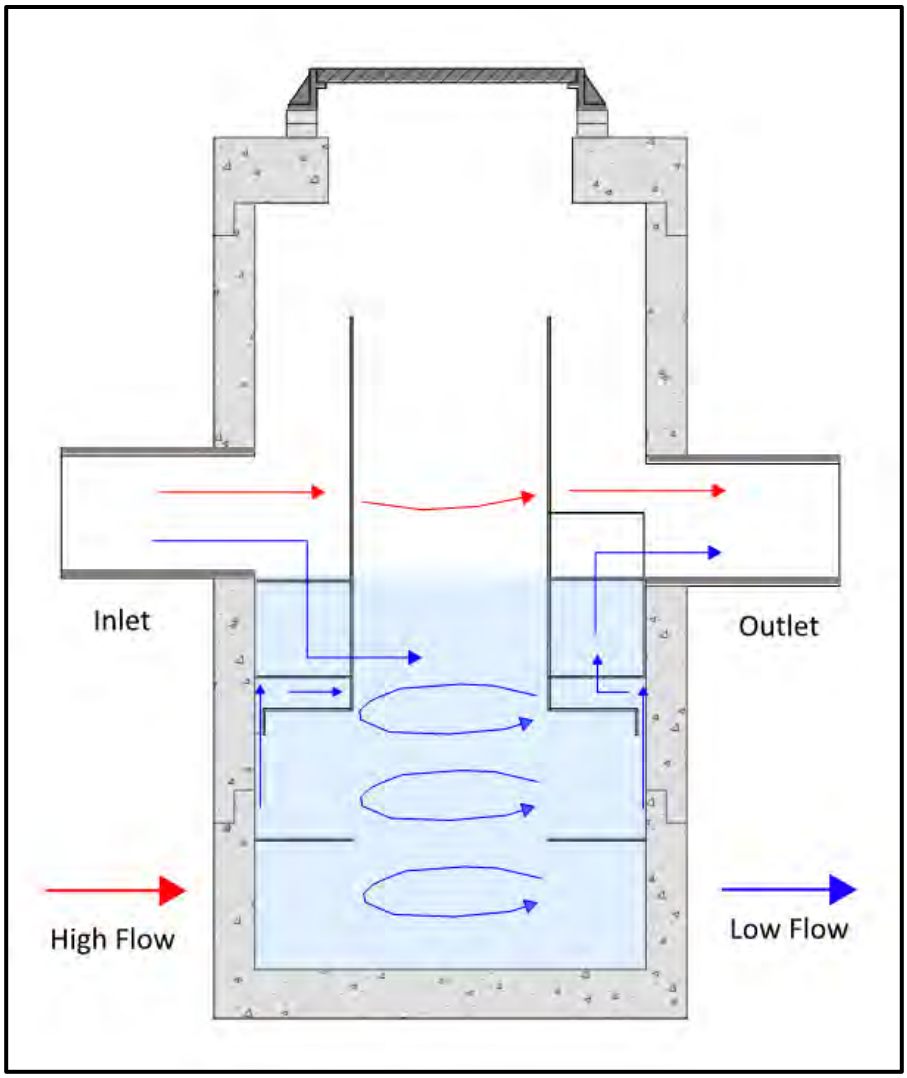

Figure 2. Hydroworks HydroStorm Operation – Profile View

The HS 4i is an inlet version of the HS 4 separator. There is a catch-basin grate on top of the HS 4i. A funnel sits sits underneath the grate on the frame and directs the water to the inlet side of the separator to ensure all lows flows are properly treated. The whole funnel is removed for inspection and cleaning.

Hydroworks

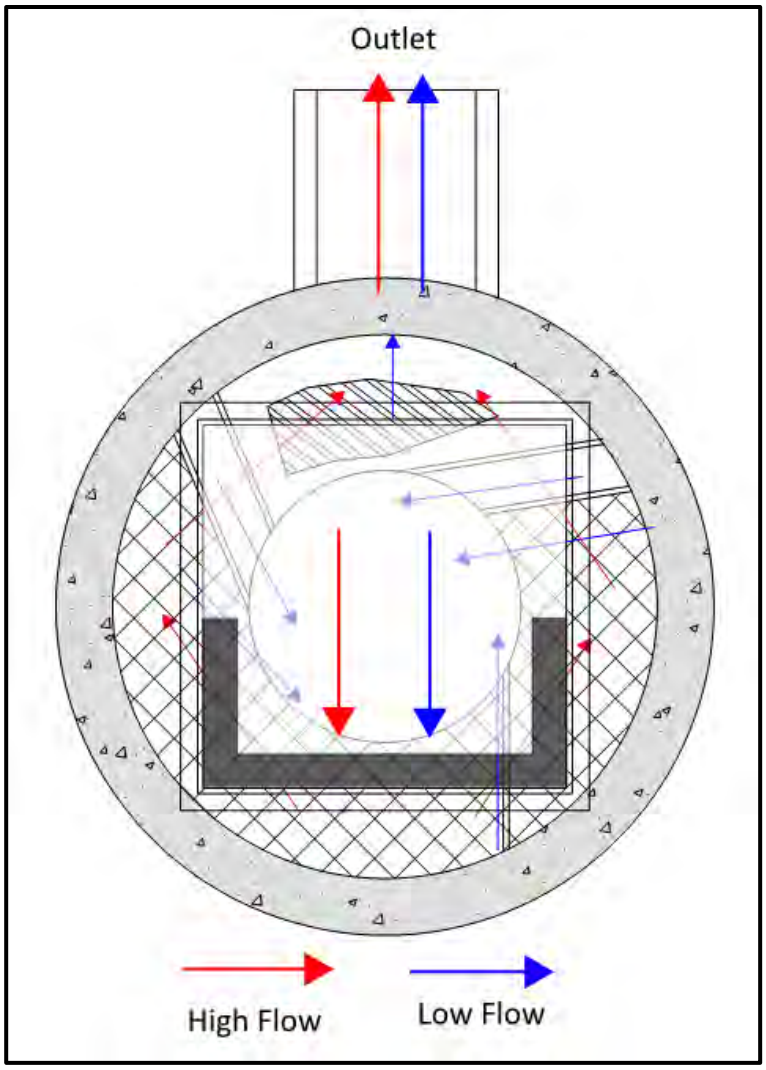

Figure 3. Hydroworks HS 4i Funnel

Inspection

Procedure

Floatables

A visual inspection can be conducted for floatables by removing the covers and looking down into the center access tube of the separator. Separators with an inlet grate (HS 4i or custom separator) will have a plastic funnel located under the grate that must be removed from the frame prior to inspection or maintenance. If you are missing a funnel please contact Hydroworks at the numbers provided at the end of this document.

Hydroworks

TSS/Sediment

Inspection for TSS build-up can be conducted using a Sludge Judge®, Core Pro®, AccuSludge® or equivalent sampling device that allows the measurement of the depth of TSS/sediment in the unit. These devices typically have a ball valve at the bottom of the tube that allows water and TSS to flow into the tube when lowering the tube into the unit. Once the unit touches the bottom of the device, it is quickly pulled upward such that the water and TSS in the tube forces the ball valve closed allowing the user to see a full core of water/TSS in the unit. The unit should be inspected for TSS through each of the access covers. Several readings (2 or 3) should be made at each access cover to ensure that an accurate TSS depth measurement is recorded.

Frequency

Construction Period

The HydroStorm separator should be inspected every four weeks and after every large storm (over 0.5" (12.5 mm) of rain) during the construction period.

Post-Construction Period

The Hydroworks HydroStorm separator should be inspected during the first year of operation for normal stabilized sites (grassed or paved areas). If the unit is subject to oil spills or runoff from unstabilized (storage piles, exposed soils) areas the HydroStorm separator should be inspected more frequently (4 times per year). The initial annual inspection will indicate the required future frequency of inspection and maintenance if the unit was maintained after the construction period.

Reporting

Reports should be prepared as part of each inspection and include the following information:

1. Date of inspection
2. GPS coordinates of Hydroworks unit
3. Time since last rainfall
4. Date of last inspection
5. Installation deficiencies (missing parts, incorrect installation of parts)
6. Structural deficiencies (concrete cracks, broken parts)
7. Operational deficiencies (leaks, blockages)
8. Presence of oil sheen or depth of oil layer
9. Estimate of depth/volume of floatables (trash, leaves) captured
10. Sediment depth measured
11. Recommendations for any repairs and/or maintenance for the unit
12. Estimation of time before maintenance is required if not required at time of inspection

A sample inspection checklist is provided at the end of this manual.

Maintenance

Procedure

The Hydroworks HydroStorm unit is typically maintained using a vacuum truck. There are numerous companies that can maintain the HydroStorm separator. Maintenance with a vacuum truck involves removing all of the water and sediment together. The water is then separated from the sediment on the truck or at the disposal facility.

A central access opening (24” or greater) is provided to the gain access to the lower treatment tank of the unit. This is the primary location to maintain by vacuum truck. The pretreatment area can also be vacuumed and/or flushed into the lower treatment tank of the separator for cleaning via the central access once the water level is lowered below the pretreatment floor.

In instances where a vacuum truck is not available other maintenance methods (i.e. clamshell bucket) can be used, but they will be less effective. If a clamshell bucket is used the water must be decanted prior to cleaning since the sediment is under water and typically fine in nature. Disposal of the water will depend on local requirements. Disposal options for the decanted water may include:

1. Discharge into a nearby sanitary sewer manhole
2. Discharge into a nearby LID practice (grassed swale, bioretention)
3. Discharge through a filter bag into a downstream storm drain connection

The local municipality should be consulted for the allowable disposal options for both water and sediments prior to any maintenance operation. Once the water is decanted the sediment can be removed with the clamshell bucket.

Disposal of the contents of the separator depend on local requirements. Maintenance of a Hydroworks HydroStorm unit will typically take 1 to 2 hours based on a vacuum truck and longer for other cleaning methods (i.e. clamshell bucket).

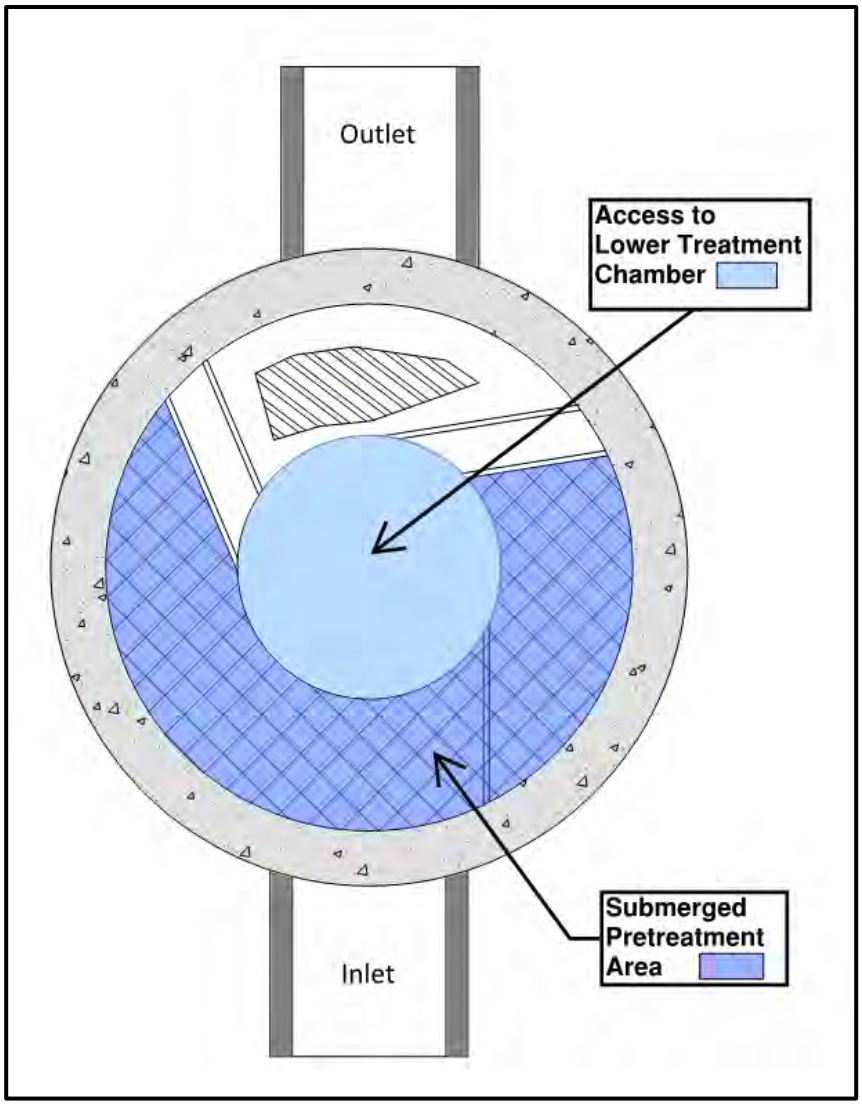

Figure 3. Maintenance Access

Frequency

Construction Period

A HydroStorm separator can fill with construction sediment quickly during the construction period. The HydroStorm must be maintained during the construction period when the depth of TSS/sediment reaches 24” (600 mm). It must also be maintained during the construction period if there is an appreciable depth of oil in the unit (more than a sheen) or if floatables other than oil cover over 50% of the area of the separator

The HydroStorm separator should be maintained at the end of the construction period, prior to operation for the post-construction period.

Post-Construction Period

The HydroStorm was independently tested by Alden Research Laboratory in 2017. A HydroStorm HS 4 was tested for scour with a 50% sediment depth of 0.5 ft. Therefore, maintenance for sediment accumulation is required if the depth of sediment is 1 ft or greater in separators with standard water (sump) depths (Table 1).

There will be designs with increased sediment storage based on specifications or site-specific criteria. A measurement of the total water depth in the separator through the central access tube should be taken and compared to water depth given in Table 1. The standard water depth from Table 1 should be subtracted from the measured water depth and the resulting extra depth should be added to the 1 ft to determine the site-specific sediment maintenance depth for that separator.

For example, if the measured water depth in the HS-7 is 7 feet, then the sediment maintenance depth for that HS-7 is 2 ft (= 1 + 7 – 6) and the separator does not need to be cleaned for sediment accumulation until the measure sediment depth is 2 ft.

The HydroStorm separator must also be maintained if there is an appreciable depth of oil in the unit (more than a sheen) or if floatables other than oil cover over 50% of the water surface of the separator.

Table 1 Standard Dimensions for Hydroworks HydroStorm Models

Model	Diameter (ft)	Total Water Depth (ft)	Sediment Maintenance Depth for Table 1 Total Water Depth(ft)
HS-3	3	3	1
HS-4	4	4	1
HS-5	5	4	1
HS-6	6	4	1
HS-7	7	6	1
HS-8	8	7	1
HS-9	9	7.5	1
HS-10	10	8	1
HS-11	11	9	1
HS-12	12	9.5	1

HYDROSTORM INSPECTION SHEET

Date _____
Date of Last Inspection _____

Site _____
City _____
State _____
Owner _____

GPS Coordinates _____

Date of last rainfall _____

Site Characteristics	**Yes**	**No**
Soil erosion evident	☐	☐
Exposed material storage on site	☐	☐
Large exposure to leaf litter (lots of trees)	☐	☐
High traffic (vehicle) area	☐	☐

HydroStorm	**Yes**	**No**
Obstructions in the inlet or outlet	☐ *	☐
Missing internal components	☐ **	☐
Improperly installed inlet or outlet pipes	☐ ***	☐
Internal component damage (cracked, broken, loose pieces)	☐ **	☐
Floating debris in the separator (oil, leaves, trash)	☐	☐
Large debris visible in the separator	☐ *	☐
Concrete cracks/deficiencies	☐ ***	☐
Exposed rebar	☐ **	☐
Water seepage (water level not at outlet pipe invert)	☐ ***	☐

Water level depth below outlet pipe invert _____“

Routine Measurements

Floating debris depth	**< 0.5” (13mm)**	☐	**>0.5” 13mm)**	☐ *
Floating debris coverage	**< 50% of surface area**	☐	**> 50% surface area**	☐ *
Sludge depth	**< 12” (300mm)**	☐	**> 12” (300mm)**	☐ *

* Maintenance required
** Repairs required
*** Further investigation is required

Hydroworks

Other Comments:

Hydroworks

Hydroworks® HydroStorm

One Year Limited Warranty

Hydroworks, LLC warrants, to the purchaser and subsequent owner(s) during the warranty period subject to the terms and conditions hereof, the Hydroworks HydroStorm to be free from defects in material and workmanship under normal use and service, when properly installed, used, inspected and maintained in accordance with Hydroworks written instructions, for the period of the warranty. The standard warranty period is 1 year.

The warranty period begins once the separator has been manufactured and is available for delivery. Any components determined to be defective, either by failure or by inspection, in material and workmanship will be repaired, replaced or remanufactured at Hydroworks' option provided, however, that by doing so Hydroworks, LLC will not be obligated to replace an entire insert or concrete section, or the complete unit. This warranty does not cover shipping charges, damages, labor, any costs incurred to obtain access to the unit, any costs to repair/replace any surface treatment/cover after repair/replacement, or other charges that may occur due to product failure, repair or replacement.

This warranty does not apply to any material that has been disassembled or modified without prior approval of Hydroworks, LLC, that has been subjected to misuse, misapplication, neglect, alteration, accident or act of God, or that has not been installed, inspected, operated or maintained in accordance with Hydroworks, LLC instructions and is in lieu of all other warranties expressed or implied. Hydroworks, LLC does not authorize any representative or other person to expand or otherwise modify this limited warranty.

The owner shall provide Hydroworks, LLC with written notice of any alleged defect in material or workmanship including a detailed description of the alleged defect upon discovery of the defect. Hydroworks, LLC should be contacted at 136 Central Ave., Clark, NJ 07066 or any other address as supplied by Hydroworks, LLC. (888-290-7900).

This limited warranty is exclusive. There are no other warranties, express or implied, or merchantability or fitness for a particular purpose and none shall be created whether under the uniform commercial code, custom or usage in the industry or the course of dealings between the parties. Hydroworks, LLC will replace any goods that are defective under this warranty as the sole and exclusive remedy for breach of this warranty.

Subject to the foregoing, all conditions, warranties, terms, undertakings or liabilities (including liability as to negligence), expressed or implied, and howsoever arising, as to the condition, suitability, fitness, safety, or title to the Hydroworks HydroStorm are hereby negated and excluded and Hydroworks, LLC gives and makes no such representation, warranty or undertaking except as expressly set forth herein. Under no circumstances shall Hydroworks, LLC be liable to the Purchaser or to any third party for product liability claims; claims arising from the design, shipment, or installation of the HydroStorm, or the cost of other goods or services related to the purchase and installation of the HydroStorm. For this Limited Warranty to apply, the HydroStorm must be installed in accordance with all site conditions required by state and local codes; all other applicable laws; and Hydroworks' written installation instructions.

Hydroworks, LLC expressly disclaims liability for special, consequential or incidental damages (even if it has been advised of the possibility of the same) or breach of expressed or implied warranty. Hydroworks, LLC shall not be liable for penalties or liquidated damages, including loss of production and profits; labor and materials; overhead costs; or other loss or expense incurred by the purchaser or any third party. Specifically excluded from limited warranty coverage are damages to the HydroStorm arising from ordinary wear and tear; alteration, accident, misuse, abuse or neglect; improper maintenance, failure of the product due to improper installation of the concrete sections or improper sizing; or any other event not caused by Hydroworks, LLC. This limited warranty represents Hydroworks' sole liability to the purchaser for claims related to the HydroStorm, whether the claim is based upon contract, tort, or other legal basis.

Attachment #3

Stormwater Management System
Quarterly Inspection Form

Inspection Form - Storm Water Management System
Noble Energy
#195, 197, 201, & 201A Charlton Road Sturbridge, Massachusetts

QUARTERLY INSPECTION AND MAINTENANCE REPORT

Jan.-Mar. Apr.-Jun. July-Sep. Oct. – Dec.

Note: This Log should be copied prior to use. Note Additional Comments on back of Form.

Inspector's Name: _____ Date: _____ Time: _____ am/pm

Inspector's Qualifications: _____

Days Since Last Rainfall: _____ Amount of Last Rainfall: _____ inches

Item/Condition to be Checked	Maintenance Required		Corrective Action & Date
	No	Yes	
CATCH BASIN DEEP SUMP W/ HOOD			*Clean when sediment Depth > 24 in. or sheen present
OIL / GRIT SEPARATOR #1 3,000 GAL. CAPACITY			Clean Unit Twice /Year or After Spill Event
OIL / GRIT SEPARATOR #2 5,000 GAL. CAPACITY			Clean Unit Twice /Year or After Spill Event
HYDROSTORM WATER QUALITY UNITS (HS-4)			
HYDROSTORM WATER QUALITY UNITS (HS-6)			
Rain Garden			
Rip-Rap Aprons			
SPILL KIT			
Parking Lot / Driveway Sweeping			*Sweep Seasonally – As Needed
Landscaping / Trash Removal			
Snow Removal (seasonal)			*All De-icing chemical storage to be inside building

Additional Comments: _____