STORMWATER DRAINAGE REPORT

FOR

PROPOSED

Giri Haverhill, LLC

Hotel & Retail/Restaurant
401 Lowell Avenue
City of Haverhill, Massachusetts
Essex County

Prepared by:

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BOHLER
ENGINEERING

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I. INTRODUCTION

The following report provides an analysis of the stormwater drainage conditions that will result from the re-development of an existing Best Western hotel site located at 401 Lowell Avenue in the City of Haverhill, Massachusetts. The subject property ("the Site") contains approximately 2.38 acres of land, is situated on the easterly side of the Blue Star Memorial Highway (Route 495) and westerly side of Lowell Avenue, and contains an existing 3-story hotel building and associated infrastructure. The western edge of the site contains wooded land with wetlands located just beyond the property line.

The proposed project will consist of razing the eastern and southern portions of the existing hotel building and maintaining and retrofitting the western 2-story portion to accommodate a single 5-story hotel. A new standalone 6,600± square foot (SF) retail and 3,000± SF restaurant building is proposed in the eastern portion of the site. Site amenities for the construction of the buildings will include new paved parking and pedestrian areas, stormwater management system and utilities.

This report includes an analysis of the existing and proposed drainage characteristics of the portion of the site that's proposed to be developed including building, parking and landscaped areas and provides a detailed analysis of the proposed stormwater facilities and best management practices (BMPs) that will control stormwater outflow associated with the post-redeveloped site which will help serve to reduce the rate of flows leaving the site.

This report addresses a comparative analysis of the pre- and post-development site stormwater runoff conditions with the following primary design constraints being:

1. The Massachusetts Department of Environmental Protection Agency's Stormwater Management Standards; and
2. The City of Haverhill Wetlands Protection Ordinance.

II. DRAINAGE – EXISTING SITE CONDITIONS

The existing site contains an existing hotel and associated driveway and parking areas, pedestrian walkways, utilities and landscaping. The site contains two (2) drainage areas (E1 & E2) as further described below, and is shown on the "Existing Drainage Tributary Map" which is included in Appendix 3 of this report.

Drainage Area E1 consists of 1.90 acres of building, paved parking and pedestrian areas, driveways, and some landscaping areas. Majority of the stormwater runoff from Drainage Area E1 sheet flows overland and discharges to existing wetlands located southwest of the site (Design Point 1, DPE1). Some runoff within the south and east parking lot is collected in catch basins and flows through a series of manholes within the adjacent CVS parking lot and eventually discharge to DPE1. Roof runoff is collected in a series of downspouts that drain primarily to perimeter drains and discharge to wetlands. Some roof drains were observed discharging to the ground surface and sheet flow to drainage structures or directly overland to wetlands.

Drainage Area E2 consists of 1.14 acres of building, paved parking and pedestrian areas, driveways, and some landscaping areas. Runoff from the landscaped courtyard, east parking lot, and a portion of the northern parking lot is collected in a series of catch basins that ultimately discharge to existing wetlands located northwest of the site (Design Point 2, DPE2). A portion of the northern parking lot sheet flows overland to DPE2. Roof runoff is collected in a series of downspouts that drain primarily to perimeter drains and discharge to wetlands. Some roof drains were observed discharging to the ground surface and sheet flow to drainage structures or directly overland to wetlands.

Based on our review of the Natural Resources Conservation Service (NRCS) WSS online soil databases, the majority of the underground soils at the subject site are classified as "Urban land", which is not provided with a Hydrologic Soil Group (HSG) classification. Areas surrounding the site to the northeast, south, and west are classified as "Canton fine sandy loam" and "Udorthents, smoothed", and are classified as HSG 'A'. Subsurface soils information is provided in a Geotechnical Summary Report prepared by KMM Geotechnical Consultants, LLC, dated August 8, 2016, and included in Appendix 9 of this report. Test-pit information was gathered by Bohler Engineering on August 18, 2016 and is provided in Appendix 9 of this report.

III. DRAINAGE- PROPOSED SITE CONDITIONS

The proposed project will consist of razing the northern, eastern, and southern portions of the existing hotel building and maintaining and retrofitting the western 2-story portion to accommodate a single 5-story hotel. New standalone 6,600± square foot (SF) retail and 3,000± SF restaurant building is proposed in the eastern portion of the site. Various site improvements including parking, utilities, landscape improvements, and stormwater management are also proposed. Refer to the Site Development Plans prepared by Bohler Engineering, dated October 20, 2016.

The goal of the stormwater management system design is to maintain existing site drainage patterns, mitigate peak post development rates, and protect water quality of the receiving waters and groundwater in accordance with MassDEP's Stormwater Management Standards and the City of Haverhill's Requirements.

Stormwater quality improvements proposed for the developed site include deep-sump hooded catch basins, a stormwater quality unit, a surface infiltration basin, and underground infiltration systems. Pretreatment devices will provide a minimum of 80 percent total suspended solids (TSS) removal from the increase in paved surfaces compared to the existing site condition prior to infiltration. Infiltration systems have been designed to achieve the recharge volume required by DEP's Stormwater Management Standards and the City of Haverhill's Standards for the increase in impervious pavement. The remaining paved area is treated to the maximum extent practicable with deep sump hooded catch basins and a water quality structure prior to discharge.

The post-development condition consists of two (2) drainage areas (P1 & P2), similar to the existing condition as described above, and as further described below. Drainage area P1 discharges to existing wetlands located northwest of the site (Design Point 1, DPP1), and P2 discharges to wetlands located southwest of the site (Design Point 2, DPP2). Refer to the "Existing Drainage Tributary Map" which is included in Appendix 3 of this report.

Drainage Area P1 consists of 1.73 acres of building, paved parking and pedestrian areas, driveways, and some landscaping areas. The drainage area is separated into three (3) sub-drainage areas (P1a, P1b & P1c). Surface runoff from a portion of the parking lot, pedestrian areas and landscaping in P1a flows to a catch basin and isolator row for pretreatment prior to discharge to a subsurface infiltration system to mitigate peak runoff rates and promote groundwater infiltration. Roof runoff from P1a flows directly to the infiltration system. Runoff from a portion of the parking lot, pedestrian areas, and landscaping in P1b is collected in a series of deep sump catch basins and is directed to a water quality unit for treatment prior to discharge to DPP1. Roof runoff from P1c is collected in a series of roof leaders and is directed to a perforated header pipe behind the building to promote recharge, and ultimately discharges to the wetlands. Runoff from landscaped surfaces in P1c flows over land to wetlands.

Drainage Area P2 consists of 1.31 acres of building, paved parking and pedestrian areas, driveways, and some landscaping areas. The drainage area is separated into four (4) sub-drainage areas (P2a, P2b, P2c & P2d). Surface runoff from a portion of the parking lot, pedestrian areas and landscaping in P2a flows to catch basins and isolator rows for pretreatment prior to discharge to a subsurface infiltration system to mitigate peak runoff rates and promote groundwater infiltration. Roof runoff from P2a flows directly to the infiltration system. A portion of the runoff from pedestrian and landscaped areas in P2b flows to an area drain, and the remaining landscaped area flows overland and discharges to the wetland. Roof runoff from P2c is directed to a surface infiltration basin and overflows via an emergency spillway to wetlands. A portion of the eastern and southern parking lots from P2d flow to existing catch basins connected to the adjacent CVS drainage system. Flows from this system ultimately discharge to the wetlands at DPP2.

Under proposed conditions the stormwater runoff rates and volumes from the proposed development are reduced from the existing condition for all storms including the 100-year storm event at both DPP1 and DPP2.

The infiltration basins have been sized to provide adequate storage and recharge to meet the City of Haverhill requirements for roof recharge. Calculations have been provided in Appendix 5 of this report.

Pipe sizing calculations have also been included in Appendix 5. The calculations demonstrate that the drainage system has sufficient capacity for the 25-year storm event.

IV. DRAINAGE ANALYSIS METHODOLGY

The methodology utilized to design the subject stormwater management system to demonstrate compliance with the City of Haverhill and State requirements / guidelines is based on the SCS TR 55 Urban Hydrology for small watersheds method. In addition, times of concentration were generated from the SCS TR 55 Urban Hydrology for small watersheds method. Runoff coefficients for the existing and proposed development conditions were developed using widely accepted runoff coefficients. The rainfall rates used were based on the TP-40 rainfall amounts for Essex County.

V. DRAINAGE ANALYSIS RESULTS

The tables below demonstrates that the post-development runoff rates and volumes associated with all storm events for the proposed development including the 2-, 10-, 25- and 100-year storms will be decreased as a result of the proposed stormwater management system.

Table 1 –Stormwater Runoff Rates to Wetlands (DPE1 vs. DPP1)
(Drainage Area E1 vs. P1)

Storm Frequency	Existing Flow (CFS)	Proposed Flow (CFS)	Change (CFS)
2-year	3.38	3.34	-0.04
10-year	6.68	6.04	-0.64
25-year	8.77	7.72	-1.05
100-year	12.01	10.77	-1.24

Table 2 –Stormwater Runoff Volumes to Wetlands (DPE1 vs. DPP1)
(Drainage Area E1 vs. P1)

Storm Frequency	Existing Volume (AF)	Proposed Volume (AF)	Change (CFS)
2-year	0.263	0.239	-0.024

10-year	0.523	0.449	-0.074
25-year	0.693	0.598	-0.095
100-year	0.962	0.834	-0.128

Table 3 –Stormwater Runoff Rates to Wetlands (DPE2 vs. DPP12)
(Drainage Area E2 vs. P2)

Storm Frequency	Existing Flow (CFS)	Proposed Flow (CFS)	Change (CFS)
2-year	2.94	1.43	-1.51
10-year	5.14	3.99	-1.15
25-year	6.50	5.43	-1.07
100-year	8.57	8.49	-0.08

Table 4 –Stormwater Runoff Volumes to Wetlands (DPE2 vs. DPP12)
(Drainage Area E2 vs. P2)

Storm Frequency	Existing Volume (AF)	Proposed Volume (AF)	Change (CFS)
2-year	0.213	0.132	-0.081
10-year	0.382	0.271	-0.111
25-year	0.489	0.374	-0.115
100-year	0.657	0.541	-0.116

VI. CONCLUSIONS

The proposed stormwater management system illustrated on the enclosed drawings prepared by Bohler Engineering, dated October 20, 2016, results in a decrease in post-development peak stormwater runoff rates and volumes for all storm events associated with the proposed development. In addition, best management practices being implemented as part of the proposed stormwater management system design will result in the required 80% TSS removal for the increase in impervious area from the pre-developed condition. The project has been designed to treat and manage stormwater onsite to the maximum extent practicable, and complies with the requirements of the Massachusetts Department of Environmental Protection Stormwater Standards and the City of Haverhill Wetlands Protection Ordinance.

VII. STORMWATER MANAGEMENT STANDARDS

As outlined below, the proposed drainage system was designed in accordance with the Massachusetts Stormwater Management Policy to the maximum extent practicable.

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

The proposed development has been designed so that all proposed pavement areas from the proposed development are collected by the stormwater management system for treatment prior to being discharged to wetlands.

Standard #2: **Stormwater management systems shall be designed so that post-development peak discharge rates do not exceed pre-development peak discharge rates.**

Runoff rates for the post-development condition were calculated for the 2-, 10-, 25- and 100-year 24-hour storm events. These calculations are provided in Appendix 4 of this report. As summarized in this report, there is no increase in peak stormwater runoff rates for the any of the storm events analyzed for the proposed development due to the implementation of a stormwater management system.

Standard #3: **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, stormwater best management practices, and good operation and maintenance.**

The project proposes two (2) underground infiltration systems and one (1) surface infiltration basin to mitigate peak runoff rates and volumes and to promote groundwater recharge. The project is a redevelopment and has been designed to recharge stormwater runoff from the site to the maximum extent practicable.

Standard #4: **Stormwater management systems shall be designed to remove 80% of the average annual post-construction load of Total Suspended Solids (TSS).**

The proposed stormwater management system has been designed to provide at least 80% removal of TSS for the increase in impervious area compared to the pre-developed condition through the use of several BMPs, including deep sump hooded catch basins and isolator rows. The remaining impervious area onsite is treated with deep sump hooded catch basins and a stormwater quality unit. A mass balance for TSS removal has been calculated, and the site achieves a weighted TSS removal of 64%. All water quality BMPs for this project have been sized to meet DEP standards.

Standard #5: **For land uses with higher potential pollutant loads, source control and pollution prevention shall be implemented in accordance with the Massachusetts Stormwater Handbook to eliminate or reduce the discharge of stormwater runoff from such land uses to the maximum extent practicable.**

Vehicle trips onsite may trigger the threshold considering the Site a Land Use with Higher Potential Pollutant Loads, therefore the project has been designed to treat stormwater discharges from the Site to the maximum extent practicable in accordance with the Massachusetts Stormwater Handbook.

Standard #6: **Stormwater discharges within the Zone II or Interim Wellhead Protection Area of a public water supply, and stormwater discharges near or to any other critical area, require the use of the specific source control and pollution prevention measures and the specific structural stormwater best management practices determined by the Department to be suitable for managing discharges to such areas, as provided in the Massachusetts Stormwater Handbook.**

The site is not located within a Zone II, Interim Wellhead Protection Area, or near to any other critical area. The site is located adjacent to wetland resource areas and proposes to achieve a minimum of 80% TSS removal for the increase in impervious area compared to the pre-developed condition, and the remaining impervious area proposes to achieve a minimum of 54% TSS removal. Treatment has been provided onsite to the maximum extent practicable. All water quality BMPs for this project have been sized to meet DEP regulations.

Standard #7: **A redevelopment project is required to meet the following Stormwater Management Standards only to the maximum extent practicable.**

The proposed project is a redevelopment, and has been designed in accordance with the Massachusetts Stormwater Management regulations to meets all the standards to the maximum extent practicable.

Standard #8: **A plan to control construction-related impacts including erosion, sedimentation and other pollutant sources during construction and land disturbance activities (construction period erosion, sedimentation, and pollution prevention plan) shall be developed and implemented.**

An Erosion and Sediment control plan has been prepared as part of the enclosed drawings prepared by Bohler Engineering. This includes implementation of a perimeter erosion control barrier along with a construction entrance, protection for catch basins inlets and protection around temporary material stock piles areas. The proposed area of disturbance is greater than one acre, therefore the project shall require filing of a Notice of Intent with EPA and shall implement a Stormwater Pollution Prevention Plan (SWPPP) during construction. The contractor will be required to maintain erosion control measures during construction and prevent erosion or sediment discharges to downstream areas.

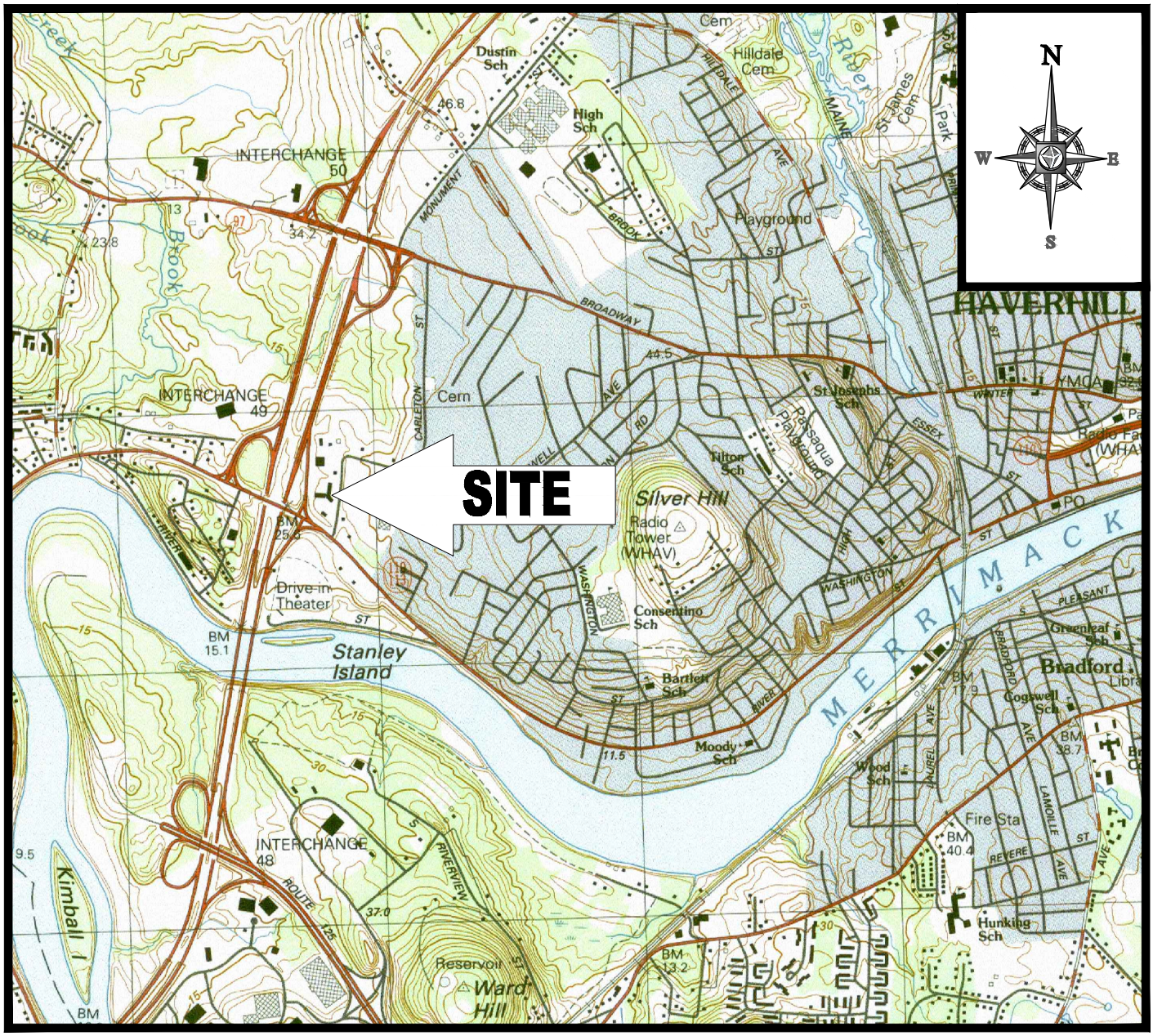
Standard #9: **A long-term operation and maintenance plan shall be developed and implemented to ensure that stormwater management systems function as designed.**

A Long Term Operation and Maintenance Plan for the proposed BMP's has been developed for this project and is included within Appendix 6 of this report. The O&M Plan outlines procedures and time tables for the long term operation and maintenance of the proposed stormwater management system, as well as includes a list of parties responsible and an estimated budget associated with inspections and maintenance.

Standard #10: **All illicit discharges to the stormwater management system are prohibited**

No illicit discharges will be created as part of the site construction for the proposed project.

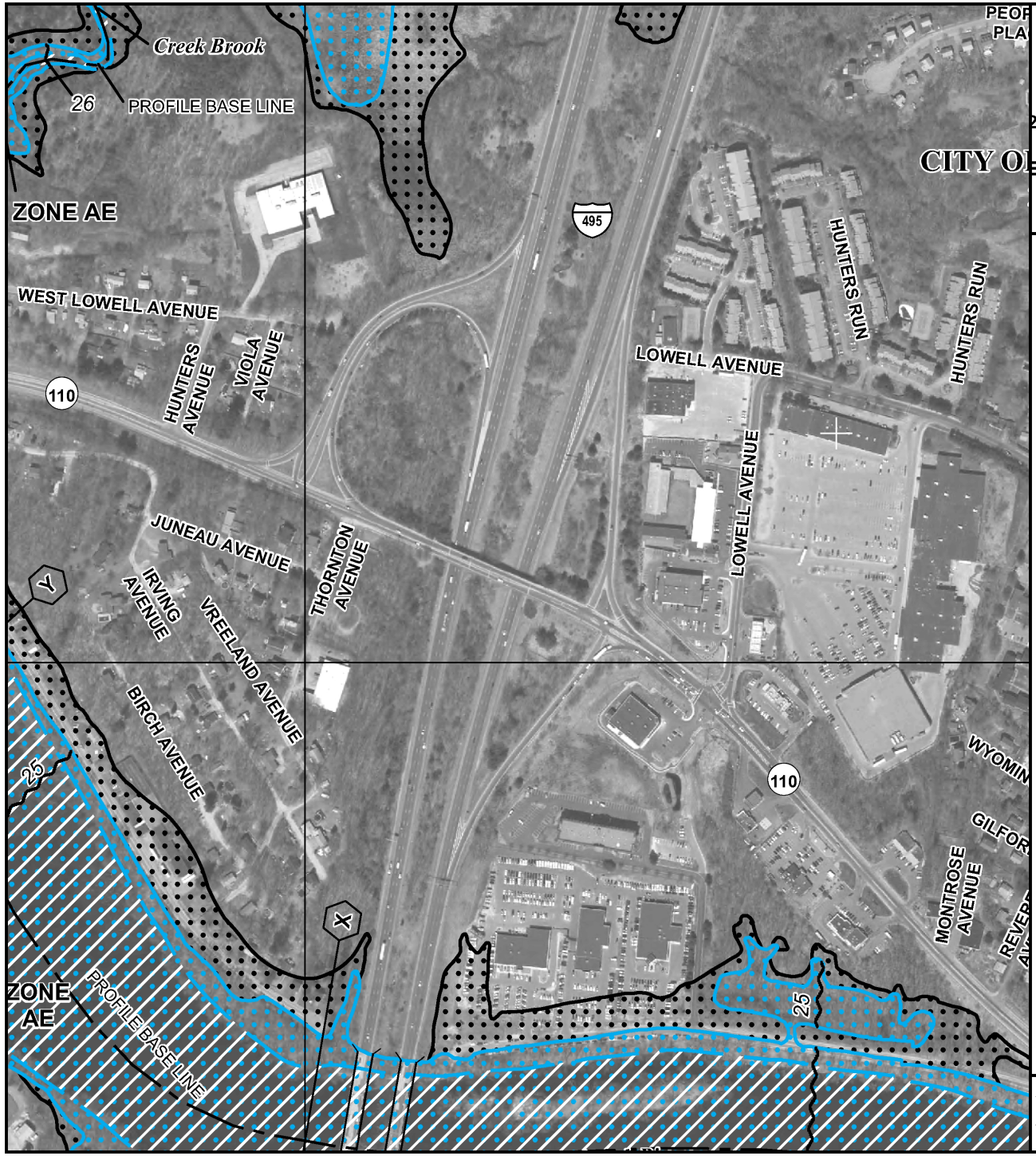
Appendix 1



LOCATION MAP

SCALE: 1"=2000'
PLAN REFERENCE: HAVERHILL, MASSACHUSETTS USGS QUADRANGLE

Appendix 2



MAP SCALE 1" = 500'

250 0 500 1000

FEET

METERS

NFIP

NATIONAL FLOOD INSURANCE PROGRAM

PANEL 0088F

FIRM

FLOOD INSURANCE RATE MAP

ESSEX COUNTY, MASSACHUSETTS

(ALL JURISDICTIONS)

PANEL 88 OF 600

(SEE MAP INDEX FOR FIRM PANEL LAYOUT)

CONTAINS:

COMMUNITY	NUMBER	PANEL	SUFFIX
HAVERHILL, CITY OF	250085	0088	F
METHUEN, CITY OF	250093	0088	F

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

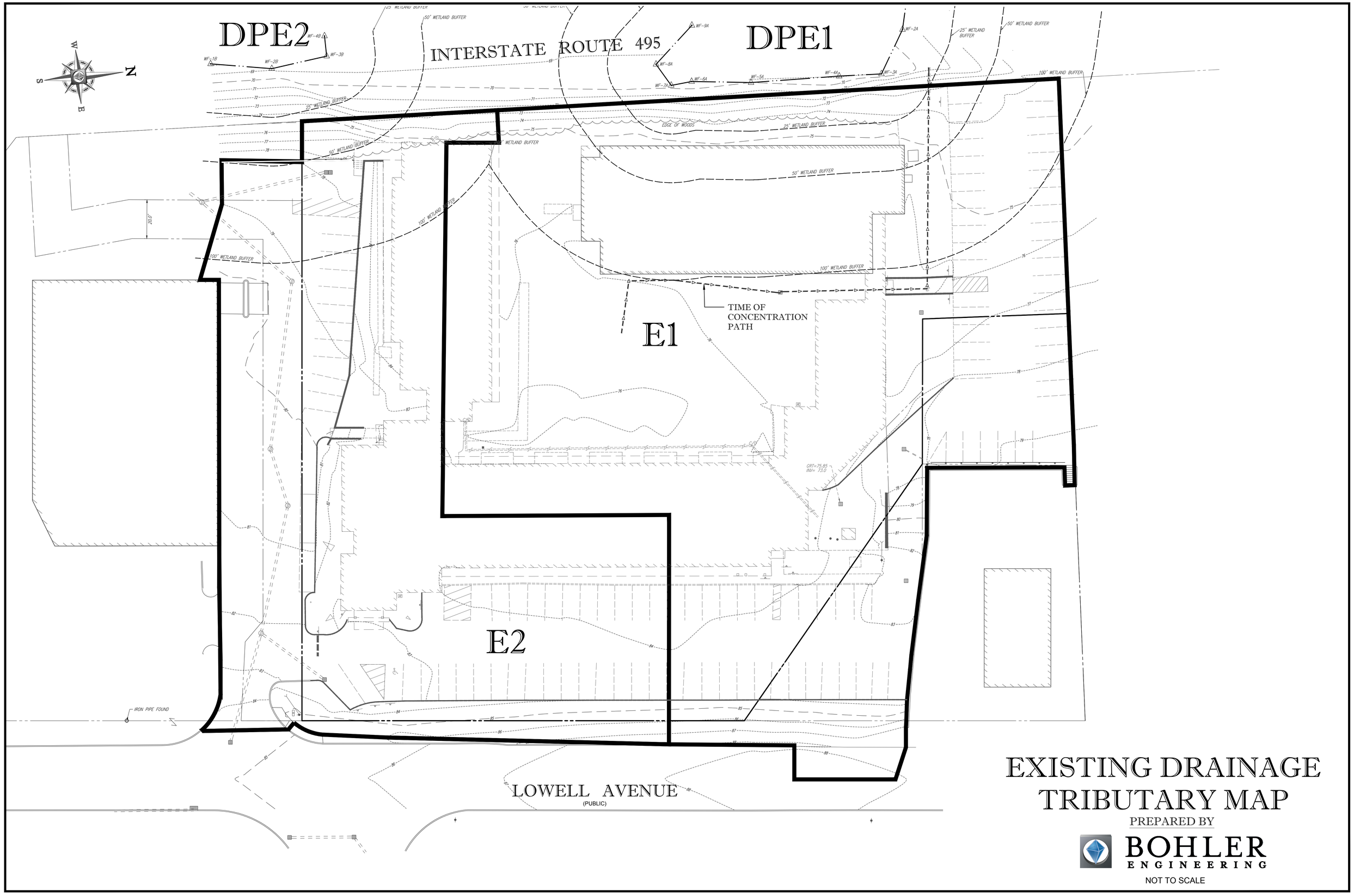
MAP NUMBER
25009C0088F

EFFECTIVE DATE
JULY 3, 2012

Federal Emergency Management Agency

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

Appendix 3

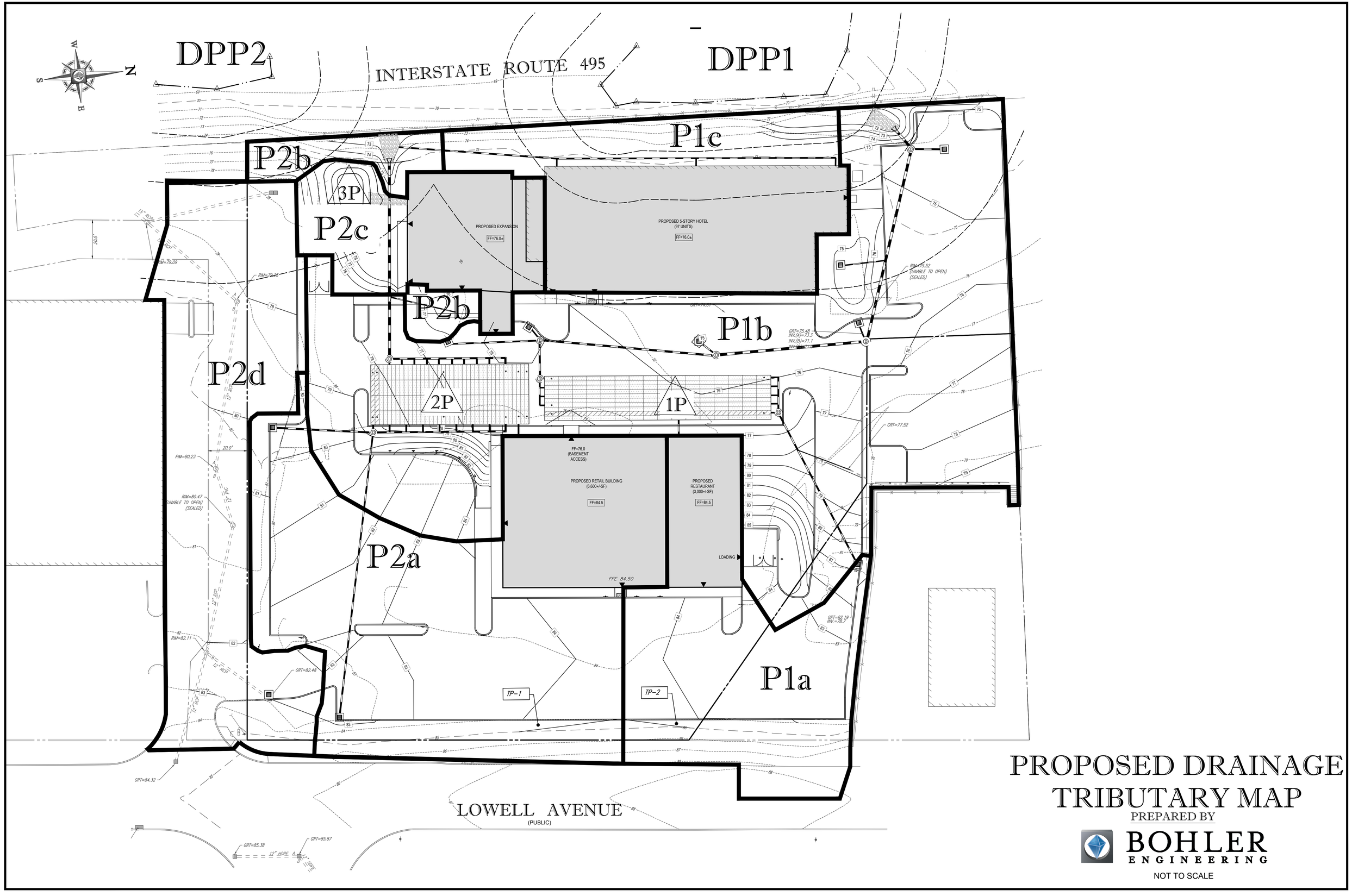


EXISTING DRAINAGE TRIBUTARY MAP

PREPARED BY

BOHLER ENGINEERING

NOT TO SCALE

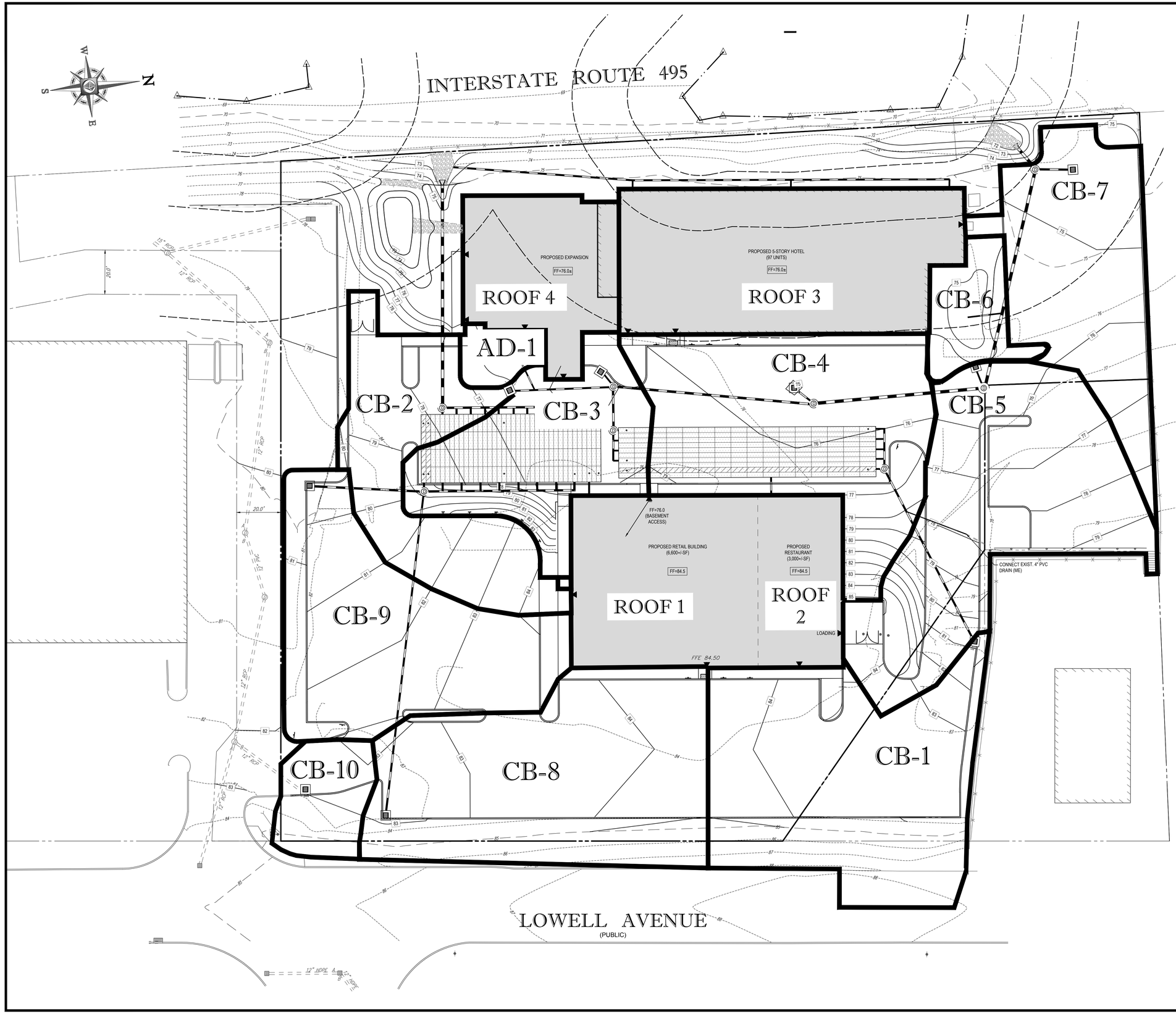


PROPOSED DRAINAGE TRIBUTARY MAP

PREPARED BY

BOHLER ENGINEERING

NOT TO SCALE



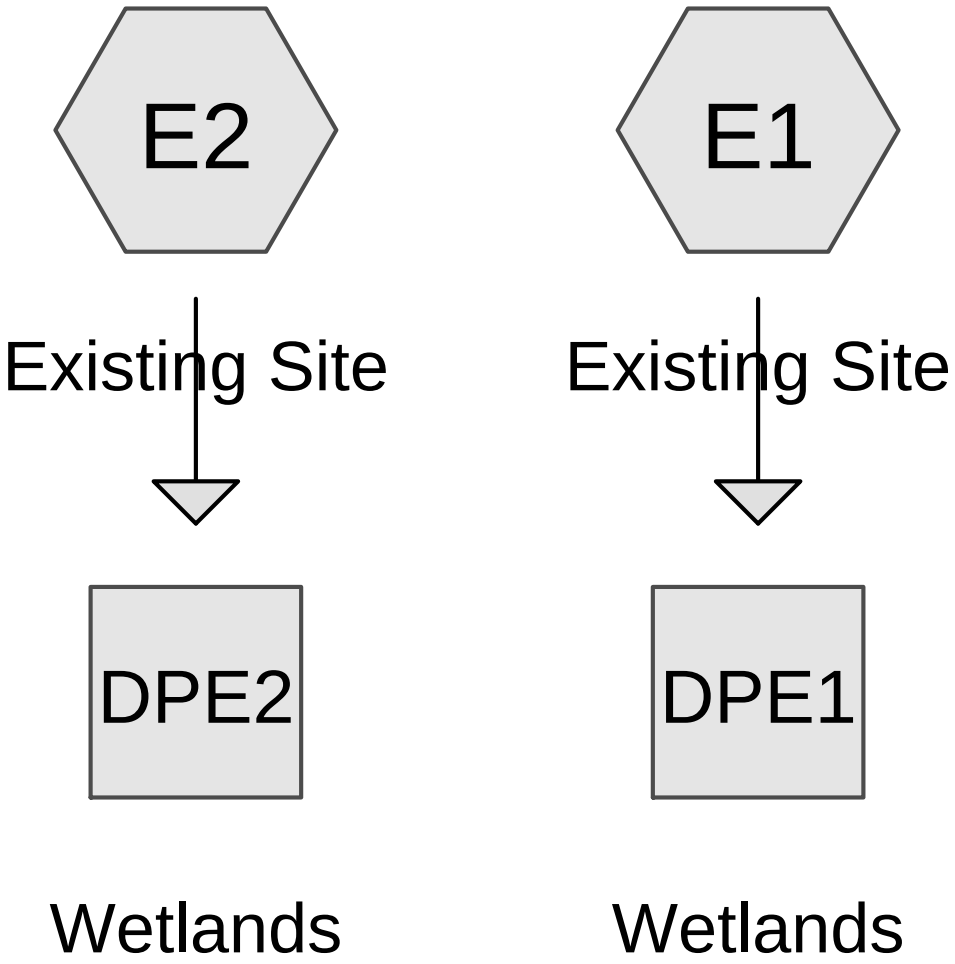
PROPOSED CATCH BASIN DRAINAGE TRIBUTARY MAP

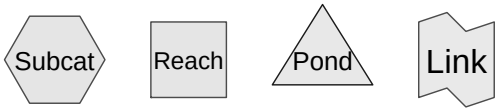
PREPARED BY

BOHLER ENGINEERING

NOT TO SCALE

Appendix 4





Routing Diagram for W1511212-2016-08-30
Prepared by Bohler Engineering, Printed 9/1/2016
HydroCAD® 10.00 s/n 08311 © 2013 HydroCAD Software Solutions LLC

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.957	61	>75% Grass cover, Good, HSG B (E1, E2)
1.270	98	Paved parking, HSG B (E1, E2)
0.810	98	Roofs, HSG B (E1, E2)
3.036	**86**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
3.036	HSG B	E1, E2
0.000	HSG C	
0.000	HSG D	
0.000	Other	
3.036		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.957	0.000	0.000	0.000	0.957	>75% Grass cover, Good	E1, E2
0.000	1.270	0.000	0.000	0.000	1.270	Paved parking	E1, E2
0.000	0.810	0.000	0.000	0.000	0.810	Roofs	E1, E2
0.000	**3.036**	**0.000**	**0.000**	**0.000**	**3.036**	**TOTAL AREA**	

Pipe Listing (selected nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	E1	0.00	0.00	189.0	0.0077	0.012	12.0	0.0	0.0

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

Subcatchment E1: Existing Site Runoff Area=82,616 sf 61.40% Impervious Runoff Depth=1.67"
Flow Length=294' Tc=8.6 min CN=84 Runoff=3.38 cfs 0.263 af

Subcatchment E2: Existing Site Runoff Area=49,634 sf 80.31% Impervious Runoff Depth=2.24"
Tc=6.0 min CN=91 Runoff=2.94 cfs 0.213 af

Reach DPE1: Wetlands Inflow=3.38 cfs 0.263 af
Outflow=3.38 cfs 0.263 af

Reach DPE2: Wetlands Inflow=2.94 cfs 0.213 af
Outflow=2.94 cfs 0.213 af

Total Runoff Area = 3.036 ac Runoff Volume = 0.476 af Average Runoff Depth = 1.88"
31.51% Pervious = 0.957 ac 68.49% Impervious = 2.079 ac

Summary for Subcatchment E1: Existing Site

Runoff = 3.38 cfs @ 12.12 hrs, Volume= 0.263 af, Depth= 1.67"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Description
26,463	98	Paved parking, HSG B
24,260	98	Roofs, HSG B
31,893	61	>75% Grass cover, Good, HSG B
82,616	84	Weighted Average
31,893		38.60% Pervious Area
50,723		61.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0120	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.10"
0.9	55	0.0234	1.07		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.7	189	0.0077	4.31	3.39	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
8.6	294	Total			

Summary for Subcatchment E2: Existing Site

Runoff = 2.94 cfs @ 12.09 hrs, Volume= 0.213 af, Depth= 2.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Description
28,842	98	Paved parking, HSG B
11,017	98	Roofs, HSG B
9,775	61	>75% Grass cover, Good, HSG B
49,634	91	Weighted Average
9,775		19.69% Pervious Area
39,859		80.31% Impervious Area

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

Summary for Reach DPE1: Wetlands

Inflow Area = 1.897 ac, 61.40% Impervious, Inflow Depth = 1.67" for 2-Year event
Inflow = 3.38 cfs @ 12.12 hrs, Volume= 0.263 af
Outflow = 3.38 cfs @ 12.12 hrs, Volume= 0.263 af, Atten= 0%, Lag= 0.0 min

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

Summary for Reach DPE2: Wetlands

Inflow Area = 1.139 ac, 80.31% Impervious, Inflow Depth = 2.24" for 2-Year event
Inflow = 2.94 cfs @ 12.09 hrs, Volume= 0.213 af
Outflow = 2.94 cfs @ 12.09 hrs, Volume= 0.213 af, Atten= 0%, Lag= 0.0 min

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

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

Subcatchment E1: Existing Site Runoff Area=82,616 sf 61.40% Impervious Runoff Depth=3.31"
Flow Length=294' Tc=8.6 min CN=84 Runoff=6.68 cfs 0.523 af

Subcatchment E2: Existing Site Runoff Area=49,634 sf 80.31% Impervious Runoff Depth=4.02"
Tc=6.0 min CN=91 Runoff=5.14 cfs 0.382 af

Reach DPE1: Wetlands Inflow=6.68 cfs 0.523 af
Outflow=6.68 cfs 0.523 af

Reach DPE2: Wetlands Inflow=5.14 cfs 0.382 af
Outflow=5.14 cfs 0.382 af

Total Runoff Area = 3.036 ac Runoff Volume = 0.904 af Average Runoff Depth = 3.57"
31.51% Pervious = 0.957 ac 68.49% Impervious = 2.079 ac

Summary for Subcatchment E1: Existing Site

Runoff = 6.68 cfs @ 12.12 hrs, Volume= 0.523 af, Depth= 3.31"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Description
26,463	98	Paved parking, HSG B
24,260	98	Roofs, HSG B
31,893	61	>75% Grass cover, Good, HSG B
82,616	84	Weighted Average
31,893		38.60% Pervious Area
50,723		61.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0120	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.10"
0.9	55	0.0234	1.07		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.7	189	0.0077	4.31	3.39	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
8.6	294	Total			

Summary for Subcatchment E2: Existing Site

Runoff = 5.14 cfs @ 12.08 hrs, Volume= 0.382 af, Depth= 4.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Description
28,842	98	Paved parking, HSG B
11,017	98	Roofs, HSG B
9,775	61	>75% Grass cover, Good, HSG B
49,634	91	Weighted Average
9,775		19.69% Pervious Area
39,859		80.31% Impervious Area

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

Summary for Reach DPE1: Wetlands

Inflow Area = 1.897 ac, 61.40% Impervious, Inflow Depth = 3.31" for 10-Year event
Inflow = 6.68 cfs @ 12.12 hrs, Volume= 0.523 af
Outflow = 6.68 cfs @ 12.12 hrs, Volume= 0.523 af, Atten= 0%, Lag= 0.0 min

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

Summary for Reach DPE2: Wetlands

Inflow Area = 1.139 ac, 80.31% Impervious, Inflow Depth = 4.02" for 10-Year event
Inflow = 5.14 cfs @ 12.08 hrs, Volume= 0.382 af
Outflow = 5.14 cfs @ 12.08 hrs, Volume= 0.382 af, Atten= 0%, Lag= 0.0 min

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

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

Subcatchment E1: Existing Site Runoff Area=82,616 sf 61.40% Impervious Runoff Depth=4.38"
Flow Length=294' Tc=8.6 min CN=84 Runoff=8.77 cfs 0.693 af

Subcatchment E2: Existing Site Runoff Area=49,634 sf 80.31% Impervious Runoff Depth=5.15"
Tc=6.0 min CN=91 Runoff=6.50 cfs 0.489 af

Reach DPE1: Wetlands Inflow=8.77 cfs 0.693 af
Outflow=8.77 cfs 0.693 af

Reach DPE2: Wetlands Inflow=6.50 cfs 0.489 af
Outflow=6.50 cfs 0.489 af

Total Runoff Area = 3.036 ac Runoff Volume = 1.182 af Average Runoff Depth = 4.67"
31.51% Pervious = 0.957 ac 68.49% Impervious = 2.079 ac

Summary for Subcatchment E1: Existing Site

Runoff = 8.77 cfs @ 12.12 hrs, Volume= 0.693 af, Depth= 4.38"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Description
26,463	98	Paved parking, HSG B
24,260	98	Roofs, HSG B
31,893	61	>75% Grass cover, Good, HSG B
82,616	84	Weighted Average
31,893		38.60% Pervious Area
50,723		61.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0120	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.10"
0.9	55	0.0234	1.07		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.7	189	0.0077	4.31	3.39	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
8.6	294	Total			

Summary for Subcatchment E2: Existing Site

Runoff = 6.50 cfs @ 12.08 hrs, Volume= 0.489 af, Depth= 5.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Description
28,842	98	Paved parking, HSG B
11,017	98	Roofs, HSG B
9,775	61	>75% Grass cover, Good, HSG B
49,634	91	Weighted Average
9,775		19.69% Pervious Area
39,859		80.31% Impervious Area

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

Summary for Reach DPE1: Wetlands

Inflow Area = 1.897 ac, 61.40% Impervious, Inflow Depth = 4.38" for 25-Year event
Inflow = 8.77 cfs @ 12.12 hrs, Volume= 0.693 af
Outflow = 8.77 cfs @ 12.12 hrs, Volume= 0.693 af, Atten= 0%, Lag= 0.0 min

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

Summary for Reach DPE2: Wetlands

Inflow Area = 1.139 ac, 80.31% Impervious, Inflow Depth = 5.15" for 25-Year event
Inflow = 6.50 cfs @ 12.08 hrs, Volume= 0.489 af
Outflow = 6.50 cfs @ 12.08 hrs, Volume= 0.489 af, Atten= 0%, Lag= 0.0 min

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

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

Subcatchment E1: Existing Site Runoff Area=82,616 sf 61.40% Impervious Runoff Depth=6.09"
Flow Length=294' Tc=8.6 min CN=84 Runoff=12.01 cfs 0.962 af

Subcatchment E2: Existing Site Runoff Area=49,634 sf 80.31% Impervious Runoff Depth=6.91"
Tc=6.0 min CN=91 Runoff=8.57 cfs 0.657 af

Reach DPE1: Wetlands Inflow=12.01 cfs 0.962 af
Outflow=12.01 cfs 0.962 af

Reach DPE2: Wetlands Inflow=8.57 cfs 0.657 af
Outflow=8.57 cfs 0.657 af

Total Runoff Area = 3.036 ac Runoff Volume = 1.618 af Average Runoff Depth = 6.40"
31.51% Pervious = 0.957 ac 68.49% Impervious = 2.079 ac

Summary for Subcatchment E1: Existing Site

Runoff = 12.01 cfs @ 12.12 hrs, Volume= 0.962 af, Depth= 6.09"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Description
26,463	98	Paved parking, HSG B
24,260	98	Roofs, HSG B
31,893	61	>75% Grass cover, Good, HSG B
82,616	84	Weighted Average
31,893		38.60% Pervious Area
50,723		61.40% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
7.0	50	0.0120	0.12		**Sheet Flow,** Grass: Short n= 0.150 P2= 3.10"
0.9	55	0.0234	1.07		**Shallow Concentrated Flow,** Short Grass Pasture Kv= 7.0 fps
0.7	189	0.0077	4.31	3.39	**Pipe Channel,** 12.0" Round Area= 0.8 sf Perim= 3.1' r= 0.25' n= 0.012 Concrete pipe, finished
8.6	294	Total			

Summary for Subcatchment E2: Existing Site

Runoff = 8.57 cfs @ 12.08 hrs, Volume= 0.657 af, Depth= 6.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Description
28,842	98	Paved parking, HSG B
11,017	98	Roofs, HSG B
9,775	61	>75% Grass cover, Good, HSG B
49,634	91	Weighted Average
9,775		19.69% Pervious Area
39,859		80.31% Impervious Area

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

Summary for Reach DPE1: Wetlands

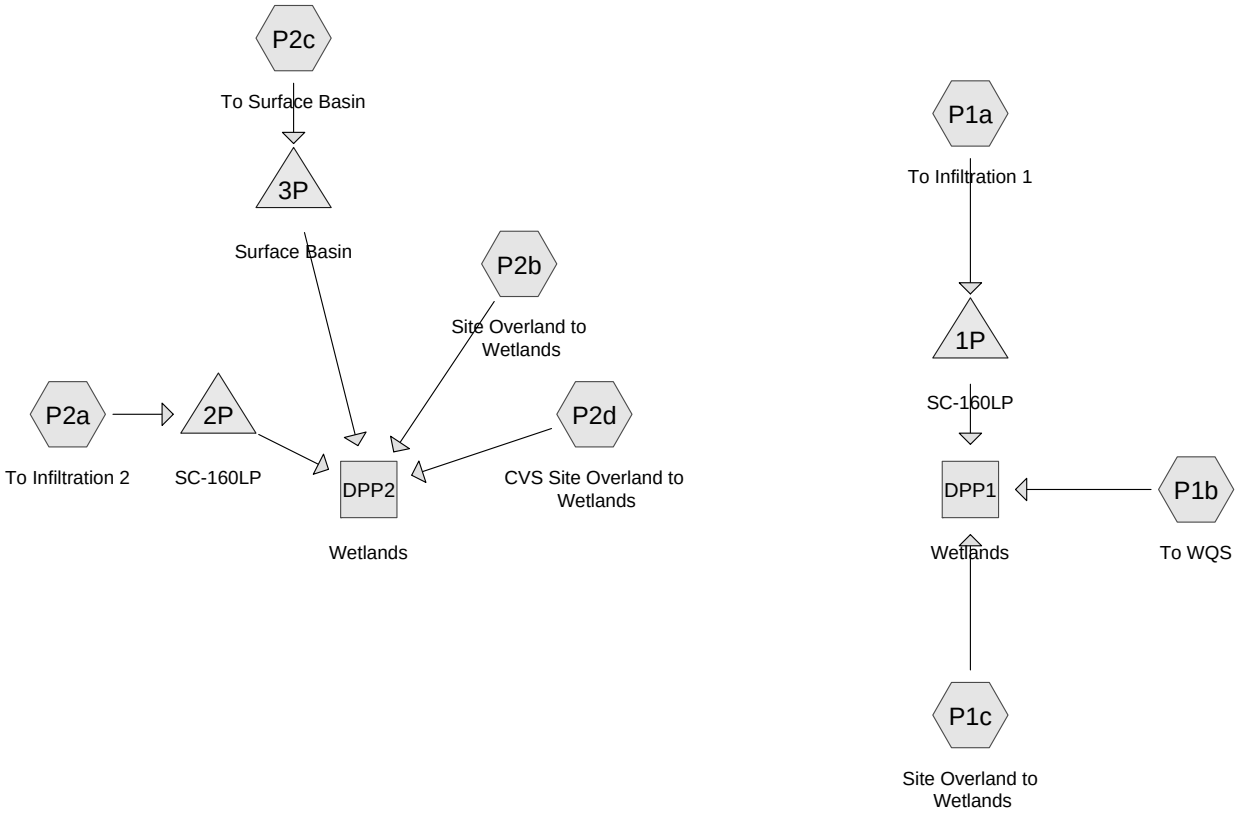
Inflow Area = 1.897 ac, 61.40% Impervious, Inflow Depth = 6.09" for 100-Year event
Inflow = 12.01 cfs @ 12.12 hrs, Volume= 0.962 af
Outflow = 12.01 cfs @ 12.12 hrs, Volume= 0.962 af, Atten= 0%, Lag= 0.0 min

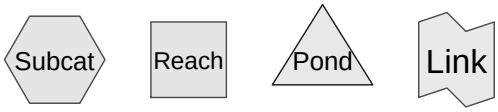
Routing by Stor-Ind+Trans method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs

Summary for Reach DPE2: Wetlands

Inflow Area = 1.139 ac, 80.31% Impervious, Inflow Depth = 6.91" for 100-Year event
Inflow = 8.57 cfs @ 12.08 hrs, Volume= 0.657 af
Outflow = 8.57 cfs @ 12.08 hrs, Volume= 0.657 af, Atten= 0%, Lag= 0.0 min

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





Routing Diagram for W1511212-2016-10-20
Prepared by Bohler Engineering, Printed 10/19/2016
HydroCAD® 10.00-18 s/n 08311 © 2016 HydroCAD Software Solutions LLC

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.698	61	>75% Grass cover, Good, HSG B (P1a, P1b, P1c, P2a, P2b, P2c, P2d)
1.712	98	Paved parking, HSG B (P1a, P1b, P2a, P2d)
0.551	98	Roofs, HSG B (P1a, P1c, P2a, P2c)
0.074	98	Unconnected pavement, HSG B (P1a, P1b, P2a, P2b, P2c)
3.036	**89**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
3.036	HSG B	P1a, P1b, P1c, P2a, P2b, P2c, P2d
0.000	HSG C	
0.000	HSG D	
0.000	Other	
3.036		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.698	0.000	0.000	0.000	0.698	>75% Grass cover, Good	P1a, P1b, P1c, P2a, P2b, P2c, P2d
0.000	1.712	0.000	0.000	0.000	1.712	Paved parking	P1a, P1b, P2a, P2d
0.000	0.551	0.000	0.000	0.000	0.551	Roofs	P1a, P1c, P2a, P2c
0.000	0.074	0.000	0.000	0.000	0.074	Unconnected pavement	P1a, P1b, P2a, P2b, P2c
0.000	**3.036**	**0.000**	**0.000**	**0.000**	**3.036**	**TOTAL AREA**	

Pipe Listing (selected nodes)

Line#	Node Number	In-Invert (feet)	Out-Invert (feet)	Length (feet)	Slope (ft/ft)	n	Diam/Width (inches)	Height (inches)	Inside-Fill (inches)
1	1P	73.60	73.20	16.0	0.0250	0.012	10.0	0.0	0.0
2	2P	73.65	73.00	106.0	0.0061	0.013	15.0	0.0	0.0

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

Subcatchment P1a: To Infiltration 1 Runoff Area=14,456 sf 77.59% Impervious Runoff Depth=0.32"
Tc=6.0 min CN=90 Runoff=0.12 cfs 0.009 af

Subcatchment P1b: To WQS Runoff Area=45,819 sf 79.49% Impervious Runoff Depth=0.32"
Tc=6.0 min CN=90 Runoff=0.37 cfs 0.028 af

Subcatchment P1c: Site Overland to Runoff Area=15,283 sf 64.03% Impervious Runoff Depth=0.17"
Tc=6.0 min CN=85 Runoff=0.05 cfs 0.005 af

Subcatchment P2a: To Infiltration 2 Runoff Area=27,614 sf 81.09% Impervious Runoff Depth=0.36"
Tc=6.0 min CN=91 Runoff=0.26 cfs 0.019 af

Subcatchment P2b: Site Overland to Runoff Area=2,716 sf 18.56% Impervious Runoff Depth=0.00"
Tc=6.0 min UI Adjusted CN=64 Runoff=0.00 cfs 0.000 af

Subcatchment P2c: To Surface Basin Runoff Area=7,960 sf 60.52% Impervious Runoff Depth=0.13"
Tc=6.0 min CN=83 Runoff=0.02 cfs 0.002 af

Subcatchment P2d: CVS Site Overland to Runoff Area=18,402 sf 90.70% Impervious Runoff Depth=0.56"
Tc=6.0 min CN=95 Runoff=0.28 cfs 0.020 af

Reach DPP1: Wetlands Inflow=0.43 cfs 0.033 af
Outflow=0.43 cfs 0.033 af

Reach DPP2: Wetlands Inflow=0.28 cfs 0.020 af
Outflow=0.28 cfs 0.020 af

Pond 1P: SC-160LP Peak Elev=72.54' Storage=0.001 af Inflow=0.12 cfs 0.009 af
Discarded=0.06 cfs 0.009 af Primary=0.00 cfs 0.000 af Outflow=0.06 cfs 0.009 af

Pond 2P: SC-160LP Peak Elev=73.19' Storage=0.004 af Inflow=0.26 cfs 0.019 af
Discarded=0.07 cfs 0.019 af Primary=0.00 cfs 0.000 af Outflow=0.07 cfs 0.019 af

Pond 3P: Surface Basin Peak Elev=73.04' Storage=12 cf Inflow=0.02 cfs 0.002 af
Discarded=0.01 cfs 0.002 af Primary=0.00 cfs 0.000 af Outflow=0.01 cfs 0.002 af

Total Runoff Area = 3.036 ac Runoff Volume = 0.083 af Average Runoff Depth = 0.33"
23.00% Pervious = 0.698 ac 77.00% Impervious = 2.338 ac

Summary for Subcatchment P1a: To Infiltration 1

Runoff = 0.12 cfs @ 12.10 hrs, Volume= 0.009 af, Depth= 0.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 1-Inch Rainfall=1.00"

Area (sf)	CN	Description
7,907	98	Paved parking, HSG B
3,239	61	>75% Grass cover, Good, HSG B
307	98	Unconnected pavement, HSG B
3,003	98	Roofs, HSG B
14,456	90	Weighted Average
3,239		22.41% Pervious Area
11,217		77.59% Impervious Area
307		2.74% Unconnected

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

Summary for Subcatchment P1b: To WQS

Runoff = 0.37 cfs @ 12.10 hrs, Volume= 0.028 af, Depth= 0.32"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 1-Inch Rainfall=1.00"

Area (sf)	CN	Description
34,679	98	Paved parking, HSG B
9,399	61	>75% Grass cover, Good, HSG B
1,741	98	Unconnected pavement, HSG B
45,819	90	Weighted Average
9,399		20.51% Pervious Area
36,420		79.49% Impervious Area
1,741		4.78% Unconnected

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

Summary for Subcatchment P1c: Site Overland to Wetlands

Runoff = 0.05 cfs @ 12.11 hrs, Volume= 0.005 af, Depth= 0.17"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 1-Inch Rainfall=1.00"

Area (sf)	CN	Description
5,497	61	>75% Grass cover, Good, HSG B
9,786	98	Roofs, HSG B
15,283	85	Weighted Average
5,497		35.97% Pervious Area
9,786		64.03% Impervious Area

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

Summary for Subcatchment P2a: To Infiltration 2

Runoff = 0.26 cfs @ 12.09 hrs, Volume= 0.019 af, Depth= 0.36"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 1-Inch Rainfall=1.00"

Area (sf)	CN	Description
15,313	98	Paved parking, HSG B
5,221	61	>75% Grass cover, Good, HSG B
489	98	Unconnected pavement, HSG B
6,591	98	Roofs, HSG B
27,614	91	Weighted Average
5,221		18.91% Pervious Area
22,393		81.09% Impervious Area
489		2.18% Unconnected

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

Summary for Subcatchment P2b: Site Overland to Wetlands

Runoff = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 1-Inch Rainfall=1.00"

Area (sf)	CN	Adj	Description
2,212	61		>75% Grass cover, Good, HSG B
504	98		Unconnected pavement, HSG B
2,716	68	64	Weighted Average, UI Adjusted
2,212			81.44% Pervious Area
504			18.56% Impervious Area
504			100.00% Unconnected

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

Summary for Subcatchment P2c: To Surface Basin

Runoff = 0.02 cfs @ 12.13 hrs, Volume= 0.002 af, Depth= 0.13"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 1-Inch Rainfall=1.00"

Area (sf)	CN	Description
4,619	98	Roofs, HSG B
3,143	61	>75% Grass cover, Good, HSG B
198	98	Unconnected pavement, HSG B
7,960	83	Weighted Average
3,143		39.48% Pervious Area
4,817		60.52% Impervious Area
198		4.11% Unconnected

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

Summary for Subcatchment P2d: CVS Site Overland to Wetlands

Runoff = 0.28 cfs @ 12.09 hrs, Volume= 0.020 af, Depth= 0.56"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 1-Inch Rainfall=1.00"

Area (sf)	CN	Description
16,691	98	Paved parking, HSG B
1,711	61	>75% Grass cover, Good, HSG B
18,402	95	Weighted Average
1,711		9.30% Pervious Area
16,691		90.70% Impervious Area

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

Summary for Reach DPP1: Wetlands

Inflow Area = 1.735 ac, 76.00% Impervious, Inflow Depth = 0.23" for 1-Inch event
Inflow = 0.43 cfs @ 12.10 hrs, Volume= 0.033 af
Outflow = 0.43 cfs @ 12.10 hrs, Volume= 0.033 af, Atten= 0%, Lag= 0.0 min

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

Summary for Reach DPP2: Wetlands

Inflow Area = 1.301 ac, 78.33% Impervious, Inflow Depth = 0.18" for 1-Inch event
Inflow = 0.28 cfs @ 12.09 hrs, Volume= 0.020 af
Outflow = 0.28 cfs @ 12.09 hrs, Volume= 0.020 af, Atten= 0%, Lag= 0.0 min

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

Summary for Pond 1P: SC-160LP

Inflow Area = 0.332 ac, 77.59% Impervious, Inflow Depth = 0.32" for 1-Inch event
Inflow = 0.12 cfs @ 12.10 hrs, Volume= 0.009 af
Outflow = 0.06 cfs @ 12.26 hrs, Volume= 0.009 af, Atten= 45%, Lag= 9.9 min
Discarded = 0.06 cfs @ 12.26 hrs, Volume= 0.009 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 72.54' @ 12.26 hrs Surf.Area= 0.061 ac Storage= 0.001 af

Plug-Flow detention time= 6.5 min calculated for 0.009 af (100% of inflow)
Center-of-Mass det. time= 6.5 min (869.4 - 862.8)

Volume	Invert	Avail.Storage	Storage Description
#1A	72.50'	0.039 af	**22.83'W x 116.39'L x 2.00'H Field A** 0.122 af Overall - 0.025 af Embedded = 0.097 af x 40.0% Voids
#2A	73.00'	0.025 af	**ADS_StormTech SC-160LP +Cap** x 160 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 10 Rows of 16 Chambers
		0.064 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	72.50'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	73.60'	**10.0" Round Culvert** L= 16.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.60' / 73.20' S= 0.0250 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.55 sf

Discarded OutFlow Max=0.06 cfs @ 12.26 hrs HW=72.54' (Free Discharge)
└**1=Exfiltration** (Controls 0.06 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=72.50' (Free Discharge)
└**2=Culvert** (Controls 0.00 cfs)

Summary for Pond 2P: SC-160LP

Inflow Area = 0.634 ac, 81.09% Impervious, Inflow Depth = 0.36" for 1-Inch event
Inflow = 0.26 cfs @ 12.09 hrs, Volume= 0.019 af
Outflow = 0.07 cfs @ 12.51 hrs, Volume= 0.019 af, Atten= 74%, Lag= 25.1 min
Discarded = 0.07 cfs @ 12.51 hrs, Volume= 0.019 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 73.19' @ 12.51 hrs Surf.Area= 0.058 ac Storage= 0.004 af

Plug-Flow detention time= 19.1 min calculated for 0.019 af (100% of inflow)
Center-of-Mass det. time= 19.1 min (874.8 - 855.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	73.00'	0.037 af	**81.17'W x 30.95'L x 2.00'H Field A** 0.115 af Overall - 0.024 af Embedded = 0.091 af x 40.0% Voids
#2A	73.50'	0.024 af	**ADS_StormTech SC-160LP +Cap** x 152 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 38 Rows of 4 Chambers
		0.060 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.50'
#2	Primary	73.65'	**15.0" Round Culvert** L= 106.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.65' / 73.00' S= 0.0061 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Discarded OutFlow Max=0.07 cfs @ 12.51 hrs HW=73.19' (Free Discharge)
└**1=Exfiltration** (Controls 0.07 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=73.00' (Free Discharge)
└**2=Culvert** (Controls 0.00 cfs)

Summary for Pond 3P: Surface Basin

Inflow Area = 0.183 ac, 60.52% Impervious, Inflow Depth = 0.13" for 1-Inch event
Inflow = 0.02 cfs @ 12.13 hrs, Volume= 0.002 af
Outflow = 0.01 cfs @ 12.53 hrs, Volume= 0.002 af, Atten= 58%, Lag= 24.5 min
Discarded = 0.01 cfs @ 12.53 hrs, Volume= 0.002 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 73.04' @ 12.53 hrs Surf.Area= 296 sf Storage= 12 cf

Plug-Flow detention time= 16.2 min calculated for 0.002 af (100% of inflow)

Center-of-Mass det. time= 16.2 min (934.3 - 918.0)

Volume	Invert	Avail.Storage	Storage Description
#1	73.00'	1,254 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
73.00	285	0	0
74.00	566	426	426
75.00	1,091	829	1,254

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	74.90'	**20.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.01 cfs @ 12.53 hrs HW=73.04' (Free Discharge)
└**1=Exfiltration** (Controls 0.01 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=73.00' (Free Discharge)
└**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

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

Subcatchment P1a: To Infiltration 1 Runoff Area=14,456 sf 77.59% Impervious Runoff Depth=2.15"
Tc=6.0 min CN=90 Runoff=0.83 cfs 0.059 af

Subcatchment P1b: To WQS Runoff Area=45,819 sf 79.49% Impervious Runoff Depth=2.15"
Tc=6.0 min CN=90 Runoff=2.62 cfs 0.188 af

Subcatchment P1c: Site Overland to Runoff Area=15,283 sf 64.03% Impervious Runoff Depth=1.74"
Tc=6.0 min CN=85 Runoff=0.72 cfs 0.051 af

Subcatchment P2a: To Infiltration 2 Runoff Area=27,614 sf 81.09% Impervious Runoff Depth=2.24"
Tc=6.0 min CN=91 Runoff=1.64 cfs 0.118 af

Subcatchment P2b: Site Overland to Runoff Area=2,716 sf 18.56% Impervious Runoff Depth=0.55"
Tc=6.0 min UI Adjusted CN=64 Runoff=0.03 cfs 0.003 af

Subcatchment P2c: To Surface Basin Runoff Area=7,960 sf 60.52% Impervious Runoff Depth=1.59"
Tc=6.0 min CN=83 Runoff=0.34 cfs 0.024 af

Subcatchment P2d: CVS Site Overland to Runoff Area=18,402 sf 90.70% Impervious Runoff Depth=2.63"
Tc=6.0 min CN=95 Runoff=1.23 cfs 0.092 af

Reach DPP1: Wetlands Inflow=3.34 cfs 0.239 af
Outflow=3.34 cfs 0.239 af

Reach DPP2: Wetlands Inflow=1.43 cfs 0.132 af
Outflow=1.43 cfs 0.132 af

Pond 1P: SC-160LP Peak Elev=73.21' Storage=0.022 af Inflow=0.83 cfs 0.059 af
Discarded=0.09 cfs 0.059 af Primary=0.00 cfs 0.000 af Outflow=0.09 cfs 0.059 af

Pond 2P: SC-160LP Peak Elev=74.05' Storage=0.035 af Inflow=1.64 cfs 0.118 af
Discarded=0.10 cfs 0.082 af Primary=0.61 cfs 0.036 af Outflow=0.71 cfs 0.118 af

Pond 3P: Surface Basin Peak Elev=74.18' Storage=535 cf Inflow=0.34 cfs 0.024 af
Discarded=0.02 cfs 0.024 af Primary=0.00 cfs 0.000 af Outflow=0.02 cfs 0.024 af

Total Runoff Area = 3.036 ac Runoff Volume = 0.537 af Average Runoff Depth = 2.12"
23.00% Pervious = 0.698 ac 77.00% Impervious = 2.338 ac

Summary for Subcatchment P1a: To Infiltration 1

Runoff = 0.83 cfs @ 12.09 hrs, Volume= 0.059 af, Depth= 2.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Description
7,907	98	Paved parking, HSG B
3,239	61	>75% Grass cover, Good, HSG B
307	98	Unconnected pavement, HSG B
3,003	98	Roofs, HSG B
14,456	90	Weighted Average
3,239		22.41% Pervious Area
11,217		77.59% Impervious Area
307		2.74% Unconnected

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

Summary for Subcatchment P1b: To WQS

Runoff = 2.62 cfs @ 12.09 hrs, Volume= 0.188 af, Depth= 2.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Description
34,679	98	Paved parking, HSG B
9,399	61	>75% Grass cover, Good, HSG B
1,741	98	Unconnected pavement, HSG B
45,819	90	Weighted Average
9,399		20.51% Pervious Area
36,420		79.49% Impervious Area
1,741		4.78% Unconnected

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

Summary for Subcatchment P1c: Site Overland to Wetlands

Runoff = 0.72 cfs @ 12.09 hrs, Volume= 0.051 af, Depth= 1.74"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Description
5,497	61	>75% Grass cover, Good, HSG B
9,786	98	Roofs, HSG B
15,283	85	Weighted Average
5,497		35.97% Pervious Area
9,786		64.03% Impervious Area

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

Summary for Subcatchment P2a: To Infiltration 2

Runoff = 1.64 cfs @ 12.09 hrs, Volume= 0.118 af, Depth= 2.24"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Description
15,313	98	Paved parking, HSG B
5,221	61	>75% Grass cover, Good, HSG B
489	98	Unconnected pavement, HSG B
6,591	98	Roofs, HSG B
27,614	91	Weighted Average
5,221		18.91% Pervious Area
22,393		81.09% Impervious Area
489		2.18% Unconnected

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

Summary for Subcatchment P2b: Site Overland to Wetlands

Runoff = 0.03 cfs @ 12.11 hrs, Volume= 0.003 af, Depth= 0.55"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Adj	Description
2,212	61		>75% Grass cover, Good, HSG B
504	98		Unconnected pavement, HSG B
2,716	68	64	Weighted Average, UI Adjusted
2,212			81.44% Pervious Area
504			18.56% Impervious Area
504			100.00% Unconnected

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

Summary for Subcatchment P2c: To Surface Basin

Runoff = 0.34 cfs @ 12.09 hrs, Volume= 0.024 af, Depth= 1.59"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Description
4,619	98	Roofs, HSG B
3,143	61	>75% Grass cover, Good, HSG B
198	98	Unconnected pavement, HSG B
7,960	83	Weighted Average
3,143		39.48% Pervious Area
4,817		60.52% Impervious Area
198		4.11% Unconnected

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

Summary for Subcatchment P2d: CVS Site Overland to Wetlands

Runoff = 1.23 cfs @ 12.08 hrs, Volume= 0.092 af, Depth= 2.63"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 2-Year Rainfall=3.18"

Area (sf)	CN	Description
16,691	98	Paved parking, HSG B
1,711	61	>75% Grass cover, Good, HSG B
18,402	95	Weighted Average
1,711		9.30% Pervious Area
16,691		90.70% Impervious Area

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

Summary for Reach DPP1: Wetlands

Inflow Area = 1.735 ac, 76.00% Impervious, Inflow Depth = 1.66" for 2-Year event
Inflow = 3.34 cfs @ 12.09 hrs, Volume= 0.239 af
Outflow = 3.34 cfs @ 12.09 hrs, Volume= 0.239 af, Atten= 0%, Lag= 0.0 min

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

Summary for Reach DPP2: Wetlands

Inflow Area = 1.301 ac, 78.33% Impervious, Inflow Depth = 1.21" for 2-Year event
Inflow = 1.43 cfs @ 12.11 hrs, Volume= 0.132 af
Outflow = 1.43 cfs @ 12.11 hrs, Volume= 0.132 af, Atten= 0%, Lag= 0.0 min

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

Summary for Pond 1P: SC-160LP

Inflow Area = 0.332 ac, 77.59% Impervious, Inflow Depth = 2.15" for 2-Year event
Inflow = 0.83 cfs @ 12.09 hrs, Volume= 0.059 af
Outflow = 0.09 cfs @ 12.81 hrs, Volume= 0.059 af, Atten= 89%, Lag= 43.6 min
Discarded = 0.09 cfs @ 12.81 hrs, Volume= 0.059 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 73.21' @ 12.81 hrs Surf.Area= 0.061 ac Storage= 0.022 af

Plug-Flow detention time= 88.1 min calculated for 0.059 af (100% of inflow)
Center-of-Mass det. time= 88.1 min (895.3 - 807.1)

Volume	Invert	Avail.Storage	Storage Description
#1A	72.50'	0.039 af	**22.83'W x 116.39'L x 2.00'H Field A** 0.122 af Overall - 0.025 af Embedded = 0.097 af x 40.0% Voids
#2A	73.00'	0.025 af	**ADS_StormTech SC-160LP +Cap** x 160 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 10 Rows of 16 Chambers
		0.064 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	72.50'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	73.60'	**10.0" Round Culvert** L= 16.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.60' / 73.20' S= 0.0250 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.55 sf

Discarded OutFlow Max=0.09 cfs @ 12.81 hrs HW=73.21' (Free Discharge)
└**1=Exfiltration** (Controls 0.09 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=72.50' (Free Discharge)
└**2=Culvert** (Controls 0.00 cfs)

Summary for Pond 2P: SC-160LP

Inflow Area = 0.634 ac, 81.09% Impervious, Inflow Depth = 2.24" for 2-Year event
Inflow = 1.64 cfs @ 12.09 hrs, Volume= 0.118 af
Outflow = 0.71 cfs @ 12.28 hrs, Volume= 0.118 af, Atten= 57%, Lag= 11.8 min
Discarded = 0.10 cfs @ 12.28 hrs, Volume= 0.082 af
Primary = 0.61 cfs @ 12.28 hrs, Volume= 0.036 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.05' @ 12.28 hrs Surf.Area= 0.058 ac Storage= 0.035 af

Plug-Flow detention time= 76.0 min calculated for 0.118 af (100% of inflow)
Center-of-Mass det. time= 76.0 min (878.7 - 802.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	73.00'	0.037 af	**81.17'W x 30.95'L x 2.00'H Field A** 0.115 af Overall - 0.024 af Embedded = 0.091 af x 40.0% Voids
#2A	73.50'	0.024 af	**ADS_StormTech SC-160LP +Cap** x 152 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 38 Rows of 4 Chambers
		0.060 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.50'
#2	Primary	73.65'	**15.0" Round Culvert** L= 106.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.65' / 73.00' S= 0.0061 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Discarded OutFlow Max=0.10 cfs @ 12.28 hrs HW=74.05' (Free Discharge)
└**1=Exfiltration** (Controls 0.10 cfs)

Primary OutFlow Max=0.61 cfs @ 12.28 hrs HW=74.05' (Free Discharge)
└**2=Culvert** (Barrel Controls 0.61 cfs @ 2.72 fps)

Summary for Pond 3P: Surface Basin

Inflow Area = 0.183 ac, 60.52% Impervious, Inflow Depth = 1.59" for 2-Year event
Inflow = 0.34 cfs @ 12.09 hrs, Volume= 0.024 af
Outflow = 0.02 cfs @ 14.19 hrs, Volume= 0.024 af, Atten= 94%, Lag= 126.0 min
Discarded = 0.02 cfs @ 14.19 hrs, Volume= 0.024 af
Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.18' @ 14.19 hrs Surf.Area= 660 sf Storage= 535 cf

Plug-Flow detention time= 316.6 min calculated for 0.024 af (100% of inflow)

Center-of-Mass det. time= 316.6 min (1,149.8 - 833.2)

Volume	Invert	Avail.Storage	Storage Description
#1	73.00'	1,254 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
73.00	285	0	0
74.00	566	426	426
75.00	1,091	829	1,254

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	74.90'	**20.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.02 cfs @ 14.19 hrs HW=74.18' (Free Discharge)
└**1=Exfiltration** (Controls 0.02 cfs)

Primary OutFlow Max=0.00 cfs @ 0.00 hrs HW=73.00' (Free Discharge)
└**2=Broad-Crested Rectangular Weir** (Controls 0.00 cfs)

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

Subcatchment P1a: To Infiltration 1 Runoff Area=14,456 sf 77.59% Impervious Runoff Depth=3.91"
Tc=6.0 min CN=90 Runoff=1.47 cfs 0.108 af

Subcatchment P1b: To WQS Runoff Area=45,819 sf 79.49% Impervious Runoff Depth=3.91"
Tc=6.0 min CN=90 Runoff=4.66 cfs 0.343 af

Subcatchment P1c: Site Overland to Runoff Area=15,283 sf 64.03% Impervious Runoff Depth=3.41"
Tc=6.0 min CN=85 Runoff=1.39 cfs 0.100 af

Subcatchment P2a: To Infiltration 2 Runoff Area=27,614 sf 81.09% Impervious Runoff Depth=4.02"
Tc=6.0 min CN=91 Runoff=2.86 cfs 0.212 af

Subcatchment P2b: Site Overland to Runoff Area=2,716 sf 18.56% Impervious Runoff Depth=1.61"
Tc=6.0 min UI Adjusted CN=64 Runoff=0.11 cfs 0.008 af

Subcatchment P2c: To Surface Basin Runoff Area=7,960 sf 60.52% Impervious Runoff Depth=3.21"
Tc=6.0 min CN=83 Runoff=0.68 cfs 0.049 af

Subcatchment P2d: CVS Site Overland to Runoff Area=18,402 sf 90.70% Impervious Runoff Depth=4.46"
Tc=6.0 min CN=95 Runoff=2.03 cfs 0.157 af

Reach DPP1: Wetlands Inflow=6.04 cfs 0.449 af
Outflow=6.04 cfs 0.449 af

Reach DPP2: Wetlands Inflow=3.99 cfs 0.271 af
Outflow=3.99 cfs 0.271 af

Pond 1P: SC-160LP Peak Elev=73.74' Storage=0.044 af Inflow=1.47 cfs 0.108 af
Discarded=0.11 cfs 0.102 af Primary=0.10 cfs 0.006 af Outflow=0.21 cfs 0.108 af

Pond 2P: SC-160LP Peak Elev=74.43' Storage=0.047 af Inflow=2.86 cfs 0.212 af
Discarded=0.12 cfs 0.108 af Primary=2.13 cfs 0.104 af Outflow=2.24 cfs 0.212 af

Pond 3P: Surface Basin Peak Elev=74.90' Storage=1,150 cf Inflow=0.68 cfs 0.049 af
Discarded=0.04 cfs 0.048 af Primary=0.02 cfs 0.001 af Outflow=0.06 cfs 0.049 af

Total Runoff Area = 3.036 ac Runoff Volume = 0.978 af Average Runoff Depth = 3.86"
23.00% Pervious = 0.698 ac 77.00% Impervious = 2.338 ac

Summary for Subcatchment P1a: To Infiltration 1

Runoff = 1.47 cfs @ 12.09 hrs, Volume= 0.108 af, Depth= 3.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Description
7,907	98	Paved parking, HSG B
3,239	61	>75% Grass cover, Good, HSG B
307	98	Unconnected pavement, HSG B
3,003	98	Roofs, HSG B
14,456	90	Weighted Average
3,239		22.41% Pervious Area
11,217		77.59% Impervious Area
307		2.74% Unconnected

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

Summary for Subcatchment P1b: To WQS

Runoff = 4.66 cfs @ 12.09 hrs, Volume= 0.343 af, Depth= 3.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Description
34,679	98	Paved parking, HSG B
9,399	61	>75% Grass cover, Good, HSG B
1,741	98	Unconnected pavement, HSG B
45,819	90	Weighted Average
9,399		20.51% Pervious Area
36,420		79.49% Impervious Area
1,741		4.78% Unconnected

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

Summary for Subcatchment P1c: Site Overland to Wetlands

Runoff = 1.39 cfs @ 12.09 hrs, Volume= 0.100 af, Depth= 3.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Description
5,497	61	>75% Grass cover, Good, HSG B
9,786	98	Roofs, HSG B
15,283	85	Weighted Average
5,497		35.97% Pervious Area
9,786		64.03% Impervious Area

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

Summary for Subcatchment P2a: To Infiltration 2

Runoff = 2.86 cfs @ 12.08 hrs, Volume= 0.212 af, Depth= 4.02"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Description
15,313	98	Paved parking, HSG B
5,221	61	>75% Grass cover, Good, HSG B
489	98	Unconnected pavement, HSG B
6,591	98	Roofs, HSG B
27,614	91	Weighted Average
5,221		18.91% Pervious Area
22,393		81.09% Impervious Area
489		2.18% Unconnected

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

Summary for Subcatchment P2b: Site Overland to Wetlands

Runoff = 0.11 cfs @ 12.10 hrs, Volume= 0.008 af, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Adj	Description
2,212	61		>75% Grass cover, Good, HSG B
504	98		Unconnected pavement, HSG B
2,716	68	64	Weighted Average, UI Adjusted
2,212			81.44% Pervious Area
504			18.56% Impervious Area
504			100.00% Unconnected

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

Summary for Subcatchment P2c: To Surface Basin

Runoff = 0.68 cfs @ 12.09 hrs, Volume= 0.049 af, Depth= 3.21"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Description
4,619	98	Roofs, HSG B
3,143	61	>75% Grass cover, Good, HSG B
198	98	Unconnected pavement, HSG B
7,960	83	Weighted Average
3,143		39.48% Pervious Area
4,817		60.52% Impervious Area
198		4.11% Unconnected

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

Summary for Subcatchment P2d: CVS Site Overland to Wetlands

Runoff = 2.03 cfs @ 12.08 hrs, Volume= 0.157 af, Depth= 4.46"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 10-Year Rainfall=5.04"

Area (sf)	CN	Description
16,691	98	Paved parking, HSG B
1,711	61	>75% Grass cover, Good, HSG B
18,402	95	Weighted Average
1,711		9.30% Pervious Area
16,691		90.70% Impervious Area

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

Summary for Reach DPP1: Wetlands

Inflow Area = 1.735 ac, 76.00% Impervious, Inflow Depth = 3.11" for 10-Year event
Inflow = 6.04 cfs @ 12.09 hrs, Volume= 0.449 af
Outflow = 6.04 cfs @ 12.09 hrs, Volume= 0.449 af, Atten= 0%, Lag= 0.0 min

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

Summary for Reach DPP2: Wetlands

Inflow Area =	1.301 ac,	78.33% Impervious,	Inflow Depth =	2.49"	for 10-Year event
Inflow =	3.99 cfs @	12.11 hrs,	Volume=	0.271 af	
Outflow =	3.99 cfs @	12.11 hrs,	Volume=	0.271 af,	Atten= 0%, Lag= 0.0 min

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

Summary for Pond 1P: SC-160LP

Inflow Area =	0.332 ac,	77.59% Impervious,	Inflow Depth =	3.91"	for 10-Year event
Inflow =	1.47 cfs @	12.09 hrs,	Volume=	0.108 af	
Outflow =	0.21 cfs @	12.59 hrs,	Volume=	0.108 af,	Atten= 86%, Lag= 30.3 min
Discarded =	0.11 cfs @	12.59 hrs,	Volume=	0.102 af	
Primary =	0.10 cfs @	12.59 hrs,	Volume=	0.006 af	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 73.74' @ 12.59 hrs Surf.Area= 0.061 ac Storage= 0.044 af

Plug-Flow detention time= 146.3 min calculated for 0.108 af (100% of inflow)
Center-of-Mass det. time= 146.3 min (936.7 - 790.5)

Volume	Invert	Avail.Storage	Storage Description
#1A	72.50'	0.039 af	**22.83'W x 116.39'L x 2.00'H Field A** 0.122 af Overall - 0.025 af Embedded = 0.097 af x 40.0% Voids
#2A	73.00'	0.025 af	**ADS_StormTech SC-160LP +Cap** x 160 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 10 Rows of 16 Chambers
		0.064 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	72.50'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	73.60'	**10.0" Round Culvert** L= 16.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.60' / 73.20' S= 0.0250 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.55 sf

Discarded OutFlow Max=0.11 cfs @ 12.59 hrs HW=73.74' (Free Discharge)
└**1=Exfiltration** (Controls 0.11 cfs)

Primary OutFlow Max=0.10 cfs @ 12.59 hrs HW=73.74' (Free Discharge)
└**2=Culvert** (Inlet Controls 0.10 cfs @ 1.59 fps)

Summary for Pond 2P: SC-160LP

Inflow Area =	0.634 ac, 81.09% Impervious, Inflow Depth = 4.02" for 10-Year event				
Inflow =	2.86 cfs @	12.08 hrs,	Volume=	0.212 af	
Outflow =	2.24 cfs @	12.15 hrs,	Volume=	0.212 af,	Atten= 22%, Lag= 3.7 min
Discarded =	0.12 cfs @	12.15 hrs,	Volume=	0.108 af	
Primary =	2.13 cfs @	12.15 hrs,	Volume=	0.104 af	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.43' @ 12.15 hrs Surf.Area= 0.058 ac Storage= 0.047 af

Plug-Flow detention time= 63.7 min calculated for 0.212 af (100% of inflow)
Center-of-Mass det. time= 63.7 min (850.3 - 786.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	73.00'	0.037 af	**81.17'W x 30.95'L x 2.00'H Field A** 0.115 af Overall - 0.024 af Embedded = 0.091 af x 40.0% Voids
#2A	73.50'	0.024 af	**ADS_StormTech SC-160LP +Cap** x 152 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 38 Rows of 4 Chambers
		0.060 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.50'
#2	Primary	73.65'	**15.0" Round Culvert** L= 106.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.65' / 73.00' S= 0.0061 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Discarded OutFlow Max=0.12 cfs @ 12.15 hrs HW=74.43' (Free Discharge)
└**1=Exfiltration** (Controls 0.12 cfs)

Primary OutFlow Max=2.12 cfs @ 12.15 hrs HW=74.43' (Free Discharge)
└**2=Culvert** (Barrel Controls 2.12 cfs @ 3.77 fps)

Summary for Pond 3P: Surface Basin

Inflow Area =	0.183 ac, 60.52% Impervious, Inflow Depth = 3.21" for 10-Year event				
Inflow =	0.68 cfs @	12.09 hrs,	Volume=	0.049 af	
Outflow =	0.06 cfs @	13.24 hrs,	Volume=	0.049 af,	Atten= 92%, Lag= 69.4 min
Discarded =	0.04 cfs @	13.24 hrs,	Volume=	0.048 af	
Primary =	0.02 cfs @	13.24 hrs,	Volume=	0.001 af	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.90' @ 13.24 hrs Surf.Area= 1,040 sf Storage= 1,150 cf

Plug-Flow detention time= 407.7 min calculated for 0.049 af (100% of inflow)

Center-of-Mass det. time= 407.8 min (1,220.9 - 813.1)

Volume	Invert	Avail.Storage	Storage Description
#1	73.00'	1,254 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
73.00	285	0	0
74.00	566	426	426
75.00	1,091	829	1,254

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	74.90'	**20.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.04 cfs @ 13.24 hrs HW=74.90' (Free Discharge)
└**1=Exfiltration** (Controls 0.04 cfs)

Primary OutFlow Max=0.01 cfs @ 13.24 hrs HW=74.90' (Free Discharge)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 0.01 cfs @ 0.14 fps)

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

Subcatchment P1a: To Infiltration 1 Runoff Area=14,456 sf 77.59% Impervious Runoff Depth=5.04"
Tc=6.0 min CN=90 Runoff=1.87 cfs 0.139 af

Subcatchment P1b: To WQS Runoff Area=45,819 sf 79.49% Impervious Runoff Depth=5.04"
Tc=6.0 min CN=90 Runoff=5.91 cfs 0.442 af

Subcatchment P1c: Site Overland to Runoff Area=15,283 sf 64.03% Impervious Runoff Depth=4.49"
Tc=6.0 min CN=85 Runoff=1.81 cfs 0.131 af

Subcatchment P2a: To Infiltration 2 Runoff Area=27,614 sf 81.09% Impervious Runoff Depth=5.15"
Tc=6.0 min CN=91 Runoff=3.61 cfs 0.272 af

Subcatchment P2b: Site Overland to Runoff Area=2,716 sf 18.56% Impervious Runoff Depth=2.41"
Tc=6.0 min UI Adjusted CN=64 Runoff=0.17 cfs 0.013 af

Subcatchment P2c: To Surface Basin Runoff Area=7,960 sf 60.52% Impervious Runoff Depth=4.28"
Tc=6.0 min CN=83 Runoff=0.90 cfs 0.065 af

Subcatchment P2d: CVS Site Overland to Runoff Area=18,402 sf 90.70% Impervious Runoff Depth=5.61"
Tc=6.0 min CN=95 Runoff=2.52 cfs 0.198 af

Reach DPP1: Wetlands Inflow=7.72 cfs 0.598 af
Outflow=7.72 cfs 0.598 af

Reach DPP2: Wetlands Inflow=5.43 cfs 0.374 af
Outflow=5.43 cfs 0.374 af

Pond 1P: SC-160LP Peak Elev=73.93' Storage=0.050 af Inflow=1.87 cfs 0.139 af
Discarded=0.12 cfs 0.115 af Primary=0.50 cfs 0.025 af Outflow=0.62 cfs 0.139 af

Pond 2P: SC-160LP Peak Elev=74.60' Storage=0.051 af Inflow=3.61 cfs 0.272 af
Discarded=0.12 cfs 0.121 af Primary=2.96 cfs 0.151 af Outflow=3.08 cfs 0.272 af

Pond 3P: Surface Basin Peak Elev=74.93' Storage=1,183 cf Inflow=0.90 cfs 0.065 af
Discarded=0.04 cfs 0.052 af Primary=0.36 cfs 0.013 af Outflow=0.39 cfs 0.065 af

Total Runoff Area = 3.036 ac Runoff Volume = 1.260 af Average Runoff Depth = 4.98"
23.00% Pervious = 0.698 ac 77.00% Impervious = 2.338 ac

Summary for Subcatchment P1a: To Infiltration 1

Runoff = 1.87 cfs @ 12.08 hrs, Volume= 0.139 af, Depth= 5.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Description
7,907	98	Paved parking, HSG B
3,239	61	>75% Grass cover, Good, HSG B
307	98	Unconnected pavement, HSG B
3,003	98	Roofs, HSG B
14,456	90	Weighted Average
3,239		22.41% Pervious Area
11,217		77.59% Impervious Area
307		2.74% Unconnected

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

Summary for Subcatchment P1b: To WQS

Runoff = 5.91 cfs @ 12.08 hrs, Volume= 0.442 af, Depth= 5.04"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Description
34,679	98	Paved parking, HSG B
9,399	61	>75% Grass cover, Good, HSG B
1,741	98	Unconnected pavement, HSG B
45,819	90	Weighted Average
9,399		20.51% Pervious Area
36,420		79.49% Impervious Area
1,741		4.78% Unconnected

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

Summary for Subcatchment P1c: Site Overland to Wetlands

Runoff = 1.81 cfs @ 12.09 hrs, Volume= 0.131 af, Depth= 4.49"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Description
5,497	61	>75% Grass cover, Good, HSG B
9,786	98	Roofs, HSG B
15,283	85	Weighted Average
5,497		35.97% Pervious Area
9,786		64.03% Impervious Area

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

Summary for Subcatchment P2a: To Infiltration 2

Runoff = 3.61 cfs @ 12.08 hrs, Volume= 0.272 af, Depth= 5.15"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Description
15,313	98	Paved parking, HSG B
5,221	61	>75% Grass cover, Good, HSG B
489	98	Unconnected pavement, HSG B
6,591	98	Roofs, HSG B
27,614	91	Weighted Average
5,221		18.91% Pervious Area
22,393		81.09% Impervious Area
489		2.18% Unconnected

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

Summary for Subcatchment P2b: Site Overland to Wetlands

Runoff = 0.17 cfs @ 12.09 hrs, Volume= 0.013 af, Depth= 2.41"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Adj	Description
2,212	61		>75% Grass cover, Good, HSG B
504	98		Unconnected pavement, HSG B
2,716	68	64	Weighted Average, UI Adjusted
2,212			81.44% Pervious Area
504			18.56% Impervious Area
504			100.00% Unconnected

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

Summary for Subcatchment P2c: To Surface Basin

Runoff = 0.90 cfs @ 12.09 hrs, Volume= 0.065 af, Depth= 4.28"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Description
4,619	98	Roofs, HSG B
3,143	61	>75% Grass cover, Good, HSG B
198	98	Unconnected pavement, HSG B
7,960	83	Weighted Average
3,143		39.48% Pervious Area
4,817		60.52% Impervious Area
198		4.11% Unconnected

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

Summary for Subcatchment P2d: CVS Site Overland to Wetlands

Runoff = 2.52 cfs @ 12.08 hrs, Volume= 0.198 af, Depth= 5.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 25-Year Rainfall=6.20"

Area (sf)	CN	Description
16,691	98	Paved parking, HSG B
1,711	61	>75% Grass cover, Good, HSG B
18,402	95	Weighted Average
1,711		9.30% Pervious Area
16,691		90.70% Impervious Area

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

Summary for Reach DPP1: Wetlands

Inflow Area = 1.735 ac, 76.00% Impervious, Inflow Depth = 4.14" for 25-Year event
Inflow = 7.72 cfs @ 12.08 hrs, Volume= 0.598 af
Outflow = 7.72 cfs @ 12.08 hrs, Volume= 0.598 af, Atten= 0%, Lag= 0.0 min

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

Summary for Reach DPP2: Wetlands

Inflow Area =	1.301 ac,	78.33% Impervious,	Inflow Depth =	3.45"	for 25-Year event
Inflow =	5.43 cfs @	12.11 hrs,	Volume=	0.374 af	
Outflow =	5.43 cfs @	12.11 hrs,	Volume=	0.374 af,	Atten= 0%, Lag= 0.0 min

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

Summary for Pond 1P: SC-160LP

Inflow Area =	0.332 ac,	77.59% Impervious,	Inflow Depth =	5.04"	for 25-Year event
Inflow =	1.87 cfs @	12.08 hrs,	Volume=	0.139 af	
Outflow =	0.62 cfs @	12.37 hrs,	Volume=	0.139 af,	Atten= 67%, Lag= 17.2 min
Discarded =	0.12 cfs @	12.37 hrs,	Volume=	0.115 af	
Primary =	0.50 cfs @	12.37 hrs,	Volume=	0.025 af	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 73.93' @ 12.37 hrs Surf.Area= 0.061 ac Storage= 0.050 af

Plug-Flow detention time= 132.1 min calculated for 0.139 af (100% of inflow)
Center-of-Mass det. time= 132.1 min (915.7 - 783.7)

Volume	Invert	Avail.Storage	Storage Description
#1A	72.50'	0.039 af	**22.83'W x 116.39'L x 2.00'H Field A** 0.122 af Overall - 0.025 af Embedded = 0.097 af x 40.0% Voids
#2A	73.00'	0.025 af	**ADS_StormTech SC-160LP +Cap** x 160 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 10 Rows of 16 Chambers
		0.064 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	72.50'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	73.60'	**10.0" Round Culvert** L= 16.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.60' / 73.20' S= 0.0250 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.55 sf

Discarded OutFlow Max=0.12 cfs @ 12.37 hrs HW=73.93' (Free Discharge)
└**1=Exfiltration** (Controls 0.12 cfs)

Primary OutFlow Max=0.50 cfs @ 12.37 hrs HW=73.93' (Free Discharge)
└**2=Culvert** (Inlet Controls 0.50 cfs @ 2.45 fps)

Summary for Pond 2P: SC-160LP

Inflow Area =	0.634 ac, 81.09% Impervious, Inflow Depth = 5.15" for 25-Year event				
Inflow =	3.61 cfs @	12.08 hrs,	Volume=	0.272 af	
Outflow =	3.08 cfs @	12.13 hrs,	Volume=	0.272 af,	Atten= 15%, Lag= 2.9 min
Discarded =	0.12 cfs @	12.13 hrs,	Volume=	0.121 af	
Primary =	2.96 cfs @	12.13 hrs,	Volume=	0.151 af	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.60' @ 12.13 hrs Surf.Area= 0.058 ac Storage= 0.051 af

Plug-Flow detention time= 60.0 min calculated for 0.272 af (100% of inflow)
Center-of-Mass det. time= 60.0 min (840.0 - 780.0)

Volume	Invert	Avail.Storage	Storage Description
#1A	73.00'	0.037 af	**81.17'W x 30.95'L x 2.00'H Field A** 0.115 af Overall - 0.024 af Embedded = 0.091 af x 40.0% Voids
#2A	73.50'	0.024 af	**ADS_StormTech SC-160LP +Cap** x 152 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 38 Rows of 4 Chambers
		0.060 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.50'
#2	Primary	73.65'	**15.0" Round Culvert** L= 106.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.65' / 73.00' S= 0.0061 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Discarded OutFlow Max=0.12 cfs @ 12.13 hrs HW=74.60' (Free Discharge)
└─**1=Exfiltration** (Controls 0.12 cfs)

Primary OutFlow Max=2.96 cfs @ 12.13 hrs HW=74.60' (Free Discharge)
└─**2=Culvert** (Barrel Controls 2.96 cfs @ 4.09 fps)

Summary for Pond 3P: Surface Basin

Inflow Area =	0.183 ac, 60.52% Impervious, Inflow Depth = 4.28" for 25-Year event				
Inflow =	0.90 cfs @	12.09 hrs,	Volume=	0.065 af	
Outflow =	0.39 cfs @	12.28 hrs,	Volume=	0.065 af,	Atten= 56%, Lag= 11.9 min
Discarded =	0.04 cfs @	12.28 hrs,	Volume=	0.052 af	
Primary =	0.36 cfs @	12.28 hrs,	Volume=	0.013 af	

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.93' @ 12.28 hrs Surf.Area= 1,056 sf Storage= 1,183 cf

Plug-Flow detention time= 336.4 min calculated for 0.065 af (100% of inflow)

Center-of-Mass det. time= 336.5 min (1,141.5 - 805.0)

Volume	Invert	Avail.Storage	Storage Description
#1	73.00'	1,254 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
73.00	285	0	0
74.00	566	426	426
75.00	1,091	829	1,254

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	74.90'	**20.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.04 cfs @ 12.28 hrs HW=74.93' (Free Discharge)
└**1=Exfiltration** (Controls 0.04 cfs)

Primary OutFlow Max=0.35 cfs @ 12.28 hrs HW=74.93' (Free Discharge)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 0.35 cfs @ 0.51 fps)

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

Subcatchment P1a: To Infiltration 1 Runoff Area=14,456 sf 77.59% Impervious Runoff Depth=6.80"
Tc=6.0 min CN=90 Runoff=2.47 cfs 0.188 af

Subcatchment P1b: To WQS Runoff Area=45,819 sf 79.49% Impervious Runoff Depth=6.80"
Tc=6.0 min CN=90 Runoff=7.84 cfs 0.596 af

Subcatchment P1c: Site Overland to Runoff Area=15,283 sf 64.03% Impervious Runoff Depth=6.20"
Tc=6.0 min CN=85 Runoff=2.46 cfs 0.181 af

Subcatchment P2a: To Infiltration 2 Runoff Area=27,614 sf 81.09% Impervious Runoff Depth=6.91"
Tc=6.0 min CN=91 Runoff=4.77 cfs 0.365 af

Subcatchment P2b: Site Overland to Runoff Area=2,716 sf 18.56% Impervious Runoff Depth=3.77"
Tc=6.0 min UI Adjusted CN=64 Runoff=0.27 cfs 0.020 af

Subcatchment P2c: To Surface Basin Runoff Area=7,960 sf 60.52% Impervious Runoff Depth=5.97"
Tc=6.0 min CN=83 Runoff=1.24 cfs 0.091 af

Subcatchment P2d: CVS Site Overland to Runoff Area=18,402 sf 90.70% Impervious Runoff Depth=7.39"
Tc=6.0 min CN=95 Runoff=3.27 cfs 0.260 af

Reach DPP1: Wetlands Inflow=10.77 cfs 0.834 af
Outflow=10.77 cfs 0.834 af

Reach DPP2: Wetlands Inflow=8.49 cfs 0.541 af
Outflow=8.49 cfs 0.541 af

Pond 1P: SC-160LP Peak Elev=74.19' Storage=0.056 af Inflow=2.47 cfs 0.188 af
Discarded=0.13 cfs 0.131 af Primary=1.34 cfs 0.057 af Outflow=1.48 cfs 0.188 af

Pond 2P: SC-160LP Peak Elev=74.82' Storage=0.056 af Inflow=4.77 cfs 0.365 af
Discarded=0.13 cfs 0.138 af Primary=4.04 cfs 0.227 af Outflow=4.17 cfs 0.365 af

Pond 3P: Surface Basin Peak Elev=74.97' Storage=1,226 cf Inflow=1.24 cfs 0.091 af
Discarded=0.04 cfs 0.057 af Primary=1.14 cfs 0.034 af Outflow=1.18 cfs 0.091 af

Total Runoff Area = 3.036 ac Runoff Volume = 1.701 af Average Runoff Depth = 6.72"
23.00% Pervious = 0.698 ac 77.00% Impervious = 2.338 ac

Summary for Subcatchment P1a: To Infiltration 1

Runoff = 2.47 cfs @ 12.08 hrs, Volume= 0.188 af, Depth= 6.80"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Description
7,907	98	Paved parking, HSG B
3,239	61	>75% Grass cover, Good, HSG B
307	98	Unconnected pavement, HSG B
3,003	98	Roofs, HSG B
14,456	90	Weighted Average
3,239		22.41% Pervious Area
11,217		77.59% Impervious Area
307		2.74% Unconnected

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

Summary for Subcatchment P1b: To WQS

Runoff = 7.84 cfs @ 12.08 hrs, Volume= 0.596 af, Depth= 6.80"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Description
34,679	98	Paved parking, HSG B
9,399	61	>75% Grass cover, Good, HSG B
1,741	98	Unconnected pavement, HSG B
45,819	90	Weighted Average
9,399		20.51% Pervious Area
36,420		79.49% Impervious Area
1,741		4.78% Unconnected

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

Summary for Subcatchment P1c: Site Overland to Wetlands

Runoff = 2.46 cfs @ 12.09 hrs, Volume= 0.181 af, Depth= 6.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Description
5,497	61	>75% Grass cover, Good, HSG B
9,786	98	Roofs, HSG B
15,283	85	Weighted Average
5,497		35.97% Pervious Area
9,786		64.03% Impervious Area

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

Summary for Subcatchment P2a: To Infiltration 2

Runoff = 4.77 cfs @ 12.08 hrs, Volume= 0.365 af, Depth= 6.91"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Description
15,313	98	Paved parking, HSG B
5,221	61	>75% Grass cover, Good, HSG B
489	98	Unconnected pavement, HSG B
6,591	98	Roofs, HSG B
27,614	91	Weighted Average
5,221		18.91% Pervious Area
22,393		81.09% Impervious Area
489		2.18% Unconnected

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

Summary for Subcatchment P2b: Site Overland to Wetlands

Runoff = 0.27 cfs @ 12.09 hrs, Volume= 0.020 af, Depth= 3.77"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Adj	Description
2,212	61		>75% Grass cover, Good, HSG B
504	98		Unconnected pavement, HSG B
2,716	68	64	Weighted Average, UI Adjusted
2,212			81.44% Pervious Area
504			18.56% Impervious Area
504			100.00% Unconnected

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

Summary for Subcatchment P2c: To Surface Basin

Runoff = 1.24 cfs @ 12.09 hrs, Volume= 0.091 af, Depth= 5.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Description
4,619	98	Roofs, HSG B
3,143	61	>75% Grass cover, Good, HSG B
198	98	Unconnected pavement, HSG B
7,960	83	Weighted Average
3,143		39.48% Pervious Area
4,817		60.52% Impervious Area
198		4.11% Unconnected

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

Summary for Subcatchment P2d: CVS Site Overland to Wetlands

Runoff = 3.27 cfs @ 12.08 hrs, Volume= 0.260 af, Depth= 7.39"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Type III 24-hr 100-Year Rainfall=7.99"

Area (sf)	CN	Description
16,691	98	Paved parking, HSG B
1,711	61	>75% Grass cover, Good, HSG B
18,402	95	Weighted Average
1,711		9.30% Pervious Area
16,691		90.70% Impervious Area

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

Summary for Reach DPP1: Wetlands

Inflow Area = 1.735 ac, 76.00% Impervious, Inflow Depth = 5.77" for 100-Year event
Inflow = 10.77 cfs @ 12.09 hrs, Volume= 0.834 af
Outflow = 10.77 cfs @ 12.09 hrs, Volume= 0.834 af, Atten= 0%, Lag= 0.0 min

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

Summary for Reach DPP2: Wetlands

Inflow Area = 1.301 ac, 78.33% Impervious, Inflow Depth = 4.99" for 100-Year event
Inflow = 8.49 cfs @ 12.11 hrs, Volume= 0.541 af
Outflow = 8.49 cfs @ 12.11 hrs, Volume= 0.541 af, Atten= 0%, Lag= 0.0 min

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

Summary for Pond 1P: SC-160LP

Inflow Area = 0.332 ac, 77.59% Impervious, Inflow Depth = 6.80" for 100-Year event
Inflow = 2.47 cfs @ 12.08 hrs, Volume= 0.188 af
Outflow = 1.48 cfs @ 12.19 hrs, Volume= 0.188 af, Atten= 40%, Lag= 6.3 min
Discarded = 0.13 cfs @ 12.19 hrs, Volume= 0.131 af
Primary = 1.34 cfs @ 12.19 hrs, Volume= 0.057 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.19' @ 12.19 hrs Surf.Area= 0.061 ac Storage= 0.056 af

Plug-Flow detention time= 117.0 min calculated for 0.188 af (100% of inflow)
Center-of-Mass det. time= 117.0 min (892.9 - 775.9)

Volume	Invert	Avail.Storage	Storage Description
#1A	72.50'	0.039 af	**22.83'W x 116.39'L x 2.00'H Field A** 0.122 af Overall - 0.025 af Embedded = 0.097 af x 40.0% Voids
#2A	73.00'	0.025 af	**ADS_StormTech SC-160LP +Cap** x 160 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 10 Rows of 16 Chambers
		0.064 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	72.50'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	73.60'	**10.0" Round Culvert** L= 16.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.60' / 73.20' S= 0.0250 '/' Cc= 0.900 n= 0.012 Concrete pipe, finished, Flow Area= 0.55 sf

Discarded OutFlow Max=0.13 cfs @ 12.19 hrs HW=74.19' (Free Discharge)
└**1=Exfiltration** (Controls 0.13 cfs)

Primary OutFlow Max=1.34 cfs @ 12.19 hrs HW=74.19' (Free Discharge)
└**2=Culvert** (Barrel Controls 1.34 cfs @ 4.53 fps)

Summary for Pond 2P: SC-160LP

Inflow Area = 0.634 ac, 81.09% Impervious, Inflow Depth = 6.91" for 100-Year event
Inflow = 4.77 cfs @ 12.08 hrs, Volume= 0.365 af
Outflow = 4.17 cfs @ 12.13 hrs, Volume= 0.365 af, Atten= 13%, Lag= 2.7 min
Discarded = 0.13 cfs @ 12.13 hrs, Volume= 0.138 af
Primary = 4.04 cfs @ 12.13 hrs, Volume= 0.227 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.82' @ 12.13 hrs Surf.Area= 0.058 ac Storage= 0.056 af

Plug-Flow detention time= 55.6 min calculated for 0.365 af (100% of inflow)
Center-of-Mass det. time= 55.6 min (828.2 - 772.6)

Volume	Invert	Avail.Storage	Storage Description
#1A	73.00'	0.037 af	**81.17'W x 30.95'L x 2.00'H Field A** 0.115 af Overall - 0.024 af Embedded = 0.091 af x 40.0% Voids
#2A	73.50'	0.024 af	**ADS_StormTech SC-160LP +Cap** x 152 Inside #1 Effective Size= 18.0"W x 12.0"H => 0.96 sf x 7.12'L = 6.8 cf Overall Size= 25.0"W x 12.0"H x 7.56'L with 0.44' Overlap 38 Rows of 4 Chambers
		0.060 af	Total Available Storage

Storage Group A created with Chamber Wizard

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.50'
#2	Primary	73.65'	**15.0" Round Culvert** L= 106.0' RCP, groove end w/headwall, Ke= 0.200 Inlet / Outlet Invert= 73.65' / 73.00' S= 0.0061 '/' Cc= 0.900 n= 0.013 Corrugated PE, smooth interior, Flow Area= 1.23 sf

Discarded OutFlow Max=0.13 cfs @ 12.13 hrs HW=74.82' (Free Discharge)
└**1=Exfiltration** (Controls 0.13 cfs)

Primary OutFlow Max=4.03 cfs @ 12.13 hrs HW=74.82' (Free Discharge)
└**2=Culvert** (Barrel Controls 4.03 cfs @ 4.38 fps)

Summary for Pond 3P: Surface Basin

Inflow Area = 0.183 ac, 60.52% Impervious, Inflow Depth = 5.97" for 100-Year event
Inflow = 1.24 cfs @ 12.09 hrs, Volume= 0.091 af
Outflow = 1.18 cfs @ 12.11 hrs, Volume= 0.091 af, Atten= 5%, Lag= 1.7 min
Discarded = 0.04 cfs @ 12.11 hrs, Volume= 0.057 af
Primary = 1.14 cfs @ 12.11 hrs, Volume= 0.034 af

Routing by Stor-Ind method, Time Span= 0.00-72.00 hrs, dt= 0.01 hrs
Peak Elev= 74.97' @ 12.11 hrs Surf.Area= 1,078 sf Storage= 1,226 cf

Plug-Flow detention time= 269.1 min calculated for 0.091 af (100% of inflow)

Center-of-Mass det. time= 269.0 min (1,064.7 - 795.7)

Volume	Invert	Avail.Storage	Storage Description
#1	73.00'	1,254 cf	**Custom Stage Data (Prismatic)**Listed below (Recalc)

Elevation (feet)	Surf.Area (sq-ft)	Inc.Store (cubic-feet)	Cum.Store (cubic-feet)
73.00	285	0	0
74.00	566	426	426
75.00	1,091	829	1,254

Device	Routing	Invert	Outlet Devices
#1	Discarded	73.00'	**1.020 in/hr Exfiltration over Surface area** Conductivity to Groundwater Elevation = 71.00'
#2	Primary	74.90'	**20.0' long x 0.5' breadth Broad-Crested Rectangular Weir** Head (feet) 0.20 0.40 0.60 0.80 1.00 Coef. (English) 2.80 2.92 3.08 3.30 3.32

Discarded OutFlow Max=0.04 cfs @ 12.11 hrs HW=74.97' (Free Discharge)
└**1=Exfiltration** (Controls 0.04 cfs)

Primary OutFlow Max=1.13 cfs @ 12.11 hrs HW=74.97' (Free Discharge)
└**2=Broad-Crested Rectangular Weir** (Weir Controls 1.13 cfs @ 0.76 fps)

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NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: MA

DATA DESCRIPTION

Data type: precipitation depth **Units:** english **Time series type:** partial duration

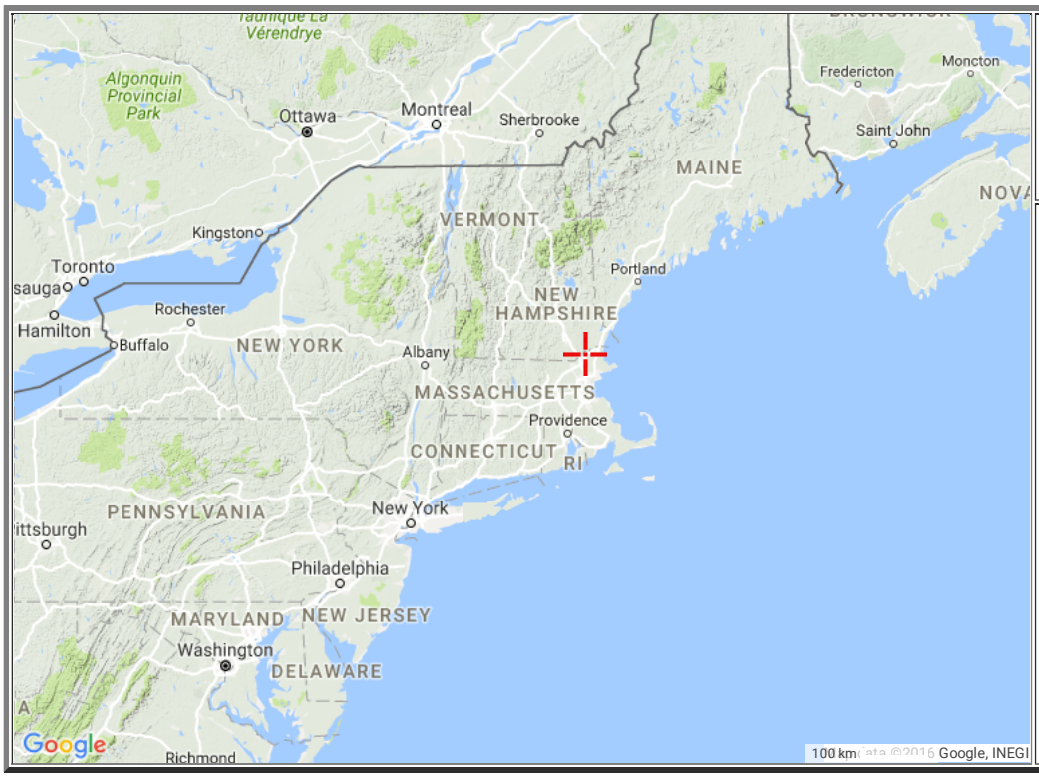
SELECT LOCATION

1. Manually:

a) Enter location (decimal degrees, use "-" for S and W): latitude: 42.7744 longitude: -71.1164 submit

b) Select station (click here for a list of stations used in frequency analysis for MA): select station

2. Use map:



a) Select location
(move crosshair or double click)

b) Click on station icon
(show stations on map)

LOCATION INFORMATION:
Name: Haverhill, Massachusetts,
Latitude: 42.7744°
Longitude: -71.1164°
Elevation: 81 ft*

* source: Google Maps

POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION
NOAA Atlas 14, Volume 10, Version 2

PF tabular PF graphical Supplementary information Print Page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	0.311 (0.242-0.391)	0.370 (0.289-0.467)	0.468 (0.364-0.592)	0.549 (0.424-0.698)	0.660 (0.494-0.876)	0.746 (0.546-1.01)	0.832 (0.591-1.17)	0.937 (0.631-1.35)	1.07 (0.697-1.60)	1.18 (0.747-1.79)
10-min	0.440 (0.344-0.554)	0.525 (0.409-0.661)	0.663 (0.515-0.838)	0.778 (0.601-0.989)	0.935 (0.699-1.24)	1.06 (0.774-1.43)	1.18 (0.838-1.65)	1.33 (0.895-1.91)	1.52 (0.987-2.27)	1.67 (1.06-2.54)
15-min	0.518 (0.404-0.652)	0.617 (0.481-0.778)	0.780 (0.606-0.986)	0.915 (0.707-1.16)	1.10 (0.823-1.46)	1.24 (0.911-1.68)	1.39 (0.985-1.95)	1.56 (1.05-2.24)	1.79 (1.16-2.67)	1.97 (1.24-2.98)
30-min	0.713 (0.556-0.897)	0.849 (0.662-1.07)	1.07 (0.834-1.36)	1.26 (0.973-1.60)	1.51 (1.13-2.01)	1.71 (1.25-2.32)	1.91 (1.36-2.68)	2.15 (1.45-3.09)	2.46 (1.60-3.67)	2.70 (1.71-4.10)
60-min	0.908 (0.708-1.14)	1.08 (0.844-1.36)	1.37 (1.06-1.73)	1.60 (1.24-2.04)	1.93 (1.44-2.56)	2.18 (1.60-2.95)	2.43 (1.73-3.41)	2.73 (1.84-3.93)	3.14 (2.03-4.67)	3.44 (2.18-5.22)
2-hr	1.17 (0.921-1.46)	1.40 (1.10-1.76)	1.78 (1.40-2.24)	2.10 (1.64-2.65)	2.54 (1.91-3.36)	2.87 (2.13-3.89)	3.21 (2.31-4.52)	3.67 (2.49-5.25)	4.30 (2.79-6.36)	4.76 (3.02-7.19)
3-hr	1.35 (1.07-1.69)	1.63 (1.29-2.03)	2.08 (1.64-2.60)	2.45 (1.92-3.09)	2.97 (2.25-3.92)	3.37 (2.50-4.55)	3.76 (2.73-5.31)	4.35 (2.95-6.20)	5.12 (3.33-7.55)	5.70 (3.63-8.57)
6-hr	1.73	2.09	2.69	3.19	3.87	4.40	4.92	5.72	6.78	7.57

	(1.38-2.14)	(1.67-2.60)	(2.13-3.35)	(2.51-3.99)	(2.96-5.09)	(3.30-5.92)	(3.60-6.92)	(3.89-8.11)	(4.43-9.93)	(4.83-11.3)
12-hr	**2.17** (1.74-2.67)	**2.65** (2.12-3.26)	**3.43** (2.74-4.24)	**4.08** (3.24-5.08)	**4.98** (3.83-6.50)	**5.67** (4.27-7.59)	**6.36** (4.67-8.88)	**7.39** (5.05-10.4)	**8.77** (5.75-12.8)	**9.80** (6.27-14.5)
24-hr	**2.56** (2.07-3.13)	**3.18** (2.57-3.90)	**4.20** (3.38-5.16)	**5.04** (4.03-6.23)	**6.20** (4.80-8.07)	**7.09** (5.39-9.46)	**7.99** (5.91-11.1)	**9.38** (6.43-13.1)	**11.2** (7.38-16.2)	**12.6** (8.10-18.6)
2-day	**2.88** (2.35-3.50)	**3.65** (2.97-4.44)	**4.91** (3.98-6.00)	**5.95** (4.80-7.31)	**7.39** (5.78-9.60)	**8.50** (6.52-11.3)	**9.61** (7.20-13.4)	**11.5** (7.89-16.0)	**13.9** (9.19-20.1)	**15.8** (10.2-23.1)
3-day	**3.15** (2.58-3.82)	**3.98** (3.26-4.83)	**5.33** (4.35-6.49)	**6.46** (5.23-7.91)	**8.00** (6.29-10.4)	**9.20** (7.09-12.2)	**10.4** (7.82-14.5)	**12.4** (8.56-17.2)	**15.1** (9.97-21.6)	**17.1** (11.0-25.0)
4-day	**3.42** (2.81-4.14)	**4.28** (3.51-5.17)	**5.67** (4.64-6.89)	**6.83** (5.55-8.34)	**8.42** (6.64-10.9)	**9.65** (7.46-12.8)	**10.9** (8.21-15.1)	**13.0** (8.97-17.9)	**15.7** (10.4-22.5)	**17.8** (11.5-26.0)
7-day	**4.17** (3.45-5.01)	**5.05** (4.18-6.09)	**6.50** (5.35-7.85)	**7.70** (6.30-9.36)	**9.35** (7.41-12.0)	**10.6** (8.24-14.0)	**11.9** (8.99-16.4)	**14.0** (9.75-19.3)	**16.9** (11.2-24.0)	**19.0** (12.3-27.5)
10-day	**4.85** (4.03-5.81)	**5.76** (4.78-6.91)	**7.25** (5.99-8.72)	**8.48** (6.96-10.3)	**10.2** (8.08-13.0)	**11.5** (8.92-15.0)	**12.8** (9.65-17.4)	**14.9** (10.4-20.4)	**17.7** (11.8-25.0)	**19.8** (12.8-28.5)
20-day	**6.78** (5.69-8.08)	**7.79** (6.52-9.28)	**9.43** (7.86-11.3)	**10.8** (8.93-13.0)	**12.7** (10.1-15.9)	**14.1** (11.0-18.1)	**15.5** (11.6-20.7)	**17.4** (12.2-23.7)	**19.9** (13.3-28.0)	**21.8** (14.2-31.3)
30-day	**8.39** (7.07-9.96)	**9.47** (7.97-11.3)	**11.2** (9.42-13.4)	**12.7** (10.6-15.2)	**14.7** (11.8-18.3)	**16.3** (12.6-20.7)	**17.8** (13.3-23.4)	**19.6** (13.8-26.4)	**21.9** (14.7-30.6)	**23.6** (15.4-33.7)
45-day	**10.4** (8.84-12.3)	**11.6** (9.81-13.7)	**13.5** (11.4-16.1)	**15.1** (12.6-18.0)	**17.3** (13.8-21.4)	**19.0** (14.8-23.9)	**20.7** (15.4-26.8)	**22.3** (15.7-29.9)	**24.4** (16.4-33.9)	**26.0** (16.9-36.9)
60-day	**12.2** (10.4-14.4)	**13.4** (11.4-15.8)	**15.4** (13.0-18.3)	**17.1** (14.4-20.4)	**19.4** (15.6-23.9)	**21.2** (16.5-26.5)	**23.0** (17.1-29.6)	**24.5** (17.4-32.9)	**26.5** (17.9-36.8)	**28.1** (18.4-39.9)

[1] Precipitation frequency (PF) estimates in this table are based on frequency analysis of partial duration series (PDS).

Numbers in parenthesis are PF estimates at low er and upper bounds of the 90% confidence interval. The probability that precipitation frequency estimates (for a given duration and average recurrence interval) w ill be greater than the upper bound (or less than the low er bound) is 5%. Estimates at upper bounds are not checked against probable maximum precipitation (PMP) estimates and may be higher than currently valid PMP values.

Please refer to NOAA Atlas 14 document for more information.

Estimates from the table in csv format: precipitation frequency estimates ▼ Submit

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National Oceanic and Atmospheric Administration
National Weather Service
Office of Water Prediction (OWP)
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Table 10.11
MANNING ROUGHNESS COEFFICIENT, *n*[1]

	Manning's *n* range[2]
I. Closed conduits:	
A. Concrete pipe	0.011–0.013
B. Corrugated-metal pipe or pipe-arch:	
1. 2⅔ by ½-in. corrugation (riveted pipe):[3]	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50 percent of circumference paved):	
(1) Flow full depth	0.021–0.018
(2) Flow 0.8 depth	0.021–0.016
(3) FLow 0.6 depth	0.019–0.013
2. 6 by 2-in. corrugation (field bolted)	0.03
C. Vitrified clay pipe	0.012–0.014
D. Cast-iron pipe, uncoated	0.013
E. Steel pipe	0.009–0.011
F. Brick	0.014–0.017
G. Monolithic concrete:	
1. Wood forms, rough	0.015–0.017
2. Wood forms, smooth	0.012–0.014
3. Steel forms	0.012–0.013
H. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017–0.022
2. Natural floor	0.019–0.025
I. Laminated treated wood	0.015–0.017
J. Vitrified clay liner plates	0.015
II. Open channels, lined[4] (straight alinement):[5]	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013–0.017
2. Trowel finish	0.012–0.014
3. Float finish	0.013–0.015
4. Float finish, some gravel on bottom	0.015–0.017
5. Gunite, good section	0.016–0.019
6. Gunite, wavy section	0.018–0.022
B. Concrete, bottom float finished, sides as indicated:	
1. Dressed stone in mortar	0.015–0.017
2. Random stone in mortar	0.017–0.020
3. Cement rubble masonry	0.020–0.025
4. Cement rubble masonry, plastered	0.016–0.020
5. Dry rubble (riprap)	0.020–0.030
C. Gravel bottom, sides as indicated:	
1. Formed concrete	0.017–0.020
2. Random stone in mortar	0.020–0.023
3. Dry rubble (riprap)	0.023–0.033
D. Brick	0.014–0.017
E. Asphalt:	
1. Smooth	0.013
2. Rough	0.016
F. Wood, planed, clean	0.011–0.013
G. Concrete-lined excavated rock:	
1. Good section	0.017–0.020
2. Irregular section	0.022–0.027
III. Open channels, excavated[4] (straight alinement,[5] natural lining):	
A. Earth, uniform section:	
1. Clean, recently completed	0.016–0.018
2. Clean, after weathering	0.018–0.020
3. With short grass, few weeds	0.022–0.027
4. In gravelly soil, uniform section, clean	0.022–0.025
B. Earth, fairly uniform section:	
1. No vegetation	0.022–0.025
2. Grass, some weeds	0.025–0.030
3. Dense weeds or aquatic plants in deep channels	0.030–0.035
4. Sides clean, gravel bottom	0.025–0.030
5. Sides clean, cobble bottom	0.030–0.040
C. Dragline excavated or dredged:	
1. No vegetation	0.028–0.033
2. Light brush on banks	0.035–0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035–0.040
b. Jagged and irregular	0.040–0.045
E. Channels not maintained, weeds and brush uncut:	
1. Dense weeds, high as flow depth	0.08–0.12
2. Clean bottom, brush on sides	0.05–0.08
3. Clean bottom, brush on sides, highest stage of flow	0.07–0.11
4. Dense brush, high stage	0.10–0.14
IV. Highway channels and swales with maintained vegetation[6 7] (vaules shown are for velocities of 2 and 6 f.p.s.):	
A. Depth of flow up to 0.7 foot:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.07–0.045
b. Length 4-6 inches	0.09–0.05
2. Good stand, any grass:	
a. Length about 12 inches	0.18–0.09
b. Length about 24 inches	0.30–0.15
3. Fair stand, any grass:	
a. Length about 12 inches	0.14–0.08
b. Length about 24 inches	0.25–0.13
B. Depth of flow 0.7-1.5 feet:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Moved to 2 inches	0.05–0.035
b. Length 4 to 6 inches	0.06–0.04
2. Good stand, any grass:	
a. Length about 12 inches	0.12–0.07
b. Length about 24 inches	0.20–0.10
3. Fair stand, any grass:	
a. Length about 12 inches	0.10–0.06
b. Length about 24 inches	0.17–0.09
V. Street and expressway gutters:	
A. Concrete gutter, troweled finish	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. For gutters with small slope, where sediment may accumulate, increase above values of *n* by	0.002

Manning's "n"
For channels

Source: Massachusetts Highway Design Manual
Chapter 10

Table 10.11 (Continued)

	Manning's *n* range[2]
VI. Natural stream channels:[8]	
A. Minor streams[9] (surface width at flood stage less than 100 ft):	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030–0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035–0.05
c. Some weeds, light brush on banks	0.035–0.05
d. Some weeds, heavy brush on banks	0.05–0.07
e. Some weeds, dense willows on banks	0.06–0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by	0.01–0.02
2. Irregular sections, with pools, slight channel meander; increase values given in 1a–e about	0.01–0.02
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04–0.05
b. Bottom cobbles, with large boulders	0.05–0.07
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030–0.035
b. High grass	0.035–0.05
2. Cultivated areas:	
a. No crop	0.03–0.04
b. Mature row crops	0.035–0.045
c. Mature field crops	0.04–0.05
3. Heavy weeds, scattered brush	0.05–0.07
4. Light brush and trees:[10]	
a. Winter	0.05–0.06
b. Summer	0.06–0.08
5. Medium to dense brush:[10]	
a. Winter	0.07–0.11
b. Summer	0.10–0.16
6. Dense willows, summer, not bent over by current	0.15–0.20
7. Cleared land with tree stumps, 100–150 per acre:	
a. No sprouts	0.4–0.05
b. With heavy growth of sprouts	0.06–0.08
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.10–0.12
b. Flood depth reaches branches	0.12–0.16
C. Major streams (surface width at flood stage more than 100 ft): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of *n* may be somewhat reduced. Follow recommendation in publication cited[8] if possible. The value of *n* for larger streams of most regular section, with no boulders or brush, may be in the range of	0.028–0.033

Reference: *Design Charts for Open Channel Flow*, HDS #3, FHWA, 1973.

1. Estimates are by Bureau of Public Roads unless otherwise noted.
2. Ranges indicated for closed conduits and for open channels, lines or excavated, are for good to fair construction (unless otherwise stated). For poor quality construction, use larger values of *n*.
3. *Friction Factors in Corrugated Metal Pipe*, by M.J. Webster and L.R. Metcalf, Corps of Engineers, Department of the Army; published in Journal of the Hydraulics Division, Proceedings of the American Society of Civil Engineers, vol. 85, No. HY9, Sept. 1959, Paper No. 2148, pp. 35–67.
4. For important work and where accurate determination of water profiles is necessary, the designer is urged to consult the following references and to select *n* by comparison of the specific conditions with the channels tested:
   Flow of Water in Irrigation and Similar Channels, by F.C. Scobey, Division of Irrigation, Soil Conservation Service, U.S. Department of Agriculture, Tech. Bull. No. 652, Feb. 1939; and
   Flow of Water in Drainage Channels, by C.E. Ramser, Division of Agricultural Engineering, Bureau of Public Roads, U.S. Department of Agriculture, Tech. Bull. No. 129, Nov. 1929.
5. With channel of an alinement other than straight, loss of head by resistance forces will be increased. A small increase in value of *n* may be made, to allow for the additional loss of energy.
6. *Handbook of Channel Design for Soil and Water Conservation*, prepared by the Stillwater Outdoor Hydraulic Laboratory in cooperation with the Oklahoma Agricultural Experiment Station; published by the Soil Conservation Service, U.S. Department of Agriculture, Publ. No. SCS-TP-61, Mar. 1947, rev. June 1954.
7. *Flow of Water in Channels Protected by Vegetative Linings*, by W.O. Ree and V.J. Palmer, Division of Drainage and Water Control, Research, Soil Conservation Service, U.S. Department of Agriculture, Tech. Bull. No. 967, Feb. 1949.
8. For calculation of stage or discharge in natural stream channels, it is recommended that the designer consult the local District Office of the Surface Water Branch of the U.S. Geological Survey, to obtain data regarding values of *n* applicable to streams of any specific locality. Where this procedure is not followed, the table may be used as a guide. The values of *n* tabulated have been derived from data reported by C.E. Ramser (see footnote 4) and from other incomplete data.
9. The tentative values of *n* cited are principally derived from measurements made on fairly short but straight reaches of natural streams. Where slopes calculated from flood elevations along a considerable length of channel, involving meanders and bends, are to be used in velocity calculations by the Manning formula, the value of *n* must be increased to provide for the additional loss of energy caused by bends. The increase may be in the range of perhaps 3 to 15 percent.
10. The presence of foliage on trees and brush under flood stage will materially increase the value of *n*. Therefore, roughness coefficients for vegetation in leaf will be larger than for bare branches. For trees in channel or on banks, and for brush on banks where submergence of branches increases with depth of flow, *n* will increase with rising stage.

Source: Massachusetts Highway Design Manual
Chapter 10

Description of Area	Runoff Coefficients
Business Downtown Neighborhood	0.70 to 0.95 0.50 to 0.70
Residential Single-Family Multi-Family, Detached Multi-Family, Attached	0.30 to 0.50 0.40 to 0.60 0.60 to 0.75
Residential (Suburban)	0.25 to 0.40
Apartment	0.50 to 0.70
Industrial Light Heavy	0.50 to 0.80 0.60 to 0.90
Parks, Cemeteries	0.10 to 0.25
Playgrounds	0.20 to 0.35
Railroad Yard	0.20 to 0.35
Unimproved	0.10 to 0.30
Woodland	0.15 to 0.25
Cultivated	0.40 to 0.60
Swamp, Marsh	0.10

Recommended Runoff Coefficients (C)
For Rational Method
(By Overall Character of Area)

Source: Highway Design Manual,
Massachusetts Department of Public Works.
July 1989.

Character of Surface	Runoff Coefficients
Pavement Asphaltic and Concrete Brick	0.70 to 0.95 0.70 to 0.85
Roofs	0.75 to 0.95
Lawns, Sandy Soil Flat, 2 Percent Average, 2 to 7 Percent Steep, 7 Percent	0.05 to 0.10 0.10 to 0.15 0.15 to 0.20
Lawns, Heavy Soil Flat, 2 Percent Average, 2 to 7 Percent Steep, 7 Percent	0.13 to 0.17 0.18 to 0.22 0.25 to 0.35

Recommended Runoff Coefficients (C)
For Rational Method
(For Surface Type)

Source: Highway Design Manual,
Massachusetts Department of Public Works.
July 1989.

Appendix 5

Standard #3 – Recharge
Required Recharge Volume

Project Name: **Haverhill Hotel & Retail/Restaurant**	Bohler Project #: **W1511212**
Location: **Haverhill, MA**	Sheet No. **1 of 1**
Prepared by: **CEM**	
Date: **10/20/16**	

INSTRUCTIONS:
1. Determine the increase in impervious area (in square feet) proposed above each Hydrologic Soil Group and input those areas in the appropriate blue cells.
2. The Required Recharge Volume (in cubic feet) will be calculated and displayed in the yellow cell.

Step No.			
1	Impervious area located above:	22,404	sf
	Hydrologic Soil Group "A" Soil =	0	sf
	Hydrologic Soil Group "B" Soil =	22,404	sf
	Hydrologic Soil Group "C" Soil =	0	sf
	Hydrologic Soil Group "D" Soil =	0	sf
2	Required Recharge Volume =	653	cf

Impervious area directed to Recharge Systems = 15,318 sf
Percentage of Impervious area directed to Recharge Systems = 15%

Recharge Volume - Static Method

Description	**Offline Static Volume (cf)**
Subsurface Infiltration System 1	864
Subsurface Infiltration System 2	689
Surface Infiltration Basin	1,039
TOTAL	**2,592**

Standard 3 – Recharge
72-Hour Drawdown Calculation

Project Name: **Haverhill Hotel & Retail/Restaurant**	Bohler Project #: **W1511212**
Location: **Haverhill, MA**	Sheet No. **1** of **1**
Prepared by: **CEM**	
Date: **10/20/2016**	

Recharge System	Method	Required Recharge Volume (cf)	Bottom Area (sf)	Texture Class	HSG	Rawls Rate (in/hr)	Drawdown Time (hr)	Check
1	Static	935	2657	TBD	B	1.02	**4.1**	OK
2	Static	1866	2512	TBD	B	1.02	**8.7**	OK
3	Static	401	285	TBD	B	1.02	**16.6**	OK

Hydrologic Soil Group (HSG) and Rals Rate selected based on results of soil testing
Recharge area is anticipated to drain in less than 72 hours.

Required Recharge Volume is calculated as 1” over the impervious area directed to the system. This includes roof and pavement areas.

City of Haverhill Engineering Requirement for Roof Recharge

Proposed Roof Area: 24,005 sf

Roof recharge depth required (per City requirements) = ½"

→Required Recharge Volume = 24,005 sf x ½"= **<u>1,000cf storage required</u>**

Underground Infiltration System 1

Static volume provided:

Bottom of chambers elevation = 73.00 (SHGW @ El. 71.00)

Outlet pipe elevation = 73.60

Total chambers = 160

5.40cf static storage provided per chamber to elevation 73.60 (excludes 6" stone base)

5.40cf x 160 = **864cf storage provided** *system drains within 72 hours (max.)

Underground Infiltration System 2

Static volume provided:

Bottom of stone elevation = 73.00 (SHGW @ El. 71.00)

Outlet pipe elevation = 73.65

Total chambers = 152

4.53cf static storage provided per chamber to elevation 73.65 (includes 6" stone base @ 40% porosity)

4.53cf x 152 = **689cf storage provided** *system drains within 72 hours (max.)

Surface Infiltration Basin

Static volume provided:

Bottom of basin = 73.00 (SHGW @ El. 71.00)

Spillway elevation = 74.90

Total static storage = **1,039cf storage provided** *system drains within 72 hours (max.)

→Total Static Storage Volume Required: 864 + 689 + 1,039cf = **<u>2,592cf storage provided</u>**

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

Q = (qu) (A) (WQV)

WQV = 1”

qu = 774 csm/in (time of concentration = 6 min. = 0.01 hr)

conversion from acres to sq. mi. = 0.0015625 mi^2/acre

<u>WQS-1</u>

Impervious Area = 0.796 Ac.

Q = 774 x 0.796 x 0.0015625 x 1”

Q = 0.963 cfs treatment rate required

<u>Isolator Row (Subsurface Infiltration System 1)</u>

Impervious Area = 0.182 Ac.

Q = 774 x 0.182 x 0.0015625 x 1”

Q = 0.220 cfs treatment rate required

<u>Isolator Row (Subsurface Infiltration System 2)</u>

Impervious Area = 0.352 Ac.

Q = 774 x 0.352 x 0.0015625 x 1”

Q = 0.426 cfs treatment rate required

Massachusetts Department of Environmental Protection Wetlands Program

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

Effective October 15, 2013, computations following the standardized method must be submitted with a Wetlands Notice of Intent (NOI) when a proprietary manufactured stormwater treatment device sized using a flow rate is proposed in connection with work proposed in a wetland resource area or associated buffer zone. The computational method will primarily affect the sizing of the proprietary manufactured stormwater treatment separators, and not other types of stormwater treatment practices that are volume based (such as extended detention basins) or proprietary stormwater treatment filters sized using the Water Quality Volume (WQV).

Stormwater Standard No. 4 requires structural stormwater management practices to be sized to capture the required WQV in accordance with the Massachusetts Stormwater Handbook (310 CMR 10.05(6)(k)(4) and 314 CMR 9.06(6)(a)(4)) . Stormwater Standard No. 4 requires that the full WQV be captured and treated to remove 80% of the Total Suspended Solid (TSS) load.

Since manufactured proprietary stormwater separators are sized using discharge rates and not volume, MassDEP is requiring the standardized method described below be used to convert the required WQV to a discharge rate (Q). No other methods are allowed to convert the WQV to the Q rate. This will ensure that flow rate based manufactured proprietary stormwater treatment practices are sized consistently from manufacturer to manufacturer. This section contains the following: caveats for method use, method description, examples of how to use the method, and documentation describing how the method was derived. This method will be incorporated into the Massachusetts Stormwater Handbook.

The following caveats apply to use of the method:

- Device sized using the Q rate must only be used as pretreatment practice.
- Device sized using this method shall be designed to be "offline", unless approved otherwise through written reciprocity granted by MassDEP to a final certification pursuant to the Technology Acceptance Reciprocity Partnership (TARP). This means the device must be sized at a minimum to fully treat the Q rate without any overflow, by-pass, surcharge of runoff, or scouring of sediments or oils previously trapped or entrained in the device.
- The computations described below must be provided in the Stormwater Report accompanying Wetlands Notice of Intent or application for 401 Water Quality Certification.
- MassDEP reserves ability to revise this method in the future as may be needed to reflect documented increases to precipitation intensity (Douglas 2011), updates to design intensity storms currently being considered by the National Weather Service or Northeast Climate Center (NECC)[1] to Technical Paper 40 (upon which this methodology is based), NRCS revisions to the WinTR55/TR20 methods,[2] or changes to the National Pollution Discharge Elimination System (NPDES) permits issued by EPA for Massachusetts.

[1] On web, see precipitation intensities at http://precip.net

[2] On web, See MA-NRCS description at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs144p2_013763.pdf

METHOD

1. Determine if the WQV is the first ½-inch or 1-inch of runoff. If WQV is the first ½ -inch, go to STEP 2. If WQV is the first 1-inch of runoff, go to STEP 7.

FOR FIRST ½ INCH RUNOFF WQV

2. Use Curve Number (CN) 98 to represent the runoff potential for impervious surfaces (see Method Derivation section below for explanation regarding how CN 98 was obtained).

   Only use impervious surfaces for these computations. Runoff from pervious surfaces should not be included in the WQV computations for the Q rate. The WQV required by the Massachusetts Wetlands Protection (310 CMR 10.05(6)(k)(4)) and 401 Water Quality Certification (314 CMR 9.06(6)(a)(4)) regulations for Stormwater Standard No. 4 is based only on impervious surfaces.

3. Compute the time of concentration (tc) using the methods described in TR-55 1986, Chapter 3.

4. Refer to Figure 1, Ia/P Curve = 0.058

5. Determine unit peak discharge using Figure 1 or 2. Figure 2 is in tabular form so is preferred. Using the tc determined in STEP 3, read the unit peak discharge (qu) from Figure 1 or Table in Figure 2. qu is expressed in the following units: cfs/mi²/watershed inches (csm/in).

6. Compute Q rate using the following equation:

$$Q_{0.5} = (qu)(A)(WQV)$$

Where:

$Q_{0.5}$ = flow rate associated with first ½ -inch of runoff

qu = the unit peak discharge, in csm/in.

A = impervious surface drainage area (in square miles)

WQV = water quality volume in watershed inches (½ -inch in this case)

See Example 1, page 8 applying use of the method to convert first ½ -inch WQV to minimum $Q_{0.5}$ rate.

Figure 1: For First ½-inch Runoff, Ia/P Curve = 0.058, Relationship Between Unit Peak Discharge and Time of Concentration for NRCS Type III Storm Distribution.

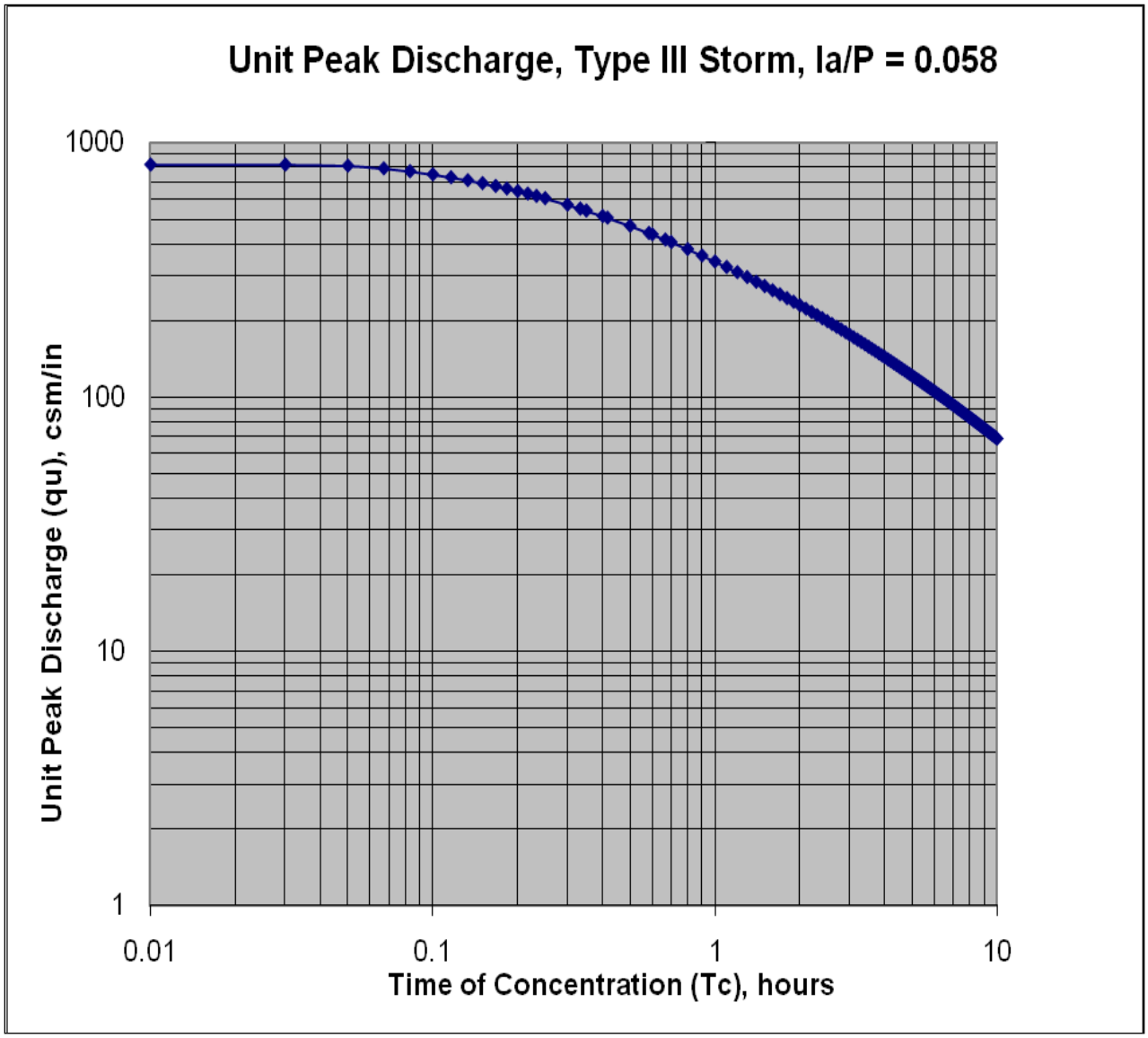

Figure 2: For First ½-inch of Runoff, Table of qu values for Ia/P Curve = 0.0.058, listed by tc, for Type III Storm Distribution

Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)	Tc (Hours)	qu (csm/in)
0.01	821	1.8	246	5.3	116	8.8	77
0.03	821	1.9	238	5.4	115	8.9	76
0.05	813	2	230	5.5	113	9	76
0.067	794	2.1	223	5.6	112	9.1	75
0.083	773	2.2	217	5.7	110	9.2	74
0.1	752	2.3	211	5.8	109	9.3	74
0.116	733	2.4	205	5.9	107	9.4	73
0.133	713	2.5	200	6	106	9.5	72
0.15	694	2.6	194	6.1	104	9.6	72
0.167	677	2.7	190	6.2	103	9.7	71
0.183	662	2.8	185	6.3	102	9.8	70
0.2	646	2.9	181	6.4	100	9.9	70
0.217	632	3	176	6.5	99	10	69
0.233	619	3.1	173	6.6	98		
0.25	606	3.2	169	6.7	97		
0.3	572	3.3	165	6.8	96		
0.333	552	3.4	162	6.9	94		
0.35	542	3.5	158	7	93		
0.4	516	3.6	155	7.1	92		
0.416	508	3.7	152	7.2	91		
0.5	472	3.8	149	7.3	90		
0.583	443	3.9	147	7.4	89		
0.6	437	4	144	7.5	88		
0.667	417	4.1	141	7.6	87		
0.7	408	4.2	139	7.7	86		
0.8	383	4.3	136	7.8	85		
0.9	361	4.4	134	7.9	84		
1	342	4.5	132	8	84		
1.1	325	4.6	130	8.1	83		
1.2	311	4.7	128	8.2	82		
1.3	297	4.8	126	8.3	81		
1.4	285	4.9	124	8.4	80		
1.5	274	5	122	8.5	79		
1.6	264	5.1	120	8.6	79		
1.7	254	5.2	118	8.7	78		

FOR FIRST 1-INCH RUNOFF WQV

7. Use Curve Number (CN) 98 to represent the runoff potential for impervious surfaces (see Method Derivation section below for explanation regarding how CN 98 was obtained).

   Only use impervious surfaces for these computations. Runoff from pervious surfaces should not be included in the WQV computations for peak WQF. The WQV required by the Massachusetts Wetlands Protection (310 CMR 10.05(6)(k)(4)) and 401 Water Quality Certification (314 CMR 9.06(6)(a)(4)) regulations for Stormwater Standard No. 4 is based only on impervious surfaces.

8. Compute the time of concentration (tc) using the methods described in TR-55 1986, Chapter 3.

9. Refer to Ia/P Curve = 0.034 (Figure 3)

10. Determine unit peak discharge using Figure 3 or 4. Figure 4 is in tabular form so is preferred. Using the tc determined in STEP 8, read the unit peak discharge (qu) from Figure 2 or from Table in Figure 4. qu is expressed in the following units: cfs/mi²/watershed inches (csm/in).

11. Compute the water quality flow (WQF) using the following equation:

$$Q_1 = (qu)(A)(WQV)$$

Where:

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

qu = the unit peak discharge, in csm/in.

A = impervious surface drainage area (in square miles)

WQV = water quality volume in watershed inches (1.0-inches in this case)

See Example 2, page 8 applying use of the method to convert first 1-inch WQV to minimum Q_1 rate.

Figure 3: For First 1-inch Runoff, Ia/P Curve = 0.034, Relationship Between Unit Peak Discharge and Time of Concentration for NRCS Type III Storm Distribution

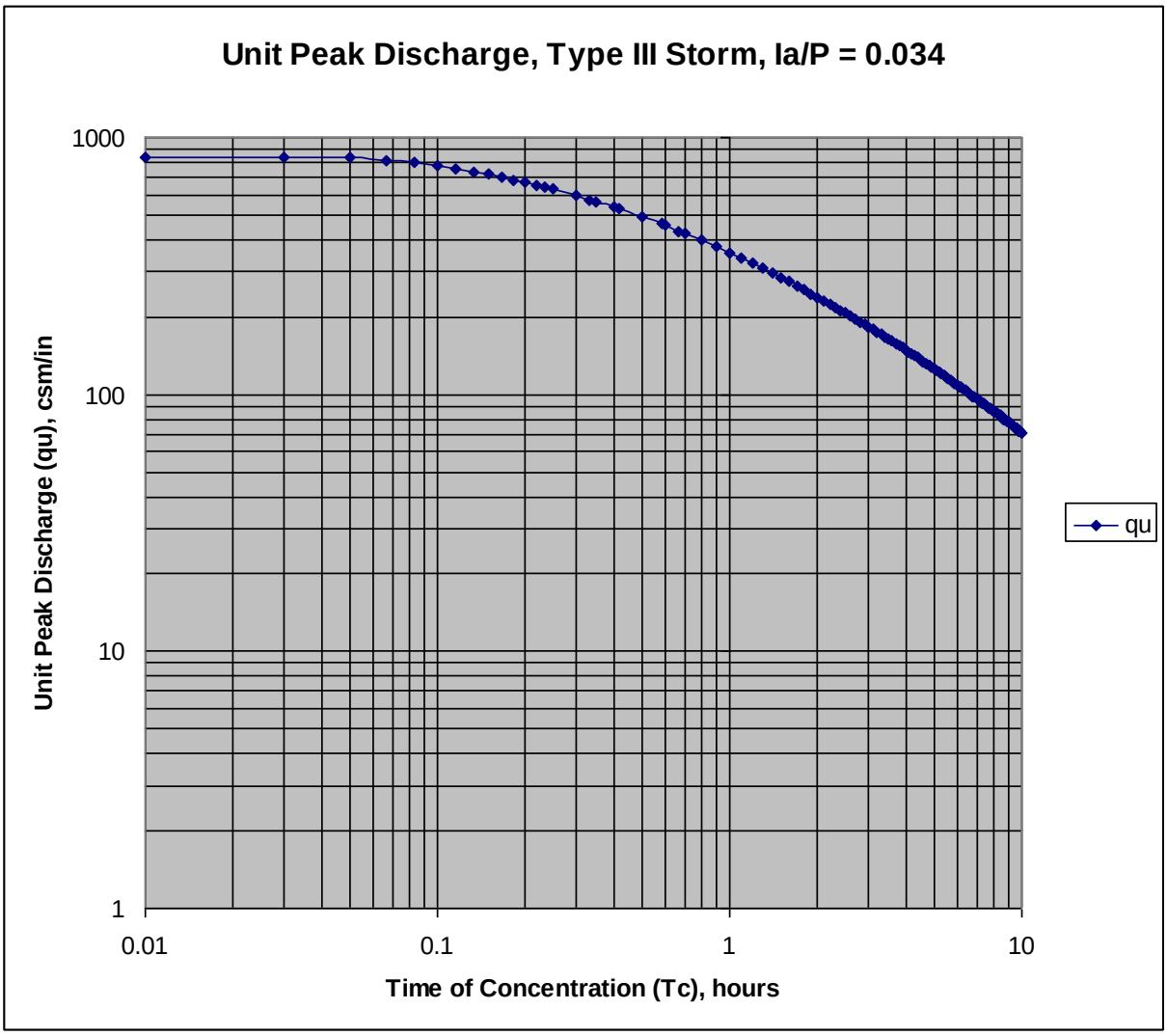

Figure 4: for First 1-inch Runoff, Table of qu values for Ia/P Curve = 0.034, listed by tc, for Type III Storm Distribution

Tc (Hours)	qu (csm/in)
0.01	835
0.03	835
0.05	831
0.067	814
0.083	795
0.1	774
0.116	755
0.133	736
0.15	717
0.167	700
0.183	685
0.2	669
0.217	654
0.233	641
0.25	628
0.3	593
0.333	572
0.35	563
0.4	536
0.416	528
0.5	491
0.583	460
0.6	454
0.667	433
0.7	424
0.8	398
0.9	376
1	356
1.1	339
1.2	323
1.3	309
1.4	296
1.5	285
1.6	274
1.7	264
1.8	255
1.9	247
2	239
2.1	232
2.2	225
2.3	219
2.4	213
2.5	207
2.6	202

Tc (Hours)	qu (csm/in)
2.7	197
2.8	192
2.9	187
3	183
3.1	179
3.2	175
3.3	171
3.4	168
3.5	164
3.6	161
3.7	158
3.8	155
3.9	152
4	149
4.1	146
4.2	144
4.3	141
4.4	139
4.5	137
4.6	134
4.7	132
4.8	130
4.9	128
5	126
5.1	124
5.2	122
5.3	120
5.4	119
5.5	117
5.6	115
5.7	114
5.8	112
5.9	111
6	109
6.1	108
6.2	106
6.3	105
6.4	104
6.5	102
6.6	101
6.7	100
6.8	99
6.9	98
7	96

Tc (Hours)	qu (csm/in)
7.1	95
7.2	94
7.3	93
7.4	92
7.5	91
7.6	90
7.7	89
7.8	88
7.9	87
8	86
8.1	85
8.2	84
8.3	84
8.4	83
8.5	82
8.6	81
8.7	80
8.8	79
8.9	79
9	78
9.1	77
9.2	76
9.3	76
9.4	75
9.5	74
9.6	74
9.7	73
9.8	72
9.9	72
10	71

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- Urban retrofit/redevelopment
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MASTEP Technology Review

Technology Name: CDS (Continuous Deflective Separator) - Contech Stormwater Solutions, Inc.

Studies Reviewed:

- NJCAT Technology Verification High Efficiency Continuous Deflective Separators CDS Technologies Inc. January 2010.
- Independent Review of CDS 2015 Product Evaluation, FB Environmental Associates, 2009.
- NJCAT Technology Verification Addendum Report High Efficiency Continuous Deflective Separators CDS Technologies Inc. December 2004
- Continuous Deflection Separation (CDS) Unit For Sediment Control In Brevard County, Florida January, 2000

Date: 5/13/2011
Reviewer: Jerry Schoen

Rating: 2

Brief rationale for rating: MASTEP rating is based primarily on NJCAT 2010 field study and FB Environmental 2009 laboratory study. Both studies generally followed TARP field or NJDEP-recommended laboratory test protocols, with some exceptions. The 2010 field study sampled storms totaling 37% of average annual rainfall (50% is required), and experienced excessively large influent particles. This is discussed further below and in the MASTEP study description. In the FB lab study, no evidence of a Quality Assurance Project Plan, little discussion of quality control, higher than recommended particle size distribution, limited range of influent sediment concentration, sediments analyzed by SSC method but not TSS.

The Florida field study monitored 5 storm events and encountered sampling/equipment problems in four of them. The NJCAT lab study was conducted on a unit that was specially modified for testing in New Jersey, and is now being sold in NJ and NY.

Other Comments:

FB Environmental Associates study:

- OK-110 sediment mix used. This is recommended by Maine DEP, but produces sediments somewhat larger than those recommended by New Jersey DEP.
- Sediment analysis conducted with whole sample; essentially SSC method. SSC is generally regarded as more accurate than TSS method, but comparisons with other studies or products that use TSS data are problematic.
- Full range of flows were tested.
- Only one target sediment concentration was tested; average influent SSC was 313 mg/l, slightly outside of recommended 100-300 mg/l range.
- Scour test was performed; system produced no scour at flows up to 137% of capacity.

NJCAT 2010 Study

- Mean influent particle size was 500-600 microns, well above the TARP criteria of < 100 microns. To address this problem, the testing agency separated samples into

filtered subsamples of several size ranges (> 2000 microns, < 2000, < 500 and < 50). Removal efficiencies were calculated for each of these ranges, with results ranging from 64% (for <50 micron particles) to 99% (for > 2000 microns).

- TSS and SSC efficiencies were calculated by Event Mean Concentration and by Sum Of Loads methods.
- Study was well document. Other than issues of particle size and % annual rainfall, study closely followed TARP guidelines.

NJCAT 2004 Study

- Expectations of sediment removal performance comparable to this study should be confined to units that contain the sediment weir and a 2400 micron screen.
- The study did not include a scour test.
- A particularly fine sediment mix (Sil-Col-Sil 106, pre-washed to remove all particles > 100 microns), which makes sediment removal more difficult. Higher removal efficiencies may be obtained if sediment particle size range is larger.
- A narrow range of influent sediment (164 – 203 mg/l, average 184), was tested but this is within the NJDEP-recommended 100-300 mg/l range.
- TSS analysis appears to have been performed by a non- standardized method.
- No discussion of quality control.

Brevard County FL study

- This study was performed before release of the TARP Tier II Protocols and does not conform to them.
- The study states that "testing under higher flow conditions would be desirable."
- TSS, BOD, COD, pH, total phosphorus, and turbidity were monitored.

DRAINAGE COMPUTATIONS

COMP. BY: CEM

PROJECT: Haverhill Hotel & Retail/Restaurant

JOB NO. W1511212

DATE: 10/20/2016

Location: Haverhill, MA

RATIONAL METHOD PIPE CALCULATIONS **DESIGN PERIOD:** **25-YEAR STORM**

LOCATION			IMPERVIOUS			LANDSCAPE			AVG			Q		Min.		Q	V
FROM	TO	A (total)	A	C	CA	A	C	CA	C	Tc	I	CxIxA	D	S	n	full	full
		(Ac)	(Ac)			(Ac)				(Min)	in/hr	(cfs)	(in)	(ft/ft)		(cfs)	(fps)
CB-1	DMH-1	0.26	0.19	0.90	0.171	0.07	0.30	0.021	0.73	5	5.5	1.06	8	0.044	0.013	2.53	7.26
CB-2	DMH-2	0.16	0.16	0.90	0.144	0.00	0.30	0.000	0.90	5	5.5	0.79	8	0.018	0.013	1.62	4.64
CB-3	DMH-2	0.15	0.11	0.90	0.099	0.04	0.30	0.012	0.74	5	5.5	0.61	8	0.010	0.013	1.21	3.46
OCS-1	DMH-2	*Peak Flow Rate										1.34	8	0.025	0.013	1.91	5.47
DMH-2	DMH-3											2.74	12	0.008	0.013	3.19	4.06
CB-4	DMH-3	0.25	0.20	0.90	0.180	0.05	0.30	0.015	0.78	5	5.5	1.07	8	0.010	0.013	1.21	3.46
DMH-3	DMH-4											3.82	15	0.005	0.013	4.57	3.72
CB-5	DMH-4	0.25	0.20	0.90	0.180	0.05	0.30	0.014	0.76	5	5.5	1.06	8	0.020	0.013	1.71	4.90
CB-6	DMH-4	0.05	0.00	0.90	0.000	0.05	0.30	0.015	0.30	5	5.5	0.08	6	0.020	0.013	0.79	4.04
DMH-4	WQS-1											4.96	15	0.006	0.013	5.05	4.11
CB-7	WQS-1	0.17	0.17	0.90	0.153	0.00	0.30	0.000	0.90	5	5.5	0.84	8	0.008	0.013	1.08	3.10
WQS-1	FES-1											5.80	15	0.008	0.013	5.89	4.80
CB-8	DMH-5	0.27	0.19	0.90	0.171	0.08	0.30	0.024	0.72	5	5.5	1.07	8	0.022	0.013	1.79	5.13
CB-9	DMH-5	0.21	0.17	0.90	0.153	0.04	0.30	0.012	0.79	5	5.5	0.91	8	0.015	0.013	1.48	4.24
AD-1	OCS-2	0.02	0.01	0.90	0.009	0.01	0.30	0.003	0.60	5	5.5	0.07	6	0.010	0.013	0.56	2.86
OCS-2	FES-2	*Peak Flow Rate										4.11	15	0.006	0.013	5.00	4.08

*Roof leader sizing to be coordinated with the Plumbing Engineer

Rip Rap and Apron Sizing Worksheet

Address: 3 Air Force Road, Boston Freightliner/Rivergreen Drive
Everett, MA
(FES-1)

Project No.: W1512311
Date: 10/20/2016
Prepared By: CEM

Apron Sizing:

$$La = \frac{1.7Q}{Do^{3/2}} + 8Do$$

$$W\ end = 3Do + 0.4La\ for\ Tailwater\ \geq 0.5Do$$
$$W\ end = 3Do + La\ for\ Tailwater < 0.5Do$$

INPUT	Quantity	Units	Notes
Do	1.25	ft	Inside diameter of culvert
Q	4.53	cfs	Pipe discharge for conduit design storm or 25 year storm, whichever is greater

OUTPUT	Quantity	Units	Notes
La	15.51039	ft	Length of apron (minimum)
For tailwater elevation greater than or equal to the elevation of the center of the pipe:			
W start	3.75	ft	Width of apron at the culvert (minimum)
W end	9.954155	ft	Width of apron end (minimum)
For tailwater elevation less than the elevation of the center of the pipe:			
W start	3.75	ft	Width of apron at the culvert (minimum)
W end	19.26039	ft	Width of apron end (minimum)

Rip Rap Sizing:

$$d - 50 = \frac{0.02}{TW} * (\frac{Q}{Do})^{4/3}$$

INPUT	Quantity	Units	Notes
TW	0.8	ft	Tailwater depth above the invert of the culvert
Do	1.25	ft	Inside diameter of culvert (defined in apron sizing)
Q	4.53	cfs	Pipe discharge for conduit design storm or 25 year storm, whichever is greater (defined in apron sizing)

OUTPUT	Quantity	Units	Notes
d-50	0.139163	ft	Median stone diameter in feet
	1.669958	in	Median stone diameter in inches

Rip Rap and Apron Sizing Worksheet

Address: 3 Air Force Road, Boston Freightliner/Rivergreen Drive
Everett, MA
(FES-2)

Project No.: W1512311
Date: 10/20/2016
Prepared By: CEM

Apron Sizing:

$$La = \frac{1.7Q}{Do^{3/2}} + 8Do$$

$$W\ end = 3Do + 0.4La\ for\ Tailwater\ \geq 0.5Do$$
$$W\ end = 3Do + La\ for\ Tailwater < 0.5Do$$

INPUT	Quantity	Units	Notes
Do	1.25	ft	Inside diameter of culvert
Q	4.01	cfs	Pipe discharge for conduit design storm or 25 year storm, whichever is greater

OUTPUT	Quantity	Units	Notes
La	14.87785	ft	Length of apron (minimum)
For tailwater elevation greater than or equal to the elevation of the center of the pipe:			
W start	3.75	ft	Width of apron at the culvert (minimum)
W end	9.701139	ft	Width of apron end (minimum)
For tailwater elevation less than the elevation of the center of the pipe:			
W start	3.75	ft	Width of apron at the culvert (minimum)
W end	18.62785	ft	Width of apron end (minimum)

Rip Rap Sizing:

$$d - 50 = \frac{0.02}{TW} * (\frac{Q}{Do})^{4/3}$$

INPUT	Quantity	Units	Notes
TW	0.675	ft	Tailwater depth above the invert of the culvert
Do	1.25	ft	Inside diameter of culvert (defined in apron sizing)
Q	4.01	cfs	Pipe discharge for conduit design storm or 25 year storm, whichever is greater (defined in apron sizing)

OUTPUT	Quantity	Units	Notes
d-50	0.140186	ft	Median stone diameter in feet
	1.682235	in	Median stone diameter in inches

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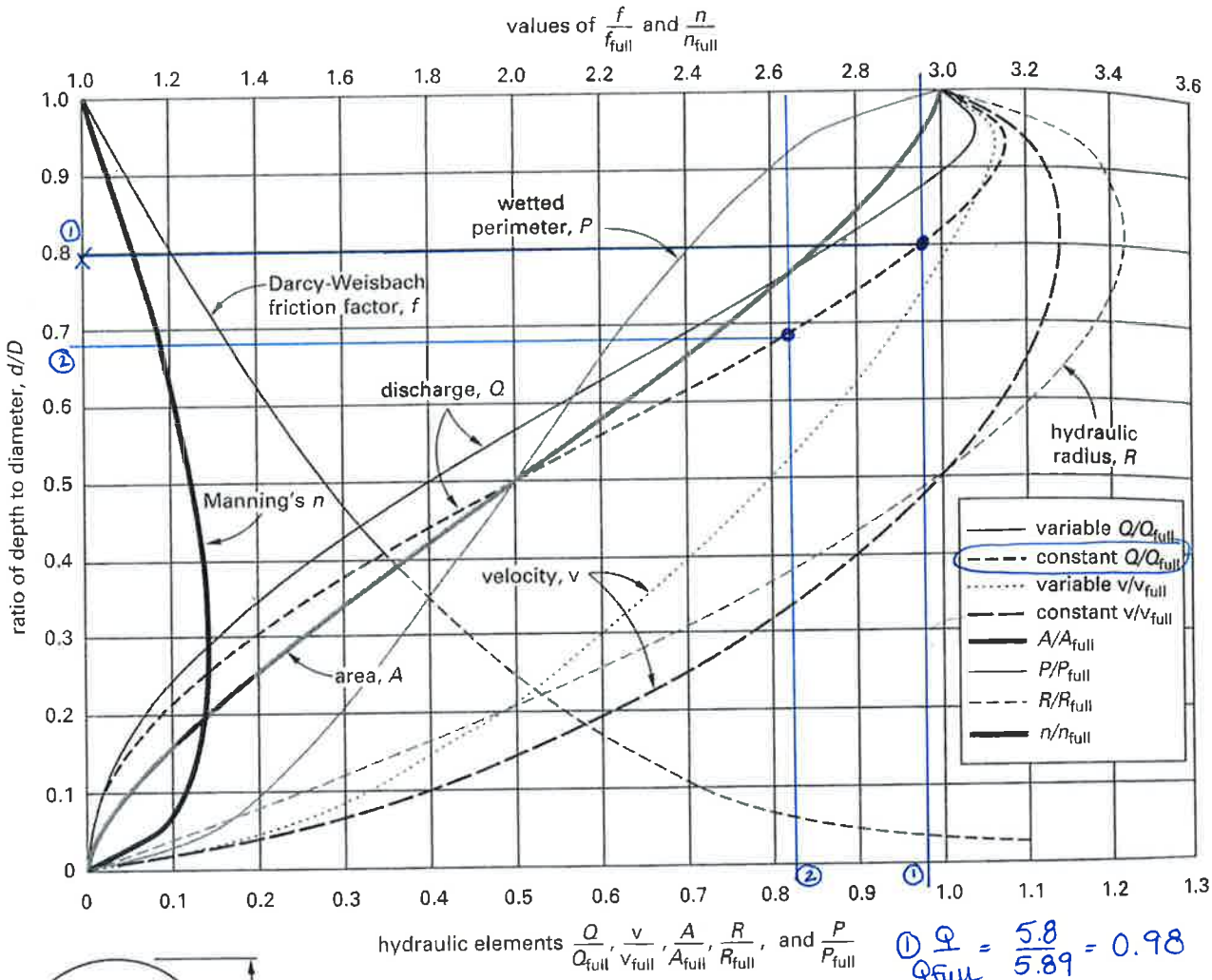
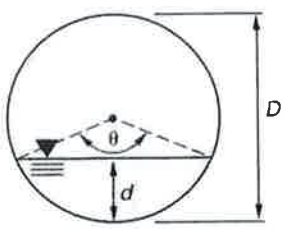
APPENDIX 19.C
Circular Channel Ratios[a,b]

Experiments have shown that n varies slightly with depth. This figure gives velocity and flow rate ratios for varyi n (solid line) and constant n (broken line) assumptions.



① $\frac{Q}{Q_{full}} = \frac{5.8}{5.89} = 0.98$

$\frac{d}{D} = 0.8$ ✓ more than 1/2 way full



① = FES-1
② = FES-2

Governing equations

$$\theta_{deg} = 2 \arccos\left(\frac{\frac{D}{2} - d}{\frac{D}{2}}\right)$$

$$A = \left(\frac{D}{2}\right)^2 \frac{\theta_{rad} - \sin\theta_{deg}}{2}$$

$$P = \frac{D\theta_{rad}}{2}$$

$$R = \frac{A}{P}$$

$$v = \left(\frac{1.486}{n}\right) R^{\frac{2}{3}} \sqrt{S}$$

$$Q = Av$$

Slope is constant.

$n = 0.013$

$$\frac{n}{n_{full}} = 1 + \left(\frac{d}{D}\right)^{0.540} - \left(\frac{d}{D}\right)^{1.200}$$

② $\frac{Q}{Q_{full}} = \frac{4.11}{5.00} = 0.82$

$\frac{d}{D} = 0.67$ ✓ more than 1/2 way full

[a] Adapted from *Design and Construction of Sanitary and Storm Sewers*, p. 87, ASCE, 1969, as originally presented in "Design of Se to Facilitate Flow," Camp, T. R., *Sewage Works Journal*, 18, 3 (1946).
[b] For $n = 0.013$

Location: Haverhill, MA

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[2]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Deep Sump and Hooded Catch Basin	**0.25**	**1.00**	**0.25**	**0.75**
Isolator Row	**0.83**	**0.75**	**0.62**	**0.13**
	0.00	**0.13**	**0.00**	**0.13**
	0.00	**0.13**	**0.00**	**0.13**
	0.00	**0.13**	**0.00**	**0.13**

Total TSS Removal = 87%

Project: **Haverhill Hotel & Retail/Restaurant**

Prepared By: **CEM**

Date: **10/20/2016**

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

1. BMP From Table on Page 1-7 of MassDEP Stormwater Mgt. Policy Handbook, Volume 1
2. TSS Removal Rate from Table on page 1-7 of the MassDEP Stormwater Mgt. Policy, Volume 1

Location: Haverhill, MA

TSS Removal Calculation Worksheet

B BMP[1]	C TSS Removal Rate[2]	D Starting TSS Load*	E Amount Removed (C*D)	F Remaining Load (D-E)
Contech CDS Unit	**0.54**	**1.00**	**0.54**	**0.46**
	0.00	**0.46**	**0.00**	**0.46**
	0.00	**0.46**	**0.00**	**0.46**
	0.00	**0.46**	**0.00**	**0.46**
	0.00	**0.46**	**0.00**	**0.46**

Total TSS Removal = 54%

Project: **Haverhill Hotel & Retail/Restaurant**

Prepared By: **CEM**

Date: **10/20/2016**

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

1. BMP From Table on Page 1-7 of MassDEP Stormwater Mgt. Policy Handbook, Volume 1
2. TSS Removal Rate from Table on page 1-7 of the MassDEP Stormwater Mgt. Policy, Volume 1

Automated 4-19-06

Appendix 6

LONG-TERM STORMWATER SYSTEM OPERATION AND MAINTENANCE PLAN

The Stormwater Management Standards

Standard 9: A Long-Term Operation and Maintenance Plan shall be developed and implemented to ensure that stormwater management systems function as designed.

The Long-Term Operation and Maintenance Plan shall at a minimum identify:

1. Stormwater management system(s) owners;
2. The party or parties responsible for operation and maintenance, including how future property owners will be notified of the presence of the stormwater management system and the requirement for proper operation and maintenance;
3. The routine and non-routine maintenance tasks to be undertaken after construction is complete and a schedule for implementing those tasks;
4. Plan that is drawn to scale and shows the location of all stormwater BMPs in each treatment train along with the discharge point;
5. Description and delineation of public safety features; and
6. Estimated operations and maintenance budget.

The Operation and Maintenance Plan shall identify best management practices for implementing maintenance activities in a manner that minimizes impacts to wetland resource areas.

The Proposal is for a private development.

Stormwater Management System

Owner: Giri Haverhill, LLC

General Contractor: TBD

The General Contractor shall have all logs and reports as stated within the Stormwater Pollution Prevention Plan readily available at all times for inspection by the City of Haverhill.

Method of recording for future Owners

☐ Deed
☐ Order of Conditions
☐ Other: _____

DRAINAGE SYSTEM

The following components shall be inspected:

- Inspection during or immediately following initial installation of sediment controls.
- Inspection following severe rainstorms to check for damage to controls.
- Inspection prior to seeding deadlines, particularly in the fall.
- Final inspection of projects nearing completion to ensure that temporary controls have been removed, stabilization is complete, drainage ways are in proper condition, and the final contours agree with the proposed contours on the approved plan.

Storm Events
2 year storm = 3.18 inches
10 year storm = 5.04 inches
25 year storm = 6.20 inches
100 year storm = 7.99 inches

After the occurrence of any of the storm events noted above, or any other heavy rainfall that may have affected stormwater management facilities, the designated inspector shall inspect the components listed below for evidence of scouring or erosion, excessive sediment deposits, clogging of stormwater structures, or any other condition that may adversely affect stormwater management operations.

If any of these conditions are observed, then appropriate actions should be taken to restore the stormwater management facility so that it operates as intended.

COMPONENT: Water Quality Structure (CDS Separator Unit)

RESPONSIBILITY:
During Construction: General Contractor - TBD
Post Construction: Giri Haverhill, LLC

ACTION: Inspection / cleaning

FREQUENCY: Per Manufacturer's Maintenance Guidelines (attached). Inspections should be performed at a minimum twice per year (spring and fall), however more frequent inspections may be required depending on the rate of sediment accumulation due to equipment washdown, winter sanding operations, or in areas where excessive amounts of trash are expected.

DESCRIPTION: See attached Manufacturer's Maintenance Guidelines. All accumulated materials shall be disposed of in accordance with DEP regulations. A vaccum truck may be required to remove sediment and debris from the sump of the water quality structure. Remove sediment when the level has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated.

BUDGET: Inspection/cleaning- $1,000/yr based on inspections and cleanings of twice a year.

COMPONENT: Detention Basin

RESPONSIBILITY:
During Construction: General Contractor - TBD
Post Construction: Giri Haverhill, LLC

ACTION: Preventative Maintenance, Inspection, Cleaning

FREQUENCY:
During Construction

1. Cleaning – As needed during construction or whenever the sediment depth exceeds a depth of six (6) inches.
2. Inspection – As needed during construction but once a month at a minimum.

Post Construction

1. Preventative Maintenance - Two times per year
2. Inspection to ensure proper function – After every major storm during the first 3 months of operation and twice a year thereafter, and after a storm event of 1-inch or greater.
3. Inspect and clean pretreatment devices- Every other month is recommended and at least twice a year and after every storm event of 1-inch or greater.

DESCRIPTION: The detention basin shall be inspected a minimum of twice a year to ensure it is operating as intended and that all components are stable and in working order. Inspections shall be by qualified personnel assigned by the property owner. The outlet of the basin, if any, shall be inspected for erosion and sedimentation, and rip-rap shall be promptly repaired in the case of erosion. Sediment collecting in the bottom of the basin shall be inspected twice annually, and removal shall commence any time the sediment reaches a depth of six inches anywhere in the basin. Any sediments removed shall be disposed of in accordance with the latest DEP guidelines for stormwater sediment disposal. The detention basin side slopes shall be mowed at least twice per year.

Inspections:

- Inlet and Outlet condition
- Sediment Accumulation
- Oil/Gas Sheen in water
- Condition of outlet structure
- General Inspection of basin

BUDGET: Cleaning - $1000/ yr
Inspection - $200/ yr

COMPONENT: Subsurface Infiltration Basin

RESPONSIBILITY:
During Construction: General Contractor - TBD
Post Construction: Giri Haverhill, LLC

ACTION: Various inspection, maintenance, and cleaning activities

FREQUENCY:
Semi-annually, and following any storm event of 1-inch or greater

Post Construction
4. Preventative Maintenance - Two times per year.
5. Inspection to ensure proper function – After every major storm during the first 3 months of operation and twice a year thereafter, and after a storm event of 1-inch or greater.
6. Inspect and clean pretreatment devices

DESCRIPTION: The isolator row is to be inspected a minimum of twice a year in March-April and October-November. Inspection ports are to be examined to determine if the underdrain system is working. There should not be any water in the system within 72 hours after the end of rainfall. If there is routinely water within the system within that time, contact a civil engineer for further observation and potential repairs. The isolator row is to be cleaned when the average depth of sediment throughout the length of the isolator row exceeds three (3) inches.

COMPONENT: Parking Lots & On-Site Driveways

RESPONSIBILITY:
During Construction: General Contractor - TBD
Post Construction: Giri Haverhill, LLC

ACTION: Sweeping and Inspection

FREQUENCY:
1. Inspection – Every six months (Spring & Fall).
2. Sweeping – Twice per year and on a more frequent basis depending on sanding operation.

DESCRIPTION: Paved surfaces shall be inspected every spring to determine if any damage has occurred from snow plowing operations. Asphalt and curbing should be inspected every six (6) months (Spring & Fall) in high traffic areas and truck travel areas for damage. Curbing and/or asphalt is to be repaired using similar materials to prevent erosion of surrounding soils. Parking lots and on-site driveways shall be swept at least twice per year and on a more frequent basis depending on sanding operations. All resulting sweepings shall be collected and properly disposed of off-site in accordance with MADEP and other applicable requirements.

BUDGET: $2,000/yr

COMPONENT: Deep sump catch basins

RESPONSIBILITY:
During Construction: General Contractor - TBD
Post Construction: Giri Haverhill, LLC

ACTION: Cleaning (Sediment removal / sump cleaning) and Inspection

FREQUENCY:
During Construction

1. Cleaning – As needed during construction or whenever the depth of deposits is greater than or equal to one half the depth from the bottom invert of the lowest pipe or is within two feet of the outlet.
2. Inspection – Weekly during construction

Post Construction

1. Cleaning – Once a year or whenever the depth of deposits is greater than or equal to one half the depth from the bottom invert of the lowest pipe in the basin.
2. Inspection – Once a year

DESCRIPTION: Basins are to be cleaned once per year. The General Contractor will monitor sumps and remove sediments as necessary. The Owner / Lessee will monitor sumps post construction on an as needed basis. Precautions shall take place to maintain the integrity of the oil trapping hoods during cleaning. The hoods shall be inspected and repaired as necessary. Accumulated Hydrocarbon shall be collected separately from accumulated sediment. All material shall be disposed of in accordance with DEP regulations.

Inspections:

- Frame and Grate
- Inlet and Outlet condition
- Cracks and settlement & joint failure & leaking
- Sediment Accumulation
- Oil/Gas Sheen in water
- Condition of hood
- General Inspection of structure

BUDGET: Inspection/cleaning- $1,000/ per basin per year based on inspections and cleanings once a year.

SAMPLE STORMWATER OPERATION & MAINTAINENCE ACTIVITY FORM

NOTE: The owner is responsible for maintaining an accurate and complete log of inspection & maintenance activities, including but not limited to, inspections, cleanings & repairs.

Inspection / Maintenance Activity	Contractor Name	Date	Observation / Action

CONTECH®
ENGINEERED SOLUTIONS

CDS Guide
Operation, Design, Performance and Maintenance

CDS®

Using patented continuous deflective separation technology, the CDS system screens, separates and traps debris, sediment, and oil and grease from stormwater runoff. The indirect screening capability of the system allows for 100% removal of floatables and neutrally buoyant material without blinding. Flow and screening controls physically separate captured solids, and minimize the re-suspension and release of previously trapped pollutants. Inline units can treat up to 6 cfs, and internally bypass flows in excess of 50 cfs (1416 L/s). Available precast or cast-in-place, offline units can treat flows from 1 to 300 cfs (28.3 to 8495 L/s). The pollutant removal capacity of the CDS system has been proven in lab and field testing.

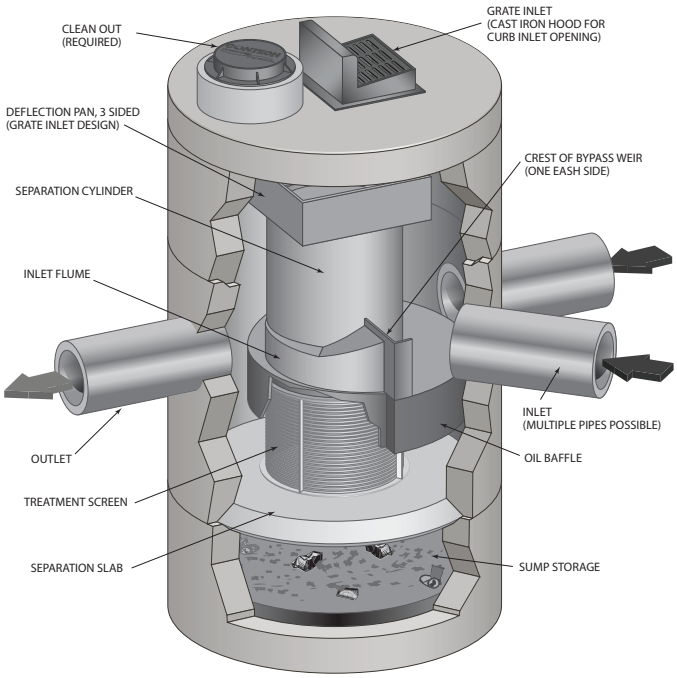
Operation Overview

Stormwater enters the diversion chamber where the diversion weir guides the flow into the unit's separation chamber and pollutants are removed from the flow. All flows up to the system's treatment design capacity enter the separation chamber and are treated.

Swirl concentration and screen deflection force floatables and solids to the center of the separation chamber where 100% of floatables and neutrally buoyant debris larger than the screen apertures are trapped.

Stormwater then moves through the separation screen, under the oil baffle and exits the system. The separation screen remains clog free due to continuous deflection.

During the flow events exceeding the treatment design capacity, the diversion weir bypasses excessive flows around the separation chamber, so captured pollutants are retained in the separation cylinder.



Design Basics

There are three primary methods of sizing a CDS system. The Water Quality Flow Rate Method determines which model size provides the desired removal efficiency at a given flow rate for a defined particle size. The Rational Rainfall Method™ or the and Probabilistic Method is used when a specific removal efficiency of the net annual sediment load is required.

Typically in the Unites States, CDS systems are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for a gradation with an average particle size (d50) of 125 microns (μm). For some regulatory environments, CDS systems can also be designed to achieve an 80% annual solids load reduction based on an average particle size (d50) of 75 microns (μm) or 50 microns (μm).

Water Quality Flow Rate Method

In some cases, regulations require that a specific treatment rate, often referred to as the water quality design flow (WQQ), be treated. This WQQ represents the peak flow rate from either an event with a specific recurrence interval, e.g. the six-month storm, or a water quality depth, e.g. 1/2-inch (13 mm) of rainfall.

The CDS is designed to treat all flows up to the WQQ. At influent rates higher than the WQQ, the diversion weir will direct most flow exceeding the WQQ around the separation chamber. This allows removal efficiency to remain relatively constant in the separation chamber and eliminates the risk of washout during bypass flows regardless of influent flow rates.

Treatment flow rates are defined as the rate at which the CDS will remove a specific gradation of sediment at a specific removal efficiency. Therefore the treatment flow rate is variable, based on the gradation and removal efficiency specified by the design engineer.

Rational Rainfall Method™

Differences in local climate, topography and scale make every site hydraulically unique. It is important to take these factors into consideration when estimating the long-term performance of any stormwater treatment system. The Rational Rainfall Method combines site-specific information with laboratory generated performance data, and local historical precipitation records to estimate removal efficiencies as accurately as possible.

Short duration rain gauge records from across the United States and Canada were analyzed to determine the percent of the total annual rainfall that fell at a range of intensities. US stations' depths were totaled every 15 minutes, or hourly, and recorded in 0.01-inch increments. Depths were recorded hourly with 1-mm resolution at Canadian stations. One trend was consistent at all sites; the vast majority of precipitation fell at low intensities and high intensity storms contributed relatively little to the total annual depth.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Rainfall Method. Since most sites are relatively small and highly impervious, the Rational Rainfall Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS system are

determined. Performance efficiency curve determined from full scale laboratory tests on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Probabilistic Rational Method

The Probabilistic Rational Method is a sizing program Contech developed to estimate a net annual sediment load reduction for a particular CDS model based on site size, site runoff coefficient, regional rainfall intensity distribution, and anticipated pollutant characteristics.

The Probabilistic Method is an extension of the Rational Method used to estimate peak discharge rates generated by storm events of varying statistical return frequencies (e.g. 2-year storm event). Under the Rational Method, an adjustment factor is used to adjust the runoff coefficient estimated for the 10-year event, correlating a known hydrologic parameter with the target storm event. The rainfall intensities vary depending on the return frequency of the storm event under consideration. In general, these two frequency dependent parameters (rainfall intensity and runoff coefficient) increase as the return frequency increases while the drainage area remains constant.

These intensities, along with the total drainage area and runoff coefficient for each specific site, are translated into flow rates using the Rational Method. Since most sites are relatively small and highly impervious, the Rational Method is appropriate. Based on the runoff flow rates calculated for each intensity, operating rates within a proposed CDS are determined. Performance efficiency curve on defined sediment PSDs is applied to calculate solids removal efficiency. The relative removal efficiency at each operating rate is added to produce a net annual pollutant removal efficiency estimate.

Treatment Flow Rate

The inlet throat area is sized to ensure that the WQQ passes through the separation chamber at a water surface elevation equal to the crest of the diversion weir. The diversion weir bypasses excessive flows around the separation chamber, thus preventing re-suspension or re-entrainment of previously captured particles.

Hydraulic Capacity

The hydraulic capacity of a CDS system is determined by the length and height of the diversion weir and by the maximum allowable head in the system. Typical configurations allow hydraulic capacities of up to ten times the treatment flow rate. The crest of the diversion weir may be lowered and the inlet throat may be widened to increase the capacity of the system at a given water surface elevation. The unit is designed to meet project specific hydraulic requirements.

Performance

Full-Scale Laboratory Test Results

A full-scale CDS system (Model CDS2020-5B) was tested at the facility of University of Florida, Gainesville, FL. This CDS unit was evaluated under controlled laboratory conditions of influent flow rate and addition of sediment.

Two different gradations of silica sand material (UF Sediment & OK-110) were used in the CDS performance evaluation. The particle size distributions (PSDs) of the test materials were analyzed using standard method "Gradation ASTM D-422 "Standard Test Method for Particle-Size Analysis of Soils" by a certified laboratory.

UF Sediment is a mixture of three different products produced by the U.S. Silica Company: "Sil-Co-Sil 106", "#1 DRY" and "20/40 Oil Frac". Particle size distribution analysis shows that the UF Sediment has a very fine gradation (d50 = 20 to 30 μm) covering a wide size range (Coefficient of Uniformity, C averaged at 10.6). In comparison with the hypothetical TSS gradation specified in the NJDEP (New Jersey Department of Environmental Protection) and NJCAT (New Jersey Corporation for Advanced Technology) protocol for lab testing, the UF Sediment covers a similar range of particle size but with a finer d50 (d50 for NJDEP is approximately 50 μm) (NJDEP, 2003).

The OK-110 silica sand is a commercial product of U.S. Silica Sand. The particle size distribution analysis of this material, also included in Figure 1, shows that 99.9% of the OK-110 sand is finer than 250 microns, with a mean particle size (d50) of 106 microns. The PSDs for the test material are shown in Figure 1.

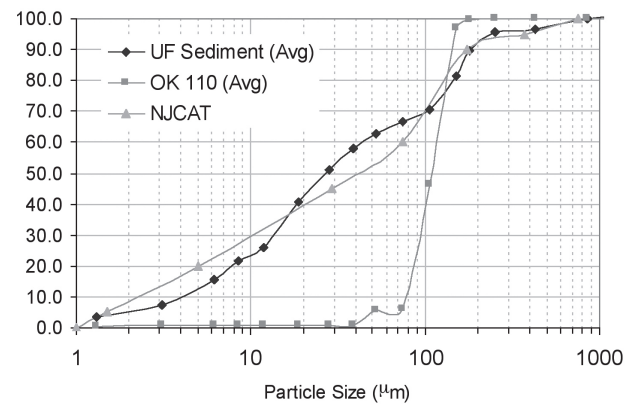


Figure 1. Particle size distributions

Tests were conducted to quantify the performance of a specific CDS unit (1.1 cfs (31.3-L/s) design capacity) at various flow rates, ranging from 1% up to 125% of the treatment design capacity of the unit, using the 2400 micron screen. All tests were conducted with controlled influent concentrations of approximately 200 mg/L. Effluent samples were taken at equal time intervals across the entire duration of each test run. These samples were then processed with a Dekaport Cone sample splitter to obtain representative sub-samples for Suspended Sediment Concentration (SSC) testing using ASTM D3977-97 "Standard Test Methods for Determining Sediment Concentration in Water Samples", and particle size distribution analysis.

Results and Modeling

Based on the data from the University of Florida, a performance model was developed for the CDS system. A regression analysis was used to develop a fitting curve representative of the scattered data points at various design flow rates. This model, which demonstrated good agreement with the laboratory data, can then be used to predict CDS system performance with respect

to SSC removal for any particle size gradation, assuming the particles are inorganic sandy-silt. Figure 2 shows CDS predictive performance for two typical particle size gradations (NJCAT gradation and OK-110 sand) as a function of operating rate.

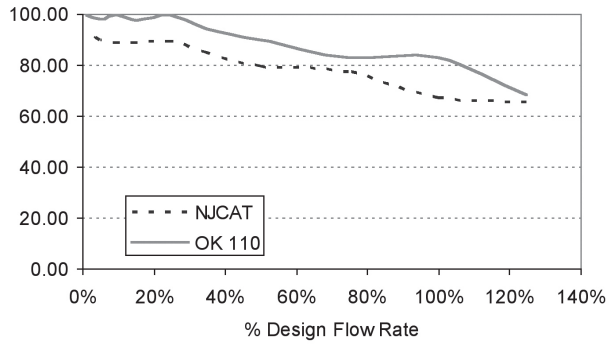


Figure 2. CDS stormwater treatment predictive performance for various particle gradations as a function of operating rate.

Many regulatory jurisdictions set a performance standard for hydrodynamic devices by stating that the devices shall be capable of achieving an 80% removal efficiency for particles having a mean particle size (d50) of 125 microns (e.g. Washington State Department of Ecology — WASDOE - 2008). The model can be used to calculate the expected performance of such a PSD (shown in Figure 3). The model indicates (Figure 4) that the CDS system with 2400 micron screen achieves approximately 80% removal at the design (100%) flow rate, for this particle size distribution (d50 = 125 μm).

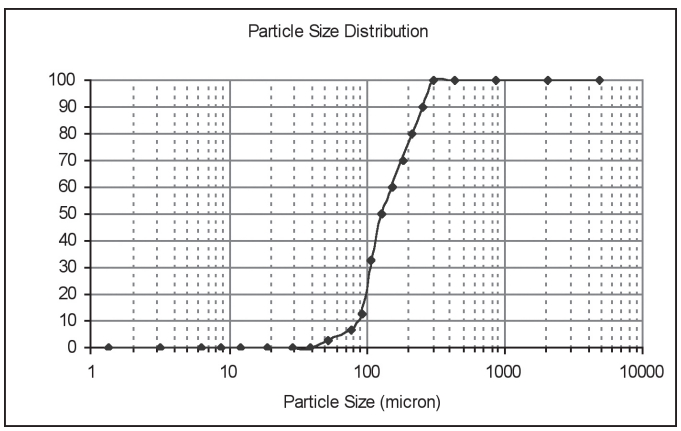


Figure 3. WASDOE PSD

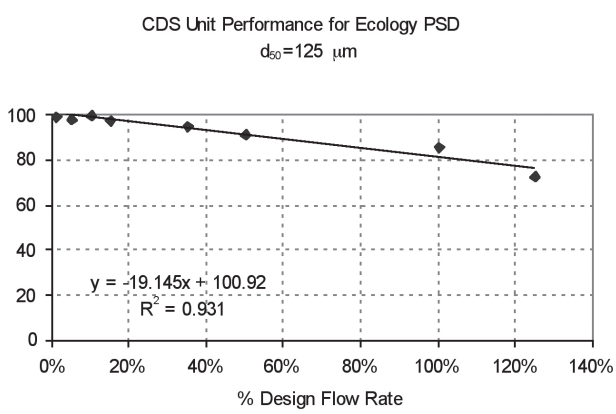


Figure 4. Modeled performance for WASDOE PSD.

Maintenance

The CDS system should be inspected at regular intervals and maintained when necessary to ensure optimum performance. The rate at which the system collects pollutants will depend more heavily on site activities than the size of the unit. For example, unstable soils or heavy winter sanding will cause the grit chamber to fill more quickly but regular sweeping of paved surfaces will slow accumulation.

Inspection

Inspection is the key to effective maintenance and is easily performed. Pollutant transport and deposition may vary from year to year and regular inspections will help ensure that the system is cleaned out at the appropriate time. At a minimum, inspections should be performed twice per year (e.g. spring and fall) however more frequent inspections may be necessary in climates where winter sanding operations may lead to rapid accumulations, or in equipment washdown areas. Installations should also be inspected more frequently where excessive amounts of trash are expected.

The visual inspection should ascertain that the system components are in working order and that there are no blockages or obstructions in the inlet and separation screen. The inspection should also quantify the accumulation of hydrocarbons, trash, and sediment in the system. Measuring pollutant accumulation can be done with a calibrated dipstick, tape measure or other measuring instrument. If absorbent material is used for enhanced removal of hydrocarbons, the level of discoloration of the sorbent material should also be identified

during inspection. It is useful and often required as part of an operating permit to keep a record of each inspection. A simple form for doing so is provided.

Access to the CDS unit is typically achieved through two manhole access covers. One opening allows for inspection and cleanout of the separation chamber (cylinder and screen) and isolated sump. The other allows for inspection and cleanout of sediment captured and retained outside the screen. For deep units, a single manhole access point would allows both sump cleanout and access outside the screen.

The CDS system should be cleaned when the level of sediment has reached 75% of capacity in the isolated sump or when an appreciable level of hydrocarbons and trash has accumulated. If absorbent material is used, it should be replaced when significant discoloration has occurred. Performance will not be impacted until 100% of the sump capacity is exceeded however it is recommended that the system be cleaned prior to that for easier removal of sediment. The level of sediment is easily determined by measuring from finished grade down to the top of the sediment pile. To avoid underestimating the level of sediment in the chamber, the measuring device must be lowered to the top of the sediment pile carefully. Particles at the top of the pile typically offer less resistance to the end of the rod than consolidated particles toward the bottom of the pile. Once this measurement is recorded, it should be compared to the as-built drawing for the unit to determine weather the height of the sediment pile off the bottom of the sump floor exceeds 75% of the total height of isolated sump.

Cleaning

Cleaning of a CDS systems should be done during dry weather conditions when no flow is entering the system. The use of a vacuum truck is generally the most effective and convenient method of removing pollutants from the system. Simply remove the manhole covers and insert the vacuum hose into the sump. The system should be completely drained down and the sump fully evacuated of sediment. The area outside the screen should also be cleaned out if pollutant build-up exists in this area.

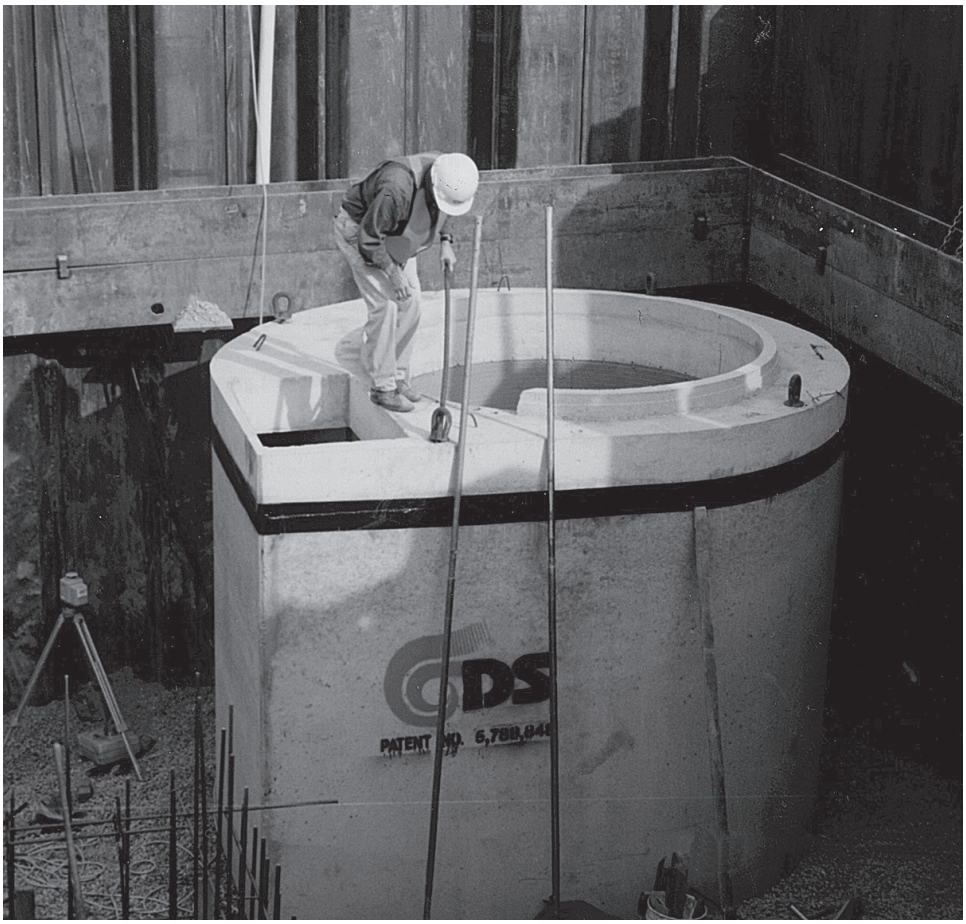
In installations where the risk of petroleum spills is small, liquid contaminants may not accumulate as quickly as sediment. However, the system should be cleaned out immediately in the event of an oil or gasoline spill. Motor oil and other hydrocarbons that accumulate on a more routine basis should be removed when an appreciable layer has been captured. To remove these pollutants, it may be preferable to use absorbent pads since they are usually less expensive to dispose than the oil/water emulsion that may be created by vacuuming the oily layer. Trash and debris can be netted out to separate it from the other pollutants. The screen should be cleaned to ensure it is free of trash and debris.

Manhole covers should be securely seated following cleaning activities to prevent leakage of runoff into the system from above and also to ensure that proper safety precautions have been followed. Confined space entry procedures need to be followed if physical access is required. Disposal of all material removed from the CDS system should be done in accordance with local regulations. In many jurisdictions, disposal of the sediments may be handled in the same manner as the disposal of sediments removed from catch basins or deep sump manholes. Check your local regulations for specific requirements on disposal.

CDS Model	Diameter		Distance from Water Surface to Top of Sediment Pile		Sediment Storage Capacity	
	ft	m	ft	m	yd3	m3
CDS2015-4	4	1.2	3.0	0.9	0.5	0.4
CDS2015	5	1.5	3.0	0.9	1.3	1.0
CDS2020	5	1.5	3.5	1.1	1.3	1.0
CDS2025	5	1.5	4.0	1.2	1.3	1.0
CDS3020	6	1.8	4.0	1.2	2.1	1.6
CDS3030	6	1.8	4.6	1.4	2.1	1.6
CDS3035	6	1.8	5.0	1.5	2.1	1.6
CDS4030	8	2.4	4.6	1.4	5.6	4.3
CDS4040	8	2.4	5.7	1.7	5.6	4.3
CDS4045	8	2.4	6.2	1.9	5.6	4.3

Table 1: CDS Maintenance Indicators and Sediment Storage Capacities

Note: To avoid underestimating the volume of sediment in the chamber, carefully lower the measuring device to the top of the sediment pile. Finer silty particles at the top of the pile may be more difficult to feel with a measuring stick. These finer particles typically offer less resistance to the end of the rod than larger particles toward the bottom of the pile.



CDS Inspection & Maintenance Log

CDS Model: _____ Location: _____

Date	Water depth to sediment[1]	Floatable Layer Thickness[2]	Describe Maintenance Performed	Maintenance Personnel	Comments

1. The water depth to sediment is determined by taking two measurements with a stadia rod: one measurement from the manhole opening to the top of the sediment pile and the other from the manhole opening to the water surface. If the difference between these measurements is less than the values listed in table 1 the system should be cleaned out. **Note: to avoid underestimating the volume of sediment in the chamber, the measuring device must be carefully lowered to the top of the sediment pile**.

2. For optimum performance, the system should be cleaned out when the floating hydrocarbon layer accumulates to an appreciable thickness. In the event of an oil spill, the system should be cleaned immediately.

Support

- Drawings and specifications are available at www.ContechES.com.
- Site-specific design support is available from our engineers.

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The product(s) described may be protected by one or more of the following US patents: 5,322,629; 5,624,576; 5,707,527; 5,759,415; 5,788,848; 5,985,157; 6,027,639; 6,350,374; 6,406,218; 6,641,720; 6,511,595; 6,649,048; 6,991,114; 6,998,038; 7,186,058; 7,296,692; 7,297,266; related foreign patents or other patents pending.

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RECYCLED PAPER

Appendix 7

Long Term Pollution Prevention Plan:
Hotel & Retail/Restaurant
in
Haverhill, Massachusetts

The Long Term Pollution Prevention Plan (LTPPP) that follows is a guideline for source control and pollution prevention to help maintain stormwater quality. In general, this facility is not expected to generate significant amounts of hazardous waste, if any, nor will there be outdoor storage of any petroleum products, chemicals, etc. The following LTPPP provides for these conditions in the event that they occur.

1.1 ROUTINE INSPECTION AND MAINTENANCE OF STORMWATER BMPs

System Inspector: The Owner shall be the Party Responsible for Inspection and Maintenance, and shall ensure that the inspection duties outlined in this section are performed. The system inspector shall be knowledgeable of the functionality of individual stormwater infrastructure components and be capable of recognizing system deficiencies due to needed maintenance or repair. The system inspector will be responsible for advising the Owner of observed conditions of the system which require attention, and shall be capable of providing maintenance instructions to infrastructure maintenance personnel for the various stormwater management components.

The system inspector will prepare inspection reports and details for the Owner's use.

Required maintenance tasks are detailed in the Operation and Maintenance Plan.

1.1.1 Proprietary Separators

Proprietary separator(s) shall be inspected no less than twice a year for the first year following installation, and no less than once per year thereafter.

Inspections and maintenance shall be performed in accordance with the manufacturer's recommendations, as detailed in the CDS® Inspection and Maintenance Guide (attached to the Operation and Maintenance Plan).

1.1.2 Sweeping and Inspection of Parking Lots & On-Site Driveways

Paved surfaces shall be inspected every spring to determine if any damage has occurred from snow plowing operations. Asphalt and curbing should be inspected every six (6) months (Spring & Fall) in high traffic areas and truck travel areas for

damage. Curbing and/or asphalt is to be repaired using similar materials to prevent erosion of surrounding soils. Parking lots and on-site driveways shall be swept at least twice per year and on a more frequent basis depending on sanding operations. All resulting sweepings shall be collected and properly disposed of off-site in accordance with MADEP and other applicable requirements.

1.1.3 Infiltration Basin

The infiltration basins shall be inspected a minimum of twice a year and after storms of one-inch or more to ensure they are fully drained within 72 hours, that they are operating as intended, and that all components are stable and in working order. Inspections shall be by qualified personnel assigned by the property owner. Sediment collecting in the isolator row and bottom of the basin shall be inspected twice annually, and removal shall commence any time the sediment reaches a depth of six inches anywhere in the basin (3 inches in the isolator row). Any sediments removed shall be disposed of in accordance with the latest DEP guidelines for stormwater sediment disposal.

1.2 SPILL PREVENTION AND RESPONSE PLAN

The following good housekeeping and material management practices shall be followed to reduce the risk of spills or other accidental exposure of hazardous materials to storm water runoff:

- Store quantities of materials required for the facility and not more,
- Store materials onsite in a neat, orderly manner in appropriate labeled containers,
- Store materials indoors or under cover, and
- Follow manufacturers' recommendations for proper use and disposal of materials.

If an emergency spill or release occurs, site personnel will report the spill or release to site management and evacuate the area. All employees shall receive Awareness Level training as part of their hazard communication training. Only employees trained at the First Responder Operations Level of 29 CFR 1910.120(q) will be authorized to respond in a defensive manner to emergency spills or releases of fuel and other materials.

If a spill occurs, site management shall be contacted and site management with assistance from appropriately trained personnel will contain the spill. If necessary, site management will contact an emergency response contractor and will also notify all other authorities and agencies in accordance with state and local regulations. Absorptive materials and other supplies will be used as needed to clean up and prevent the spill from spreading. The source of the spill shall be eliminated immediately. Water shall not be used to wash the spill down. Recycled oil and oily wastes shall be disposed in accordance with all applicable federal, state, tribal, and local requirements.

In the event that an accident or some other incident, such as an explosion, a release to groundwater or the environment, or an exposure to toxic chemical levels as described in 310 CMR 40.1600, Revised Massachusetts Contingency Plan, occurs, the Massachusetts Department of Environmental Protection, (Northeast Region) in Wilmington (978-694-3200), MassDEP Emergency Response (888-304-1133) the Local Emergency Planning Committee (LEPC), Department of Public Works, and all other appropriate federal, state, and local authorities and agencies will be notified by site management in accordance with 310 CMR 40.0333. The local Fire Department should be notified of any releases or incidents at 911 for emergencies.

The National Response Center (NRC) must be notified at 800-424-8802 where a leak, spill, or other release containing a hazardous substance or oil in an amount equal to or in excess of a reportable quantity established under either 40 CFR Part 110, 40 CFR Part 117, or 40 CFR Part 302 occurs during a 24-hour period. A description of the release, the circumstances leading to the release, and the date of the release must be provided within 7 calendar days of the knowledge of the release.

1.3 MAINTENANCE OF LAWNS, GARDENS, AND OTHER LANDSCAPED AREAS

Maintenance of lawns, gardens, and landscaped areas will be completed by the Owner in accordance with their standard policies and schedules.

Management of fertilizers, herbicides, and pesticides will follow the guidelines set forth below in Section 1.6. Integrated Pest Management (IPM) will be utilized.

1.4 STORAGE AND USE OF FERTILIZERS, HERBICIDES, AND PESTICIDES

Fertilizers, herbicides, and pesticides should be stored indoors or under cover. Partially used bags of fertilizers should be stored in sealable plastic bins. Application and disposal of such materials will be completed in accordance with manufacturer's instructions.

Discharges of fertilizers containing nitrogen or phosphorus to watercourses, wetlands, or other offsite areas shall be minimized as follows:

- Apply at a rate and in amounts consistent with manufacturers' specifications,
- Apply at the appropriate time of year for the site's location and to coincide as closely as possible to the period of maximum vegetation uptake and growth,
- Avoid applying before heavy rains that could wash away the fertilizer,
- Never apply to frozen ground,
- Never apply to stormwater conveyance channels that contain flowing water, and

- Follow all federal, state, tribal, and local requirements regarding fertilizer application.

1.5 PROPER MANAGEMENT OF DEICING CHEMICALS AND SNOW

Snow removal service will adhere to the MassDEP Snow Removal Guidance document (attached). It is not anticipated that sand piles will be maintained on the property. However, should sand piles be maintained on the property, they will be contained and stabilized to prevent the discharge of sand to wetlands or waterbodies, and covered, where feasible. Deicing chemicals should be stored indoors or under cover. The amount of road salt or deicing chemicals applied should be limited to that required to maintain safety by the use of spreaders equipped with calibration devices.

1.6 STREET SWEEPING

Paved access ways will be swept clean by a high efficiency vacuum sweeper monthly on average with sweeping scheduled primarily in the spring and fall. Special attention will be given to an increased sweeping frequency in March/April before residual sand from winter deicing applications is captured by stormwater runoff from spring rains. Street sweepings are regulated as a solid waste and will be managed in accordance with the MassDEP's Bureau of Waste Prevention written policy regarding the reuse and disposal of street sweepings.

1.7 PROVISIONS FOR PREVENTION OF ILLICIT DISCHARGES TO THE STORMWATER MANAGEMENT SYSTEM

No chemicals, litter, trash or other materials shall be dumped into or otherwise allowed to enter the stormwater drainage system. Only stormwater and the following non-stormwater discharges may enter the storm drainage system:

a. Water line flushing
b. Landscape irrigation
c. Diverted stream flows
d. Rising ground water
e. Uncontaminated ground water infiltration (as defined at 40 CFR 35.2005(20))
f. Uncontaminated pumped ground water
g. Discharge from potable water sources
h. Foundation drains
i. Air conditioning condensation
j. Irrigation water, springs
k. Water from crawl space pumps

l. Footing drains
m. Lawn watering
n. Individual resident car washing
o. Flow from riparian habitats and wetlands
p. De-chlorinated swimming pool discharges
q. Street wash waters and
r. Residential building wash waters without detergents

1.8 PROVISIONS FOR SOLID WASTE MANAGEMENT

All solid waste management systems shall be inspected and maintained in accordance with all local, state and federal requirements.

1.9 REQUIREMENTS FOR THE USE OF SALT, SAND, AND HEAVY EQUIPMENT FOR SNOW PLOWING OPERATIONS

Snow removal shall be the responsibility of the property owner. Salting and/or sanding of pavement / walkway areas during winter conditions shall only be done in accordance with all state/local requirements and approvals.

Snow piles shall be located adjacent to or on pervious surfaces in upland areas. In no case shall snow be disposed of or stored in the detention basins, infiltration basins or bioretention areas. In no case shall snow be disposed of or stored in resource areas (wetlands, floodplain, streams or other water bodies).

If necessary, stockpiled snow will be removed from the Site and disposed of at an off-site location in accordance with all local, state and federal regulations. Storage of salt and sand stockpiles must be covered at all times. Heavy equipment can only be stored at designated locations.

Illicit Discharge Statement

Certain types of non-stormwater discharges are allowed under the U.S. Environmental Protection Agency Construction General Permit. These types of discharges will be allowed under the conditions that no pollutants will be allowed to come in contact with the water prior to or after its discharge. The control measures which have been outlined previously in this LTPPP will be strictly followed to ensure that no contamination of these non-storm water discharges takes place. Any existing illicit discharges, if discovered during the course of the work, will be reported to MassDEP, as applicable, to be addressed in accordance with their respective policies. No illicit discharges will be allowed in conjunction with the proposed improvements.

1.10 CONTACT INFORMATION

In case of emergency, please contact:

- Haverhill Police Department
  40 Bailey Blvd
  Haverhill, MA 01830
  (978) 373-1212
  Emergency Number: 911

- Haverhill Fire Department
  131 Water Street
  Haverhill, MA 01830
  (978) 373-3833
  Emergency Number: 911

Snow Disposal Guidance

Effective Date: March 8, 2001

Guideline No. BRPG01-01

Applicability: Applies to all federal, state, regional and local agencies, as well as to private businesses.

Supersedes: BRP Snow Disposal Guideline BRPG97-1 issued 12/19/97, and all previous snow disposal guidance

Approved by: Glenn Haas, Assistant Commissioner for Resource Protection

PURPOSE: To provide guidelines to all government agencies and private businesses regarding snow disposal site selection, site preparation and maintenance, and emergency snow disposal options that are acceptable to the Department of Environmental Protection, Bureau of Resource Protection.

APPLICABILITY: These Guidelines are issued by the Bureau of Resource Protection on behalf of all Bureau Programs (including Drinking Water Supply, Wetlands and Waterways, Wastewater Management, and Watershed Planning and Permitting). They apply to public agencies and private businesses disposing of snow in the Commonwealth of Massachusetts.

INTRODUCTION

Finding a place to dispose of collected snow poses a challenge to municipalities and businesses as they clear roads, parking lots, bridges, and sidewalks. While we are all aware of the threats to public safety caused by snow, collected snow that is contaminated with road salt, sand, litter, and automotive pollutants such as oil also threatens public health and the environment.

As snow melts, road salt, sand, litter, and other pollutants are transported into surface water or through the soil where they may eventually reach the groundwater. Road salt and other pollutants can contaminate water supplies and are toxic to aquatic life at certain levels. Sand washed into waterbodies can create sand bars or fill in wetlands and ponds, impacting aquatic life, causing flooding, and affecting our use of these resources.

There are several steps that communities can take to minimize the impacts of snow disposal on public health and the environment. These steps will help communities avoid the costs of a contaminated water supply, degraded waterbodies, and flooding. Everything we do on the land has the potential to impact our water resources. Given the authority of local government over the use of the land, municipal officials and staff have a critically important role to play in protecting our water resources.

The purpose of these guidelines is to help municipalities and businesses select, prepare, and maintain appropriate snow disposal sites before the snow begins to accumulate through the winter.

RECOMMENDED GUIDELINES

These snow disposal guidelines address: (1) site selection; (2) site preparation and maintenance; and (3) emergency snow disposal.

1. SITE SELECTION

The key to selecting effective snow disposal sites is to locate them adjacent to or on pervious surfaces in upland areas away from water resources and wells. At these locations, the snow meltwater can filter in to the soil, leaving behind sand and debris which can be removed in the springtime. The following areas should be avoided:

- Avoid dumping of snow into any waterbody, including rivers, the ocean, reservoirs, ponds, or wetlands. In addition to water quality impacts and flooding, snow disposed of in open water can cause navigational hazards when it freezes into ice blocks.
- Do not dump snow within a Zone II or Interim Wellhead Protection Area (IWPA) of a public water supply well or within 75 feet of a private well, where road salt may contaminate water supplies.

- Avoid dumping snow on MassDEP-designated high and medium-yield aquifers where it may contaminate groundwater (see the next page for information on ordering maps from MassGIS showing the locations of aquifers, Zone II's, and IWPAs in your community).
- Avoid dumping snow in sanitary landfills and gravel pits. Snow meltwater will create more contaminated leachate in landfills posing a greater risk to groundwater, and in gravel pits, there is little opportunity for pollutants to be filtered out of the meltwater because groundwater is close to the land surface.
- Avoid disposing of snow on top of storm drain catch basins or in stormwater drainage swales or ditches. Snow combined with sand and debris may block a storm drainage system, causing localized flooding. A high volume of sand, sediment, and litter released from melting snow also may be quickly transported through the system into surface water.

Site Selection Procedures

a. It is important that the municipal Department of Public Works or Highway Department, Conservation Commission, and Board of Health work together to select appropriate snow disposal sites. The following steps should be taken:
b. Estimate how much snow disposal capacity is needed for the season so that an adequate number of disposal sites can be selected and prepared.
c. Identify sites that could potentially be used for snow disposal such as municipal open space (e.g., parking lots or parks).
d. Sites located in upland locations that are not likely to impact sensitive environmental resources should be selected first.
e. If more storage space is still needed, prioritize the sites with the least environmental impact (using the site selection criteria, and local or MassGIS maps as a guide).

MassGIS Maps of Open Space and Water Resources

If local maps do not show the information you need to select appropriate snow disposal sites, you may order maps from MassGIS (Massachusetts Geographic Information System) which show publicly owned open spaces and approximate locations of sensitive environmental resources (locations should be field-verified where possible). Different coverages or map themes depicting sensitive environmental resources are available from MassGIS on the map you order. At a minimum, you should order the Priority Resources Map. The Priority Resources Map includes aquifers, public water supplies, MassDEP-approved Zone II's, Interim Wellhead Protection Areas, Wetlands, Open Space, Areas of Critical Environmental Concern, NHESP Wetlands Habitats, MassDEP Permitted Solid Waste facilities, Surface Water Protection areas (Zone A's) and base map features. The cost of this map is $25.00. Other coverages or map themes you may consider, depending on the location of your city or town, include Outstanding Resource Waters and MassDEP Eelgrass Resources. These are available at $25.00 each, with each map theme being depicted on a separate map. Maps should be ordered from MassGIS via the Internet at http://www.mass.gov/mgis. Maps may also be ordered by fax at (617) 626-1249 (order form available from the MassGIS web site) or mail. For further information, contact MassGIS at (617) 626-1189.

2. SITE PREPARATION AND MAINTENANCE

In addition to carefully selecting disposal sites before the winter begins, it is important to prepare and maintain these sites to maximize their effectiveness. The following maintenance measures should be undertaken for all snow disposal sites:

- A silt fence or equivalent barrier should be placed securely on the downgradient side of the snow disposal site.
- To filter pollutants out of the meltwater, a 50-foot vegetative buffer strip should be maintained during the growth season between the disposal site and adjacent waterbodies.
- Debris should be cleared from the site prior to using the site for snow disposal.
- Debris should be cleared from the site and properly disposed of at the end of the snow season and no later than May 15.

3. EMERGENCY SNOW DISPOSAL

As mentioned earlier, it is important to estimate the amount of snow disposal capacity you will need so that an adequate number of upland disposal sites can be selected and prepared.

If despite your planning, upland disposal sites have been exhausted, snow may be disposed of near waterbodies. A vegetated buffer of at least 50 feet should still be maintained between

the site and the waterbody in these situations. Furthermore, it is essential that the other guidelines for preparing and maintaining snow disposal sites be followed to minimize the threat to adjacent waterbodies.

Under extraordinary conditions, when all land-based snow disposal options are exhausted, disposal of snow that is not obviously contaminated with road salt, sand, and other pollutants may be allowed in certain waterbodies under certain conditions. In these dire situations, notify your Conservation Commission and the appropriate MassDEP Regional Service Center before disposing of snow in a waterbody.

Use the following guidelines in these emergency situations:

- Dispose of snow in open water with adequate flow and mixing to prevent ice dams from forming.
- Do not dispose of snow in saltmarshes, vegetated wetlands, certified vernal pools, shellfish beds, mudflats, drinking water reservoirs and their tributaries, Zone IIs or IWPAs of public water supply wells, Outstanding Resource Waters, or Areas of Critical Environmental Concern.
- Do not dispose of snow where trucks may cause shoreline damage or erosion.
- Consult with the municipal Conservation Commission to ensure that snow disposal in open water complies with local ordinances and bylaws.

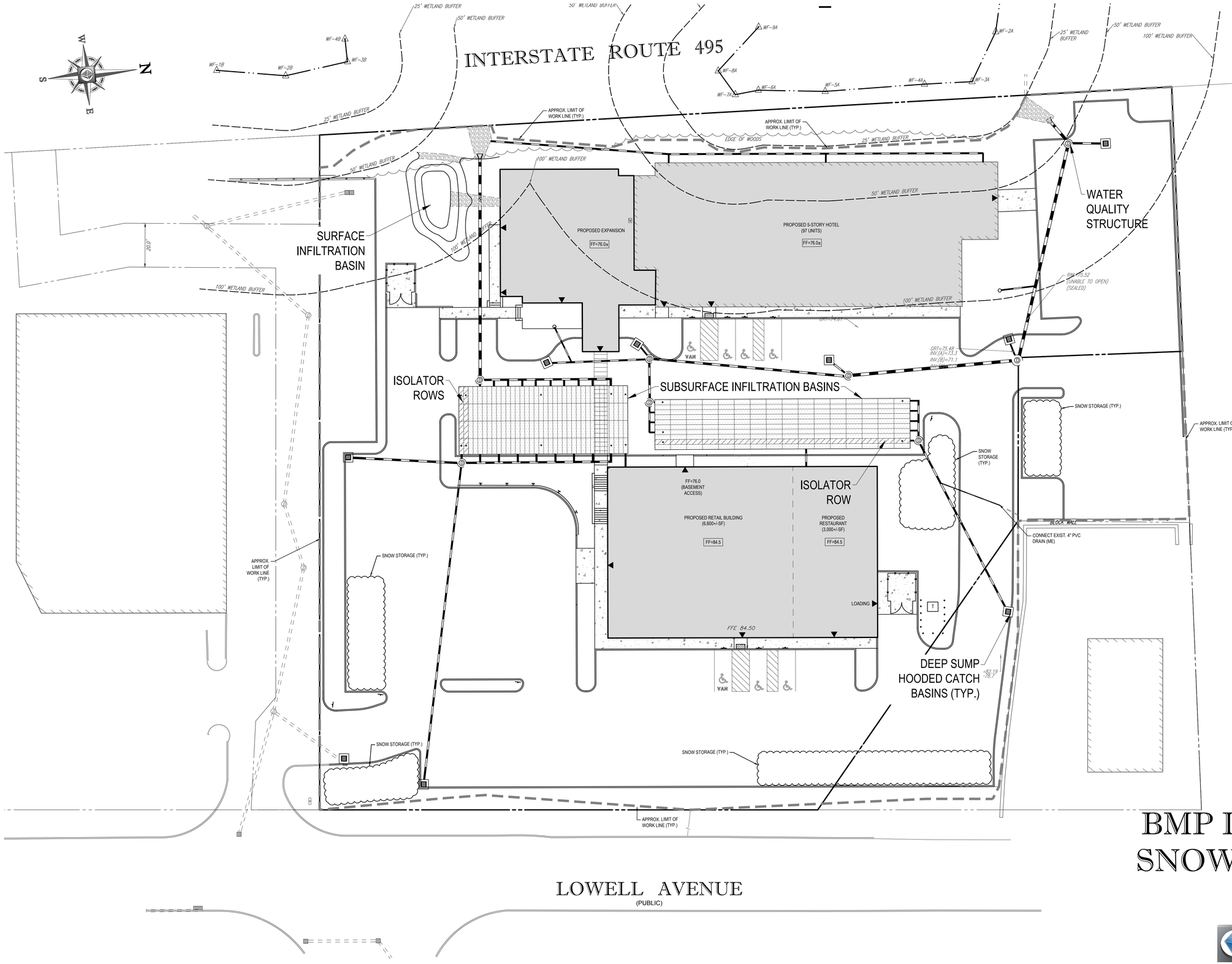
FOR MORE INFORMATION

If you need more information, contact one of MassDEP's Regional Service Centers:

Northeast Regional Office, Wilmington, 978-694-3200
Southeast Regional Office, Lakeville, 508-946-2714
Central Regional Office, Worcester, 508-792-7683
Western Regional Office, Springfield, 413-755-2214

or

Call Thomas Maguire of DEP's Bureau of Resource Protection in Boston at 617-292-5602.



DRAFT

BMP LOCATIONS AND SNOW STORAGE PLAN

PREPARED BY

BOHLER ENGINEERING

NOT TO SCALE

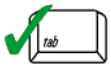
Appendix 8

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): Underground Infiltration System & Surface Infiltration Basin

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

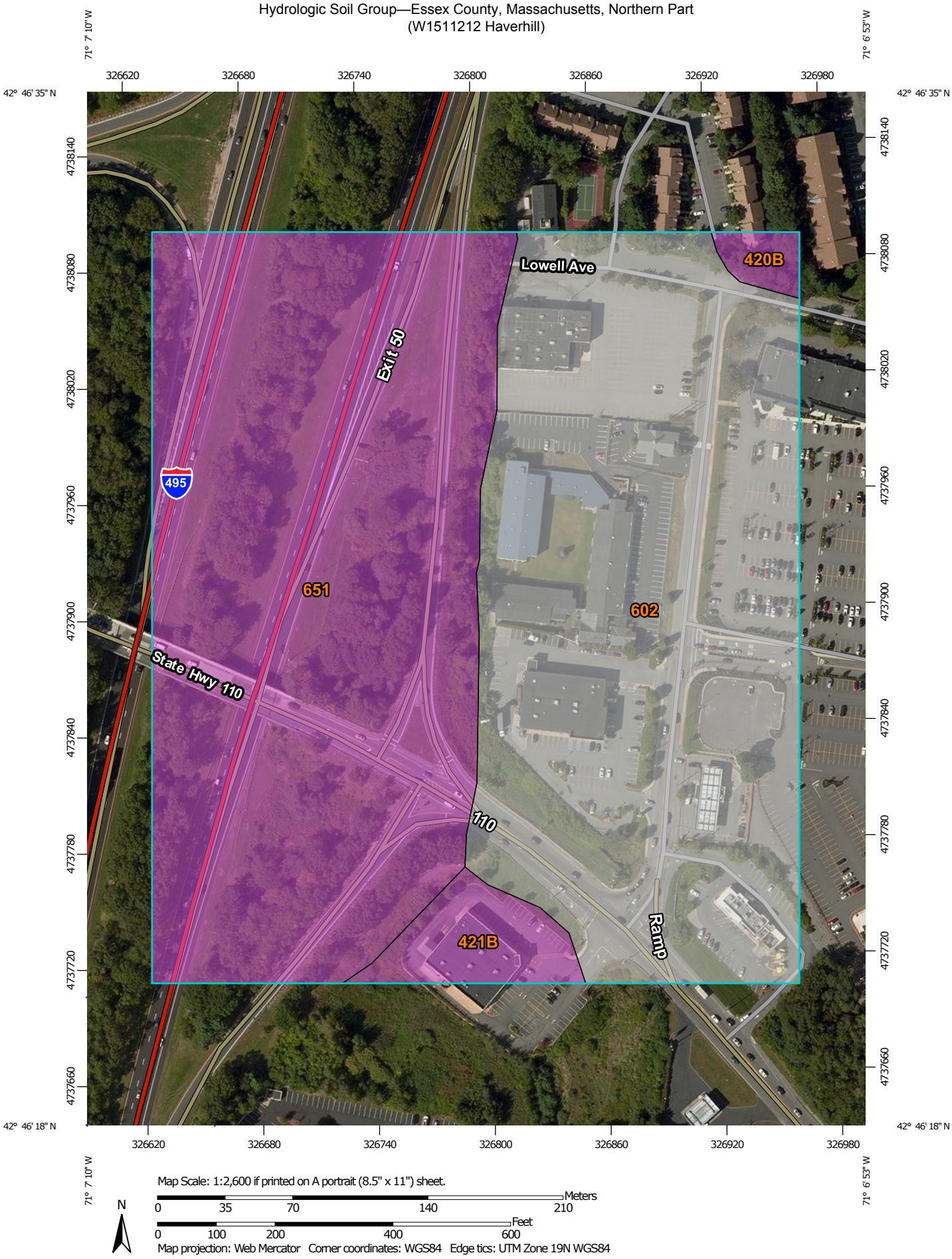
☒ The Long-Term Pollution Prevention Plan includes measures to prevent illicit discharges;

☐ 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 9

Hydrologic Soil Group—Essex County, Massachusetts, Northern Part
(W1511212 Haverhill)



MAP LEGEND

Area of Interest (AOI)

- Area of Interest (AOI)

Soils

Soil Rating Polygons

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Lines

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

Soil Rating Points

- A
- A/D
- B
- B/D
- C
- C/D
- D
- Not rated or not available

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 1:15,800.

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

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

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

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

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

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

Soil Survey Area: Essex County, Massachusetts, Northern Part
Survey Area Data: Version 11, Sep 28, 2015

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

Date(s) aerial images were photographed: Aug 29, 2014—Sep 19, 2014

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.

Hydrologic Soil Group

Hydrologic Soil Group— Summary by Map Unit — Essex County, Massachusetts, Northern Part (MA605)				
Map unit symbol	**Map unit name**	**Rating**	**Acres in AOI**	**Percent of AOI**
420B	Canton fine sandy loam, 3 to 8 percent slopes	A	0.3	0.9%
421B	Canton fine sandy loam, 3 to 8 percent slopes, very stony	A	1.1	3.3%
602	Urban land		14.9	46.2%
651	Udorthents, smoothed	A	16.0	49.7%
Totals for Area of Interest			**32.3**	**100.0%**

Description

Hydrologic soil groups are based on estimates of runoff potential. Soils are assigned to one of four groups according to the rate of water infiltration when the soils are not protected by vegetation, are thoroughly wet, and receive precipitation from long-duration storms.

The soils in the United States are assigned to four groups (A, B, C, and D) and three dual classes (A/D, B/D, and C/D). The groups are defined as follows:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

If a soil is assigned to a dual hydrologic group (A/D, B/D, or C/D), the first letter is for drained areas and the second is for undrained areas. Only the soils that in their natural condition are in group D are assigned to dual classes.

Rating Options

Aggregation Method: Dominant Condition

Component Percent Cutoff: *None Specified*

Tie-break Rule: Higher

Site Location or lot #	Best Western; 401 Lowell Avenue, Haverhill, MA			DEEP HOLE # TP-1
Applicant/owner:	Giri Haverhill, LLC			
DATE:	8/18/16	WEATHER:	Sunny	TEMP: 75 º
LOCATION: (Refer to sketch attached)	In grass area near Lowell Avenue (see sketch)			
PERFORMED BY:	Marc N. Belanger, PE (MADEP SE#123)			
WITNESSED BY:	N/A			
Land Use:	Commercial / existing Best Western	Landform:		
Vegetation:	Grass	Slope:	>10% (landscaped area)	
Stone Walls:	☐ Y ☒ N	Surface Stones:	☐ Y ☒ N	

Distance From:			
Open Water Bodies:	>100 ft.	Possible Wet Area:	>100 ft.
Drinking Water Well:	>100 ft.	Drainageway:	>100 ft.
Property Line:	5 ft.	Other:	

DEEP OBSERVATION HOLE LOG

Depth	Soil Horizon	Soil Texture	Soil Color	Other: Structures; Stones; Boulders; Consistency; % gravel
0”-24”	N/A	Mixed	N/A	Mixed fill / graded soils
24”-120”	C	Loamy Sand	10YR 7/2	

Parent Material (geologic):	Glacial Till	Depth to Bedrock:	None found to 120”
Depth to Groundwater:	Standing Water in Hole:	100”	
	Weeping From Pit Face:	100”	
	Estimated Seasonal High Groundwater:		60”

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method used:		Depth observed standing in obs. hole:					
		Depth to weeping from side of obs. hole:					
		Depth to soil mottles, description:			60”, distinct, common (10YR 6/8)		
		Groundwater adjustment:					
Index Well #:		Reading Date:		Index Well Level:		Adj. Factor:	
Adj. ground water level:							

Notes:	For drainage design only.

Site Location or lot #	Best Western; 401 Lowell Avenue, Haverhill, MA			DEEP HOLE # TP-2
Applicant/owner:	Giri Haverhill, LLC			
DATE:	8/18/16	WEATHER:	Sunny	TEMP: 75 º
LOCATION: (Refer to sketch attached)	In grass area near Lowell Avenue (see sketch)			
PERFORMED BY:	Marc N. Belanger, PE (MADEP SE#123)			
WITNESSED BY:	N/A			
Land Use:	Commercial / existing Best Western	Landform:		
Vegetation:	Grass	Slope:	>10% (landscaped area)	
Stone Walls:	☐ Y ☒ N	Surface Stones:	☐ Y ☒ N	
Distance From:				
Open Water Bodies:	>100 ft.	Possible Wet Area:	>100 ft.	
Drinking Water Well:	>100 ft.	Drainageway:	>100 ft.	
Property Line:	5 ft.	Other:		

DEEP OBSERVATION HOLE LOG

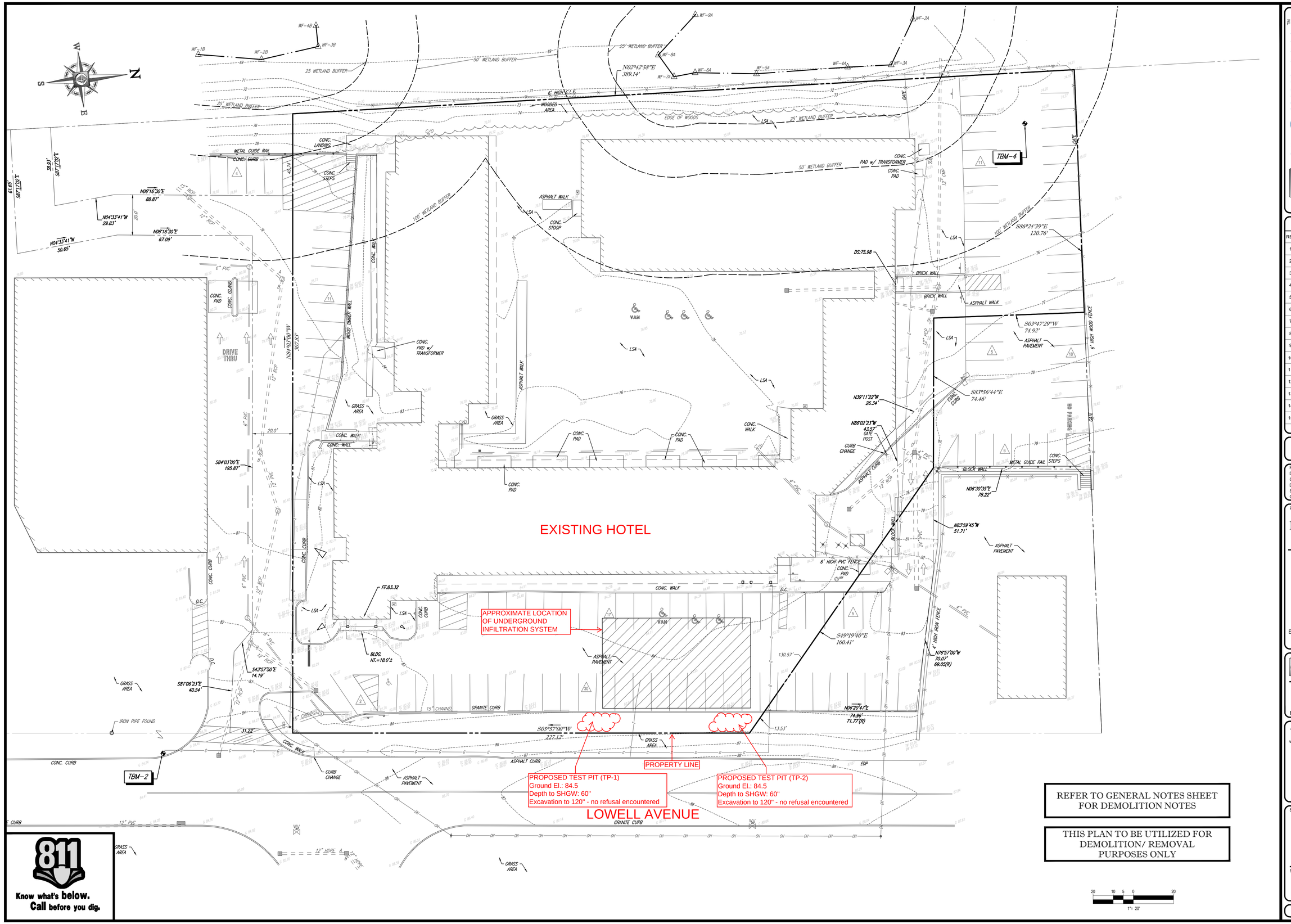
Depth	Soil Horizon	Soil Texture	Soil Color	Other: Structures; Stones; Boulders; Consistency; % gravel
0”-30”	N/A	Mixed	N/A	Mixed fill / graded soils
30”-120”	C	Loamy Sand	10YR 7/2	

Parent Material (geologic):	Glacial Till	Depth to Bedrock:	None found to 120”
Depth to Groundwater:	Standing Water in Hole:	100”	
	Weeping From Pit Face:	96”	
	Estimated Seasonal High Groundwater:		60”

DETERMINATION FOR SEASONAL HIGH WATER TABLE

Method used:		Depth observed standing in obs. hole:					
		Depth to weeping from side of obs. hole:					
		Depth to soil mottles, description:			60”, distinct, common (10YR 6/8)		
		Groundwater adjustment:					
Index Well #:		Reading Date:		Index Well Level:		Adj. Factor:	
Adj. ground water level:							

Notes:	For drainage design only.



BOHLER ENGINEERING

SITE CIVIL AND CONSULTING ENGINEERING
LAND SURVEYING
SUSTAINABLE DESIGN
PROGRAM MANAGEMENT
LANDSCAPE ARCHITECTURE
TRANSPORTATION SERVICES
UPSTATE NEW YORK
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NEW YORK METRO
NEW JERSEY
LEHIGH VALLEY PA
SOUTHEASTERN PA
WILMINGTON, DE
PHILADELPHIA, PA
BALTIMORE, MD
RALEIGH, NC
CHARLOTTE, NC
ATLANTA, GEORGIA
TAMPA, FL
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REVISIONS

REV	DATE	COMMENT	BY
1			
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DRAFT

PROJECT No.:	W1511212
DRAWN BY:	CEM
CHECKED BY:	AFT/MDS
DATE:	08/03/16
SCALE:	AS NOTED
CAD I.D.:	W1511212SS0

PROJECT:
SITE DEVELOPMENT PLANS
FOR
GIRI HAVERHILL, LLC

LOCATION OF SITE
MAP# 569, BLOCK# 2, LOT# 1
401 LOWELL AVENUE
CITY OF HAVERHILL
ESSEX COUNTY, MASSACHUSETTS

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SHEET TITLE:
DEMOLITION PLAN

SHEET NUMBER:
3
OF 1

SS 0 - 08/03/2016

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