
TECHNICAL MEMORANDUM

To: Ray Cody and Karen Simpson, United States Environmental Protection Agency, Region 1
From: Matt Lundsted and Nick Cristofori, CEI and Bruce Jacobs and Ken Hickey, WaterVision
Subject: **Task 1 Summary Memo: A description of recently completed data collection, conceptual design, and associated tasks.**
Date: February 17, 2015

This memo provides a summary of tasks completed to-date as part of the United States Environmental Protection Agency (EPA) project entitled; *Design and Construction of a Green Infrastructure Stormwater BMP Retrofit for One or More Municipal Properties on Cape Cod: A Demonstration and Education and Outreach Project*. We have completed the following preliminary tasks:

1. Chatham Site - Data collection and conceptual designs for a potential stormwater Best Management Practice (BMP);
2. Barnstable Site - Data collection and conceptual designs for a potential stormwater BMP;
3. Assessment of permitting requirements associated with the two sites;
4. Recommendations for in-kind services to be provided by the municipalities; and
5. Assessment of the monitoring program design.

Each of these tasks is described below. This work is being conducted by Water Vision, LLC and Comprehensive Environmental, Inc. (CEI), referred to herein as the Design Team. Please note that a brief literature and technology review of nitrogen-removal stormwater BMPs has also been conducted and will be summarized in a separate technical memorandum.

A draft version of this memo dated January 9 was provided to the EPA and discussed at a meeting at the Boston EPA office on January 13. Subsequent to that meeting, the EPA provided a set of comments on the conceptual design that had been presented at the January 13 meeting. This memo has been modified to include the original comments and our responses as Attachment D. Modified design plans and design calculations are also attached. During the preparation of this memo, we received additional comments from the UNH Stormwater Center and from the staff of the towns of Barnstable and Chatham. This memo does not describe subsequent modifications made in response to the UNH or town comments and discussions.

1. Chatham BMP Site

Kickoff Meeting

On October 23, 2014, a kickoff meeting was conducted in the Town of Chatham to discuss a potentially suitable BMP site at the intersection of Oyster Pond Furlong and Absegami Run in Chatham (Figure 1). This meeting was attended by Robert Duncanson (Chatham), Johanna Hunter, Ray Cody, and Karen Simpson (EPA), Ken Hickey and Bruce Jacobs (WaterVision), and Matt Lundsted and Nick Cristofori (CEI). The kickoff meeting consisted of a sit-down meeting at the town offices followed by a visit to the proposed BMP site. Dr. Duncanson is the Storm Water Management Program Coordinator for the Town of Chatham and assured the group that Chatham would be fully supportive of a BMP demonstration project.

BMP Site Overview

The potential BMP site is situated in Chatham, Massachusetts on Cape Cod (Figure 1). The proposed BMP would divert stormwater from a trunk line that drains approximately 16.9 acres that could be intercepted according to information provided by the Town of Chatham. An estimated 5.7 acres of the drained area is impervious. The stormwater network currently discharges at an outfall within the Oyster Pond estuary. The potential BMP at this site has been tentatively named the Oyster Pond BMP.

The Oyster Pond BMP site location was observed to be heavily overgrown and located within a depression approximately ten feet below the adjacent roadways. Although the overall undeveloped parcel is large in size, a large portion is occupied by a drainage ditch and associated wetland areas. As a result, the available area for the BMP is limited to a relatively small parcel near the intersection of Oyster Pond Furlong and Absegami Run. There are numerous underground utilities along Oyster Pond Furlong, including water, gas, and a new sewer line.

A 24-inch diameter drainage trunk line runs down Oyster Pond Furlong. For the Oyster Pond BMP, the trunk line would be intercepted and a portion of stormwater flow would be directed into a stormwater BMP at this site.

Field Data Collection and Analysis

On December 10, Soil Exploration Corp. of Leominster, Massachusetts drilled two on-site soil borings at the Oyster Pond BMP site. A groundwater monitoring well was also installed so that depth to groundwater could be monitored as needed during the coming months. Prior to performing onsite geotechnical investigations, the Town of Chatham marked for DigSafe and performed limited site clearing to create access pathways for drilling equipment. The Design Team then coordinated with DigSafe at least 72 hours in advance of conducting work at the site.

Soil borings were advanced to a depth of approximately 12-feet below grade. Soils at the Oyster Pond BMP site were found to be generally loose, fine sand with some silt. Soil borings revealed a shallow groundwater table, approximately one foot below the surface of the ground at approximately elevation 12 (NAVD88). However, the days prior to the measurement of depth to water had seen approximately two to three inches of rain fall over the area, likely contributing to an artificially high groundwater table.



Based on previously completed soil borings near the Oyster Pond BMP site, it is estimated that typical groundwater depths are approximately two feet below the level measured in the field at elevation 10 (NAVD88).

Based on these findings, we recommend that the Oyster Pond stormwater BMP design include an impermeable membrane lining on the bottom and sides to ensure horizontal subsurface flow, maximize treatment capabilities and minimize potential contact between groundwater and stormwater.

Copies of soil borings obtained at the Oyster Pond BMP site are included as **Attachment A** to this Summary Memorandum.

Conceptual Design

After the kickoff meeting, the Town of Chatham provided the Design Team with available site information, including watershed delineation and sizes, limited survey information, drainage network connectivity with elevations (NAD83 horizontal, NAVD88 vertical), and property ownership records. The Design Team has incorporated available information into a preliminary conceptual design for the Oyster Pond BMP.

A surface gravel wetland is proposed for the Oyster Pond BMP site. The proposed gravel wetland treatment system has been designed to accommodate 0.3 inches of runoff over the contributing impervious area. Current design practices for a gravel wetland are to size it to accommodate the water quality volume (WQV), defined as 1-inch of runoff over the contributing impervious area, however there is insufficient space to enable that level of treatment at this site. Space at the site is limited due to a combination of regulated resource areas and existing grades. As noted by the UNH Stormwater Center, “the majority of nitrogen washoff in parking lots occurs with the first 0.3-inch of precipitation” (Gunderson et al., 2012). Therefore, this stormwater BMP has been designed to treat a minimum of 0.3-inches of runoff from the contributing impervious area.

Figures 2 and 3 provides maps of the preliminary Oyster Pond BMP design with infrastructure, resource areas, and slopes indicated. Figure 4 provides a cross-section view of the conceptual BMP with a description of the stormwater treatment process. The general design components are as follows:

- Pretreatment sediment forebay approximately 3-feet deep and capable of holding in excess of 10% of the water quality volume. Additionally, two gravel wetland cells approximately 3-feet deep will be constructed, each capable of holding in excess of 0.15-inches of runoff over the impervious area;
- The trench fill will consist of 24 inches of crushed stone, topped by 6 inches of smaller pea stone and 8 inches of loam / wetland soil mix capable of supporting plant life;
- The gravel wetland cells will be interconnected with subsurface pervious piping systems to achieve lateral water flow through the BMP;
- The sediment forebay and bioretention cells will be lined on the sides and bottoms with an impervious liner to eliminate contact between stormwater and groundwater. Additionally, a



perimeter drain will be installed around a portion of the stormwater BMP to help dewater the area;

- A construction access and maintenance road will be constructed with access off of Absegami Run. The road will surround the sediment forebay on three sides to facilitate sediment removal, and provide access along the east side of the gravel wetland cells;
- To feed the gravel wetland, a new manhole will be cut into the existing trunk line running down Oyster Pond Furlong. A diversion wall will also be constructed within this manhole to direct low flows into the stormwater BMP via a new pipe while allowing storms exceeding BMP capacity to bypass through the existing drainage trunk line down Oyster Pond Furlong;
- Overflow from the sediment forebay will be directed into the first gravel wetland cell via an outlet control structure, possibly equipped with a trash rack. An emergency bypass will also be constructed to safely pass excess stormwater flows through the basin;
- Overflow from the second gravel wetland cell will be controlled by an outlet structure, capable of releasing water into the downstream drainage channel. The overflow structure, combined with the lined basins will serve to always maintain a water level within the underlying gravel layer to maintain horizontal subsurface flow paths and anaerobic conditions suitable for nitrogen removal; and
- An emergency riprap overflow level spreader will be installed in the second wetland cell, capable of bypassing stormwater in excess of the outlet structure capacity.

An Oyster Pond stormwater BMP, as shown in Figures 2 through 4 and described above, appears feasible at this location, based on available information. Conceptual design and supporting calculations are included as **Attachment B** to this Summary Memorandum. A proposed schedule for permitting and construction is included as Attachment C.



2. Barnstable BMP Site

Kickoff Meeting

On October 23, 2014, a kickoff meeting was conducted in the Town of Barnstable to discuss a potentially suitable BMP site at the intersection of South Street and Pleasant Street in Hyannis, a village within the Town of Barnstable (Figure 5). This meeting was attended by Roger Parsons, Dale Saad, Robert D. Golden (Barnstable), Johanna Hunter, Ray Cody, and Karen Simpson (EPA), Ken Hickey and Bruce Jacobs (WaterVision), and Matt Lundsted and Nick Cristofori (CEI). The kickoff meeting consisted of a sit-down meeting at the town offices followed by a visit to the proposed BMP site. The Town of Barnstable officials assured the group that Barnstable would be fully supportive of a BMP demonstration project.

Site Overview

The potential BMP site is situated in Hyannis (Figure 5). The proposed BMP would divert and treat stormwater from a 24-inch diameter drainage trunk line that runs north to south adjacent to the site. The trunk line drains approximately 6.9 acres that could be intercepted (according the information provided by the Town of Barnstable), with an estimated 3.5 acres of impervious area. The stormwater line currently discharges to Hyannis Inner Harbor in the Gateway Marina area. The potential BMP at this site has been tentatively named the Gateway Marina BMP.

The Gateway Marina BMP site was observed to be a relatively flat open space adjacent to a pleasant pedestrian walkway. Although small in size, the site is ideally suited as a public demonstration project because public access is already in place. There are numerous underground utilities present along South Street, including water, gas, sewer and telephone. For the Gateway Marina BMP, the drain line would be intercepted and a portion of the stormwater flow would be directed into a stormwater BMP at the site.

Field Data Collection and Analysis

On December 10, Soil Exploration Corp. of Leominster, MA drilled two on-site soil borings at the Gateway Marina BMP site. A groundwater monitoring well was also installed so that depth to groundwater could be monitored as needed during the coming months. Prior to performing onsite geotechnical investigations, the Town of Barnstable marked for DigSafe. The Design Team then coordinated with DigSafe at least 72 hours in advance of conducting work at the site.

Soil borings were advanced to a depth of approximately 12-feet below grade. Soils at the Gateway Marina BMP site were found to be loose and varied between gravel, sand, silt, and peat. These soils are likely representative of a mixture of native soil and fill materials associated with prior construction at the site. Soil borings revealed a shallow groundwater table, approximately one foot below the surface of the ground at approximately elevation 12 (NAVD88). The measured depth to water may be atypical since the area had recently received two to three inches of rain. It is estimated that typical groundwater depths are approximately two feet below the level measured in the field at elevation 10 (NAVD88).



Based on these findings, we recommend that the Gateway Marina stormwater BMP design include an impermeable membrane lining on the bottom and sides to ensure horizontal subsurface flow, maximize treatment capabilities and minimize potential contact between groundwater and stormwater.

Copies of soil borings obtained at the Gateway Marina BMP site are included as **Attachment A** to this Summary Memorandum.

Conceptual Design

After the kickoff meeting, the Town of Barnstable provided the Design Team with available site information, including watershed delineation and sizes, limited survey information, drainage network connectivity with elevations (NAD83 horizontal, NAVD88 vertical), and property ownership records. The Design Team has incorporated available information into a preliminary conceptual design for the Gateway Marina BMP.

A subsurface gravel wetland is proposed for the Gateway Marina BMP site adjacent to the pedestrian walkway area near the intersection of South Street and Pleasant Street. The proposed subsurface gravel wetland treatment system has been designed to accommodate 0.3 inches of runoff over the contributing impervious area. Standard design practice for subsurface gravel wetland would be to size the wetland to accommodate the water quality volume (WQV), defined as 1-inch of runoff over the contributing impervious area. There is insufficient space to provide for the full 1-inch of runoff over the contributing impervious area within a subsurface gravel wetland at this site. As noted by the UNH Stormwater Center, “the majority of nitrogen washoff in parking lots occurs with the first 0.3-inch of precipitation” (Gunderson et al., 2012). Therefore, this stormwater BMP has been designed to treat a minimum of 0.3-inches of runoff from the contributing impervious area.

Figures 6 and 7 provide maps of the preliminary Gateway Marina BMP design with infrastructure and slopes indicated. Figure 8 provides a cross-section view of the preliminary BMP with a description of the stormwater treatment process. The general design components are as follows:

- The gravel wetland will consist of two cells situated adjacent to each other. The first cell will be located aboveground and provide aerobic conditions for nitrogen removal. The second cell will be located underground and will provide anaerobic conditions for nitrogen removal.
- Each cell will be filled with 24 inches of crushed stone, topped by 6 inches of smaller pea stone and 8 inches of loam / wetland soil mix. Combined, both cells will be capable of holding in excess of 0.30-inches of runoff over the contributing impervious area;
- The bioretention cells will be lined on the sides and bottoms with an impervious liner to eliminate contact between stormwater and groundwater.
- To feed the gravel wetland, a new deep sump manhole with trash rack and oil/water separator will be cut into the existing pipe that runs perpendicular to the foot path. The manhole will then discharge via a flared end section onto a riprap pad in the first gravel wetland cell. This manhole will also provide limited pretreatment by removing sediment prior to entering the BMP;



- A diversion wall will also be constructed within the new manhole to direct low flows into the stormwater BMP while allowing storms exceeding BMP capacity to bypass through the existing line into the harbor. Limited surcharging of the existing drainage system will be required in order to limit the surface depth of the proposed BMP to approximately two feet; and
- Overflow from the subsurface gravel wetland will be controlled by a new outlet structure that is capable of releasing water into the adjacent existing stormwater pipe. The overflow structure will serve to always maintain a water level within the underlying gravel layer. This will ensure the maintenance of horizontal subsurface flow paths and anaerobic conditions suitable for nitrogen removal.

A Gateway Marina stormwater BMP, as shown in Figures 6 through 8 and described above, appears feasible at this location, based on available information. Conceptual design and supporting calculations are included as **Attachment B** to this Summary Memorandum. A proposed schedule for permitting and construction is included as Attachment C.



3. Assessment of Permitting Requirements

At the Oyster Pond BMP site, most of the work would take place immediately adjunct to bordering vegetated wetlands (BVW) including within the 100-foot buffer zone, with very limited, localized impacts to the BVW itself associated with the emergency overflow and bypass pipe. Therefore, a Notice of Intent (NOI) should be filed with the Chatham Conservation Commission to permit proposed construction. This permitting task could be performed as an in-kind service by the Town (see Section 4 below).

At the Gateway Marina BMP site, the proposed BMP is situated within a Flood Insurance Rate Map (FIRM) Special Flood Hazard Area (SFHA) area, classified as Zone AE with a Base Flood Elevation (BFE) of elevation 12 (NAVD88) based on FIRM Panel 0569J for Barnstable County. This zone is classified as an area subject to inundation by the 1-percent-annual-chance flood event, also known as the 100-year storm floodplain. As the proposed BMP location is situated within a tidal flood zone, it is considered Land Subject to Coastal Storm Flowage, also known as the Velocity Zone or Coastal High Hazard Area and thus is subject to regulation under the Massachusetts Wetland Protection Act 310 CMR 10.00. A NOI must be filed for this project with the Barnstable Conservation Commission. Note that no floodplain filling is proposed for this project. This BMP will result in a net cut, thus providing additional flood storage in the event of a storm event.

Permitting at both sites is not expected to substantially impact project costs. In terms of timing, the permitting process should begin in February 2015 using the best plans available in order obtain permits and to maintain the current project schedule. If permitting of either site should prove unattainable, then construction at that location would be infeasible.

Additional street opening permits may be required by one or both towns to perform trenching work associated with new drainage pipe. Street opening permit requirements should be determined in the near future. This task could also be performed as an in-kind service by the Town (see Section 4 below).



4. Potential In-kind Services

In-kind services can help foster partnerships between stakeholders and expedite stormwater BMP construction. The Towns of Chatham and Barnstable have already provided some in-kind services and have expressed interest in offering additional in-kind services to help ensure project success. During the October through December 2014 time period, both communities provided services to EPA and the Design Team, including:

- Providing limited vegetation clearing, removal, and disposal;
- Identifying relevant local bylaws regarding permitting requirements; and
- Provide available site information, including storm drain as-builts and detailed watershed delineation.

It would be very beneficial if the municipalities could provide the following additional in-kind services to support the BMP demonstration projects:

- Provide BMP monitoring and sampling services;
- Provide assistance with stormwater system access for sampling to confirm absence of illicit discharges;
- Provide Long-term Operation and Maintenance (O&M) of BMP;
- Provide permitting representation before the local Conservation Commission regarding compliance with Wetlands Protection Act (WPA);
- Assist with other Town permits, such as street opening, if applicable;
- Provide outreach assistance to coordinate with neighborhood associations for site access;
- Identify critical property and/or features of concern;
- Assume lead role in public outreach,
- Provide control and access to construction areas, including traffic management;
- Assist with materials management, including stockpile and reuse of excavated materials;
- Provide electrical service (115V) for monitoring shed; and
- Install fencing of sloped area(s) if needed.

We recommend meeting with municipal officials and seeking the in-kind services outlined above.



5. Monitoring Program Design

The monitoring program design outlined in the WaterVision technical response of September 15, 2014 remains valid and suitable to serve as a basis for monitoring program design. We recommend modifying the monitoring program schedule to allow the proposed BMP treatment systems to become fully functional before monitoring is to begin. Gravel wetland and subsurface gravel wetland system depend on bacteria and other microbes to reduce nitrogen and other pollutant loads. The microbes require a significant amount of time (e.g., two or more seasons), from construction and “seeding” to full functionality in removing nitrogen and other pollutants. It would be unfortunate to expend resources (time and funds) monitoring gravel wetland BMP system performance before the system becomes fully functional. Therefore we recommend delaying the initial monitoring time to allow for that to occur.

The stormwater BMPs are scheduled to be constructed in the spring to early summer 2015 time period. We recommend commencing the monitoring program in the early summer of 2016 to ensure that the BMP is fully functional throughout the duration of the monitoring program.



Reference

J. Gunderson, R. Roseen, T. Ballesterio, A. Watts, J. Houle, and K. Farah, Subsurface Gravel Wetlands for Stormwater Management. November 12, 2012.

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Figure 1. Potentially-suitable stormwater BMP site near Oyster Pond, Chatham

Figure 2. Proposed Conceptual Design: Chatham (Plan-view)

Figure 3. Oyster Pond BMP, Gravel Wetland: Chatham (Plan-view)

Figure 4. Oyster Pond BMP, Gravel Wetland: Chatham (Cross-sectional view)

Figure 5. Potentially-suitable stormwater BMP site near Gateway Marina, Hyannis

Figure 6. Proposed Conceptual Design: Barnstable (Plan-view)

Figure 7. Gateway Marina BMP, Subsurface Gravel Wetland, Barnstable (Plan-view)

Figure 8. Gateway Marina BMP, Subsurface Gravel Wetland, Barnstable (Cross-sectional view)

List of Attachments

The following supporting information is included as attachments to this Summary Memorandum:

- Attachment A – Soil Boring Logs
- Attachment B – Conceptual Design Calculations
- Attachment C – Project Schedule
- Attachment D – EPA Comments and Design Team Responses





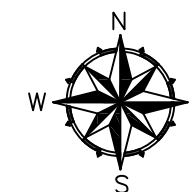
Figure 1. Potentially-suitable stormwater BMP site near Oyster Pond, Chatham



CHATHAM, PROPOSED CONCEPTUAL DESIGN
INTERSECTION OF OYSTER POND FURLONG AND ABSEGAMI RUN

General Notes

1. THE LOCATION OF UNDERGROUND UTILITIES HAVE NOT BEEN VERIFIED OR INSPECTED. THE CONTRACTOR, PRIOR TO COMMENCEMENT OF CONSTRUCTION, SHALL VERIFY THE LOCATION OF ALL UTILITIES AND CONTACT "DIG-SAFE" AT 1-888-344-7233.
2. THE CONTRACTOR SHALL EXERCISE EXTREME CAUTION TO PREVENT ANY DAMAGE TO ADJACENT PROPERTIES. ALL AREAS WHICH ARE AFFECTED BY THE CONTRACTOR'S OPERATIONS SHALL BE RETURNED TO THEIR ORIGINAL CONDITION OR BETTER, AT NO ADDITIONAL COST TO THE OWNER.
3. ANY CHANGE IN FIELD CONDITIONS SHALL BE REPORTED TO THE ENGINEER TO INSURE THAT ANY MODIFICATIONS TO THE ORIGINAL DESIGN ARE PROPER AND ADEQUATE TO SERVE THE PROJECT'S NEEDS AND COMPLY WITH THE APPLICABLE STANDARDS AND REGULATIONS.
4. CONTRACTOR SHALL IMMEDIATELY REPAIR OR FILL ANY POTHOLE THAT OCCUR DUE TO CONSTRUCTION.
5. CONTRACTOR SHALL REPAIR ALL PAVING ON SITE DAMAGED OR REMOVED DURING CONSTRUCTION.
6. EROSION CONTROL SUCH AS SILT FENCE AND/OR HAY BALES SHALL BE INSTALLED TO PREVENT SEDIMENT FROM ENTERING ANY ADJACENT RESOURCE AREAS.
7. REMOVE ALL TEMPORARY EROSION CONTROLS FROM THE SITE AT THE CONCLUSION OF CONSTRUCTION ACTIVITIES.
8. STORMWATER SHALL NOT BE DIRECTED INTO THE BASIN UNTIL ALL PLANTINGS ARE SUITABLY ESTABLISHED. CONTRACTOR SHALL EITHER TIE INTO THE EXISTING CATCH BASIN LAST OR INSTALL A REMOVAL PLUG.



No.	Revision/Issue	Date
2	60% Design	02/15
1	Conceptual	01/15

WV WaterVision, LLC

481 GREAT ROAD, SUITE 3
ACTON, MA 01720

**COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED**

21 DEPOT STREET
MERRIMACK, NH 03054

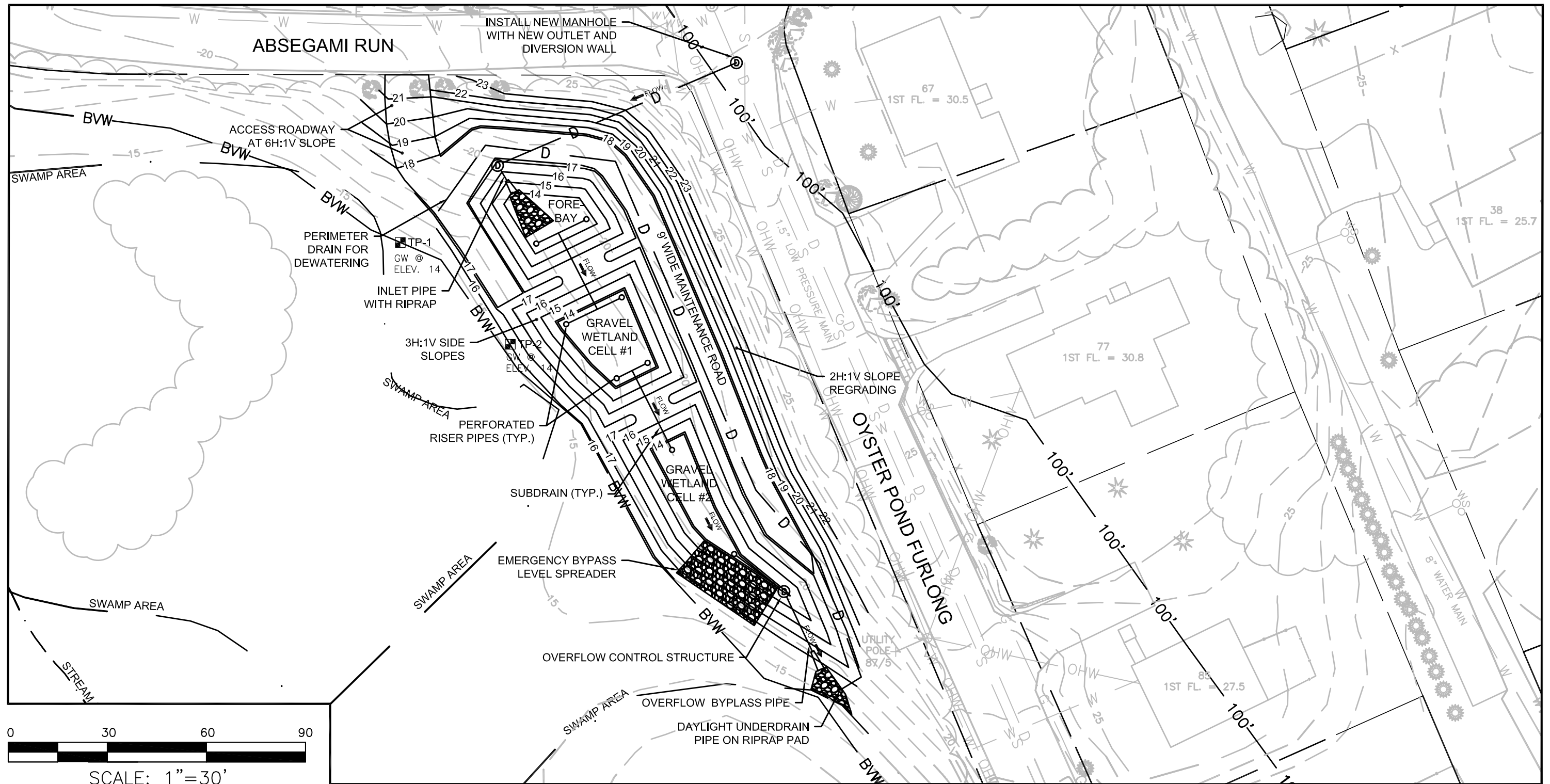
EPA Green Infrastructure
Education and Outreach Project

SURFACE AND SUBSURFACE
GRAVEL WETLAND

Chatham and Barnstable, MA

Project No.: 677-2
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**OYSTER POND BMP,
GRAVEL WETLAND**

Oyster Pond Furlong and
Absegami Run, Chatham MA

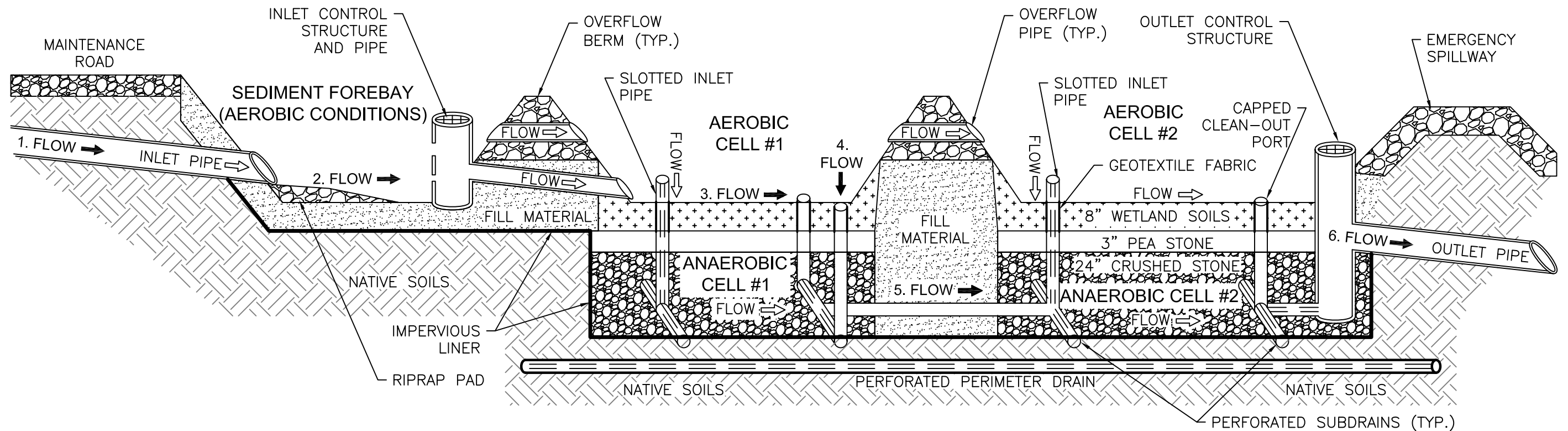
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STORMWATER TREATMENT PROCESS

- STEP 1:** A DIVERSION WEIR IS CONSTRUCTED IN THE EXISTING MANHOLE TO DIVERT SMALL STORMS INTO THE NEW STORMWATER BMP WHILE LARGER STORMS FLOW OVER THE WEIR INTO THE EXISTING DRAINAGE SYSTEM, BYPASSING THE BMP.
- STEP 2:** DIVERTED STORMWATER FLOWS INTO THE SEDIMENT FOREBAY FOR PRETREATMENT. SEDIMENT SETTLES OUT AND CONCENTRATES INTO ONE LOCATION, MAKING MAINTENANCE EASIER.
- STEP 3:** STORMWATER FLOWS INTO THE FIRST GRAVEL WETLAND CELL WHERE STORMWATER IS EXPOSED TO AEROBIC BACTERIA FOR AEROBIC NITROGEN CONVERSION AND REMOVAL. PLANT MATTER PROVIDES FURTHER NUTRIENT UPTAKE THROUGH THE ROOT SYSTEMS.
- STEP 4:** STORMWATER PERCOLATES THROUGH THE PLANT ROOT SYSTEM AND WETLAND SOILS OR IS COLLECTED IN PERFORATED RISER PIPES AND IS CONVEYED TO AN UNDERLYING GRAVEL LAYER WHERE ANAEROBIC BACTERIA PROVIDE NUTRIENT REMOVAL VIA CONVERSION OF OXYGENATED NITROGEN TO NITROGEN GAS. THE NITROGEN GAS IS THEN VENTED TO THE AIR.
- STEP 5:** STORMWATER PASSES INTO THE NEXT STORMWATER CELL FOR FURTHER AEROBIC AND/OR ANAEROBIC ACTIVITY AND CONVERSION.
- STEP 6:** TREATED STORMWATER WILL BE RELEASED IN A CONTROLLED MANNER THROUGH THE OUTLET CONTROL STRUCTURE. IF NEEDED, EXCESS STORMWATER WILL OVERFLOW THE BASIN VIA AN EMERGENCY SPILLWAY.
- OTHER:** THE BASIN IS LINED WITH AN IMPERMEABLE MEMBRANE TO PREVENT CONTACT WITH GROUNDWATER AND STORMWATER. A PERIMETER DRAIN WILL HELP ALLEVIATE HYDRAULIC PRESSURE ON THE LINER.
- AN ACCESS ROAD WILL BE CONSTRUCTED AROUND A PORTION OF THE BASIN TO ALLOW FOR MAINTENANCE PURPOSES SUCH AS REMOVAL OF SEDIMENT AND HARVESTING / REPLACEMENT OF PLANT MATERIAL.

OYSTER POND BMP, CHATHAM GRAVEL WETLAND CONCEPTUAL DESIGN

NOTE: SHOWN AT APPROXIMATE SCALE OF 1H:5V



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**OYSTER POND BMP,
GRAVEL WETLAND**

Oyster Pond Furlong and
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**Figure
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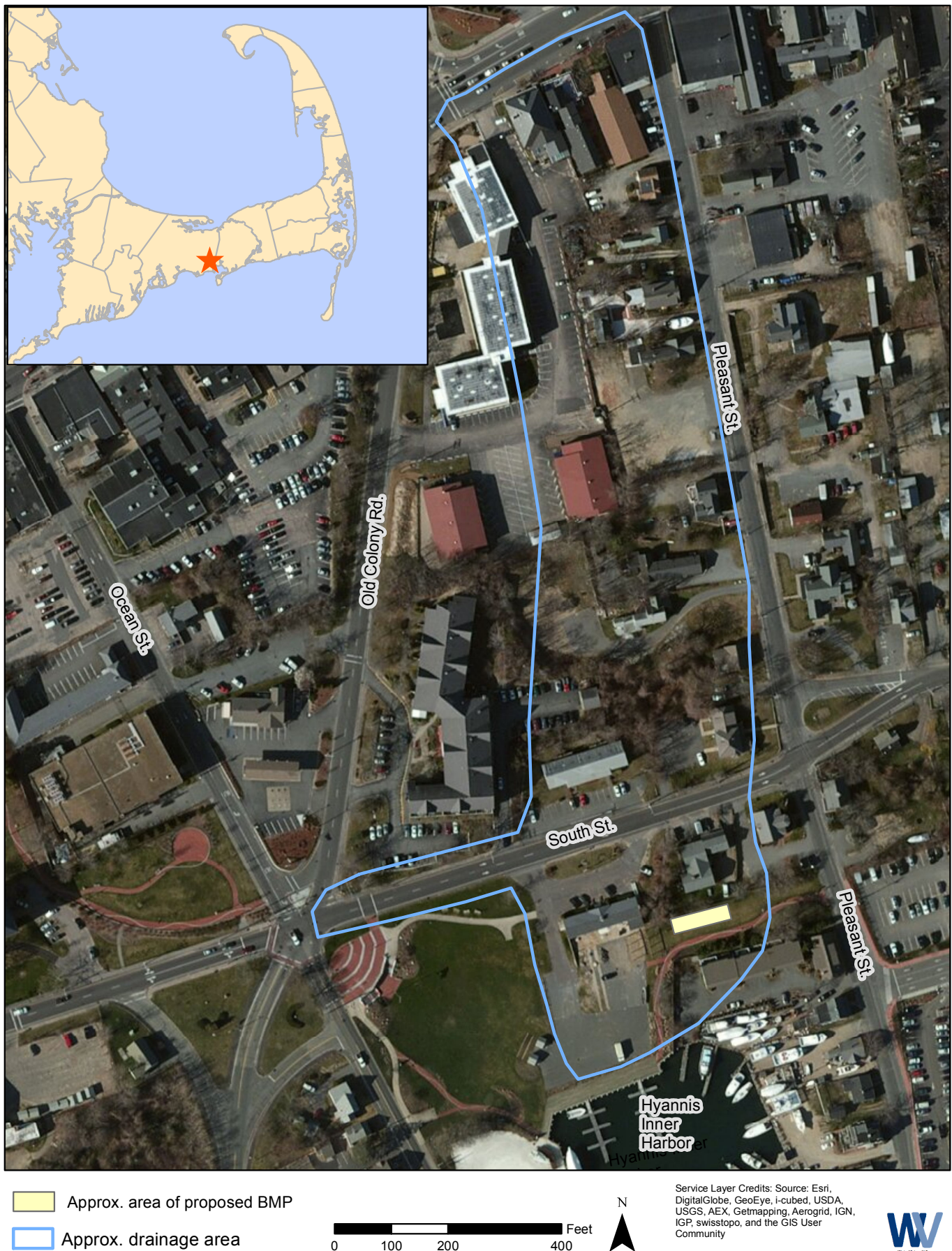


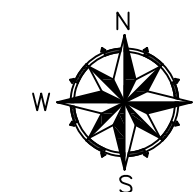
Figure 5. Potentially-suitable stormwater BMP site near Gateway Marina, Hyannis



BARNSTABLE, PROPOSED CONCEPTUAL DESIGN
INTERSECTION OF SOUTH STREET AND PLEASANT STREET

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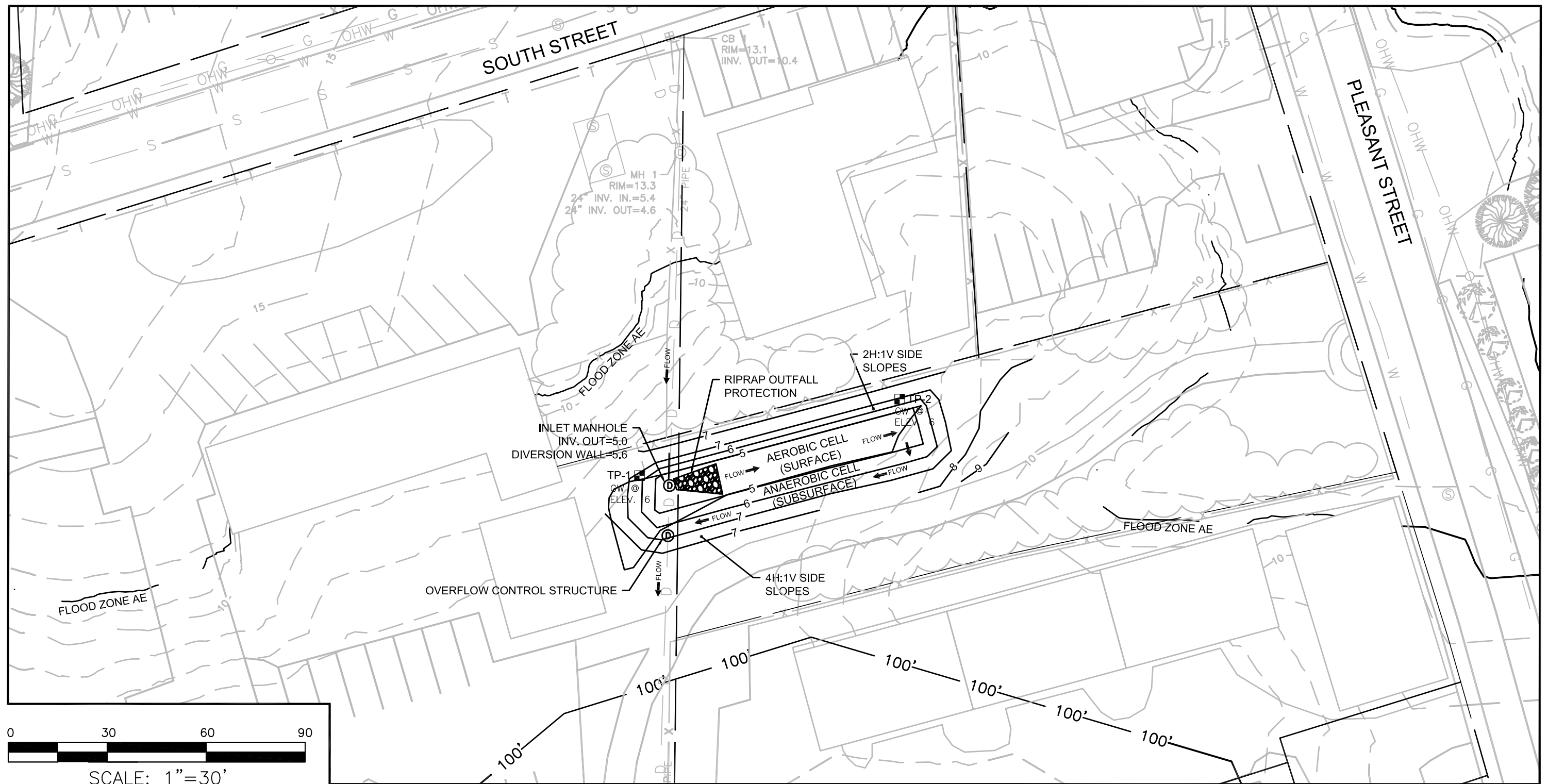
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GRAVEL WETLAND**



Chatham and Barnstable, MA

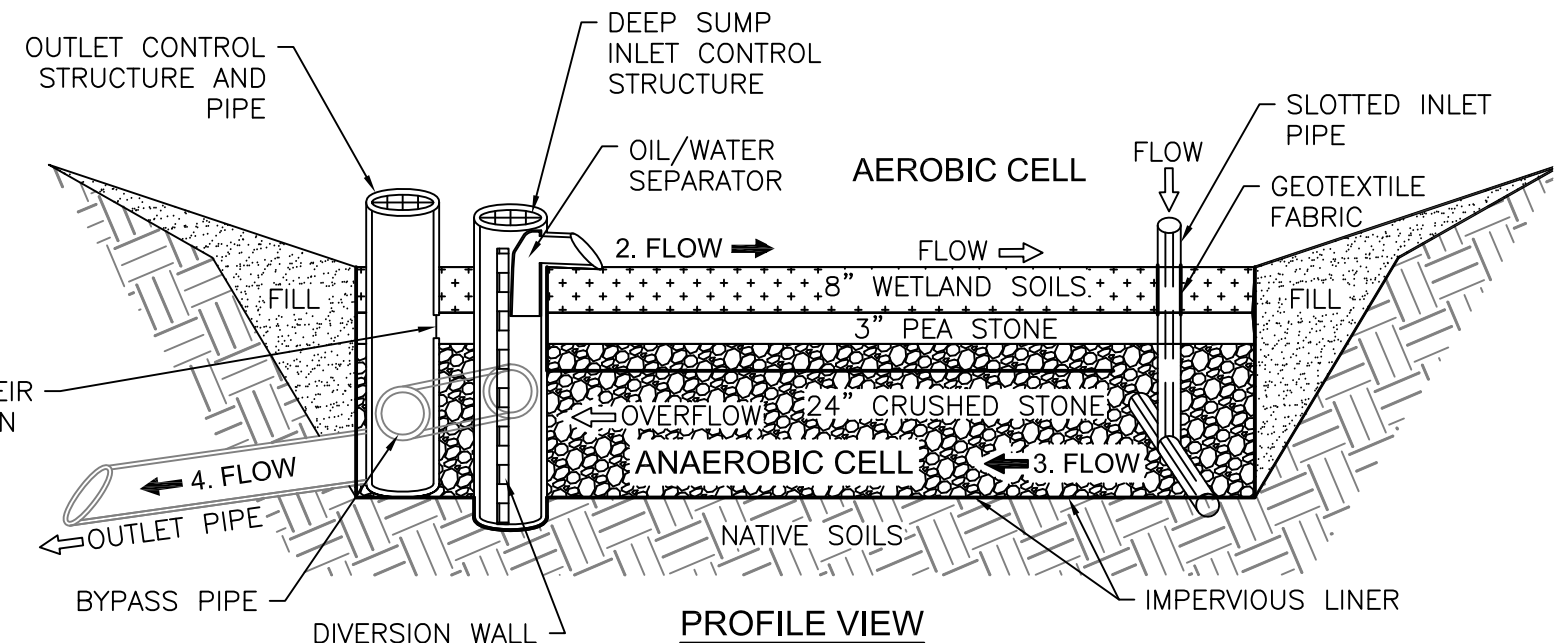
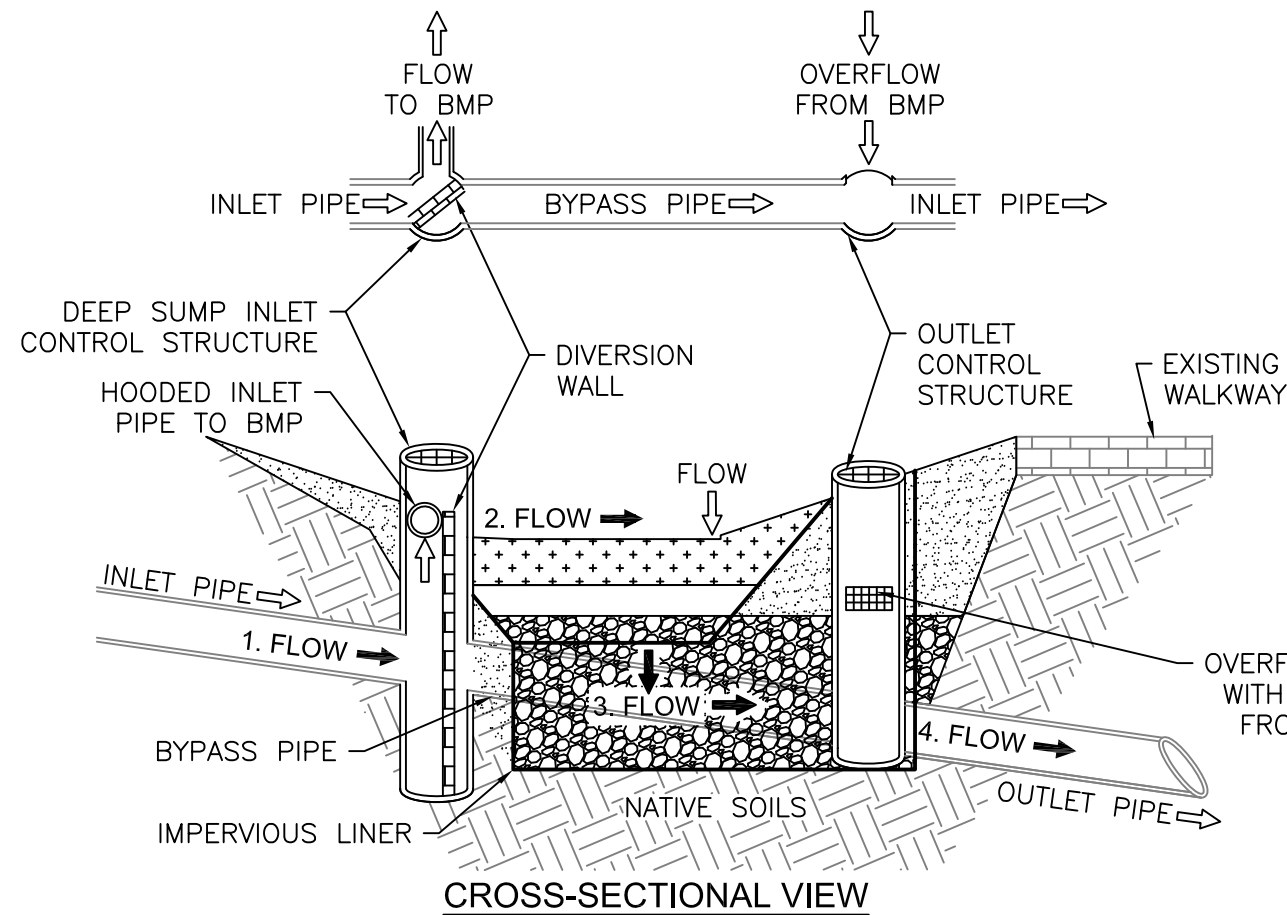
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Figure
6



 <p>COMPREHENSIVE ENVIRONMENTAL INCORPORATED 21 DEPOT STREET MERRIMACK, NH 03054</p>	 <p>WaterVision, LLC 481 GREAT ROAD, SUITE 3 ACTON, MA 01720</p>	<p>EPA Green Infrastructure Education and Outreach Project</p> <p>GATEWAY MARINA BMP, SUBSURFACE GRAVEL WETLAND</p> <p>South Street and Pleasant Street, Barnstable MA</p>	<p>Project No.: 677-2 Date: FEBRUARY 2015</p> <p>Drawn By: NC Checked By: BL</p> <p>Horizontal Datum: NAD88 Vertical Datum: NAVD88</p>	<p>Sheet</p> <p>Figure 7</p>
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STORMWATER TREATMENT PROCESS

- STEP 1:** A NEW DEEP SUMP DRAINAGE MANHOLE IS CONSTRUCTED IN LINE WITH THE EXISTING DRAINAGE TRUNK LINE, AND A DIVERSION WEIR IS CONSTRUCTED TO DIVERT SMALL STORMS INTO THE NEW STORMWATER BMP WHILE LARGER STORMS FLOW OVER THE WEIR INTO THE EXISTING DRAINAGE SYSTEM, BYPASSING THE BMP. A DEEP SUMP PROVIDES SEDIMENT STORAGE WHILE AN OIL/WATER SEPARATOR HELPS PREVENT FLOATABLES FROM ENTERING THE BMP.
- STEP 2:** STORMWATER FLOWS Laterally INTO THE SURFACE GRAVEL WETLAND CELL WHERE STORMWATER IS EXPOSED TO AEROBIC BACTERIA FOR AEROBIC NITROGEN CONVERSION AND REMOVAL. PLANT MATTER PROVIDES FURTHER NUTRIENT UPTAKE THROUGH THE ROOT SYSTEMS.
- STEP 3:** STORMWATER MOVES PERCOLATES THROUGH THE PLANT ROOT SYSTEM AND IS CONVEYED TO AN UNDERLYING GRAVEL LAYER WHERE ANAEROBIC BACTERIA PROVIDE NUTRIENT REMOVAL VIA CONVERSION OF OXYGENATED NITROGEN TO NITROGEN GAS. THE NITROGEN GAS IS THEN VENTED TO THE AIR. AN IMPERMEABLE LINER SEPARATES THE TWO LAYERS.
- STEP 4:** TREATED STORMWATER WILL BE RELEASED IN A CONTROLLED MANNER THROUGH THE OUTLET CONTROL STRUCTURE. IF NEEDED, EXCESS STORMWATER WILL OVERFLOW THE BASIN VIA AN EMERGENCY SPILLWAY OVERFLOW FITTED ON TOP OF THE OUTLET STRUCTURE.
- OTHER:** THE BASIN IS LINED WITH AN IMPERMEABLE MEMBRANE TO PREVENT CONTACT WITH GROUNDWATER AND STORMWATER. A PERIMETER DRAIN WILL HELP ALLEVIATE HYDRAULIC PRESSURE ON THE LINER.

GATEWAY MARINA BMP, BARNSTABLE SUBSURFACE GRAVEL WETLAND CONCEPTUAL DESIGN



COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED

21 DEPOT STREET
MERRIMACK, NH 03054



WaterVision, LLC

481 GREAT ROAD, SUITE 3
ACTON, MA 01720

EPA Green Infrastructure
Education and Outreach Project

GATEWAY MARINA BMP,
SUBSURFACE GRAVEL WETLAND

South Street and Pleasant
Street, Barnstable MA

Project No.: 677-2
Date: FEBRUARY 2015

Drawn By: NC
Checked By: BL

Horizontal Datum: NAD88
Vertical Datum: NAVD88

Sheet

Figure
8

Attachment A – Soil Boring Logs



TEST BORING LOG

SHEET 1

Soil Exploration Corp.
Geotechnical Drilling
Groundwater Monitor Well
148 Pioneer Drive
Leominster, MA 01453
978 840-0391

Comprehensive Environmental
Site: Absegami Run/Oyster Pond Furl.
Chatham, MA

BORING B-1

PROJECT NO. 14-1222

DATE: December 12, 2014

Ground Elevation:
Date Started: December 10, 2014
Date Finished: December 10, 2014
Driller: DL

GROUNDWATER OBSERVATIONS

DATE	DEPTH	CASING	STABILIZATION

Soil Engineer/Geologist:

Depth Ft.	Casing bl/ft	Sample				Strata	Visual Identification of Soil and / or Rock Sample
		No.	Pen/Rec	Depth	Blows/6"		
1		1	10"	0-2'0"	1-1-1-3	2'0"	Moist to wet, very loose fine sand, some organic silt.
5		2	18"	5'0"-7'0"	3-3-5-8		
10		3	15"	10'0"-12'0"	1-2-3-6	12'0"	Wet, loose fine sand, trace inorganic silt.
15							End of boring at 12'0". Water encountered at 1'0". Set temporary well at 10'0".
20							
25							
30							
35							
39							

Notes: 3" Casing

Cohesionless: 0 - 4 V. Loose, 4 - 10 Loose, 10 -30 M Dense, 30 -50 Dense, 50+ V Dense.	Trace 0 to 10% Little 10 to 20% Some 20 to 35% And 35% to 50%	CASING	SAMPLE	CORE TYPE
Cohesive: 0 -2 V Soft, 2 -4 Soft, 4 -8 M Stiff 8 -15 Stiff, 15 -30 V. Stiff, 30 + Hard.		ID SIZE (IN) HAMMER WGT (LB) HAMMER FALL (IN)	SS 140 lb. 30"	

TEST BORING LOG

SHEET 2

Soil Exploration Corp.
Geotechnical Drilling
Groundwater Monitor Well
148 Pioneer Drive
Leominster, MA 01453
978 840-0391

Comprehensive Environmental
Site: Absegami Run/Oyster Pond Furl.
Chatham, MA

BORING B-2

PROJECT NO. 14-1222

DATE: December 12, 2014

Ground Elevation:
Date Started: December 10, 2014
Date Finished: December 10, 2014
Driller: DL

GROUNDWATER OBSERVATIONS

DATE	DEPTH	CASING	STABILIZATION

Soil Engineer/Geologist:

Depth Ft.	Casing bl/ft	Sample				Strata	Visual Identification of Soil and / or Rock Sample
		No.	Pen/Rec	Depth	Blows/6"		
1		1	18"	0-2'0"	1-2-2-5	2'0"	Moist to wet, loose fine sand, some organic silt.
5		2	20"	5'0"-7'0"	2-3-4-2		
10		3		10'0"-12'0"	2-2-5-5	12'0"	Wet, loose, very fine to fine sand and inorganic silt.
15							End of boring at 12'0". Water encountered at 1'0".
20							
25							
30							
35							
39							

Notes: 3" Casing

Cohesionless: 0 - 4 V. Loose, 4 - 10 Loose, 10 -30 M Dense, 30 -50 Dense, 50+ V Dense.	Trace 0 to 10% Little 10 to 20% Some 20 to 35% And 35% to 50%	CASING	SAMPLE	CORE TYPE
Cohesive: 0 -2 V Soft, 2 -4 Soft, 4 -8 M Stiff 8 -15 Stiff, 15 -30 V. Stiff, 30 + Hard.		ID SIZE (IN) HAMMER WGT (LB) HAMMER FALL (IN)	SS 140 lb. 30"	

TEST BORING LOG

SHEET 3

Soil Exploration Corp.
Geotechnical Drilling
Groundwater Monitor Well
148 Pioneer Drive
Leominster, MA 01453
978 840-0391

Comprehensive Environmental
Site: South Street/Pleasant Street
Batnstable, MA

BORING B-3

PROJECT NO. 14-1222

DATE: December 12, 2014

Ground Elevation:
Date Started: December 10, 2014
Date Finished: December 10, 2014
Driller: DL

GROUNDWATER OBSERVATIONS

DATE	DEPTH	CASING	STABILIZATION

Soil Engineer/Geologist:

Depth Ft.	Casing bl/ft	Sample				Strata	Visual Identification of Soil and / or Rock Sample
		No.	Pen/Rec	Depth	Blows/6"		
1		1	10"	0-2'0"	3-3-3-4	3'0"	Moist to wet, loose, fine to coarse sand, trace inorganic silt.
5		2	11"	5'0"-7'0"	1-2-4-2	7'0"	Wet soft peat.
10		3	11"	10'0"-12'0"	3-2-2-7	12'0"	Wet, loose, fine to coarse sand, trace inorganic silt.
15							End of boring at 12'0". Water encountered at 1'0". Set temporary well at 10'0".
20							
25							
30							
35							
39							

Notes: 3" Casing

Cohesionless: 0 - 4 V. Loose, 4 - 10 Loose, 10 -30 M Dense, 30 -50 Dense, 50+ V Dense.	Trace 0 to 10% Little 10 to 20% Some 20 to 35% And 35% to 50%	CASING	SAMPLE	CORE TYPE
Cohesive: 0 -2 V Soft, 2 -4 Soft, 4 -8 M Stiff 8 -15 Stiff, 15 -30 V. Stiff, 30 + Hard.		ID SIZE (IN) HAMMER WGT (LB) HAMMER FALL (IN)	SS 140 lb. 30"	

TEST BORING LOG

SHEET 4

Soil Exploration Corp.
Geotechnical Drilling
Groundwater Monitor Well
148 Pioneer Drive
Leominster, MA 01453
978 840-0391

Comprehensive Environmental
Site: South Street/Pleasant Street
Batnstable, MA

BORING B-4

PROJECT NO. 14-1222

DATE: December 12, 2014

Ground Elevation:
Date Started: December 10, 2014
Date Finished: December 10, 2014
Driller: DL

GROUNDWATER OBSERVATIONS

DATE	DEPTH	CASING	STABILIZATION

Soil Engineer/Geologist:

Depth Ft.	Casing bl/ft	Sample				Strata	Visual Identification of Soil and / or Rock Sample
		No.	Pen/Rec	Depth	Blows/6"		
1		1	21"	0-2'0"	2-2-2-4		
5		2	10"	5'0"-7'0"	2-6-6-2		Wet, loose to medium dense, fine to coarse sand, trace inorganic silt and fine gravel.
10		3	6"	10'0"-12'0"	1-2-2-4	12'0"	
15							End of boring at 12'0". Water encountered at 1'0".
20							
25							
30							
35							
39							

Notes: 3" Casing

Cohesionless: 0 - 4 V. Loose, 4 - 10 Loose, 10 -30 M Dense, 30 -50 Dense, 50+ V Dense.	Trace 0 to 10% Little 10 to 20% Some 20 to 35% And 35% to 50%	CASING	SAMPLE	CORE TYPE
Cohesive: 0 -2 V Soft, 2 -4 Soft, 4 -8 M Stiff 8 -15 Stiff, 15 -30 V. Stiff, 30 + Hard.		ID SIZE (IN)	SS	
		HAMMER WGT (LB)	140 lb.	
		HAMMER FALL (IN)	30"	

Attachment B – Conceptual Design Calculations





COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED

Client: U.S. ENVIRONMENTAL PROTECTION AGENCY

Project: LID IMPLEMENTATION Sheet 1 of 1

Subject: CHATHAM GRAVEL WETLAND, CONCEPTUAL BMP SIZING

Completed by: NC Date: 12/16/14

Revised by: Date:

Checked by: BL Date: 01/07/15

CHATHAM GRAVEL WETLAND, CONCEPTUAL BMP SIZING

- THE FOLLOWING WORKSHEET DETAILS CONCEPTUAL STORMWATER BMP SIZING FOR THE PROPOSED GRAVEL WETLAND AND SEDIMENT FOREBAY AT THE INTERSECTION OF OYSTER POND FURLONG AND ABSEGAMI RUN IN CHATHAM, MASSACHUSETTS.

- CONTRIBUTING LAND USE SIZE AND TYPES ARE PROVIDED BELOW:

LAND USE TYPES	AREA		% OF TOTAL (%)
	(SQ. FT.)	(ACRES)	
IMPERVIOUS LAND USES			
ROOFTOPS	38,100	0.87	5%
ROADS AND DRIVEWAYS	210,800	4.84	29%
TOTAL	248,900	5.71	34%
PERVIOUS LAND USES			
PERVIOUS GRASS, LAWN, ETC.	487,200	11.18	66%
TOTAL	487,200	11.18	66%
TOTALS	736,100	16.90	100%

- NOTES:

* CONTRIBUTING WATERSHED AREA DELINEATED BY THE TOWN OF CHATHAM.

- PER THE MASSACHUSETTS STORMWATER HANDBOOK, GRAVEL WETLAND BMP SIZING IS BASED ON THE WATER QUALITY VOLUME (WQV), OR 1" OF RUNOFF OVER THE CONTRIBUTING IMPERVIOUS AREA.
TOTAL IMPERVIOUS AREA = 5.71 ACRES (SEE TABLE ABOVE)

WATER QUALITY VOLUME (WQV) = 1 INCH OF RUNOFF OVER THE CONTRIBUTING IMPERVIOUS AREA.

AREA = 5.71 ACRES x 43,560 SF PER ACRE 1 INCH x 1 FT PER 12 INCHES

WQV = 20,742 CUBIC FEET

- PROPOSED STORMWATER BMP = **GRAVEL WETLAND**

FOR OPTIMAL NITROGEN REMOVAL, STORMWATER BMPS SHOULD HOLD A MINIMUM OF 0.3 INCHES OF RUNOFF OVER THE CONTRIBUTING IMPERVIOUS AREA.

AREA = 5.71 ACRES x 43,560 SF PER ACRE 0.3 INCH x 1 FT PER 12 INCHES

0.3-INCH VOLUME = 6,223 CUBIC FEET

REQUIRED SIZING = 6,223 CUBIC FEET

ADDITIONALLY, INFILTRATION PRACTICES MUST HAVE PRETREATMENT OF 10% OF THE WQV.

- PROPOSED PRETREATMENT BMP = **SEDIMENT FOREBAY**

PER MA STORMWATER MANUAL, SEDIMENT FOREBAYS MUST HOLD 10% OF THE WQV.

WATER QUALITY VOL. 20,742 CUBIC FEET

REQUIRED SIZING = 20,742 CUBIC FEET x 10%

REQUIRED SIZING = 2,074 CUBIC FEET

Job # 677-2
 Calculated By: NC
 Checked By: BL

Cape Cod, Chatham
 1/29/2015



Pretreatment Sediment Forebay Volume					
Elevation (ft)	Area (sf)	Avg Surface Area (sf)	Void Space	Incremental Storage (cf)	Accumulated Storage (cf)
Surface (assume unrestricted voids)					
14.0	318	0	1	0	0
14.5	444	381	1	190	190
15.0	569	506	1	253	444
15.5	728	649	1	324	768
16.0	887	808	1	404	1,172
16.5	1078	983	1	491	1,663
17.0	1269	1,174	1	587	2,250
		Total Volume			2,250

Required 0.1" Storage Volume (cf)	2,074
Total Forebay Storage Volume (cf)	2,250
Storage Volume with 1' Freeboard (cf)	1,663

v

Job # 677-1
 Calculated By: NC
 Checked By: BL

Cape Cod, Chatham
 2/2/2015



Gravel Wetland, Cell #1					
Elevation (ft)	Area (sf)	Avg Surface Area (sf)	Void Space	Incremental Storage (cf)	Accumulated Storage (cf)
Subsurface (assume 0.3 void ratio for crushed stone, 0.2 for pea stone)					
11.08	511	0	0.3	0	0
11.58	511	511	0.3	77	77
12.08	511	511	0.3	77	153
12.58	511	511	0.3	77	230
13.08	511	511	0.3	77	307
13.33	511	511	0.2	26	332
Total Volume					332
Wetland Soils (assume zero void space)					
13.33	511	511	0	0	0
14.00	511	511	0	0	0
Total Volume					0
Surface (assume unrestricted voids)					
14.00	511	511	1	0	0
14.50	666	589	1	294	294
15.00	821	744	1	372	666
15.50	1013	917	1	458	1,124
16.00	1204	1,108	1	554	1,679
16.50	1432	1,318	1	659	2,337
17.00	1659	1,545	1	773	3,110
Total Volume					3,442

Gravel Wetland, Cell #2					
Elevation (ft)	Area (sf)	Avg Surface Area (sf)	Void Space	Incremental Storage (cf)	Accumulated Storage (cf)
Subsurface (assume 0.3 void ratio for crushed stone, 0.2 for pea stone)					
11.08	394	0	0.3	0	0
11.58	394	394	0.3	59	59
12.08	394	394	0.3	59	118
12.58	394	394	0.3	59	177
13.08	394	394	0.3	59	236
13.33	394	394	0.2	20	256
Total Volume					256
Wetland Soils (assume zero void space)					
13.33	511	453	0	0	0
14.00	511	511	0	0	0
Total Volume					0
Surface (assume unrestricted voids)					
14.00	394	394	1	0	0
14.50	622	508	1	254	254
15.00	849	735	1	368	622
15.50	1126	988	1	494	1,115
16.00	1403	1,265	1	632	1,748
16.50	1727	1,565	1	782	2,530
17.00	2050	1,888	1	944	3,474
Total Volume					3,730

Desired 0.3" Storage Volume (cf)	6,223
Total Storage Volume (cf)	7,172 ^v



COMPREHENSIVE
ENVIRONMENTAL
INCORPORATED

Client: U.S. ENVIRONMENTAL PROTECTION AGENCY

Project: LID IMPLEMENTATION Sheet 1 of 1

Subject: BARNSTABLE SUBSURFACE GRAVEL WETLAND, CONCEPTUAL

Completed by: NC Date: 12/16/14

Revised by: Date:

Checked by: BL Date: 01/07/15

BARNSTABLE GRAVEL WETLAND, CONCEPTUAL BMP SIZING

- THE FOLLOWING WORKSHEET DETAILS CONCEPTUAL STORMWATER BMP SIZING FOR THE PROPOSED SUBSURFACE GRAVEL WETLAND AT THE INTERSECTION OF SOUTH STREET AND PLEASANT STREET IN BARNSTABLE, MASSACHUSETTS.

- CONTRIBUTING LAND USE SIZE AND TYPES ARE PROVIDED BELOW:

LAND USE TYPES	AREA		% OF TOTAL (%)
	(SQ. FT.)	(ACRES)	
IMPERVIOUS LAND USES			
ROADS, DRIVEWAYS, AND ROOFS	150,718	3.46	50%
TOTAL	150,718	3.46	50%
PERVIOUS LAND USES			
PERVIOUS GRASS, LAWN, ETC.	150,718	3.46	50%
TOTAL	150,718	3.46	50%
TOTALS	301,435	6.92	100%

- NOTES:

* CONTRIBUTING WATERSHED AREA DELINEATED BY THE TOWN OF BARNSTABLE
* PER DISCUSSIONS WITH THE TEAM, PERCENT IMPERVIOUS IS ASSUMED TO BE 35%
HOWEVER A DESKTOP ANALYSIS INDICATES THAT THE AREA IS CLOSER TO 50%.

- PER THE MASSACHUSETTS STORMWATER HANDBOOK, GRAVEL WETLAND BMP SIZING IS BASED ON THE WATER QUALITY VOLUME (WQV), OR 1" OF RUNOFF OVER THE CONTRIBUTING IMPERVIOUS AREA.

TOTAL IMPERVIOUS AREA = 3.46 ACRES (SEE TABLE ABOVE)

WATER QUALITY VOLUME (WQV) = 1 INCH OF RUNOFF OVER THE CONTRIBUTING IMPERVIOUS AREA.

AREA = 3.46 ACRES x 43,560 SF PER ACRE 1 INCH x 1 FT PER 12 INCHES

WQV = 12,560 CUBIC FEET

- PROPOSED STORMWATER BMP = **GRAVEL WETLAND**

FOR OPTIMAL NITROGEN REMOVAL, STORMWATER BMPs SHOULD HOLD A MINIMUM OF 0.3 INCHES OF RUNOFF OVER THE CONTRIBUTING IMPERVIOUS AREA.

AREA = 3.46 ACRES x 43,560 SF PER ACRE 0.3 INCH x 1 FT PER 12 INCHES

0.3-INCH VOLUME = 3,768 CUBIC FEET

REQUIRED SIZING = 3,768 CUBIC FEET

- PROPOSED PRETREATMENT BMP = **NOT APPLICABLE**

THIS LOCATION DOES NOT HAVE ADEQUATE SPACE FOR CONSTRUCTION OF A PRETREATMENT DEVICE.

Job # 677-1
 Calculated By: NC
 Checked By: BL

Cape Cod, Barnstable
 2/2/2015



Subsurface Gravel Wetland, Aerobic Cell					
Elevation (ft)	Area (sf)	Avg Surface Area (sf)	Void Space	Incremental Storage (cf)	Accumulated Storage (cf)
Subsurface (assume 0.3 void ratio in stone)					
2.08	0	0	0.3	0	0
2.58	0	0	0.3	0	0
3.08	0	0	0.3	0	0
3.58	0	0	0.3	0	0
4.08	0	0	0.3	0	0
4.33	0	0	0.2	0	0
Total Subsurface Storage Volume					0
Wetland Soils (assume zero void space)					
4.33	914	914	0	0	0
5.00	914	914	0	0	0
Total Wetland Soils Storage Volume					0
Surface (assume unrestricted voids)					
5.00	914	457	1	0	0
5.50	1225	1,070	1	535	535
6.00	1536	1,381	1	690	1,225
6.50	1880	1,708	1	854	2,079
7.00	2223	2,051	1	1,026	3,105
Total Surface Storage Volume					3,105

Subsurface Gravel Wetland, Anerobic Cell					
Elevation (ft)	Area (sf)	Avg Surface Area (sf)	Void	Incremental	Accumulated
Subsurface (assume 0.3 void ratio in stone)					
2.08	1677	0	0.3	0	0
2.58	1677	1,677	0.3	252	252
3.08	1677	1,677	0.3	252	503
3.58	1677	1,677	0.3	252	755
4.08	1677	1,677	0.3	252	1,006
4.33	1677	1,677	0.2	84	1,090
Total Subsurface Storage Volume					1,090
Wetland Soils (assume zero void space)					
4.33	1677	1677	0	0	0
5.00	1677	1677	0	0	0
Total Wetland Soils Storage Volume					0
Surface (assume unrestricted voids)					
5.00	1677	1,677	1	0	0
5.50	0	0	1	0	0
6.00	0	0	1	0	0
6.50	0	0	1	0	0
7.00	0	0	1	0	0
Total Surface Storage Volume					0

Desired 0.3" Storage Volume (cf)	3,768	✓
Total Storage Volume (cf)	4,195	✓

Attachment C – Project Schedule



Project Schedule - Cape Cod BMPs

Design and Construction of Green Infrastructure Stormwater BMP Retrofits

[illegible]

Schedule Notes:

1. It is estimated that total construction duration for the Gateway Marina BMP is approximately 4 weeks. 1 additional week is provided for contingency purposes, should a schedule extension be required. Due to the sensitive location of this project, it is recommended that this location be constructed first.
2. It is estimated that total construction duration for the Oyster Pond BMP site in Chatham is approximately 6 weeks. 1 additional week is provided for contingency purposes, should a schedule extension be required.
3. The schedule allows for an additional two weeks of construction in June before the beginning summer vacation. It is not anticipated that this time will be required, however if due to unforeseen circumstances construction is delayed, this window will allow an additional contingency for construction completion.

Attachment D – EPA Comments and Design Team Responses

This attachment contains comments received from EPA staff following the meeting of January 13, 2015 on the conceptual design of the proposed BMP projects. Design Team responses follow each comment in italicized text.

1. I read the document and reviewed the plans. I agree that according to the plan Figure 2 for Oyster Pond BMP in Chatham that a Corps permit would not be required according to these plans which depict no action [sic] physical filling in wetlands. The emergency bypass level spreader and overflow bypass pipe riprap is depicted adjacent to the wetland line. The plans do not indicate a datum which must be included and typically is required in NAVD 88 datum. [Edward Reiner]

Acknowledged. Revised design plans and final Task 1 Summary Memo (T1SM) now indicate a horizontal datum of NAD83 and a vertical datum of NAVD88, consistent with survey information and MassGIS LiDAR used for design purposes.

2. The plans for the Hyannis site depict and claim that no permitting will be needed since the location is not in wetlands and out of the buffer zone. I noticed, however, that the site itself may be in the 100-year flood plain and the aerobic cell (surface) will be excavated below 5 feet elevation (no datum reference provided). The plans should provide the datum reference (NAVD 88) and information on the 100-year floodplain. The potential impacts of sea level rise should also be considered as it relates to any backwater from the culvert drain at Hyannis Harbor. [Edward Reiner]

The Barnstable location is situated within a Flood Insurance Rate Map (FIRM) Special Flood Hazard Area (SFHA) area, classified as Zone AE with a Base Flood Elevation (BFE) of elevation 12.0 (NAVD88) based on FIRM Panel 0569J for Barnstable County. This zone is classified as areas subject to inundation by the 1-percent-annual-chance flood event, also known as the 100-year storm flood zone. Design plans have been updated to reflect this area.

As the proposed BMP location is situated within a tidal flood zone, it is considered Land Subject to Coastal Storm Flowage, also known as the Velocity Zone or Coastal High Hazard Area and thus is subject to regulation under the Massachusetts Wetland Protection Act 310 CMR 10.00. A Notice of Intent (NOI) must be filed for this project with the local Conservation Commission. The final T1SM has been updated to include this information. Note that no floodplain filling is proposed for this project. This BMP will result in a net cut, thus providing additional flood storage in the event of a storm event.

Final design will evaluate the feasibility of installing a tide gate or backflow preventer on this pipe to reduce potential flooding impacts. Additional funding may be required to purchase and install this device unless the Town of Barnstable would like to perform this item as part of an in-kind service. Note that this device may assist with flooding prevention during smaller flood events, but a 100-year storm will inundate the entire area regardless of the

presence of a tide gate. A new section in the final Cost Memo titled Optional Items has been added to address this item.

3. In addition, the site plan should include the wetlands on the site plan so we can see how close along with the elevations, etc. This is important to minimize all impacts to wetlands since the BMP is so close. [Lynne Hamjian]

Plans provided with the draft T1SM were optimized to fit on an 11"x17" sheet of paper while showing relevant information. Thus, portions of the surrounding area were "clipped" in order to fit the paper. The final T1SM includes full-sized sheets that depict known resource areas within the project vicinity, shown on construction sheets C-1 and C-2.

4. Lastly, insofar as the overflow bypass pipe on the site plan (and the bottom of page 3 of the write up) which appears to discharge into the wetland area, would it not be advisable or preferred best engineering practice to avoid discharging into the wetland system? If additional funding could be obtained, is there a way to move this pipe and/or tie back into the MS4 system? It might at least be helpful to consider other options and cost them out. [Lynne Hamjian]

The commenter is correct that the overflow bypass pipe should ideally not discharge directly into the wetland area in order to preserve existing hydrologic characteristics. The bulk of wetland areas are located directly west of the proposed BMP. As the wetland complex moves further south, it becomes channelized into a drainage ditch which drains through a culvert below two driveways associated with house numbers 98 and 100 on Oyster Pond Furlong. At this point, it no longer functions as a wetland, but instead as a drainage conveyance channel. This channel ultimately flows back into the drainage trunk line below Oyster Pond Furlong south of the southernmost driveway where it outlets into Oyster Pond approximately 500-feet further. Pending final design, it appears likely that the overflow pipe and erosion pad will be rotated such that it faces nearly due south, and thus discharges directly into the drainage channel portion rather than wetland areas. The final T1SM has been updated to clarify these connections.

The entirety of small storms of approximately 0.3-inches and smaller will be designed to flow into the stormwater BMP and ultimately into the adjacent drainage channel. Small storms are expected to have a negligible impact on adjacent land areas. In large storms, we would expect a maximum runoff volume of 0.3 inches would be diverted into the stormwater BMP and that the remainder of the runoff volume from these large storms would continue down the drainage trunk line to Oyster Pond as currently occurs.

Should additional funding be available, it appears feasible to tie back into the existing drainage system. This option would either include installation of an additional new manhole in Oyster Pond Furlong and trenching an additional 75 linear feet of pipe, or tying into an existing manhole and trenching an additional 140 linear feet of pipe. Costs for either option are estimated to be approximately \$30,000. A new section in the final Cost Memo titled Optional Items has been added to address this item.



5. In Chatham, I would like to know whether or to what extent bacteria might be treated in addition to nitrogen. If some additional funding might be available, could the design be modified to control or better control both nitrogen and bacteria? Related: to what extent is the conceptual design for Chatham a reflection of (a) site constraints, (b) funding, or (c) both (a) and (b). [Lynne Hamjian]

The proposed surface gravel wetland at the Chatham site is expected to provide excellent nutrient and bacteria removal as currently designed. Per the Massachusetts stormwater handbook, constructed stormwater wetlands provide up to 75% pathogen removal. Although this BMP is designed to treat only the 0.3-inch storm, it is anticipated that nutrient and bacteria removal will remain high.

Due to presence of site constraints such as wetlands and associated buffer areas in close proximity to the proposed BMP, it is unlikely that stormwater storage and/or treatment may be substantially increased without impacts to resource areas. Additional funding may allow some additional treatment options (e.g. replacing gravel in the anaerobic zone with a different technology offering additional storage or installation of an organic supplement to encourage bacteria growth). More information will be available as the design is progressed to final design.

6. Reminder: Although the diversion structure may be constructed / retrofit, no discharge into the BMP may occur until the MS4 is tested to reasonably confirm an absence of bacteria / illicit connections. [Lynne Hamjian]

Acknowledged. EPA will perform testing to confirm that there are no suspected illicit connections within existing drainage lines in Chatham and Barnstable. Stormwater will not be directed into either proposed stormwater BMP until sampling is complete and determined to be free of potential illicit discharges.

7. On the top of page 4 of the T1SM, the first bullet discusses emergency riprap overflow level spreader. Mark V. mentioned this system will be designed with a diverter so the system can't really overflow. On large storms, water after 0.3 will stay in the stormwater pipe. My question is, will this overflow or not, and how will this impact the adjacent wetland? [Lynne Hamjian]

Under normal operation, the emergency riprap overflow level spreader will never be used. This feature is designed as an emergency structure to safely bypass stormwater in a controlled manner to the adjacent land area. This should only happen in the event of a failure within the existing drainage trunk line, obstruction of the outlet, or an exceptionally large or unusual storm event. Most stormwater release from the BMP will take place via the outlet control structure, bypassing relatively small stormwater quantities over a period of time to the adjacent drainage ditch. For additional explanation on the wetland and nearby drainage ditch, please see the response under the last part of Comment #1.



The proposed diversion wall in the drainage structure just upgradient from the stormwater BMP will cause a backup of stormwater within the existing system of approximately 2-feet in elevation. It is expected that the 24-inch trunk line will back up to approximately the next upgradient structure, located approximately 300-feet northeast up Oyster Pond Furlong. Stormwater volume associated with this surcharge is estimated at approximately 950 cubic feet. As currently designed, this volume will not flow into the stormwater BMP or adjacent wetland area. Conceptual design has assumed that this volume will remain in the system until displaced by the next storm, however internal discussions have identified the possibility of coring a small hole (e.g. 2-inch or 3-inch diameter) at the base of the diversion wall to allow this volume to drain slowly into Oyster Pond via the existing drainage trunk line. This is a delicate item, as if the hole is too big then increasingly large storms will then bypass the stormwater BMP via this orifice and not receive treatment, while too small a hole will become clogged and quickly lose function. Additional evaluation during the final design process is needed to evaluate potential trade-offs between treatment and system functionality.

8. Re: monitoring plan. Even though there is agreement to delay monitoring until 2016, the implications of a final Monitoring Plan on BMP construction needs to be considered now as part of the final design and construction phases. [Lynne Hamjian]

We agree that the implications of the final monitoring plan BMP construction need to be considered during design. A QAPP for the monitoring plan is currently being prepared by the EPA. The system design will reflect the contents of the monitoring plan so as to facilitate taking water samples during storm events from both the inflow and outflow points.

9. Does the absence of a sediment forebay (due to space limitations) impact BMP operation and performance? Is there an alternative method to trap sediment for O&M by the Town? [Lynne Hamjian]

Due to limited space at the Barnstable location, a sediment forebay is not feasible without additional impacts to the park area, as well as an additional cost component. Based on discussions at the January 13, 2015 meeting, some pretreatment may be provided by installing of a deep sump catch basin immediately prior to the proposed stormwater BMP. Due to the limited space for sediment collection, diligent operation and maintenance would be critical to maintaining the function of this structure during the life of the BMP. Additional pretreatment operations will be discussed during the final design process. The final T1SM has been updated to reflect installation of a deep sump stormwater structure for pretreatment.

10. These projects are part of a larger picture - the Southeast New England Coastal Watershed Restoration Program (SNECWRP). The SNECWRP funding is to restore physical processes, improve water quality, and restore key habitat to the region's coastal waters by integrating new technologies, and applying the latest scientific developments into restoration projects. It is with this in mind that I give you the comments below: [Ann Rodney]



- a. Use innovative technologies wherever possible (push the envelope).

Additional innovative technologies, such as replacing crushed stone in the underlying anaerobic layers at the Chatham location with an alternative media as commonly used in water treatment to increase void space or amending the anaerobic layer with an organic supplement, will be evaluated during the final design process. Additionally, the proposed BMP at the Barnstable location has necessitated an innovative design in order to provide effective treatment within a relatively small area while preserving the open space characteristics of the site.

- b. Monitoring is essential to measure successful (or unsuccessful) technologies used in restoration.

We agree. As noted in the design memo, we intend to monitor in order to measure and report on the effectiveness of the BMP.

- c. Transferability of knowledge and technology for use elsewhere

The Chatham and Barnstable designs may easily be adapted to use at other sites, both large and small. The Chatham design is ideally suited to treating large watershed areas at a location with ample room for BMP construction. The Barnstable design may be easily adapted to relatively small sites where space is at a premium. Additionally, the Barnstable site can be readily used in an off-line configuration due to the close proximity of the inlet and outlet control structures. Proposed monitoring efforts will allow for BMP performance evaluation of both designs.

11. I strongly encourage you to monitor the effectiveness of the practices for reducing bacteria. Many cape communities are working to address bacteria impairments causing swimming beach and shellfish closures. It will be important to know if the stormwater practices installed in Chatham and Hyannis can be used to address both nitrogen and bacteria, since communities will want to get the “best bang for their buck.” Cape communities already have arrangements to monitor bacteria levels at their beaches, so they probably have at least some capability to monitor the practices for bacteria. [MaryJo Feuerbach]

The proposed BMPs should provide nutrient and bacteria removal as currently designed. Per the Massachusetts stormwater handbook, constructed stormwater wetlands provide up to 75% pathogen removal. Although these BMPs are designed to treat only the 0.3-inch storm, it is anticipated that nutrient and bacteria removal will remain high. Inclusion of analyses for detection of bacteria in water samples will be determined as the monitoring plan is finalized. We do not anticipate changes to the conceptual design as presented in order to allow for analysis of samples for bacteria.

12. While the operational monitoring will not begin until 2016, this year there may be a few requests for NERL Chemistry Lab analysis for some grab samples during rain events to determine the range of concentrations of Total Nitrogen and TSS. There may also be grab



samples for pathogen indicators, which will be analyzed by a municipality's lab, or other lab near to the site. [Diane Switzer]

This comment and others that follow from Diane Switzer relate to the monitoring program. Although the TSM1 does not include details of the monitoring program design, we appreciate her comments and note that we intend to work closely with the EPA to ensure that the monitoring program will satisfy the project objectives.

13. Three composite samples will be collected for each rain event – one at the main line, one at inflow to the BMP, and one at outflow from the BMP. These should be flow-composited. If an event lasts longer than 24 hours, at 24 hour intervals, the existing composites will be collected and preserved according to the designated protocols. [Diane Switzer]

The monitoring plan will be developed with your cooperation. Thank you for keeping us apprised as to your thoughts.

14. We'll need to submit the analytical request to the NERL Chemistry Lab for this year and next. Once we know how many rain events it could be for this year, I can draft the request. [Diane Switzer]

Thank you for letting us know about the need to submit requests to the NERL lab.

15. A 48 hour heads up to the Chemistry Lab is needed, to make sure they have the staff notified to expect samples. This is helpful, even if the rain event ends up not being sampled. [Diane Switzer]

Thank you for advising us as to the need to provide a heads-up to the lab. We'll keep this in mind as we develop the monitoring plan in cooperation with technical staff at the EPA.

16. Once the draft QAPP is completed after all the reviews and amendments, the final QAPP will need to have the completed Monitoring Plan attached as an appendix, since it will have the details necessary for the QA Officer's review and approval. [Diane Switzer]

We acknowledge your comment on the need to attached the monitoring plan to the QAPP. We will work closely with the EPA in development of both the QAPP and the monitoring program.

17. Parshall Flume installed on influent and effluent. This would give an accurate total flow to system. Some stormwater maybe lost to the ground during treatment if it isn't completely sealed. I heard "99%" sealed in the meeting which means where they put the risers in is probably going to be a leaky area. [Tim Bridges]

It is expected that there will be minimal leakage around the stormwater BMP associated with drainage structures, pipes, and any other features that penetrate the impermeable liner. It is not expected that this minimal leakage will adversely impact stormwater treatment or monitoring program integrity. We are currently evaluating use of a flume along with other approaches to measuring flow in the BMP system.



18. Sampling access to adequately collect a grab sample if needed. To monitor other parameters including turbidity and fecal coliform may be needed. Fecal or entero maybe a key long-term due to shellfish areas in Chatham as well as Hyannis harbor. [Tim Bridges]

The final design will indicate locations for sampling inflow to and discharge from the gravel wetland. We recognize that sampling locations must be accessible to facilitate sampling and will include this requirement in the final BMP designs. Given interest expressed in this comment and others, we envision that the monitoring plan will include analyses for suspended solids and fecal and total coliform.

19. Install recording rain gage on site. Rainfall varies throughout the area. These small watersheds may not be represented by other locations such as the Barnstable County airport. [Tim Bridges]

We will evaluate the utility of the rain gage at the site, balancing the associated expenses with the benefits of obtaining onsite rainfall data.

20. Install state of the art equipment. This is the first of its kind project and technology needs to be out in front of other projects. Other towns will be looking to use this as an example of what they should build. [Tim Bridges]

We agree. As noted above, the proposed systems are innovative while making use of established design practices. We are currently considering the use of an alternative to gravel as the fill media that would be an innovative practice that to our knowledge has not been utilized elsewhere in treatment of storm water.

21. Kiosk must be approved by Ray Cody. Too many times, I see the kiosk that doesn't have enough information or give all organizations credit to those groups involved. Both projects are in somewhat high vis areas, especially Hyannis which is on the walking path from parking to the Nantucket ferry. [Tim Bridges]

We agree. The Design Team recently coordinated with Ray Cody and others at EPA to design and install a kiosk for a BMP in Providence. We will follow a similar protocol for the kiosks on Cape Cod.

22. Trash screen into system installed on influent to takeout debris as well as installed in the system outlet control structures. This is somewhat easy do which will save maintenance down the road. [Tim Bridges]

Final design may include a trash screen on inlet and/or outlet control structures at both sites as appropriate. Based on preliminary design, a trash screen may be installed on the inlet control structure between the sediment forebay and first gravel wetland cell at the Chatham location, and within the deep sump structure at the Barnstable location. Flapper valve at end of pipe at harbor to prevent critters from getting into system as well as eliminate backflow coming into system during storms. [Tim Bridges]



Final design will evaluate the feasibility of a tide gate or backflow preventer valve installed at the end of this pipe. Additional funding may be required to purchase and install this device unless the Town of Barnstable would like to perform this item as part of an in-kind service. Note that this device may assist with flooding prevention during smaller flood events, but a 100-year storm will inundate the entire area regardless of the presence of a tide gate. A new section in the final Cost Memo titled Optional Items has been added to address this item.

23. Oil skimmer system installed in the BMP which can be some type of pad system that is serviced. [Tim Bridges]

If desired, an oil skimmer system could be installed as supplementary pretreatment at each site. Additional funding is required to purchase and install these devices unless Towns would like to perform this item as part of an in-kind service. Timely operation and maintenance of this item are critical to ongoing performance, and thus towns must be willing to diligently perform the maintenance associated with an oil skimmer system. Based on contributing watershed land uses, an oil skimmer system is probably not necessary unless oil or other floatables have been observed to be a problem at these locations. The watershed at the Chatham location is largely comprised of low-density residential development that typically will not produce large quantities of floatables and debris. Barnstable is largely comprised of medium density residential and commercial buildings such as apartments and hotels, however these land uses are not typically associated with large quantities of floatable pollutants. Therefore, it is recommended that an oil/water separator hood be installed at the Barnstable location to remove floatables as part of the proposed design, however is not necessary at the Chatham location based on surrounding land use. A new section in the final Cost Memo titled Optional Items has been added to address this item.

24. “Driveable” grass on top of Hyannis system due to limited space and access. This is a product that will help protect the unit when servicing and give more strength to prevent damage to BMP. [Tim Bridges]

Most of the proposed design will make use of the nearby brick walking path to access the site. If desired, a stabilized grass area can be created (e.g. from plastic grids or mats), however this will be an added cost item that can be addressed during final design. Construction is anticipated to use plywood sheets that can be used to temporarily cover grass areas as needed to minimize disturbance. The same method can be used during maintenance operations. Alternatively, the Town of Barnstable could implement this option on its own at the conclusion of construction if desired. A new section in the final Cost Memo titled Optional Items has been added to address this item.

25. It would be useful to note whether or not there is any base flow from groundwater infiltration in the drains. If there is, this will become a design consideration in the development of the final design. [Mark Voorhees]



To date, the Design Team has performed two site visits to each location. Unfortunately both site visits have occurred during and/or immediately after the conclusion of heavy rain events. An additional site visit(s) during the final design process will evaluate the presence or absence of base flow in each system.

26. Both systems will be off line systems which is preferable for water quality performance and should eliminate concerns of high flow overflows from the control structures and downstream impacts. High flow bypasses will occur at the diversion structure. The final T1SM should mention that the diversion structures will be designed to bypass high flows up to a certain design storm frequency (e.g., 10 yr) over the diversion wall without causing upstream flooding problems due to system surcharging. [Mark Voorhees]

Existing drainage systems at both the Chatham and Barnstable sites will be partially surcharged in order to bring the water level up to a suitable elevation for conveyance into the proposed stormwater BMPs. Conceptual designs have traced the existing systems upgradient to ensure that stormwater surcharge will not adversely affect the drainage system (e.g. floating manhole covers or surcharging out of catch basin grates). Final design will confirm this, as well as evaluate the proposed drainage configuration for up to and including the 100-year storm.

27. The final T1SM should also mention that, to the extent possible, the hydraulic design of the diversion structures and hydraulic controls within treatment systems will be optimized to provide full water quality treatment of the design capacity (e.g., 0.3 inches) such that hydraulic overloading does not occur and retentions times in the saturated reservoir needed for denitrification are maintained. [Mark Voorhees]

Acknowledged. Stormwater BMPs will be designed to treat 0.3 inches of runoff from contributing impervious areas while safely bypassing larger storms via the diversion wall into the existing drainage system or bypass structures within the BMP. The final design process will involve modeling the existing and proposed system using Autodesk Storm and Sanitary Analysis software to evaluate hydraulic function of the stormwater BMP, including the proposed diversion walls and stormwater structures.

28. The final T1SM should include for each system the ratio of saturated storage to total system storage and discuss its relevance as an important design criterion. I believe UNH has guidelines that they use on designing these systems. [Mark Voorhees]

We are currently consulting with UNH and will ensure that the system meets the recommended design criterion. Documentation of final design ratio will be provided in the full BMP design memo.

29. For the final designs the design team might consider the inclusion of deep sump catch basins as added pre-treatment measures to facilitate maintenance by the municipality. [Mark Voorhees]



Final design will review the possibility of installing pretreatment structures at each site. Based on discussions during the January 13 meeting, final design of the Barnstable site will likely include a deep sump structure or equivalent for pretreatment sediment removal. The final T1SM has been updated to reflect this change. The Chatham site is currently designed with a sediment forebay for pretreatment, however may also be replaced with a deep sump catch basin for pretreatment. This will allow enlargement of the treatment cells and/or further setback from the nearby bordering vegetated wetland.

30. For future monitoring it would be desirable to monitor the systems at three locations each: 1) the main drain line upstream of the diversion wall; 2) upstream of the treatment system (e.g., the diversion flow); and 3) the effluent of the treatment system. [Mark Voorhees]

We agree. Access to the main drain line upstream may be difficult at both sites and is currently being evaluated.

31. Keeping bacteria on the table as a potential parameter to sample for a subset of sampling events could provide very valuable performance information. [Mark Voorhees]

We agree. This will be determined as the monitoring plan is finalized. We do not anticipate changes to the conceptual design as presented in order to allow for analysis of samples for bacteria.

32. Mass Balance / Retention Time (Rt). It would be helpful to understand BMP performance and unit costs as a function of (a) nitrogen input-output mass balance and (b) retention time (Rt) - perhaps the predominant parameter for de-nitrification performance according to UNHSC. With regards to (a), please consider / advise on how final designs might be modified, if at all, to accommodate an accurate accounting of the total mass of nitrogen treated by each BMP, including how and where additional sampling might be conducted for this purpose (e.g., total mass of nitrogen before diversion, after diversion (pre-BMP) and after treatment (post-BMP)). With regards to (b), available precipitation data for New England and Cape Cod should be utilized to calculate an average time between storm events to compare with a range of Rt to help anticipate BMP performance and to ensure that the time required for de-nitrification is not somehow on average routinely offset / impacted. As I understood the conversation from our January 13th Meeting, Mark Voorhees would perform some or all of these calculations and provide you with some or all of the results for your consideration and incorporation into the project. [Ray Cody]

We have obtained data and calculations of detention time from Mark Voorhees and will examine the expected residence times as they relate to guidance obtained from UNH on design guidelines for residence time.

33. Design Figures. As we discussed, it would help to clarify / label the aerobic versus anaerobic zones of the treatment cells; otherwise, as we discussed, it almost appears as if the entire first of the two cells is an aerobic treatment cell and that the system only treats



0.15 inches WQV. In addition, could a legend be provided to help explain design features? [Ray Cody]

Acknowledged. Revised design plans are attached to this response to clarify aerobic and anaerobic portions of each cell. Additionally, Figure 4 and Figure 7 contain cross sections for each BMP and outline a step-by-step guide to the stormwater treatment process and identifies all major design features.

34. Dewatering. For either or both sites, and considering the anticipated quite shallow groundwater table, will construction of the BMPs require compliance with the Construction General Permit (CGP)? If so, how will compliance with the CGP be implemented / accomplished? [Ray Cody]

Based on field work performed to date and proposed design, it is anticipated that dewatering will be required for at least part of construction efforts at each site. The final 2012 National Pollutant Discharge Elimination System General Permit for Discharges from Construction Activities (the CGP) applies to projects that disturb 1 or more acres of land. The Chatham and Barnstable sites combined do not proposed to disturb greater than 1 acre of land, and thus the CGP does not apply.

A draft Dewatering General Permit is available for Massachusetts, however is not currently effective. While not subject to the above EPA permits, both projects will have erosion controls as required for in compliance with the Massachusetts Wetland Protection Act.

35. Logistics and Schedule. Even if plans change, please include a brief description of how you conceptualize the schedule at this time, particularly considering that two (2) BMPs are to be constructed at different sites and, ostensibly at least, both constructed during the same spring period of April – May/June 2015. I suggest the *.xlsx Schedule you provided in response to our PWS could and should be updated and used as the best representation of the schedule. Again, we understand this schedule may change thereby requiring more or less routine updating until the project is completed. [Ray Cody]

Acknowledged. A proposed schedule is attached to this response. Note that this is tentative, and ultimately depends on several items, including final design, acceptance by both towns, weather, contractor availability, etc. The schedule has been prepared to fit construction of both BMPs between March and the end of May. This schedule is very tight, however should construction prove infeasible within this timeframe, construction may be moved or continued to the fall months. Due to Barnstable's location within a pedestrian-sensitive area, it is recommended that this BMP be constructed first. Chatham is also more conducive to construction split between two phases (spring and fall) than Barnstable.

36. Re: Barnstable. As requested in the PWS, and to the extent possible, please confirm that limited surcharging of the existing drainage system would occur under most conditions. Please include consideration of storm volumes that may exceed the 95% percentile (e.g., very large volume 'climate change' storm events). [Ray Cody]



Note that moderately large and large storms, including those exceeding the 95% percentile will likely inundate the entire area with an ocean storm surge, thereby rendering the surrounding area under water. The surface of this BMP is located at approximately elevation 7.0 (NAVD88), or approximately 5-feet below the 100-year floodplain located at elevation 12.0 (NAVD88).

The system is currently designed with limited surcharging, estimated to occur up to approximately elevation 6.5. Stormwater will then back up to approximately the upgradient structure located just north of South Street. This elevation is not anticipated to cause any adverse impacts to the drainage system, as all rim elevations are well above this elevation. The final design process will involve modeling the existing and proposed system using Autodesk Storm and Sanitary Analysis software to evaluate hydraulic function of the stormwater BMP, including the proposed diversion walls and stormwater structures.

37. Re: Chatham.

- a. BMP Overflow. Is it certain that BMP output flow / overflow can be discharged via the existing ditch / channel without adverse effects to the down gradient private properties. Also, is such a discharge as contemplated likely to impact to the wetlands area such that compliance with local (Mass) and/or federal permitting may be required? [Ray Cody]

The bulk of wetland areas are located directly west of the proposed BMP and will not be impacted by the proposed BMP construction. However, construction will take place within the buffer zone and thus will be permitted through the conservation commission via the submission of a NOI. Note that no direct impacts to the resource areas are anticipated, and thus no permitting beyond a standard NOI is required. Final design will evaluate the feasibility of shifting the bulk of the stormwater BMP further away from the wetland to further minimize resource area impacts.

As the wetland complex moves further south, it becomes channelized into a drainage ditch which drains through a culvert below two driveways associated with house numbers 98 and 100 on Oyster Pond Furlong. At this point, it no longer functions as a wetland, but instead as a drainage conveyance channel. This channel ultimately flows back into the drainage trunk line below Oyster Pond Furlong south of the southernmost driveway where it outlets into Oyster Pond approximately 500-feet further. The proposed BMP overflow will outlet into the drainage ditch and not the wetland complex. The entirety of small storms of approximately 0.3-inches and smaller will be designed to flow into the stormwater BMP and ultimately into the adjacent drainage channel. Small storms are expected to have a negligible impact on adjacent land areas and driveway culvert(s) due to the small design of the BMP (0.3-inch storm) and small diameter inlet pipe.

In large storms, we would expect a maximum runoff volume of 0.3 inches would be diverted into the stormwater BMP and that the remainder of the runoff volume from



these large storms would continue down the drainage trunk line to Oyster Pond as currently occurs.

- b. Perimeter Drain. I thought this was a very simple yet quite helpful design component. Should or could it not also extend to encompass the 10' Wide Maintenance Road as well, if possible, in order to maintain access and condition of the road during the wetter seasons? [Ray Cody]

Based on the current design, it is not anticipated that the maintenance road will be impacted by high water levels. The function of the perimeter drain is to reduce groundwater impacts on the BMP itself. Based on field efforts to date, the seasonal high groundwater elevation is expected to be no higher than elevation 14.0 (NAVD88). The maintenance and access road is expected to be located between elevations 17.0 and 18.0 (NAVD88), and thus will be above the seasonal high groundwater elevation. Additionally, the access roadway is designed to be covered with crushed stone to allow access nearly year-round without becoming eroded or muddy.

- 38. Use of Innovative Materials for Enhanced Porosity. Bruce J. raised an interesting possibility regarding materials having porosities as high as 0.9. Please seriously consider whether such materials may be available and appropriate, and perhaps check with UNHSC for its opinion on such a modification to the basic design specification. [Ray Cody]

Acknowledged. Final design will evaluate potential innovative technologies that could potentially improve stormwater storage capacity and/or treatment while preserving the anticipated construction budget.

