MASSACHUSETTS
watershed·based plans

WATERSHED-BASED PLAN

West Monponsett Pond Watershed
Town of Halifax

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Prepared By:

Town of Halifax
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Prepared For:

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

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Contents

Executive Summary

Introduction: The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows USEPA's recommended format for "nine-element" watershed plans. This WBP was developed by Geosyntec Consultants (Geosyntec) under the direction of the Town of Halifax Board of Health with funding, input, and collaboration with the Massachusetts Department of Environmental Protection (MassDEP).

This WBP focuses on the West Monponsett Pond watershed. West Monponsett Pond is primarily located in the Town of Halifax and is designated as a tributary to a Public Water Supply and an Outstanding Resource Water. Primary inflows into the pond come from East Monponsett Pond and White Oak Brook. Water discharges from the pond via Stump Brook to Plymouth Street Pond and ultimately to the Taunton River. Stump Brook Dam is located approximately 0.8 river miles downstream of the pond along Stump Brook, which regulates the flow out of the pond. Water from the West Monponsett Pond is also diverted to Silver Lake for the City of Brockton's water supply and is subject to certain seasonal operating restrictions. The approximate 6.5 square-mile (4,187 acres) drainage area of West Monponsett Pond is part of the greater Taunton watershed and is primarily located within the Towns of Halifax, Hanson, Pembroke, and Plympton.

Impairments and Pollution Sources: West Monponsett Pond is listed under category 5 of the 2016 Massachusetts List of Integrated Waters (303 (d) list) due to five impairments, including total phosphorus (TP), harmful algal blooms, secchi disk transparency, chlorophyll-a, and non-native aquatic plants. The sources of the impairments are generally listed as unknown, except for the non-native aquatic plants, which are listed as accidentally or intentionally introduced. However, the Draft TMDL (MassDEP, 2019) concluded that the major sources of TP were cranberry bogs, internal release from sediments, natural wetlands and runoff from developed areas.

Monitoring data in West Monponsett Pond suggests that the pond has experienced elevated levels of TP but has substantially improved in recent years. Samples taken in 2006 had the highest concentrations of TP with a maximum of 1,710 ug/L. Data from 2016—2018 indicated substantial reduction in the TP concentration, which was most likely due to fertilizer reduction practices at cranberry bogs located within the watershed. Aluminum treatments of the pond also occurred in 2013, 2015, 2016, 2017, 2018 and 2019 to address internal TP loads (MassDEP, 2019). Additionally, beach closing data available from the Halifax Board of Health, for 2009—2019, indicated that the beaches at West Monponsett Pond have had closings every summer, often for weeks at a time, due to algae or elevated levels of E. Coli.

Goals, Management Measures, and Funding: Water quality goals for this WBP are based on the goals for TP presented in the draft Total Maximum Daily Load (TMDL) for West Monponsett Pond and East Monponsett Pond (MassDEP, 2019). It is expected that TP reductions will result in improvements to the other listed impairments for West Monponsett Pond as well. This WBP includes an adaptive sequence to establish and track specific water quality goals. As future monitoring results become available, the goals may be revisited and adjusted, if needed.

It is expected that goals will be accomplished primarily through in-lake aluminum treatments, fertilizer reduction practices at adjacent cranberry bogs, installation of structural BMPs to capture runoff and reduce loading, implementation of non-structural BMPs (e.g., street sweeping, catch basin cleaning), and watershed education and outreach.

It is expected that future funding for management measures will be obtained from a variety of sources including Section 319 Grant funding, Town Capital funds, volunteer efforts, and other sources.

Public Education and Outreach: Goals of public education and outreach are to provide information about proposed management measures and their anticipated benefits and to promote watershed stewardship. The Town of Halifax aims to engage watershed residents and businesses through interpretive signage, educational mailing, online resources, school visit programs, and a variety of other means. It is expected that these programs will be evaluated by tracking coverage from local media, number of mailers distributed, online resource user activity, and other tools applicable to the type of outreach performed.

Implementation Schedule and Evaluation Criteria: Project activities will be implemented based on information outlined in the following elements for monitoring, implementation of BMPs, and public education and outreach activities. It is expected that water quality monitoring will enable direct evaluation of improvements over time. Other indirect evaluation metrics are also recommended, included quantification of potential pollutant load reductions from non-structural BMPs (e.g., street sweeping). The long-term goal of this WBP is to de-list West Monponsett Pond from the 303(d) list. The WBP will be re-evaluated and adjusted as needed with a minimum of once every three years.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

The purpose of a WBP is to organize information about Massachusetts' watersheds, and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the USEPA's recommended format for "nine-element" watershed plans, as described below.

All states are required to develop WBPs, but not all states have taken the same approach. Most states develop watershed-based plans only for selected watersheds. MassDEP's approach has been to develop a tool to support statewide development of WBPs, so **that good projects in all areas of the state may be eligible for federal watershed implementation grant funds** under Section 319 of the Clean Water Act.

USEPA guidelines promote the use of Section 319 funding for developing and implementing WBPs. WBPs are required for all projects implemented with Section 319 funds, and are recommended for all watershed projects, whether they are designed to protect unimpaired waters, restore impaired waters, or both.

Watershed-Based Plan Outline

This WBP for the West Monponsett Pond watershed includes nine (9) elements (a through i) in accordance with USEPA Guidelines:

a. An **identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this WBP (and to achieve any other watershed goals identified in the WBP), as discussed in item (b) immediately below.

b. An **estimate of the load reductions** expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time).

c. A **description of the nonpoint source (NPS) management measures** needed to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this WBP), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d. An **estimate of the amounts of technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, United States Department of Agriculture's (USDA) Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

e. An **information/education component** that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f. A **schedule for implementing the NPS management measures** identified in this plan that is reasonably expeditious.

g. A description of **interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

h. A set of **criteria to determine if loading reductions are being achieved** over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this WBP needs to be revised or, if a NPS Total Maximum Daily Load (TMDL) has been established, whether the TMDL needs to be revised.

i. A **monitoring component** to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Project Partners and Stakeholder Input

This WBP was developed by Geosyntec Consultants (Geosyntec) under the direction of the Town of Halifax with funding, input, and collaboration from the MassDEP. This WBP was developed using funds from the Section 319 program to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool. The Town of Halifax was a recipient of Section 319 funding in Fiscal Year 2017 to implement water quality improvements in the West Monponsett Pond watershed.

Core project stakeholders include:

- Cathleen Drinan, Health Agent – Town of Halifax Board of Health
- Matt Reardon– MassDEP

This WBP was developed as part of an iterative process. The Geosyntec project team collected and reviewed existing data from the Town of Halifax. This information was then used to develop a preliminary WBP for review by the Town of Halifax. The WBP was finalized once comments were incorporated from the Town of Halifax. Future iterations of the plan may include input from additional stakeholders in the watershed.

Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's Watershed-Based Plan Tool and supplemented by information provided in the Monponsett Pond's Remediation Program: West Monponsett Pond Nutrient Management Project Section 319 Nonpoint Source Pollution Grant Program application (Town of Halifax, 2016) and final report (Town of Halifax, 2019). Additional data sources were reviewed and relevant information is summarized in subsequent sections of this WBP.

Summary of Past and Ongoing Work

A comprehensive list of past work for West Monponsett Pond (as well as East Monponsett Pond) is compiled in the Halifax Conservation Commission webpage located here: http://www.halifax-ma.org/conservation-commission/pages/monponsett-pond-and-mosquitoes (4/2020). Significant studies for West Monponsett Pond are described in more detail below.

Phosphorus/Phytoplankton Study of West Monponsett Pond (Lycott, 2007)

A study of phosphorus and phytoplankton was conducted for West Monponsett Pond in 2007 to assess the source and status of seasonal algal blooms that had occurred annually for several decades in the pond. The study included phosphorus and phytoplankton sampling and analysis that concluded phosphorus levels had increased in the past 20 years due to loading from the surrounding watershed. Aluminum sulfate water treatment was recommended to reduce phosphorus concentrations in the pond.

Sustainable Water Management Initiative Report – Monponsett Pond and Silver Lake Water Use Operations and Improvement (Princetown Hydro, 2013)

The Town of Halifax was awarded funding in 2013 for the Monponsett Pond and Silver Lake Water Use Operations and Improvement project to evaluate water management practices, investigate options to improve water quality, and evaluate methods to improve streamflow in Stump Brook (the outlet of West Monponsett Pond). The Brockton Water Supply (BWS) system diverts water from Monponsett Pond (as well as Furnace Pond and Silver Lake). The study concluded that the water management practices by the BWS that involve Silver Lake/Monponsett Pond/Furnace Pond are not sustainable and have contributed to negative impacts on water quality and ecological functions. The reports suggest changes to the water management practices of the BWS to reduce its reliance on the three ponds, including the use of desalinated water available from Aquaria located in Dighton, Massachusetts.

Stormwater Outfall Assessment for the East and West Monponsett Ponds (GHD, 2017)

The Town of Halifax hired GHD Inc. to assess the stormwater outfalls that discharge to East Monponsett Pond and West Monponsett Pond. As part of the assessment, conceptual stormwater BMP designs were developed for each of the outfalls that discharge directly to East Monponsett Pond or West Monponsett Pond. A prioritization matrix was developed, which ranked the BMP designs. Parameters used in the prioritization matrix included: location of outfall discharge (i.e., in West Monponsett Pond or East Monponsett Pond); total impervious area (TIA) within drainage area; total surface area of drainage area; planning-level costs of BMP implementation; and required operation and maintenance (O&M) of the BMP. Thirteen outfalls were identified that either discharge directly to West Monponsett Pond or areas abutting the pond; a BMP concept was developed for each of the thirteen outfalls. The top three BMP designs from the prioritization matrix were all within the West Monponsett Pond watershed. These designs were developed into more detailed preliminary designs, which included a detailed topographic survey, wetland delineation, preliminary project specifications and invert and elevation information for each of the individual systems.

Project Final Report – West Monponsett Pond Nutrient Management Project (Town of Halifax, 2019)

The West Monponsett Pond Nutrient Management Project was awarded Section 319 funding in Fiscal Year 2017 to implement water quality treatment to reduce phosphorus loading that has caused algal blooms in West Monponsett Pond. The project was conducted between January 2017 and June 2019 and included two project amendments to continue treatment of the pond. The goal of the project was to use aluminum sulfate treatments to reduce phosphorus loading that have caused increased concentrations of blue green algae. The pond was dosed with aluminum sulfate in June 2017 (dosage: 17 g/m^2), May 2018 (dosage: 10 g/m^2), and June 2019 (dosage: 8

g/m^2). The treatments resulted in an estimated average annual TP reduction of 305 lbs/year. While the water quality of the pond still required recreational closures in the Summer of 2017, improvements to water quality allowed the pond to stay open to recreational activities for the entire Summer of 2018.

Element A: Identify Causes of Impairment & Pollution Sources

Element A: Identify the causes and sources or groups of similar sources that need to be controlled to achieve the necessary pollutant load reductions estimated in the watershed based plan (WBP).

General Watershed Information

West Monponsett Pond is primarily located in the Town of Halifax, MA and is designated as a tributary to a Public Water Supply and an Outstanding Resource Water (the northern edge of the pond is in Hanson, MA). The pond is approximately 283 acres and is relatively shallow (approximately 12 feet at its deepest). The pond is bordered by residential development to the South, North and East, active cranberry bogs to the West and undeveloped wetlands/swamps to the North. The pond serves multiple public interests, including water supply, fish and wildlife habitat, flood control, and recreation (e.g., beaches, boating, and fishing); however, recreational uses of the pond have been limited in recent years due to cyanobacteria algal blooms.

Primary inflows into the pond come from East Monponsett Pond and White Oak Brook. Water discharges from the pond via Stump Brook to Plymouth Street Pond and ultimately to the Taunton River. Stump Brook Dam is located approximately 0.8 river miles downstream of the pond along Stump Brook, which regulates the flow out of the pond. Water from the West Monponsett Pond is also diverted to Silver Lake for the town of Brockton's water supply and is subject to certain seasonal operating restrictions. The approximate 4,187-acre drainage area of West Monponsett Pond is part of the greater Taunton watershed and is primarily located within the Towns of Halifax, Hanson, Pembroke, and Plympton. **Table A-1** presents the general watershed information for West Monponsett Pond and **Figure A-1** includes a map of the watershed.

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID):	Monponsett Pond (MA62119)
Major Basin:	TAUNTON
Watershed Area (within MA):	4187.1 (ac)
Water Body Size:	283 (ac)

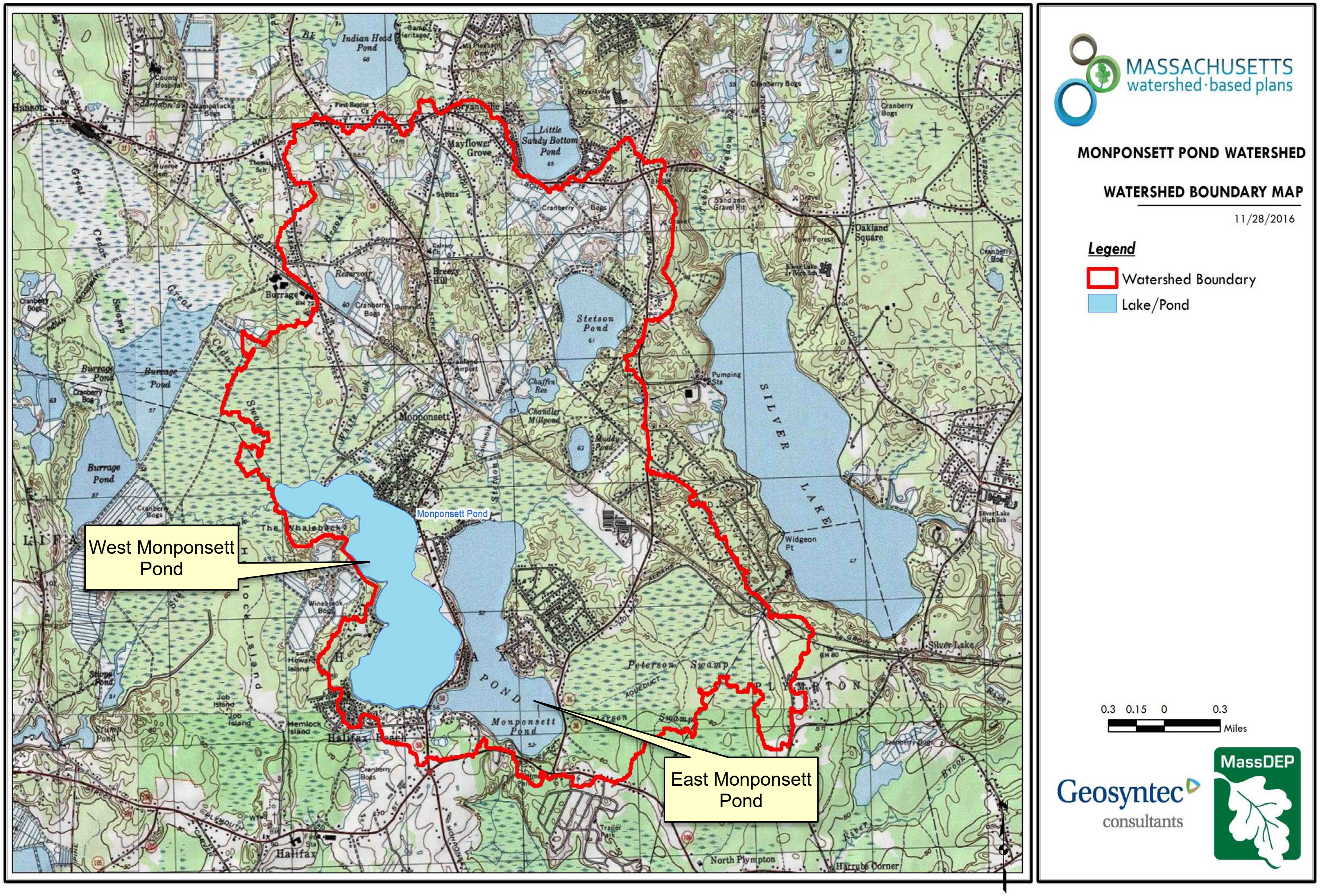

Figure A-1: Watershed Boundary Map

(MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Total Phosphorus (TP) Water Quality Data

Water quality data collected over the past thirty-five years in West Monponsett Pond has indicated elevated concentrations of TP compared to the water quality goal (see Table A-5 below). The Taunton River Watershed 2001 Water Quality Assessment Report (MassDEP, 2005) concluded that the major source of TP in the pond was septic systems based on the Lycott (1987) Diagnostic and Feasibility Study. However, the Draft TMDL (MassDEP, 2019) concluded that the major source of TP were cranberry bogs, internal release from sediments, natural wetlands and runoff from developed areas. Table A-2 includes a summary of the available TP water quality data in the pond from 1985—2018.

Table A-2: Summary of Total Phosphorus (TP) Data at West Monponsett Pond

Sample Date	Number of locations sampled	Average TP (ug/L)	Maximum TP (ug/L)	Source
5/29/1985	5	82	180	Lycott, 1987
6/11/1985	3	103	180	Lycott, 1987
7/8/1985	4	60	100	Lycott, 1987
8/13/1985	3	103	250	Lycott, 1987
8/28/1985	3	29	43	Lycott, 1987
9/11/1985	5	59	94	Lycott, 1987
9/26/1985	3	43	71	Lycott, 1987
10/10/1985	4	25	71	Lycott, 1987
10/25/1985	4	63	191	Lycott, 1987
11/13/1985	5	39	60	Lycott, 1987
11/25/1985	5	25	41	Lycott, 1987
12/20/1985	4	40	40	Lycott, 1987
1/22/1986	3	52	95	Lycott, 1987
2/13/1986	5	17	46	Lycott, 1987
3/31/1986	5	25	49	Lycott, 1987
4/17/1986	5	23	35	Lycott, 1987
5/14/1986	4	22	82	Lycott, 1987
6/28/2006	15	173	532	Lycott, 2007
7/26/2006	15	331	1710	Lycott, 2007
8/23/2006	15	284	1045	Lycott, 2007
9/20/2006	15	171	792	Lycott, 2007
6/23/2016	2	20	21	MassDEP, 2019
7/14/2016	2	27	27	MassDEP, 2019
8/25/2016	2	20	20	MassDEP, 2019
6/5/2017	3	28	36	Town of Halifax, 2019
6/28/2017	3	28	36	Town of Halifax, 2019
7/28/2017	3	14	14	Town of Halifax, 2019
8/16/2017	3	25	30	Town of Halifax, 2019
9/19/2017	3	14	15	Town of Halifax, 2019
10/26/2017	3	15	22	Town of Halifax, 2019
5/14/2018	3	24	28	Town of Halifax, 2019
6/28/2018	3	15	16	Town of Halifax, 2019
7/11/2018	3	12	14	Town of Halifax, 2019
8/6/2018	3	22	23	Town of Halifax, 2019
10/19/2018	3	10	10	Town of Halifax, 2019

Samples taken in 2006 had the highest concentrations of TP with a maximum of 1,710 ug/L. Data from 2016—2018 indicates substantial reduction in the TP concentration from the 2006 levels, which was most likely due to fertilizer reduction practices at cranberry bogs located within the watershed. Aluminum treatments of the pond also occurred in 2013, 2015, 2016, 2017, 2018 and 2019 to address internal TP loads (MassDEP, 2019).

E. Coli Water Quality Data

The Taunton River Watershed 2001 Water Quality Assessment Report (MassDEP, 2005) indicated that weekly testing for *E.coli* was conducted at two different beaches of West Monponsett Pond (Halifax Beach and the Lingan Street beach). In 2001, a total of 33 samples were collected with one exceedance of 4,800 cfu/100 ml. In 2002, a total of 33 samples were collected with one exceedance of 2,400 cfu/ml. Halifax Beach was also closed once in 2002 from August 21—29 due to elevated bacteria counts. Additionally, beach closing data available from the Halifax Board of Health, for 2009—2019, indicated that the beaches at West Monponsett Pond have had closings every summer, often for weeks at a time, due to algae or elevated levels of E. Coli.

Water Quality Impairments

West Monponsett Pond is listed under category 5 of the 2016 Massachusetts List of Integrated Waters (303 (d) list) due to five impairments, including TP, harmful algal blooms, secchi disk transparency, chlorophyll-a, and non-native aquatic plants. Refer to **Table A-3** for applicable integrated waters categories and to **Table A-4** for a summary of the impairments and their sources within the watershed. The sources of the impairments are generally listed as unknown, except for the non-native aquatic plants, which are listed as accidentally or intentionally introduced.

Table A-3: 2016 MA Integrated List of Waters Categories

Integrated List Category	Description
1	Unimpaired and not threatened for all designated uses.
2	Unimpaired for some uses and not assessed for others.
3	Insufficient information to make assessments for any uses.
4	Impaired or threatened for one or more uses, but not requiring calculation of a Total Maximum Daily Load (TMDL), including: 4a: TMDL is completed 4b: Impairment controlled by alternative pollution control requirements 4c: Impairment not caused by a pollutant - TMDL not required
5	Impaired or threatened for one or more uses and requiring preparation of a TMDL.

Table A-4: Water Quality Impairments

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA62119	**Monponsett Pond**	**5**	Aesthetic	Harmful Algal Blooms	Source Unknown
MA62119	**Monponsett Pond**	**5**	Aesthetic	Secchi disk transparency	Source Unknown
MA62119	**Monponsett Pond**	**5**	Fish, other Aquatic Life and Wildlife	Non-Native Aquatic Plants	Introduction of Non-native Organisms (Accidental or Intentional)
MA62119	**Monponsett Pond**	**5**	Fish, other Aquatic Life and Wildlife	Phosphorus (Total)	Source Unknown
MA62119	**Monponsett Pond**	**5**	Primary Contact Recreation	Harmful Algal Blooms	Source Unknown
MA62119	**Monponsett Pond**	**5**	Primary Contact Recreation	Secchi disk transparency	Source Unknown
MA62119	**Monponsett Pond**	**5**	Secondary Contact Recreation	Harmful Algal Blooms	Source Unknown
MA62119	**Monponsett Pond**	**5**	Secondary Contact Recreation	Secchi disk transparency	Source Unknown
MA62119	**Monponsett Pond**	**5**		Chlorophyll-A	

Water Quality Goals

Refer to **Table A-5** for a list of water quality goals. West Monponsett Pond has a Draft Total Maximum Daily Load (TMDL) for TP established by MassDEP and the United States Environmental Protection Agency (USEPA), which indicates the maximum amount of TP that the waterbody can receive and still safely meet water quality standards. The information from the Draft TMDL (MassDEP, 2019) is included as the water quality goal. There are multiple impairments for West Monponsett Pond; however, water quality goals are focused on reducing TP because it is expected that efforts to reduce loads of this common pollutant will also result in improvements to the other listed impairments for the waterbody (e.g., algal growth, secchi disk transparency, and non-native aquatic plants).

Additionally, Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013) prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. Monponsett Pond (MA62119) is a Class 'A' waterbody. The water quality goal for *E. Coli* is based on the Massachusetts Surface Water Quality Standards.

Table A-5: Water Quality Goals

Pollutant	Goal	Source
Total Phosphorus (TP)	Total Phosphorus should not exceed 18 ppb (18 ug/L) in West Monponsett Pond	Draft Final West and East Monponsett Pond System Total Maximum Daily Loads For Total Phosphorus (MassDEP, 2019)
Bacteria	**Class A Standards** • Public Water Supply Intakes in Unfiltered Public Water Supplies: For samples from any 6 month period, either fecal coliform shall not exceed 20 organisms/100 ml in all samples, or total coliform shall not exceed 100 organisms/100 ml in 90% of samples. If both fecal and total coliform are measured, only fecal coliform criterion apply. • Public Bathing Beaches: For E. coli, geometric mean of 5 most recent samples shall not exceed 126 colonies/100 ml and no single sample during the bathing season shall exceed 235 colonies/100 ml. For enterococci, geometric mean of 5 most recent samples shall not exceed 33 colonies/100 ml and no single sample during bathing season shall exceed 61 colonies/100 ml; • Other Waters and Non-bathing Season at Bathing Beaches: For E. coli, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml (typically based on min. 5 samples) and no single sample shall exceed 235 colonies/100 ml. For enterococci, geometric mean from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)

Land Use Information

Land use information and impervious cover is presented by the tables and figures below. Land use source data is from 2005 and was obtained from MassGIS (2009b).

Watershed Land Uses

As summarized by **Table A-6**, land use in the West Monponsett Pond watershed is mostly forested (approximately 46 percent); approximately 25 percent of the watershed is residential; approximately 19 percent is open land or water; approximately 9 percent is devoted to agriculture; approximately 2 percent is designated as highways; and approximately 1 percent is commercial or industrial.

Table A-6: Watershed Land Uses

Land Use	Area (acres)	% of Watershed
Forest	1,908.6	45.6
Water	750.1	17.9
Low Density Residential	647.5	15.5
Agriculture	360.4	8.6
Medium Density Residential	326.2	7.8
Highway	65.5	1.6
High Density Residential	51.7	1.2
Commercial	43.8	1
Open Land	28.1	0.7
Industrial	5.1	0.1

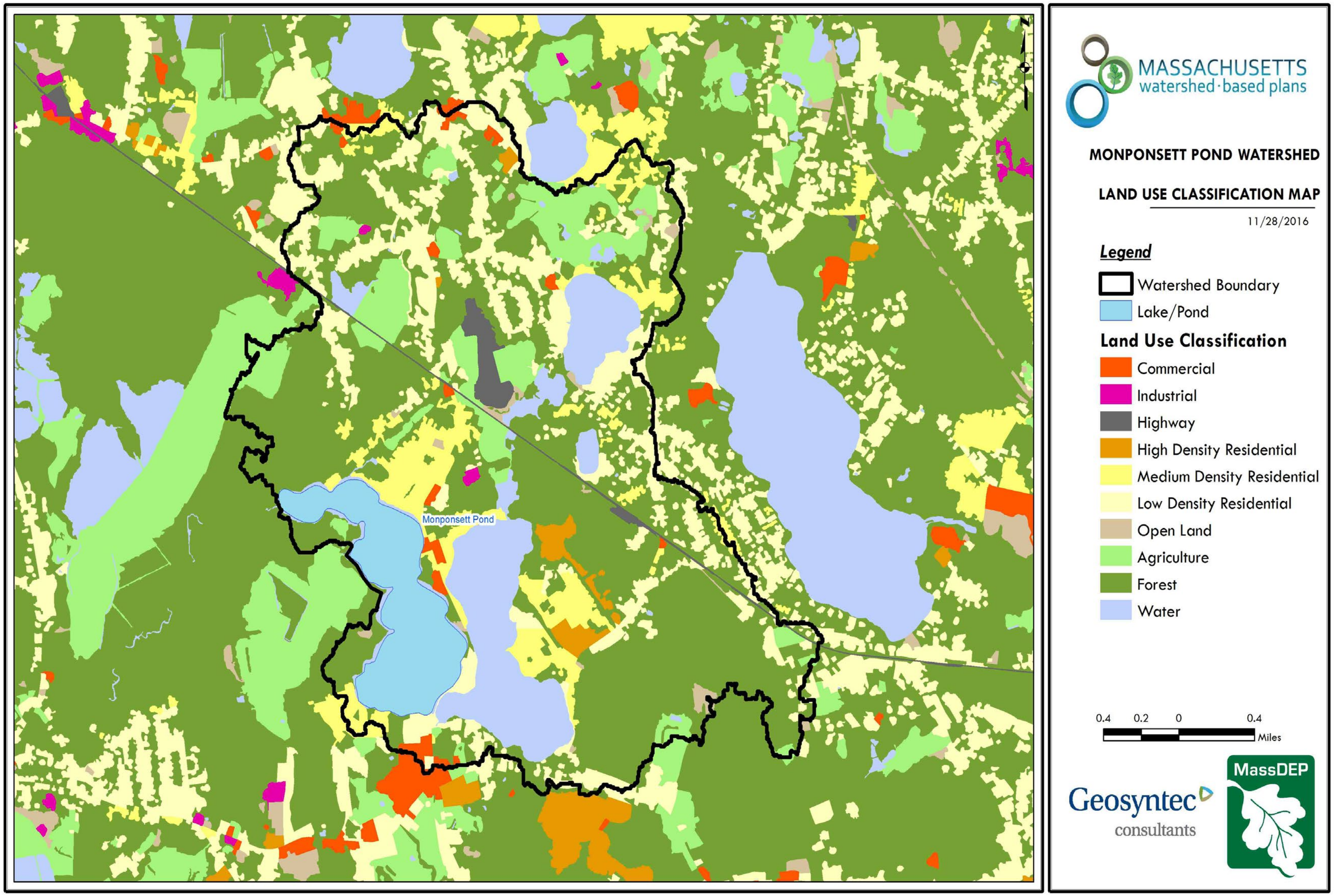

Figure A-2: Watershed Land Use Map

(MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Watershed Impervious Cover

There is a strong link between impervious land cover and stream water quality. Impervious cover includes land surfaces that prevent the infiltration of water into the ground, such as paved roads and parking lots, roofs, basketball courts, etc. Impervious area in the West Monponsett Pond watershed is not heavily concentrated and is distributed throughout the watershed, as illustrated by **Figure A-3** below.

Impervious areas that are directly connected (DCIA) to receiving waters (via storm sewers, gutters, or other impervious drainage pathways) produce higher runoff volumes and transport stormwater pollutants with greater efficiency than disconnected impervious cover areas which are surrounded by vegetated, pervious land. Runoff volumes from disconnected impervious cover areas are reduced as stormwater infiltrates when it flows across adjacent pervious surfaces.

An estimate of DCIA for the watershed was calculated based on the Sutherland equations. USEPA provides guidance (USEPA, 2010) on the use of the Sutherland equations to predict relative levels of connection and disconnection based on the type of stormwater infrastructure within the total impervious area (TIA) of a watershed. Within each subwatershed, the total area of each land use were summed and used to calculate the percent TIA (**Table A-7**).

Table A-7: TIA and DCIA Values for the Watershed

	Estimated TIA (%)	Estimated DCIA (%)
West Monponsett Pond Watershed	10.5	6.2

The relationship between TIA and water quality can generally be categorized as listed by **Table A-8** (Schueler et al. 2009). The TIA value for the watershed is 10.5%; therefore, tributaries and waterbodies can be expected to show good water quality.

Table A-8: Relationship between Total Impervious Area (TIA) and water quality (Schueler et al. 2009)

% Watershed Impervious Cover	Stream Water Quality
0-10%	Typically high quality, and typified by stable channels, excellent habitat structure, good to excellent water quality, and diverse communities of both fish and aquatic insects.
11-25%	These streams show clear signs of degradation. Elevated storm flows begin to alter stream geometry, with evident erosion and channel widening. Streams banks become unstable, and physical stream habitat is degraded. Stream water quality shifts into the fair/good category during both storms and dry weather periods. Stream biodiversity declines to fair levels, with most sensitive fish and aquatic insects disappearing from the stream.
26-60%	These streams typically no longer support a diverse stream community. The stream channel becomes highly unstable, and many stream reaches experience severe widening, downcutting, and streambank erosion. Pool and riffle structure needed to sustain fish is diminished or eliminated and the substrate can no longer provide habitat for aquatic insects, or spawning areas for fish. Biological quality is typically poor, dominated by pollution tolerant insects and fish. Water quality is consistently rated as fair to poor, and water recreation is often no longer possible due to the presence of high bacteria levels.
>60%	These streams are typical of “urban drainage”, with most ecological functions greatly impaired or absent, and the stream channel primarily functioning as a conveyance for stormwater flows.

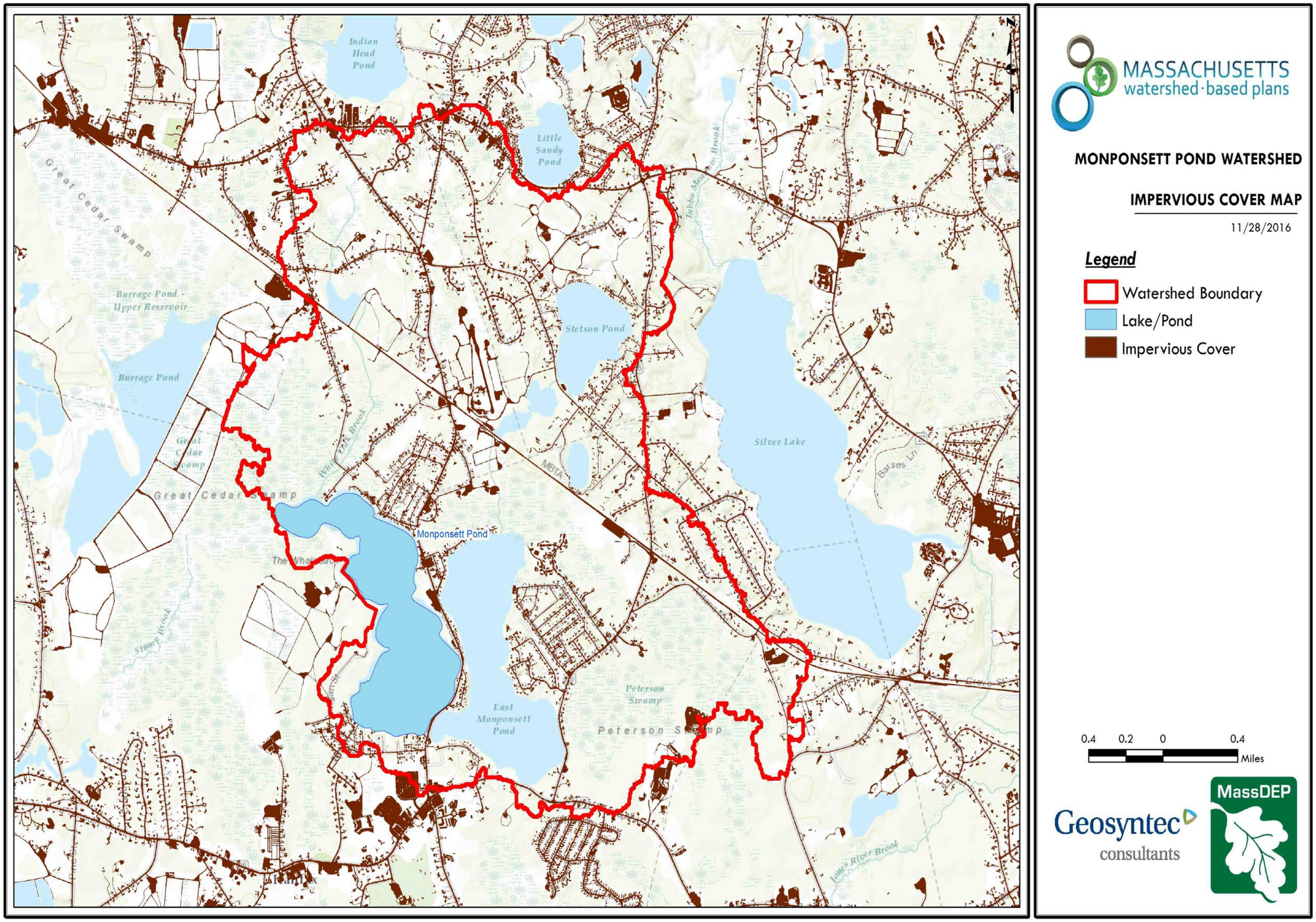

Figure A-3: Watershed Impervious Surface Map

(MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Pollutant Loading

The land use data (MassGIS, 2009b) was intersected with impervious cover data (MassGIS, 2009a) and United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soils data (USDA NRCS and MassGIS, 2012) to create a combined land use/land cover grid. The grid was used to sum the total area of each unique land use/land cover type.

The amount of DCIA was estimated using the Sutherland equations as described above and any reduction in impervious area due to disconnection (i.e., the area difference between TIA and DCIA) was assigned to the pervious D soil category for that land use to simulate that some infiltration will likely occur after runoff from disconnected impervious surfaces passes over pervious surfaces.

Pollutant loading for key nonpoint source pollutants in the watershed was estimated by multiplying each land use/cover type area by its pollutant load export rate (PLER). The PLERs are an estimate of the annual total pollutant load exported via stormwater from a given unit area of a particular land cover type. The PLER values for TN, TP and TSS were obtained from USEPA (Voorhees, 2016b) (see documentation provided in **Appendix A**) as follows:

$$L_n = A_n * P_n$$

Where L_n = Loading of land use/cover type n (lb/yr); A_n = area of land use/cover type n (acres); P_n = pollutant load export rate of land use/cover type n (lb/acre/yr)

The estimated land use-based phosphorus loading from the watershed to West Monponsett Pond is 881 pounds per year, as presented by **Table A-9**. The largest contributor of land use-based phosphorus load originates from areas designated as forested (32% of the total phosphorus load). Phosphorus generated from forested areas is a result of natural process such as decomposition of leaf litter and other organic material; these portions of the watershed are unlikely to provide opportunities for nutrient load reductions through best management practices. The second largest contributor of land-used based phosphorus originates from areas designated as residential and agricultural. There are usually opportunities for BMP implementation within residential and agricultural land uses.

Table A-9: Estimated Pollutant Loading for Key Nonpoint Source Pollutants

Land Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
Forest	280	1,470	61.6
Agriculture	193	1,192	22.9
Low Density Residential	161	1,550	22.0
Medium Density Residential	104	842	12.2
Commercial	45	388	4.85
High Density Residential	38	239	3.65
Highway	37	295	18.4
Open Land	19	147	3.85
Industrial	5.0	40	0.50
TOTAL	881	6,163	149.9

[1]These estimates do not consider loads from point sources or septic systems.

It is important to note that the pollutant loads presented in **Table A-9** do not consider loads from point sources or septic systems. Additionally, in West Monponsett Pond, discharge from cranberry bogs and internal loading has been identified as a significant source of TP loading that are not accounted for in **Table A-9**. The draft TMDL (MassDEP, 2019) used the Lake Loading Response Model (LLRM) to estimate existing TP loads to West Monponsett Pond. The draft TMDL estimated an existing TP load to West Monponsett Pond of 676 kg/year (1,491 lb/year) (MassDEP, 2019); the difference between the TMDL value for TP loading and the value presented in **Table A-9** is mainly because the LLRM model also considers internal TP sources and point sources to the lake (such as cranberry bogs) whereas the methodology presented above does not. Since the cranberry bogs and internal TP sources are significant in this watershed, the TP loading estimate from the draft TMDL was used for estimating the TP loading reduction needed (See Element B).

Element B: Determine Pollutant Load Reductions Needed to Achieve Water Quality Goals

Element B of your WBP should:
Determine the pollutant load reductions needed to achieve the water quality goals established in Element A. The water quality goals should incorporate Total Maximum Daily Load (TMDL) goals, when applicable. For impaired water bodies, a TMDL establishes pollutant loading limits as needed to attain water quality standards.

Estimated Pollutant Loads

Estimated pollutant loads for total phosphorus (TP) (881 lbs/yr), total nitrogen (TN) (6,163 lb/yr), and total suspended solids (TSS) (150 tons/yr) were previously presented in **Table A-9** of this WBP. *E. coli* loading has not been estimated for this WBP, because there are no known PLERs for *E. coli*. As is explained in Element A, the TP loading estimate from the draft TMDL was used for estimating the TP loading reduction needed (not the value presented in **Table A-9**. **Table B-1** presents the current TP loading estimate from the draft TMDL (MassDEP, 2019).

Water Quality Goals

There are many methodologies that can be used to set pollutant load reduction goals for a WBP. Goals can be based on water quality criteria, surface water standards, existing monitoring data, existing TMDL criteria, or other data.

As discussed in Element A, water quality goals for this WBP are focused on reducing TP loading to West Monponsett Pond. TP water quality goals from this WBP are based on criteria from the draft TMDL and are presented in **Table B-1** (MassDEP, 2019). The draft TMDL established an overall goal to reduce the TP loading to West Monponsett Pond from 1,491 lb/yr to 409.6 lb/yr (a 73 percent load reduction). The TMDL requires the largest TP load reduction from internal P Sources (mainly through aluminum addition) of 615 lb/yr. It requires a TP load reduction from cranberry bogs (mainly through fertilizer reduction practices) of 345 lb/yr. Additionally, the draft TMDL requires a TP load reduction from stormwater loads of 81 lb/yr. For implementing management measures to achieve the stormwater load reduction goal, it is recommended that management measures be focused on impervious surfaces located within the following land use categories: high intensity agriculture, low intensity development, medium intensity development, high intensity development and natural (MassDEP, 2019).

E. Coli water quality goals of this WBP are based on MSWQS concentration standards and are difficult to predict based on estimated annual loading (see **Table B-2**). Since it is not practical to estimate *E. coli* in terms of loading, the pollutant load reductions needed to achieve water quality goals are focused on TP. It is expected that efforts to reduce TP loading may also result in improvements to *E. Coli* in West Monponsett Pond.

The existing and proposed projects described in this plan are expected to reduce TP loads to West Monponsett Pond. However, additional load reductions will be required to meet the water quality goals. Considering known pollutant loads for existing and proposed BMPs (please refer to the Introduction or Element C for more details on existing and proposed BMPs), it is anticipated that aluminum treatments implemented in the past three years have reduced internal TP loading by 305 lb/year (Town of Halifax, 2019) and proposed BMPs may reduce the land use-based TP loading by 4.5 lb/year (GHD, 2017).

As future monitoring results become available (see Element I), it is recommended that the estimated load reduction of the implemented BMPs be re-evaluated for their effectiveness at reducing in-lake TP and/or other indicator parameters established by Table A-4 of this WBP (i.e., harmful algal blooms, secchi disk transparency, chlorophyll-a, and non-native aquatic plants). Results can further be used to periodically inform or adjust load reduction goals, if needed, to eventually lead to the delisting of West Monponsett Pond from the 303(d) list.

Table B-1: TP Load Reduction Goals – Current TP Loads and Allocated TP Loads for West Monponsett Pond
(Table adapted from "Draft Final West and East Monponsett Pond System Total Maximum Daily Loads For Total Phosphorus" (MassDEP, 2019))

Source	Current TP Loading (lb/yr)	Target TP Load Allocation (lb/yr)	Required Load Reduction (lb/yr)	% Required Load Reduction
Atmospheric	48.5	48.5	0.0	0%
Internal	647.1	32.4	614.7	95%
Septic System	35.7	35.7	0.0	0%
Watershed Load				
High Intensity Agriculture (Cranberry bogs)	392.4	47.2	345.2	88%
Forested Wetland	69.0	69.0	0.0	0%
Non-forested Wetland	17.2	17.2	0.0	0%
High Intensity Development	11.7	6.0	5.8	50%
Natural	3.1	3.1	0.0	0%
Medium Intensity Development	23.4	11.7	11.7	50%
Abandoned Cranberry Bogs	1.5	1.5	0.0	0%
Low Intensity Agriculture	0.2	0.2	0.0	0%
Low Intensity Development	46.7	23.4	23.4	50%
Total Watershed Load	**565.3**	**179.2**	**386.0**	**68%**
Total Load Allocation	**1,296.6**	**295.9**	**1,000.7**	**77%**
Stormwater Load By Land use				
High Intensity Agriculture (Cranberry bogs)	44.1	33.1	11.0	25%
Forested Wetland	24.9	24.9	0.0	0%
Non-forested Wetland	8.8	8.8	0.0	0%
High Intensity Development	5.1	2	3.1	60%
Natural	30.6	12.3	18.4	60%
Medium Intensity Development	53.1	21.2	31.9	60%
Abandoned Cranberry Bogs	0.2	0.2	0.0	0%
Low Intensity Agriculture	0	0	0.0	0%
Low Intensity Development	27.8	11.2	16.7	60%
Waste Load Allocation	**194.6**	**113.7**	**80.9**	**42%**
Total Load	**1,491.2**	**409.6**	**1,081.6**	**73%**

Table B-2: Bacteria (*E. coli*) Goals for West Monponsett Pond Watershed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Bacteria[1]	*MSWQS for bacteria are concentration standards (e.g., colonies of fecal coliform bacteria per 100 ml), which are difficult to predict based on estimated annual loading. In 2001 a total of 33 tests were performed with one exceedance of 4,800 cfu/100 ml. In 2002 a total of 33 tests were performed with one exceedance of 2,400 cfu/ml. Halifax Beach was closed once in 2002 from August 21—29 due to elevated bacteria counts (MassDEP, 2005).*	**Class A Standards** • Public Water Supply Intakes in Unfiltered Public Water Supplies: For samples from any 6 month period, either fecal coliform shall not exceed 20 organisms/100 ml in all samples, or total coliform shall not exceed 100 organisms/100 ml in 90% of samples. If both fecal and total coliform are measured, only fecal coliform criterion apply. • Public Bathing Beaches: For E. coli, geometric mean of 5 most recent samples shall not exceed 126 colonies/100 ml and no single sample during the bathing season shall exceed 235 colonies/100 ml. For enterococci, geometric mean of 5 most recent samples shall not exceed 33 colonies/100 ml and no single sample during bathing season shall exceed 61 colonies/100 ml; • Other Waters and Non-bathing Season at Bathing Beaches: For E. coli, geometric mean of samples from most recent 6 months shall not exceed 126 colonies/100 ml (typically based on min. 5 samples) and no single sample shall exceed 235 colonies/100 ml. For enterococci, geometric mean from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	*Concentration Based*

Notes:

1. *The water quality goal for bacteria is based on the Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013) that applies to the Water Class of West Monponsett Pond, which is Class A.*

Element C: Describe management measures that will be implemented to achieve water quality goals

Element C: A description of the nonpoint source management measures needed to achieve the pollutant load reductions presented in Element B, and a description of the critical areas where those measures will be needed to implement this plan.

Existing Management Measures

Aluminum treatments of the pond occurred in 2013, 2015 and 2016 to address internal TP loads (MassDEP, 2019). Additionally, fertilizer reduction practices have been underway since 2009 at Morse Brothers cranberry bog #19 and at the small 2-acre section of their Winebrook Bog next to the pond. Reductions in the measured concentration of TP in West Monponsett Pond have resulted from the implementation of these practices (MassDEP, 2019). In addition, the Town of Halifax was awarded funding through the Fiscal Year 2017 Section 319 Nonpoint Source Pollution Grant Program to implement aluminum sulfate treatment in West Monponsett Pond. Aluminum sulfate was applied in 2017, 2018, and 2019 in the 232 acres of surface water of West Monponsett Pond in order to reduce TP in the water column. In 2017, a total of 33,162 gallons of aluminum sulfate and 16,762 gallons of sodium aluminate were applied to the pond. In 2018, a total of 19,000 gallons of aluminum sulfate and 9,500 gallons of sodium aluminate were applied. In 2019, a total of 14,561 gallons of aluminum sulfate and 7,301 gallons of sodium aluminate were applied. It was estimated that these treatments resulted in an in-lake TP average annual reduction of 305 lbs/year (Town of Halifax, 2019).

Future Management Measures

As discussed by Element B, it is recommended that future planning initially focus on water goals related to TP in the West Monponsett Pond watershed. It is recommended that management measures be recommended for future BMPs that emphasize reducing TP loading to meet target water quality goals, as feasible.

A stormwater outfall assessment for East and West Monponsett Ponds was prepared for the Town of Halifax in 2017 (GHD, 2017). As part of the assessment, conceptual stormwater BMP designs were developed for each of the outfalls that discharge directly to East Monponsett Pond or West Monponsett Pond. A prioritization matrix was developed, which ranked the BMP designs. The parameters used in the prioritization matrix included: location of outfall discharge (i.e., in West Monponsett Pond or East Monponsett Pond); TIA within drainage area; total surface area of drainage area; planning-level costs of BMP implementation; and required operation and maintenance (O&M) of the BMP. Thirteen outfalls were identified that either discharge directly to West Monponsett Pond or areas abutting the pond; a BMP concept was developed for each of the thirteen outfalls. The top three BMP designs from the prioritization matrix were all within the West Monponsett Pond watershed. These designs were developed into more detailed preliminary designs, which included a detailed topographic survey, wetland delineation, preliminary project specifications and invert and elevation information for each of the individual systems. The preliminary design drawings for the three proposed BMP sites are included in Appendix B.

Outfall OW-09 BMP

The preliminary design for outfall "OW-09" is located at adjacent to the Halifax Beach Association on Richview Avenue and proposes connecting the existing drainage system to an 8,000-gallon settling tank that flows into an infiltration field underneath the beach. The proposed infiltration field would consist of 21 Cultec 330XLHD units reportedly designed to store approximately 43% of the 1-inch runoff volume from the contributing drainage area. This system will reportedly be capable of removing approximately 1.15 pounds/year of TP from entering the West Monponsett Pond (GHD, 2017).

Outfall OW-16 BMP

The preliminary design for outfall "OW-16" has two components ("System #1" and "System #2"). The outfall is connected to a culvert underneath Monponsett Street (Route 58). System #1 will connect to the existing drainage system to the North of the outfall location and System #2 will connect to the existing drainage system to the South of the outfall location. System #1 is designed to install a drainage pipe from the drain manhole in the street to a 6,000-gallon settling tank, before conveying runoff into an infiltration field. The infiltration field for System #1 includes four (4) – six (6) feet diameter by four (4) feet deep leaching pits. System #2 will include a 10,000-gallon settling tank that connects to the existing drainage system, discharges to an infiltration area, and then overflows into a surface treatment system. System #1 and System #2 were reportedly designed to store approximately 48% and 35% of the 1-inch runoff volume from the contributing drainage area, respectively. System #1 will reportedly be capable of removing approximately 0.78 pounds of phosphorus and System #2 will reportedly be capable of removing 1.85 pounds/year of TP from entering the West Monponsett Pond (GHD, 2017).

Outfall OW-19 BMP

The preliminary design for outfall "OW-19" includes the installation of a new deep sump catch basin and the installation of a stormwater management system. The outfall is located on Ocean Avenue in the Town of Hanson. The existing drainage system will be connected to a 10,000-gallon settling tank before discharging into an infiltration field. The proposed infiltration field would consist of 24 Cultec 330XLHD units and will be located beneath Ocean Avenue, with parts of the infiltration field in the Town of Hanson and parts in the Town of Halifax. The stormwater management system for OW-19 was designed to store approximately 35% of the 1-inch runoff volume from the contributing drainage area. This system will reportedly be capable of removing approximately 1.52 pounds/year of TP from entering the West Monponsett Pond (GHD, 2017).

Additional BMP Opportunities

Once these BMPs have been implemented and/or deemed infeasible for implementation upon further analysis, Halifax may consider additional investigation with the following recommended general sequence to identify and implement future structural BMPs within the West Monponsett Pond watershed:

1. **Identify Potential Implementation Locations:** Perform a desktop analysis using aerial imagery and GIS data to develop a preliminary list of potentially feasible implementation locations based on soil type (i.e., hydrologic soil groups A and B); available public open space (e.g., lawn area in front of a police station); potential redevelopment sites where public-private partnerships may be leveraged; and other factors such as proximity to receiving waters, known problem areas, or publicly owned right of ways or easements. Additional

analysis can also be performed to fine-tune locations to maximize pollutant removals such as performing loading analysis on specifically delineated subwatersheds draining to single outfalls and selecting those subwatersheds with the highest loading rates per acre.

2. **Visit Potential Implementation Locations:** Perform field reconnaissance, preferably during a period of active runoff-producing rainfall, to evaluate potential implementation locations, gauge feasibility, and identify potential BMP ideas. During field reconnaissance, assess identified locations for space constraints, potential accessibility issues, presence of mature vegetation that may cause conflicts (e.g., roots), potential utility conflicts, site-specific drainage patterns, and other factors that may cause issues during design, construction, or long-term maintenance.

3. **Develop BMP Concepts:** Once potential BMP locations are conceptualized, use the BMP-selector tool on the watershed-based planning tool to help develop concepts. The concepts developed in the GHD (2017) assessment may also be adapted/referenced. Concepts can vary widely. One method is to develop 1-page fact sheets for each concept that includes a site description, including definition of the problem, a description of the proposed BMPs, annotated site photographs with conceptual BMP design details, and a discussion of potential conflicts such as property ownership, O&M requirements, and permitting constraints. The fact sheet can also include information obtained from the BMP-selector tool including cost estimates, load reduction estimates, and sizing information (i.e., BMP footprint, drainage area, etc.).

4. **Rank BMP Concepts:** Once BMP concepts are developed, perform a priority ranking based on site-specific factors to identify the implementation order. Ranking can include many factors including cost, expected pollutant load reductions, implementation complexity, potential outreach opportunities and visibility to public, accessibility, expected operation and maintenance effort, and others.

Prioritized BMP concepts should focus on reducing TP loading to West Monponsett Pond, as summarized by the water quality goals (**Element B**).

Non-Structural BMPs

Planned BMPs can also be non-structural and can include practices such as street sweeping and catch basin cleaning to reduce TP, TSS, and TN loading; as well as Illicit Discharge Detection and Elimination (IDDE) to reduce TP, TSS, and TN loading and *E. Coli* concentrations. It is recommended that these municipal programs be evaluated and potentially optimized. First, it is recommended that potential removals from ongoing activities be calculated in accordance with Elements H&I. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency or improved technology.

Septic Improvements

Additionally, the Town of Halifax has identified all addresses within 100 feet of West Monponsett Pond in need of septic system upgrading and repairs. Some of the systems identified have already been upgraded or repaired, but the project is still ongoing. Also, if any of the addresses within 100 feet of the pond have a change in ownership, they must have a septic inspection done every year.

Element D: Identify Technical and Financial Assistance Needed to Implement Plan

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

Current and Ongoing Management Measures

The funding needed to implement the aluminum treatment management measures of 2015, 2016, 2017, 2018 and 2019 presented in Element C of this WBP is based on reported values in the West Monponsett Pond Nutrient Management Project Final Report (Town of Halifax, 2019). The total costs to implement the treatment program were estimated to be $619,705, as detailed by **Table D-1**.

Table D-1: Summary of BMP Costs

Task/Objective	Cost
Engineering Services	$32,000
Alum Pond Treatment	$451,070
Feasibility and Design Memorandum for Automated Water Controls	$72,450
Automated Water Controls Install	$35,000
Grant Management/Town Labor	$29,185
Total	**$619,705**

Future Management Measures

Funding for future BMP installations to further reduce loads within the watershed may be provided by a variety of sources, such as the Section 319 Nonpoint Source Pollution Grant Program, town capital funds, state grants such as Coastal Pollution Remediation grants, Municipal Vulnerability Preparedness or other grant programs such as hazard mitigation funding. The Town has previously and will continue to pursue funding for efforts through programs like the Department of Ecological Restoration's Priority Project program. Guidance is available to provide additional information on potential funding sources for nonpoint source pollution reduction efforts[1].

The total planning-level costs to implement the three proposed BMP sites described in Element C (OW-09, OW-16, and OW-19) were estimated, by GHD (2017), to be $320,000. This estimate included construction cost, engineering, permitting, and contingency. The report did not provide operation and maintenance or monitoring

[1] Guidance on funding sources to address nonpoint source pollution: http://prj.geosyntec.com/prjMADEPWBP_Files/Guide/Element%20D%20-%20Funds%20and%20Resources%20Guide.pdf

costs for the proposed designs, but these costs will be added as the concepts are refined during subsequent design stages.

Element E: Public Information and Education

Element E: Information and Education (I/E) component of the watershed plan used to:

1. Enhance public understanding of the project; and
2. Encourage early and continued public participation in selecting, designing, and implementing the NPS management measures that will be implemented.

Step 1: Goals and Objectives

The goals and objectives for the watershed information and education program.

1. Provide information about proposed stormwater improvements and their anticipated water quality benefits.
2. Provide information to promote watershed stewardship.

Step 2: Target Audience

Target audiences that need to be reached to meet the goals and objectives identified above.

1. All watershed residents.
2. Businesses and local government within the watershed.
3. Watershed organizations and other user groups.
4. Cranberry Bog owners and operators.

Step 3: Outreach Products and Distribution

The outreach product(s) and distribution form(s) that will be used for each.

1. Weekly Facebook postings on cyanobacteria counts
2. “Science Shorts” posted on Facebook
3. Radio interviews & panel discussions on WATD on Monday Night Talk with Kevin Tocci (e.g., panel discussion on watershed issues/concerns – 1/29/2018 and 3/4/2018)
4. Numerous local public health columns
5. Visits to sixth grade classes for Monponsett Pond health and groundwater discussions and demonstrations
6. Announce updates and results of treatment program at Board of Selectmen meetings and Monponsett Watershed Association meetings.

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

1. Track Facebook page visits
2. Track the number of local public health columns distributed

3. Record the number of students attending education program
4. Track attendance at meetings when project updates are announced.
5. Record number of educational flyers distributed

Additional outreach products will be determined when future management measures and activities are planned for implementation in the watershed. This section of the WBP will be updated when the plan is re-evaluated in 2023 in accordance with Element F&G.

Elements F & G: Implementation Schedule and Measurable Milestones

Element F: Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

Element G: A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

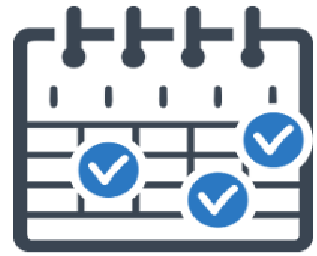

Table FG-1 provides a preliminary schedule for implementation of recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated at least once every three (3) years, or as needed, based on ongoing monitoring results and other ongoing efforts.

Table FG-1: Implementation Schedule and Interim Measurable Milestones[2]

Category	Action	Estimated Cost	Year(s)
Monitoring / Vegetation	Write Quality Assurance Project Plan (QAPP) for sampling and establish water quality monitoring program		2020
	Perform annual water quality sampling per Element H&I monitoring guidance		Annual
Structural BMPs	Complete aluminum treatment	$619,705	2019
	Obtain funding and implement 2-3 BMPs	$320,000	2022
	Obtain funding and implement 2-3 BMPs	$320,000	2024
	Obtain funding and implement 2-3 BMPs	$320,000	2026
Nonstructural BMPs	Document potential pollutant removals from ongoing non-structural BMP practices (i.e., street sweeping, catch basin cleaning)		2020
	Evaluate ongoing non-structural BMP practices and determine if modifications can be made to optimize pollutant removals (e.g., increase frequency).		2021
	Routinely implement optimized non-structural BMP practices		Annual
Public Education and Outreach *(See Element E)*	Weekly Facebook postings on cyanobacteria counts		periodical
	"Science Shorts" posted on Facebook		periodical
	Radio interviews & panel discussions on WATD on Monday Night Talk with Kevin Tocci		periodical
	Publish public health columns		periodical
	Visits to sixth grade classes for Monponsett Pond health and groundwater discussions and demonstrations		Annual
Adaptive Management and Plan Updates	Establish working group comprised of stakeholders and other interested parties to implement recommendations and track progress. Meet at least twice per year.		2020
	Re-evaluate Watershed Based Plan at least once every three (3) years and adjust, as needed, based on ongoing efforts (e.g., based on monitoring results, 319 funding, etc.). – Next update, December 2023		2023
	Use monitoring results to re-evaluate BMP effectiveness at reducing TP and/or other indicator parameters in West Monponsett Pond and establish additional long-term reduction goal(s), if needed.		**2023**
	De-list West Monponsett Pond from the 303(d) list		**2030**

[2] Note that goals and milestones of this WBP are intended to be adaptable and flexible. Goals and milestones are not intended to be tied to Municipal Separate Storm Sewer (MS4) permit requirements. Stakeholders will perform tasks contingent on available resources and funding.

Elements H & I: Progress Evaluation Criteria and Monitoring

Element H: A set of criteria used to determine (1) if loading reductions are being achieved over time and (2) if progress is being made toward attaining water quality goals. Element H asks "**how will you know if you are making progress towards water quality goals?**" The criteria established to track progress can be direct measurements (e.g., E. coli bacteria concentrations) or indirect indicators of load reduction (e.g., number of beach closings related to bacteria).

Element I: A monitoring component to evaluate the effectiveness of implementation efforts over time, as measured against the Element H criteria. Element I asks "**how, when, and where will you conduct monitoring?**"

The water quality target concentration(s) is presented under Element A of this plan. To achieve this target concentration, the annual loading must be reduced to the amount described in Element B. Element C of this plan describes the various management measures that will be implemented to achieve this targeted load reduction. The evaluation criteria and monitoring program described will be used to measure the effectiveness of the proposed management measures (described in Element C) in improving the water quality of West Monponsett Pond.

Indirect Indicators of Load Reduction

Non-Structural BMPs

Potential load reductions from non-structural BMPs (i.e., street sweeping and catch basin cleaning) can be estimated from indirect indicators, such as the number of miles of streets swept or the number of catch basins cleaned. As indicated by **Element C**, it is recommended that potential phosphorus removal from these ongoing actives be estimated. Next, it is recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency or improved technology.

Phosphorus load reductions can be estimated in accordance with Appendix F of the 2016 Massachusetts Small MS4 General Permit as summarized by **Figure HI-1 and HI-2**

$$\text{Credit}_{\text{sweeping}} = \text{IA}_{\text{swept}} \times \text{PLE}_{\text{IC-land use}} \times \text{PRF}_{\text{sweeping}} \times \text{AF} \qquad \textbf{(Equation 2-1)}$$

Where:

Credit $_{sweeping}$ = Amount of phosphorus load removed by enhanced sweeping program (lb/year)

IA $_{swept}$ = Area of impervious surface that is swept under the enhanced sweeping program (acres)

PLE $_{IC\text{-}land\ use}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)

PRF $_{sweeping}$ = Phosphorus Reduction Factor for sweeping based on sweeper type and frequency (see Table 2-3).

AF = Annual Frequency of sweeping. For example, if sweeping does not occur in Dec/Jan/Feb, the AF would be 9 mo./12 mo. = 0.75. For year-round sweeping, AF=1.0[1]

As an alternative, the permittee may apply a credible sweeping model of the Watershed and perform continuous simulations reflecting build-up and wash-off of phosphorus using long-term local rainfall data.

Table 2-3: Phosphorus reduction efficiency factors ($PRF_{sweeping}$) for sweeping impervious areas

Frequency[1]	Sweeper Technology	PRF $_{sweeping}$
2/year (spring and fall)[2]	Mechanical Broom	0.01
2/year (spring and fall)[2]	Vacuum Assisted	0.02
2/year (spring and fall)[2]	High-Efficiency Regenerative Air-Vacuum	0.02
Monthly	Mechanical Broom	0.03
Monthly	Vacuum Assisted	0.04
Monthly	High Efficiency Regenerative Air-Vacuum	0.08
Weekly	Mechanical Broom	0.05
Weekly	Vacuum Assisted	0.08
Weekly	High Efficiency Regenerative Air-Vacuum	0.10

Figure HI-1. Street Sweeping Calculation Methodology

$$\text{Credit}_{\text{CB}} = \text{IA}_{\text{CB}} \times \text{PLE}_{\text{IC-land use}} \times \text{PRF}_{\text{CB}} \qquad \textbf{(Equation 2-2)}$$

Where:

Credit $_{CB}$ = Amount of phosphorus load removed by catch basin cleaning (lb/year)

IA $_{CB}$ = Impervious drainage area to catch basins (acres)

PLE $_{IC\text{-}and\ use}$ = Phosphorus Load Export Rate for impervious cover and specified land use (lb/acre/yr) (see Table 2-1)

PRF $_{CB}$ = Phosphorus Reduction Factor for catch basin cleaning (see Table 2-4)

Table 2-4: Phosphorus reduction efficiency factor (PRF $_{CB}$) for semi-annual catch basin cleaning

Frequency	Practice	PRF $_{CB}$
Semi-annual	Catch Basin Cleaning	0.02

Figure HI-2. Catch Basin Cleaning Calculation Methodology

Project-Specific Indicators

Number of BMPs Installed and Pollutant Reduction Estimates

Anticipated pollutant load reductions from existing, ongoing, and future BMPs will be tracked as BMPs are installed. For example, efforts to treat West Monponsett Pond as part of the West Monponsett Pond Nutrient Management Project resulted in an estimated in-lake average annual TP load reduction of 305 pounds/year.

TMDL Criteria

The Draft TMDL (MassDEP, 2019) requirements include:

- Continued monitoring (as needed) of the cyanobacteria numbers by the Massachusetts Department of Public Health.
- As resources allow, future lake surveys by MassDEP including Secchi disk transparency; nutrient analyses; temperature and dissolved oxygen profiles; and aquatic vegetation maps of distribution and density.
- Monitoring of TP concentrations and transparency by local volunteer groups is encouraged when possible.

Direct Measurements

Direct measurements are generally expected to be performed as described below. Sampling procedures should be consistent with the existing QAPP and/or Standard Operating Procedures (SOPs) for consistency among sample collection and analysis. Water quality monitoring may be performed through a volunteer training program to save on costs in accordance with established practices for MassDEP's environmental monitoring for volunteers.

In-Lake Phosphorus and Water Quality Monitoring

Water quality monitoring in West Monponsett Pond should be continued to track water quality improvements and the progress towards meeting water quality goals. Monitoring locations should at a minimum include the outlet of the pond, tributaries, and the deepest "in-lake" location[3]. It is recommended that sampling programs focus on nutrient-related parameters, including analysis of secchi disk transparency, phosphorus, chlorophyll-a, turbidity, temperature/oxygen profiles, and aquatic vegetation. These parameters will also enable tracking relative to Carlson's state trophic index to evaluate improvements over time.

Adaptive Management

Long-term goals will be re-evaluated at least **once every three years** and adaptively adjusted based on additional monitoring results and other indirect indicators. If monitoring results and indirect indicators do not show improvement to the nutrient concentrations, as well as other indicators (e.g., algal growth) measured within the watershed, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

[3] Additional guidance is provided at: https://www.epa.gov/sites/production/files/2015-06/documents/lakevolman.pdf

References

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Appendices

Appendix A – Pollutant Load Export Rates (PLERs)

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
AGRICULTURE, HSG A	0.45	7.14	2.59
AGRICULTURE, HSG B	0.45	29.4	2.59
AGRICULTURE, HSG C	0.45	59.8	2.59
AGRICULTURE, HSG D	0.45	91.0	2.59
AGRICULTURE, IMPERVIOUS	1.52	650	11.3
COMMERCIAL, HSG A	0.03	7.14	0.27
COMMERCIAL, HSG B	0.12	29.4	1.16
COMMERCIAL, HSG C	0.21	59.8	2.41
COMMERCIAL, HSG D	0.37	91.0	3.66
COMMERCIAL, IMPERVIOUS	1.78	377	15.1
FOREST, HSG A	0.12	7.14	0.54
FOREST, HSG B	0.12	29.4	0.54
FOREST, HSG C	0.12	59.8	0.54
FOREST, HSG D	0.12	91.0	0.54
FOREST, HSG IMPERVIOUS	1.52	650	11.3
HIGH DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
HIGH DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
HIGH DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
HIGH DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
HIGH DENSITY RESIDENTIAL, IMPERVIOUS	2.32	439	14.1
HIGHWAY, HSG A	0.03	7.14	0.27
HIGHWAY, HSG B	0.12	29.4	1.16
HIGHWAY, HSG C	0.21	59.8	2.41
HIGHWAY, HSG D	0.37	91.0	3.66
HIGHWAY, IMPERVIOUS	1.34	1,480	10.2
INDUSTRIAL, HSG A	0.03	7.14	0.27

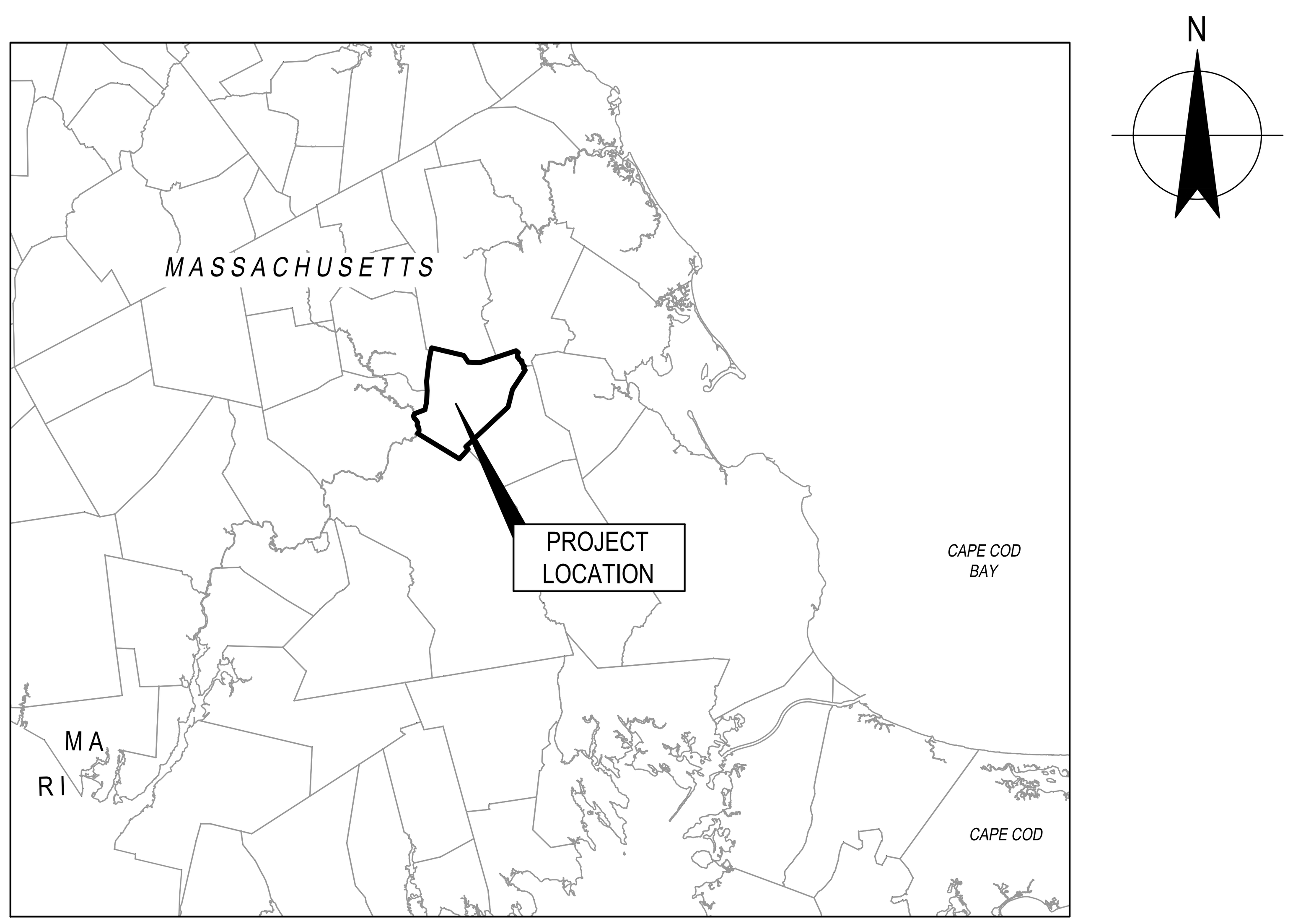
INDUSTRIAL, HSG B	0.12	29.4	1.16
INDUSTRIAL, HSG C	0.21	59.8	2.41
INDUSTRIAL, HSG D	0.37	91.0	3.66
INDUSTRIAL, IMPERVIOUS	1.78	377	15.1
LOW DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
LOW DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
LOW DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
LOW DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
LOW DENSITY RESIDENTIAL, IMPERVIOUS	1.52	439	14.1
MEDIUM DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.27
MEDIUM DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.16
MEDIUM DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.41
MEDIUM DENSITY RESIDENTIAL, HSG D	0.37	91.0	3.66
MEDIUM DENSITY RESIDENTIAL, IMPERVIOUS	1.96	439	14.1
OPEN LAND, HSG A	0.12	7.14	0.27
OPEN LAND, HSG B	0.12	29.4	1.16
OPEN LAND, HSG C	0.12	59.8	2.41
OPEN LAND, HSG D	0.12	91.0	3.66
OPEN LAND, IMPERVIOUS	1.52	650	11.3
[1]HSG = Hydrologic Soil Group			

Appendix B – Proposed BMP Preliminary Design Drawings (GHD, 2017)

TOWN OF HALIFAX, MASSACHUSETTS

EAST AND WEST
MONPONSETT PONDS
STORMWATER IMPROVEMENTS

APRIL, 2017



VICINITY MAP
NOT TO SCALE

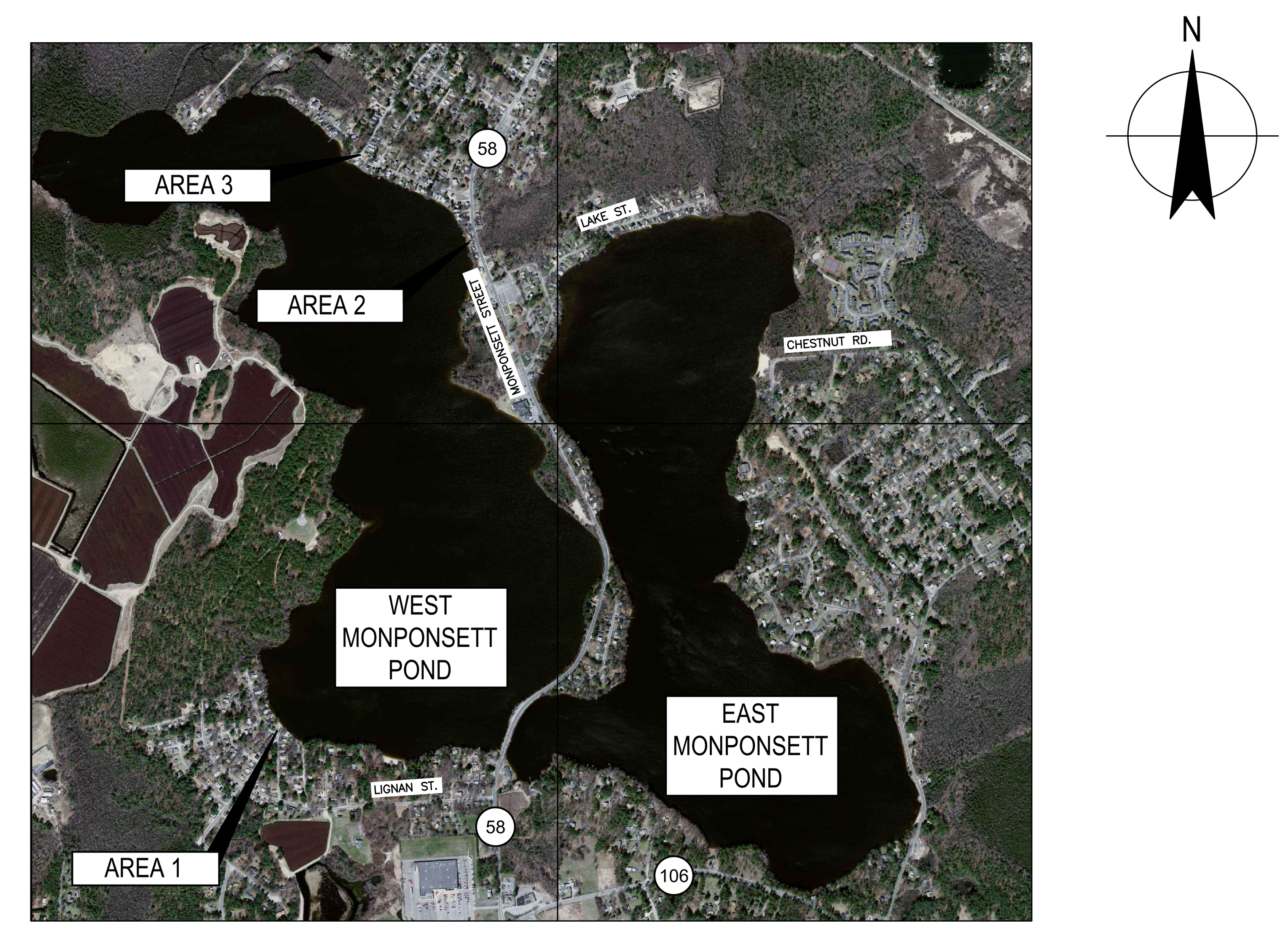
TOWN PERSONNEL

TOWN ADMINISTRATOR
CHARLIE SEELIG

BOARD OF HEALTH, HEALTH AGENT
CATHLEEN DRINAN

HIGHWAY DEPARTMENT, HIGHWAY SURVEYOR
ROBERT BADORE

BOARD OF SELECTMEN
THOMAS MILLIAS, KIM ROY, AND TROY E. GARRON



LOCATION MAP
NOT TO SCALE

No	Revision	Drawn	Job Manager	Project Director	Date
1	PRELIMINARY DESIGN				4/2017

Note: * indicates signatures on original issue of drawing or last revision of drawing

NOTES: UNDERGROUND FACILITIES, STRUCTURES, AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE SURVEYS AND RECORDS, AND THEREFORE THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHERS, THE EXISTENCE OF WHICH IS PRESENTLY NOT KNOWN. ANYONE USING UTILITY INFORMATION AND DATA PROVIDED HEREIN SHALL CALL DIG SAFE AT 811 SEVENTY TWO (72) HOURS, 3 BUSINESS DAYS IN ADVANCE TO VERIFY THE LOCATION OF UTILITIES PRIOR TO START OF CONSTRUCTION.

GHD Inc.
1545 Iyannough Road, Hyannis Massachusetts 02601 USA
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E hyamail@ghd.com **W** www.ghd.com

Drawn	Designer
Drafting Check	Design Check
Approved (Project Director)	
Date	
Scale AS SHOWN	This Drawing shall not be used for Construction unless Signed and Sealed For Construction

Client **TOWN OF HALIFAX, MASSACHUSETTS**
Project **STORMWATER IMPROVEMENTS**
Title **COVER SHEET, VICINITY MAP & LOCATION MAP**

Contract No.

Original Size Arch D **Drawing No: 11110997-G01** **Rev: 0**

Plot Date: 21 April 2017 - 11:19 AM Plotted by: Craig Curtin Cad File No: G:\111\11110997 Stormwater Outfall Assessment for the East and West Monponsett Ponds\CADD\Drawings\Preliminary Designs\General\11110997-G001.dwg

CONSTRUCTION NOTES

1. BASE PLANIMETRIC SURVEY INFORMATION PROVIDED BY GREEN SEAL ENVIRONMENTAL, INC SAGAMORE BEACH , MA DATED 2/15/2017 IN NAVD88 DATUM.

2. LIMIT OF WORK SHALL BE WITHIN THE PUBLIC RIGHT OF WAY. NO WORK SHALL BE CONDUCTED ON PRIVATE PROPERTY UNLESS OTHERWISE NOTED.

3. CONTRACTOR SHALL RETURN ALL AREAS TO ORIGINAL CONDITION OR BETTER INCLUDING, BUT NOT LIMITED TO, ROADWAYS, BITUMINOUS CONCRETE, LANDSCAPED AREAS AND CURBING, UNLESS OTHERWISE NOTED.

4. THE MASSACHUSETTS DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES ARE INCORPORATED INTO THESE PLANS BY REFERENCE. THE TERM "MASS HIGHWAY" OR "SPECIFICATION" SHALL MEAN THE MASSACHUSETTS DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES, DATED 1988. UNLESS OTHERWISE INDICATED, ALL MATERIALS AND METHODS SHALL BE IN CONFORMANCE WITH MASS HIGHWAY SPECIFICATIONS.

5. PROPOSED CONDITIONS SHOWN HEAVY. EXISTING CONDITIONS SHOWN LIGHT.

6. ALL CONCRETE STRUCTURES SHALL HAVE OFFSET SLAB TOP OR ECCENTRIC CONE TOP UNLESS OTHERWISE INDICATED ON PLANS.

7. ALL DRAINAGE PIPING SHALL BE 12" INSIDE DIAMETER CORRUGATED HDPE TYPE N-12 PIPE MANUFACTURED BY ADS OR EQUAL SUITABLE FOR H-20 LOADING AT MINIMUM BURIED DEPTH OF 24". PIPE SHALL BE SUPPLIED IN 20 FT LENGTHS. JOINTS SHALL BE SOIL TIGHT PUSH ON JOINTS.

8. CATCH BASINS SHALL BE PROVIDED WITH SINGLE GRATE INLET PER MASS HIGHWAY STANDARDS, UNLESS OTHERWISE NOTED.

9. FINAL LOCATION OF ALL DRAINAGE STRUCTURES TO BE COORDINATED WITH RESIDENT PROJECT REPRESENTATIVE PRIOR TO STARTING WORK.

10. PIPE SHALL BE SLOPED AT A MINIMUM OF 1.0% UNLESS OTHERWISE NOTED.

11. CONTRACTOR IS RESPONSIBLE FOR VERIFYING ALL UTILITIES PRIOR TO EXCAVATION, INCLUDING UTILITIES NOT MARKED BY DIG-SAFE (888-DIG-SAFE (344-7233)), NOT SHOWN ON THE SURVEY, OR NOT MARKED BY THE HALIFAX HIGHWAY DEPARTMENT. CONTRACTOR IS RESPONSIBLE FOR ANY AND ALL DAMAGES IF AN UNDERGROUND UTILITY IS DAMAGED DURING THE COURSE OF CONSTRUCTION.

12. IN THE EVENT THAT ANY UTILITY, UNDERGROUND OR OVERHEAD, IS DAMAGED DURING CONSTRUCTION, CONTRACTOR SHALL IMMEDIATELY NOTIFY ENGINEER, HALIFAX HIGHWAY DEPARTMENT, AND THE APPROPRIATE UTILITY COMPANY.

13. ALL PAVEMENT TO BE SAW-CUT.

14. ALL CONNECTIONS BETWEEN PRECAST CONCRETE SECTIONS SHALL BE SEALED WITH NON-SHRINK GROUT.

15. LEACHING PITS, SETTLING TANKS, FLOW CONTROL STRUCTURES AND INLETS SHALL BE CONSTRUCTED IN ACCORDANCE WITH THE MASSACHUSETTS HIGHWAY DEPARTMENT STANDARD SPECIFICATIONS FOR HIGHWAYS AND BRIDGES, UNLESS OTHERWISE NOTED.

16. ALL PRECAST CONCRETE STRUCTURES SHALL BE RATED FOR AASHTO/H-20 LOADING.

17. ALL MATERIALS USED AND CONSTRUCTION METHODS EMPLOYED ARE TO BE IN ACCORDANCE WITH THE LATEST FEDERAL, STATE AND TOWN REGULATIONS.

18. NOT ALL EXISTING ITEMS (INCLUDING TREES, PLANTERS, HEDGES, SIDEWALKS, FENCE, GUIDE LINES, ETC.) ARE SHOWN ON DRAWINGS. HOWEVER THE CONTRACTOR SHALL BE RESPONSIBLE FOR ANY DAMAGE TO EXISTING ITEMS, INCLUDING BUT NOT LIMITED TO LANDSCAPING, CURBING AND SIDEWALKS. ALL DAMAGED ITEMS SHALL BE RESTORED TO THEIR EXISTING CONDITION OR BETTER AND AT NO ADDITIONAL COST TO THE OWNER.

19. CONTRACTOR SHALL REMOVE AND REPLACE ANY TREES DAMAGED BY CONSTRUCTION OPERATIONS THAT ARE NOT DESIGNATED FOR CLEARING.

20. CONTRACTOR IS RESPONSIBLE FOR DETERMINING DEPTH OF GROUNDWATER AND FOR ALL COSTS ASSOCIATED WITH DEWATERING NECESSARY TO INSTALL STRUCTURES OR PIPING.

21. ANY UNSUITABLE MATERIAL ENCOUNTERED DURING EXCAVATION (ORGANICS, PEAT, ETC.) FOR DRAINAGE STRUCTURES SHALL BE DISPOSED OF BY THE CONTRACTOR AT THEIR EXPENSE. CONTRACTOR IS RESPONSIBLE FOR PROVIDING SUITABLE CLEAN BACKFILL PER THE CONTRACT DOCUMENTS FOR BACKFILL AND COMPACTION.

22. ALL MANHOLE COVERS, PULL BOXES, CATCH BASIN GRATES AND OTHER UTILITY COVERS SHALL BE RAISED AS NEEDED TO BE FLUSH WITH THE TEMPORARY PAVING IF APPLICABLE.

23. ALL TEMPORARY PAVING SHALL BE MAINTAINED ON AN AS-NEEDED BASIS BY THE CONTRACTOR PER THE REQUEST OF THE TOWN OF HALIFAX. ANY IMPERFECTIONS IN THE TEMPORARY PAVEMENT THAT ARE SUBSTANTIATED DURING THE CONTRACT TIMES SHALL BE RESTORED BY THE CONTRACTOR AT NO ADDITIONAL COST TO THE OWNER.

24. ALL FINAL PAVING SHALL BE GUARANTEED FOR A PERIOD OF ONE YEAR AFTER INSTALLATION. ANY DEFORMATIONS, CRACKS OR DEVIATIONS SHALL BE REPAIRED AT THE EXPENSE OF THE CONTRACTOR, SEE SPECIFICATIONS SECTION 02980.

25. ANY DISTURBED PAVEMENT MARKINGS OR STRIPING BY THE CONSTRUCTION ACTIVITIES SHALL BE REPLACED AT AN EQUAL OR BETTER CONDITION, INCLUDING COLOR, THICKNESS, WIDTH, TYPE AND LOCATION. SEE SPECIFICATION SECTION 02980.

26. COVERS IN ROAD MUST BE PLACED NEAR CENTER OF TRAVEL LANE AS POSSIBLE. OFFSET STRUCTURE COVERS MAY BE NECESSARY BASED ON LOCATION OF UTILITIES IN FIELD OR OTHER CONDITIONS.

BASIS OF DESIGN (FOR INFORMATION ONLY)

1. STORMWATER CONTROL SYSTEMS WERE DESIGNED TO PROVIDE INCREMENTAL IMPROVEMENT BY CAPTURING AND INFILTRATING RUNOFF FROM RAIN THAT FALLS ON THE IMPERVIOUS SURFACE (TOWN ROADS) TO THE MAXIMUM EXTENT PRACTICABLE.

EROSION & SEDIMENTATION CONTROL NOTES

1. ALL EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE INSPECTED BY THE CONTRACTOR DAILY AND IMMEDIATELY AFTER PERIODS OF RAINFALL. REPAIR AND/OR MAINTENANCE OF SEDIMENTATION AND EROSION CONTROL MEASURES SHALL BE MADE AS SOON AS NEEDED. THE CONTRACTOR IS RESPONSIBLE FOR THE IMPLEMENTATION AND MAINTENANCE OF ALL CONTROL MEASURES ON THIS SITE.

2. FINAL LOCATION OF ALL SEDIMENTATION CONTROL MEASURES SHALL BE COORDINATED WITH THE TOWN CONSERVATION OFFICE PRIOR TO CONSTRUCTION.

3. LAND DISTURBANCE SHALL BE KEPT TO A MINIMUM. RESTABILIZATION WILL BE SCHEDULED IMMEDIATELY AFTER ANY DISTURBANCE.

4. EROSION AND SEDIMENTATION CONTROL MEASURES SHALL BE INSTALLED PRIOR TO ALL CONSTRUCTION ACTIVITIES.

5. ANCHOR ALL TOPSOIL STOCK PILES WITH STRAW MULCH AND RING WITH SILT FENCE, OR HAYBALE BARRIER.

6. SEDIMENT REMOVAL FROM CONTROL STRUCTURES SHALL BE THE RESPONSIBILITY OF THE CONTRACTOR. SEDIMENT SHALL BE DISPOSED OF IN A MANNER WHICH DOES NOT RESULT IN ADDITIONAL EROSION AND WHICH IS CONSISTENT WITH THE CONTRACT DOCUMENTS AND REGULATORY REQUIREMENTS.

7. THE EROSION AND SEDIMENTATION CONTROL MEASURES DESCRIBED HEREIN ARE INTENDED AS A GENERAL GUIDE FOR THE CONTRACTOR. IT IS THE CONTRACTOR'S RESPONSIBILITY TO PROVIDE ANY AND ALL WORK NECESSARY TO PREVENT EROSION OF SOIL FROM THE CONSTRUCTION SITE. TO PREVENT EROSION, THE CONTRACTOR SHALL PROVIDE SILT FENCES OR OTHER CONTROL MEASURES AS THE NEED ARISES DURING CONSTRUCTION AT NO ADDITIONAL COST TO THE OWNER.

8. PAVED ROADWAYS SHALL BE KEPT CLEAN AT ALL TIMES.

9. CATCH BASINS NOT SHOWN ON SURVEY WITHIN THE CONTRACTORS STAGING AREA MAY BE SUBJECT TO EROSION AND SEDIMENTATION CONTROL MEASURES IF SO DIRECTED BY THE ENGINEER.

LEGEND

FOR PROPOSED CONDITIONS

1+00	CONSTRUCTION BASELINE AND STATION
62	MAJOR CONTOUR INTERVAL
	CAPE COD BERM
	CRUSHED STONE / RIP RAP
	CATCH BASIN
	HEAVY DUTY INFILTRATOR
D — D — D	HDPE DRAIN PIPE
	LIMIT OF TEMPORARY PAVEMENT REPLACEMENT
	8' DIA. SINGLE LEACHING PIT W/STONE LIMITS
	8' DIA. MULTIPLE LEACHING PITS W/STONE LIMITS
SF — SF	SILT FENCE\HAYBALE LIMIT
	ASPHALT PATCH

LEGEND

FOR EXISTING CONDITIONS

D — D — D — D	UNDERGROUND DRAIN LINE
G — G — G — G	UNDERGROUND GAS LINE
OHW — OHW — OHW	OVERHEAD WIRES
T — T — T — T	UNDERGROUND COMMUNICATION LINE
W — W — W — W	UNDERGROUND WATER LINE
	FENCE LINE
	TREE LINE
45	CONTOUR MINOR
46	CONTOUR MAJOR
	EDGE OF ASPHALT
	GIS PARCEL LINES
	WATER GATE
	FIRE HYDRANT
	CATCH BASIN
	TEST PIT
	UTILITY POLE
	GUY POLE
	BOLLARD
x20.87	SPOT ELEVATION
BC	BIT. CURB
SWL	SOLID WHITE LANE
BB	BIT. BERM
DYL	TEST PIT
BIT.	BITUMINOUS CONCRETE
EM	ELECTRIC METER
OW	OUTFALL WEST MONPONSETT POND
OE	OUTFALL EAST MONPONSETT POND
	EDGE OF BUILDING
	RIPRAP / STONES

No	Revision	Drawn	Job Manager	Project Director	Date
1	PRELIMINARY DESIGN				4/2017

Note: * indicates signatures on original issue of drawing or last revision of drawing

NOTES: UNDERGROUND FACILITIES, STRUCTURES, AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE SURVEYS AND RECORDS, AND THEREFORE THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHERS, THE EXISTENCE OF WHICH IS PRESENTLY NOT KNOWN. ANYONE USING UTILITY INFORMATION AND DATA PROVIDED HEREIN SHALL CALL DIG SAFE AT 811 SEVENTY TWO (72) HOURS, 3 BUSINESS DAYS IN ADVANCE TO VERIFY THE LOCATION OF UTILITIES PRIOR TO START OF CONSTRUCTION.

GHD Inc.

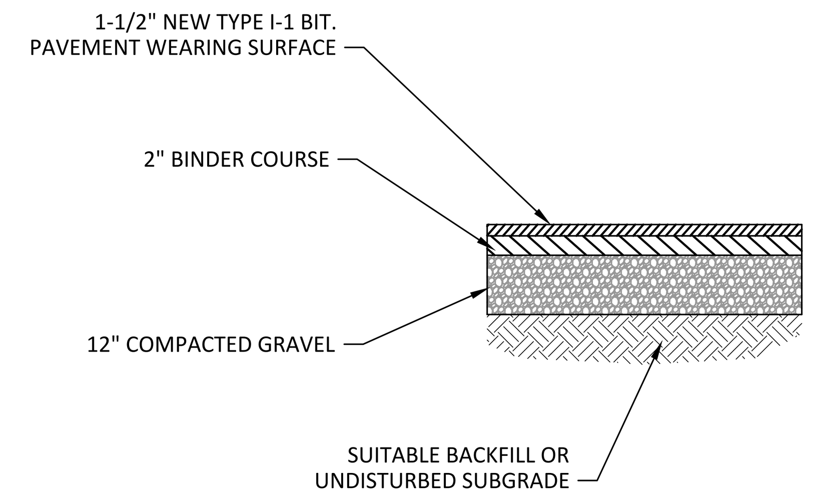
1545 Iyannough Road, Hyannis Massachusetts 02601 USA
T 1 774 470 1630 **F** 1 774 470 1631
E hyamail@ghd.com **W** www.ghd.com

Drawn		Designer	
Drafting Check		Design Check	
Approved (Project Director)			
Date			
Scale	AS SHOWN	This Drawing shall not be used for Construction unless Signed and Sealed For Construction	

Client **TOWN OF HALIFAX, MASSACHUSETTS**
Project **STORMWATER IMPROVEMENTS**
Title **NOTES & LEGEND**

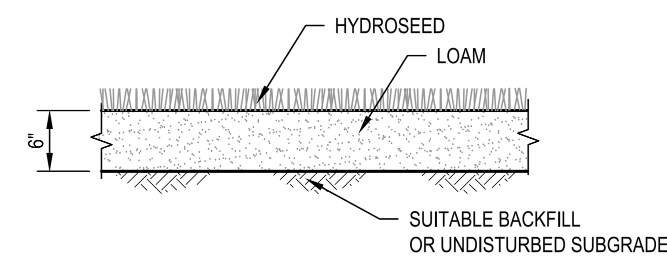
Contract No.

Original Size **Arch D** **Drawing No: 11110997-G02** **Rev: 0**



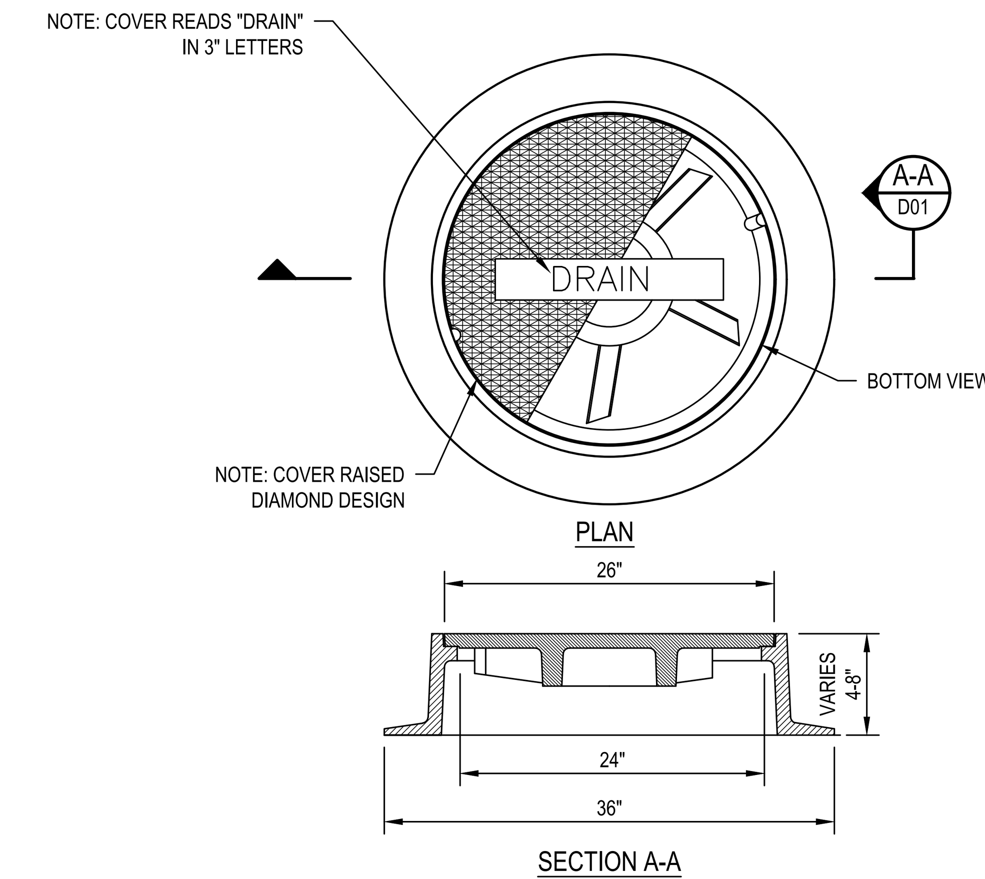
1 D01 TYPICAL PAVED SURFACE TREATMENT DETAIL

NOT TO SCALE



2 D01 LOAM AND SEED-SECTION

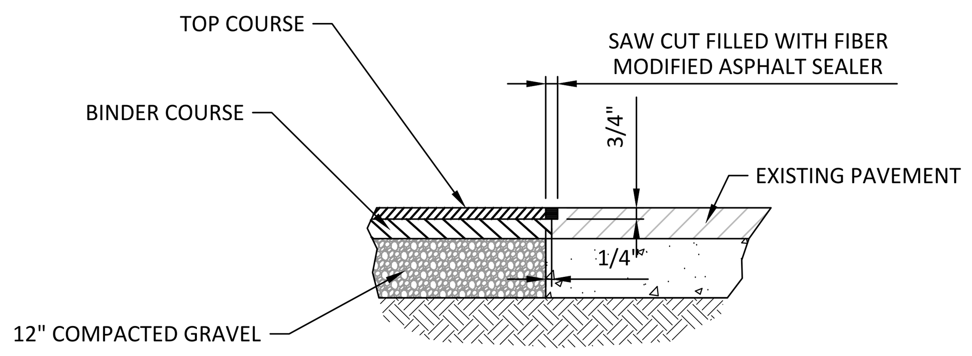
NOT TO SCALE



NOTE:
ALL MANHOLE FRAME AND COVERS TO BE EJ 0MA226000002 OR EQUAL UNLESS OTHERWISE SPECIFIED ON THE CONTRACT DRAWINGS.

8 D01 MANHOLE FRAME AND COVER DETAIL

NOT TO SCALE

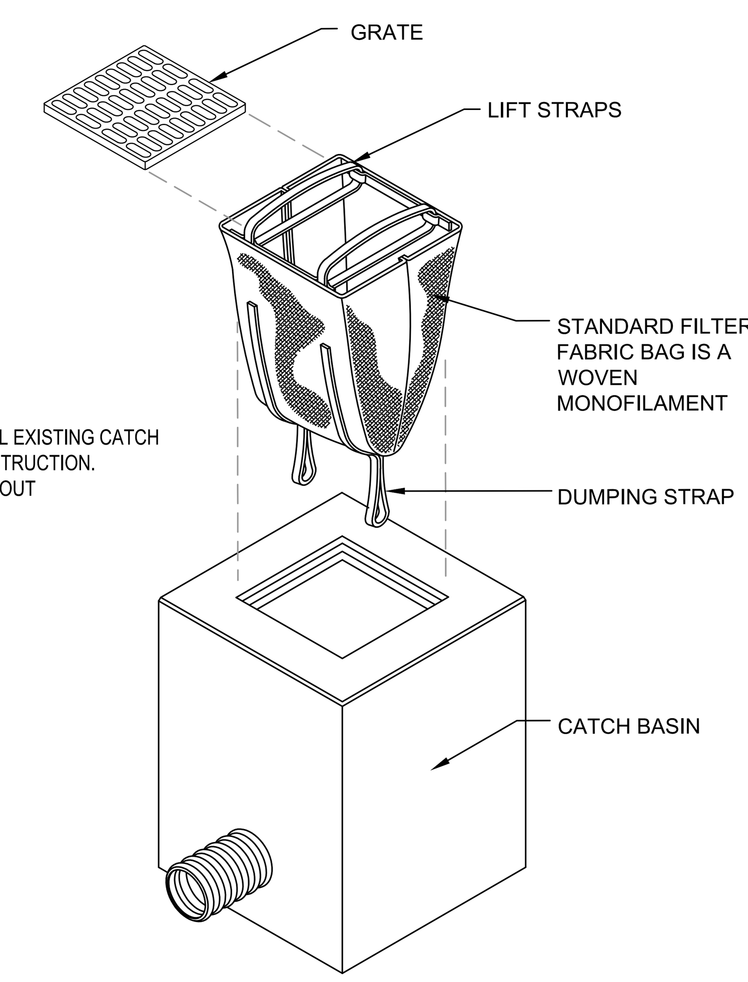


NOTES:
1. EXISTING BITUMINOUS PAVEMENT SHALL BE REMOVED TO A CLEAN STRAIGHT EDGE VIA SAW CUTTING. THE SAW CUT SHALL BE COMPLETED PERPENDICULAR TO THE ROADWAY/SIDEWALK.
2. PRIOR TO INSTALLING THE WEARING COURSE THE EXISTING VERTICAL PAVEMENT SURFACE SHALL BE SWEPT COMPLETELY CLEAN.
3. AFTER PROPER COMPACTION SAW CUT NEW PAVEMENT ABUTMENT 3/4" DEEP AND FILL WITH FIBER MODIFIED ASPHALT SEALER AS SHOWN.

3 D01 TYPICAL PAVEMENT PATCH DETAIL

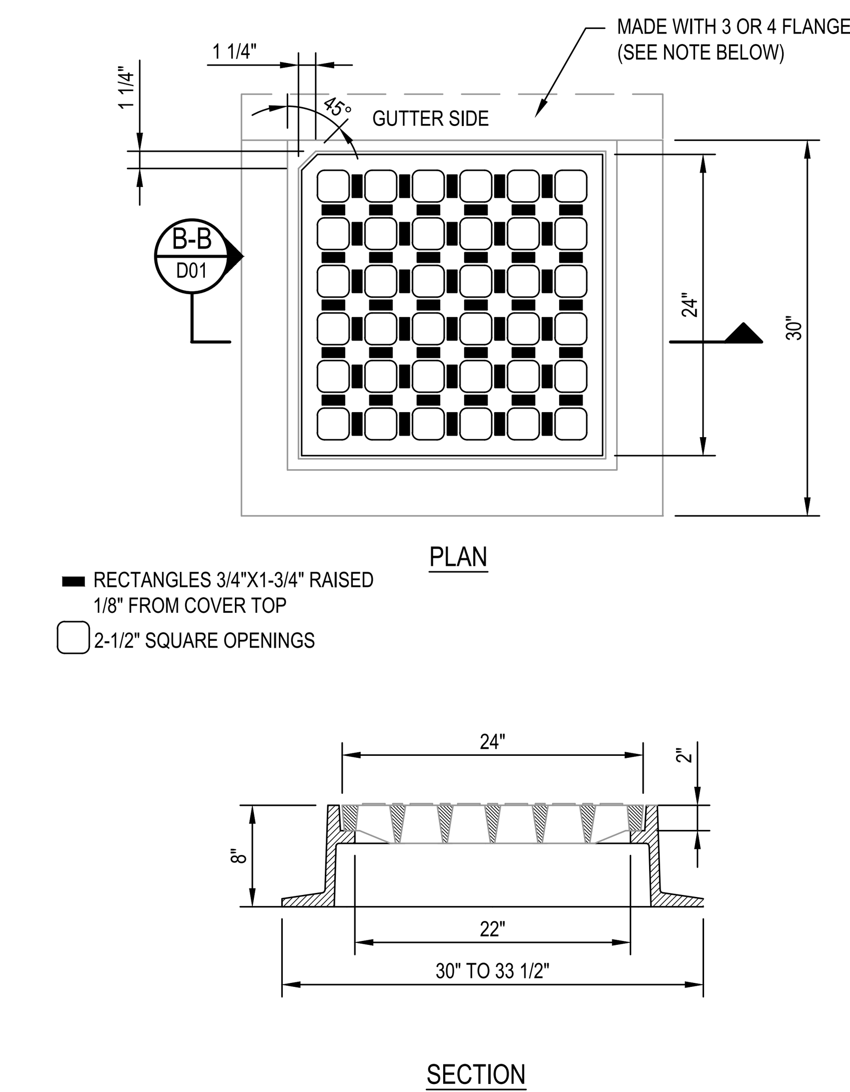
NOT TO SCALE

NOTE:
TO BE INSTALLED AT ALL EXISTING CATCH BASINS PRIOR TO CONSTRUCTION. (MAINTAINED THROUGHOUT CONSTRUCTION)



4 D01 EROSION CONTROL AT CATCH BASIN

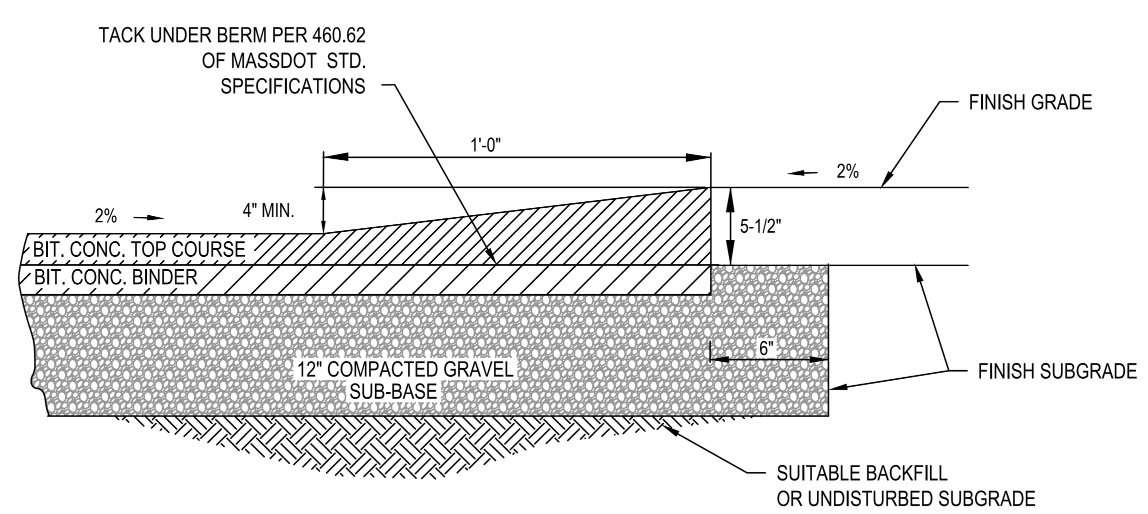
NOT TO SCALE



NOTE:
ALL CATCH BASIN FRAME AND GRATES TO BE EJ 0MA554000006 OR EQUAL WITH 4 FLANGES UNLESS OTHERWISE SPECIFIED ON THE CONTRACT DRAWINGS.

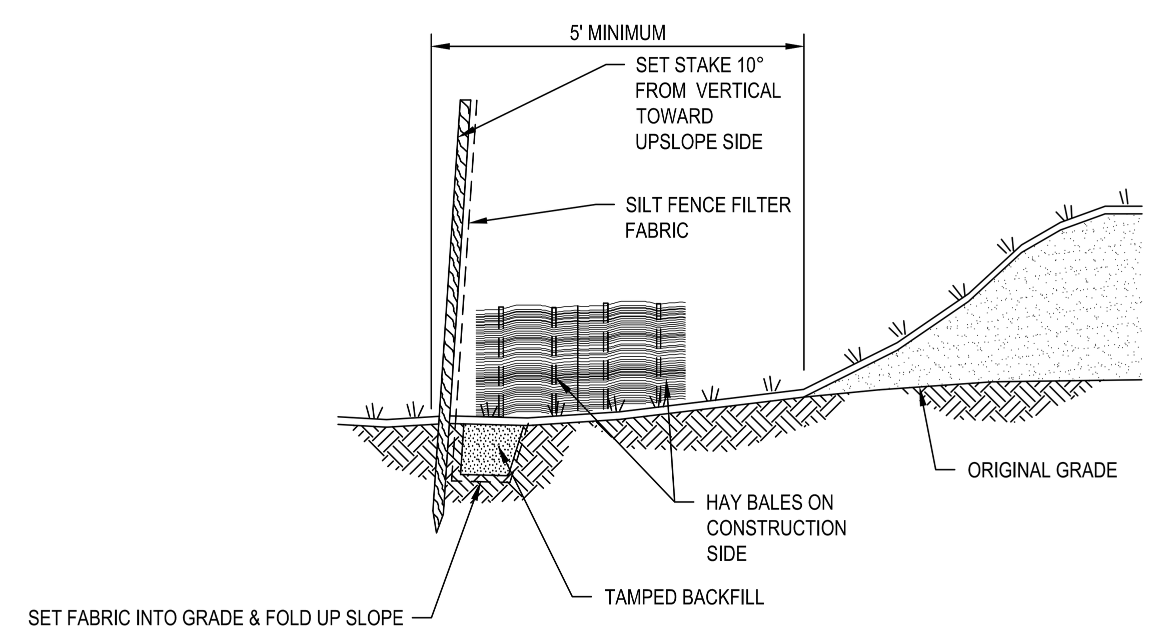
9 D01 CATCH BASIN FRAME AND GRATE DETAIL

NOT TO SCALE



5 D01 CAPE COD BERM DETAIL

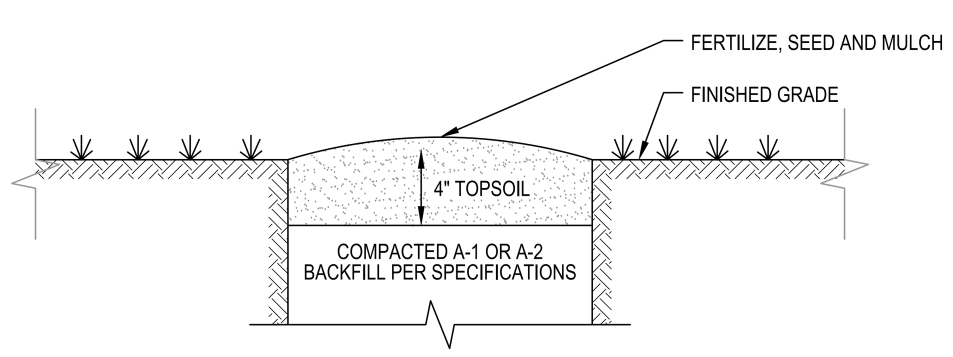
NOT TO SCALE



NOTE:
SILT FENCE AND POSTS FROM APPROVED MANUFACTURER/SUPPLIER. SET TO MANUFACTURERS DIRECTIONS.

7 D01 SILT FENCE WITH HAY BALE DETAIL

NOT TO SCALE



6 D01 TRENCH SURFACE RESTORATION DETAIL - NON-PAVED, NON-TRAVELLED WAY

NOT TO SCALE

No	Revision	Drawn	Job Manager	Project Director	Date
1	PRELIMINARY DESIGN				4/2017

Note: * indicates signatures on original issue of drawing or last revision of drawing

NOTES: UNDERGROUND FACILITIES, STRUCTURES, AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE SURVEYS AND RECORDS, AND THEREFORE THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHERS, THE EXISTENCE OF WHICH IS PRESENTLY NOT KNOWN. ANYONE USING UTILITY INFORMATION AND DATA PROVIDED HEREIN SHALL CALL DIG SAFE AT 811 SEVENTY TWO (72) HOURS, 3 BUSINESS DAYS IN ADVANCE TO VERIFY THE LOCATION OF UTILITIES PRIOR TO START OF CONSTRUCTION.

GHD Inc.
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E hyamail@ghd.com W www.ghd.com

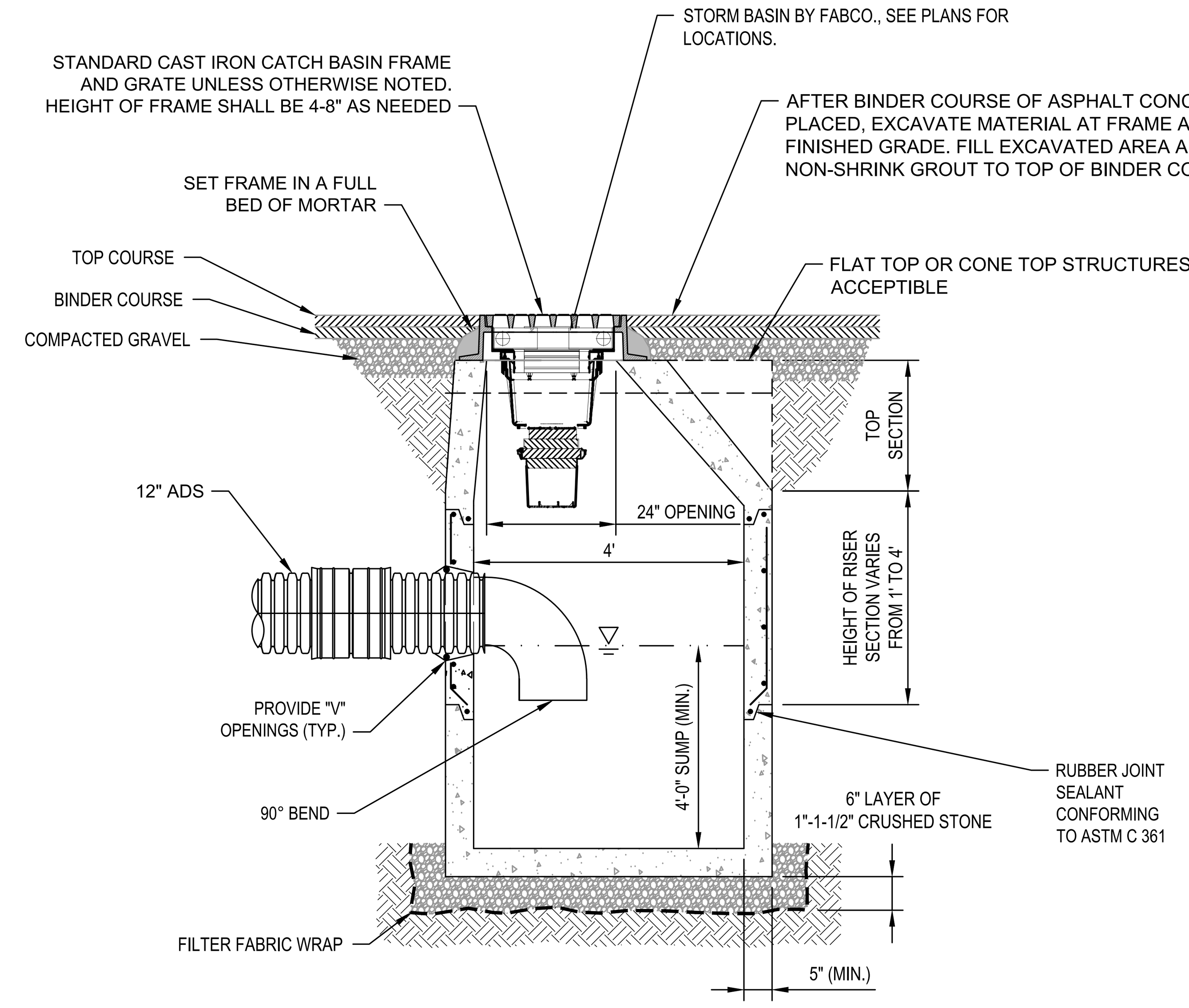
Drawn | Designer
Drafting Check | Design Check
Approved (Project Director)
Date
Scale AS SHOWN

This Drawing shall not be used for Construction unless Signed and Sealed For Construction

Client: TOWN OF HALIFAX, MASSACHUSETTS
Project: STORMWATER IMPROVEMENTS
Title: CONSTRUCTION DETAILS - 1

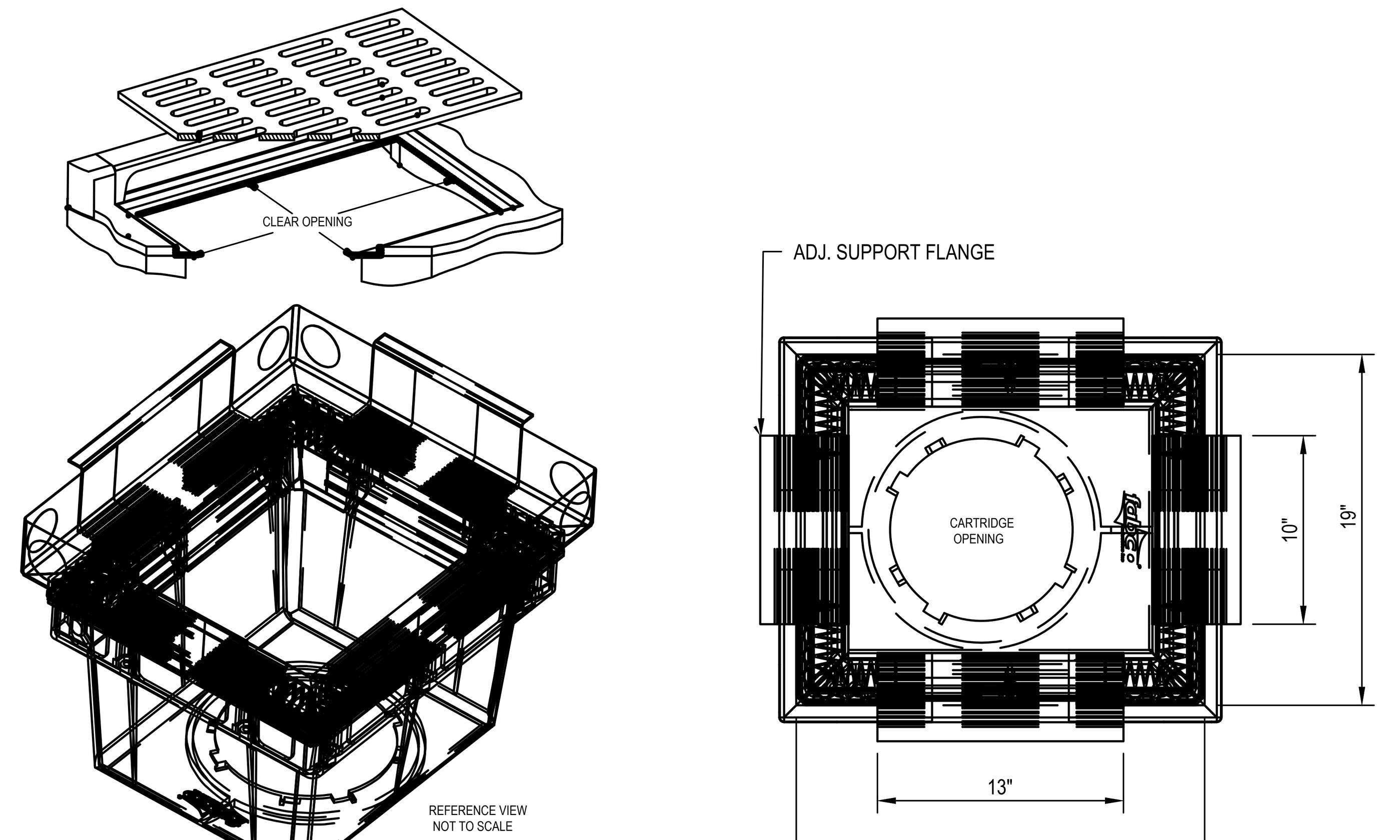
Original Size: Arch D
Drawing No: 11110997-D01
Rev: 0

Plot Date: 21 April 2017 - 11:19 AM Plotted by: Craig Curtin Cad File No: G:\111\11110997 Stormwater Outfall Assessment for the East and West Monponsett Ponds\CADD\Drawings\Preliminary Designs\Detail\11110997-D01.dwg

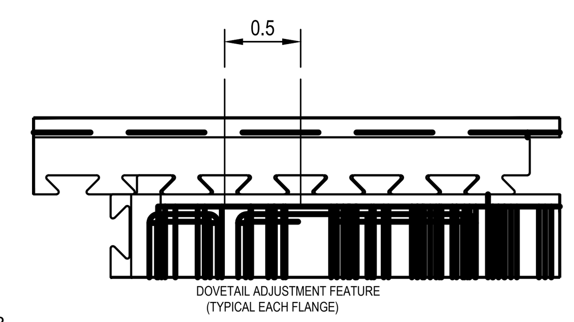


1 D02 CATCH BASIN DETAIL
NOT TO SCALE

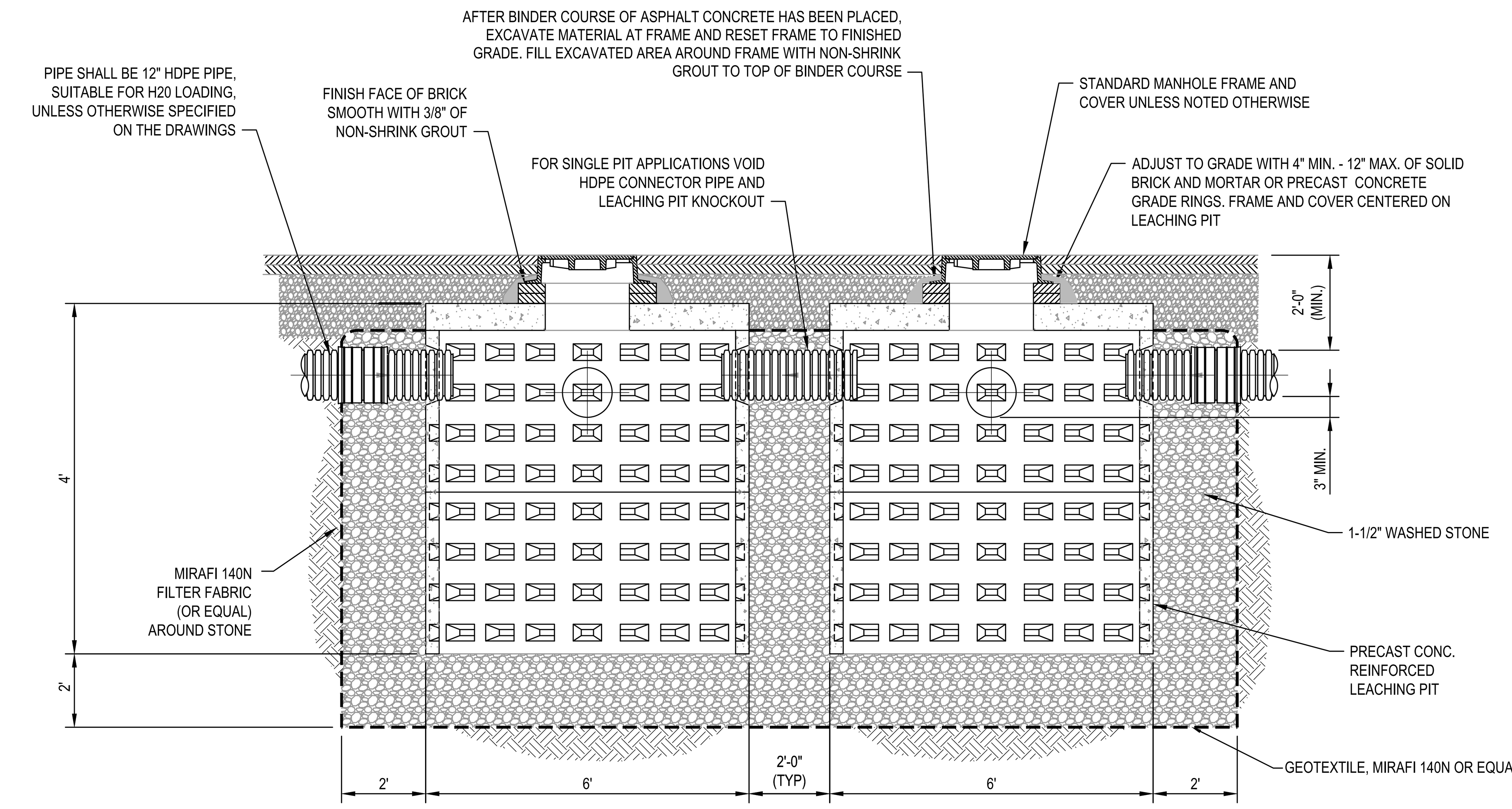
NOTES:
1. ALL CATCH BASINS SHALL BE 4' DIAMETER.
2. EXTERIOR SURFACES TO BE SEALED WITH COLD APPLIED BITUMINOUS SEALER.
3. REINFORCEMENT SHALL BE MIN, 0.12 SQ. IN. PER VERTICAL FOOT, PLACED IN ACCORDANCE WITH AASHTO DESIGNATION M-199.
4. FACE OF PIPE FLUSH OR NOT TO PROJECT MORE THAN 4-IN. FROM FACE OF WALL ALONG CENTERLINE OF PIPE.
5. ALL CATCH BASINS SHALL MEET THE REQUIREMENTS OF THE HALIFAX HIGHWAY DEPARTMENT.
6. ANY CATCH BASINS INSTALLED ADJACENT TO GRANITE CURBING MUST RECEIVE GRANITE THROAT STONES.



NOTES:
1. WEIGHT (EMPTY): 35 LB MAX, NO CARTRIDGE.
2. MATERIAL:
A) ADJUSTABLE FLANGE AND DEFLECTOR: ALUMINUM ALLOY 6063-T6
B) BASIN (PLASTIC): POLYPROPYLENE POLYETHYLENE COPOLYMER
C) CORNER FILL: ALUMINUM ALLOY 5052-H32
D) SUPPORT HARDWARE: CRES 300 SERIES OR EQUAL
3. PERFORMANCE CHARACTERISTICS (TYP):
A) DEBRIS CAPACITY: 2.5 CU-FT
B) FILTERED FLOW RATE (CLEAN, STANDARD CARTRIDGE): 115 GPM (0.25 CFS)
C) PROTECTED BYPASS FLOW RATE: 900 GPM (2.0 CFS)
4. CLEAR OPENING RANGE (.5 INCREMENTS):
A) MINIMUM SIZE: 19.0 X 22.0
B) MAXIMUM SIZE: 24.0 X 27.0
5. RECOMMENDED MINIMUM VAULT DEPTH: 2-IN BELOW CARTRIDGE
6. TYPICAL INSTALLATION: REMOVE STORM GRATE, MEASURE CATCH BASIN CLEAR OPENING AND ADJUST FLANGES TO REST ON GRATE SUPPORT LEDGE, INSTALL CORNER FILL PIECES, REINSTALL STORM GRATE DIRECTLY ON STORMBASIN SUPPORT FLANGES.
7. USE ONLY FABCO REPLACEABLE MEDIA CARTRIDGES.

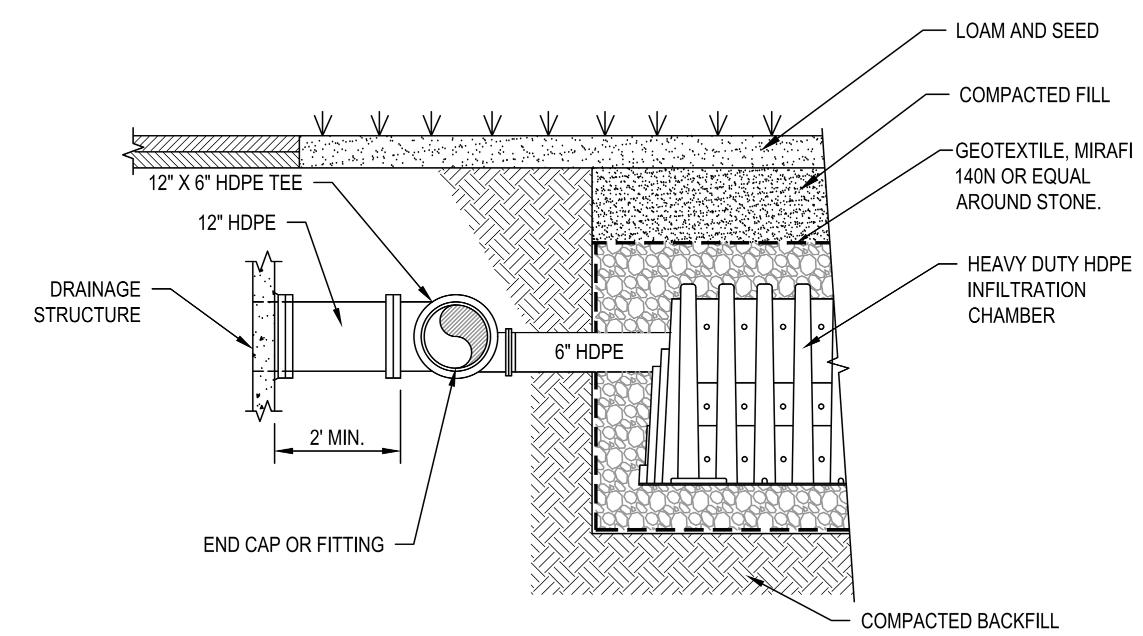


2 D02 STORMBASIN BY FABCO
NOT TO SCALE

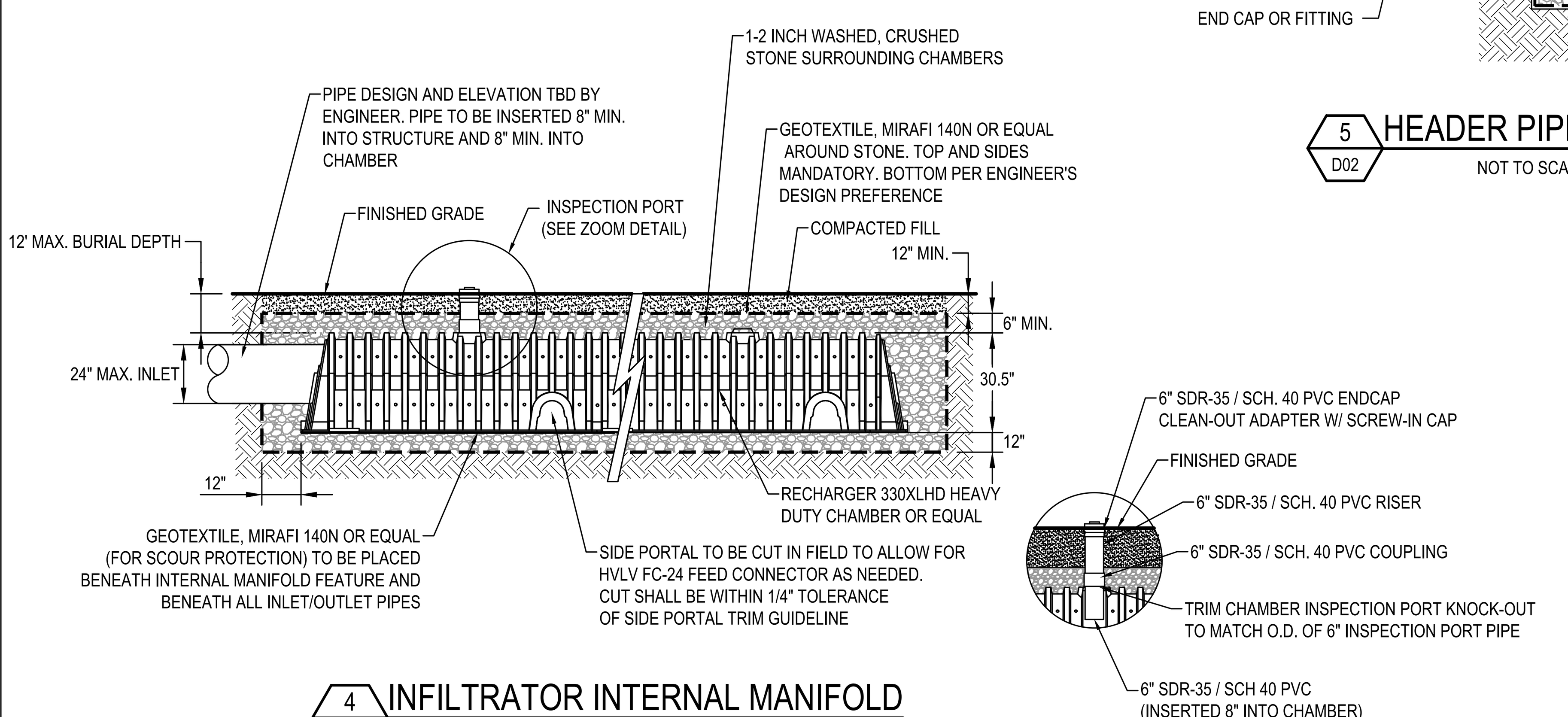


3 D02 STANDARD SINGLE OR MULTIPLE PRECAST CONCRETE LEACHING PIT
NOT TO SCALE

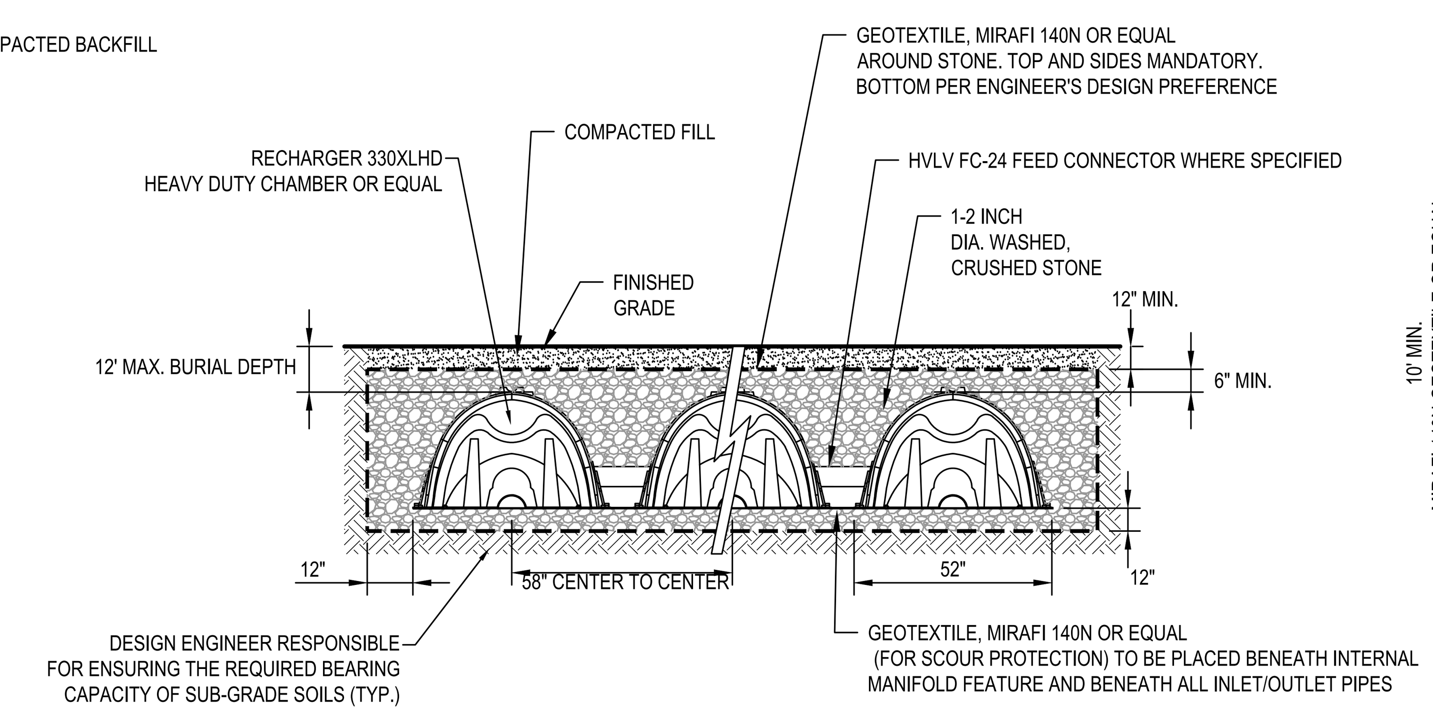
NOTES:
1. CONCRETE MINIMUM STRENGTH SHALL BE 4,000 PSI @ 28 DAYS.
2. STEEL REINFORCEMENT: AS-615, GRADE 60.
3. DESIGN LOADING: AASHO-HS-20.



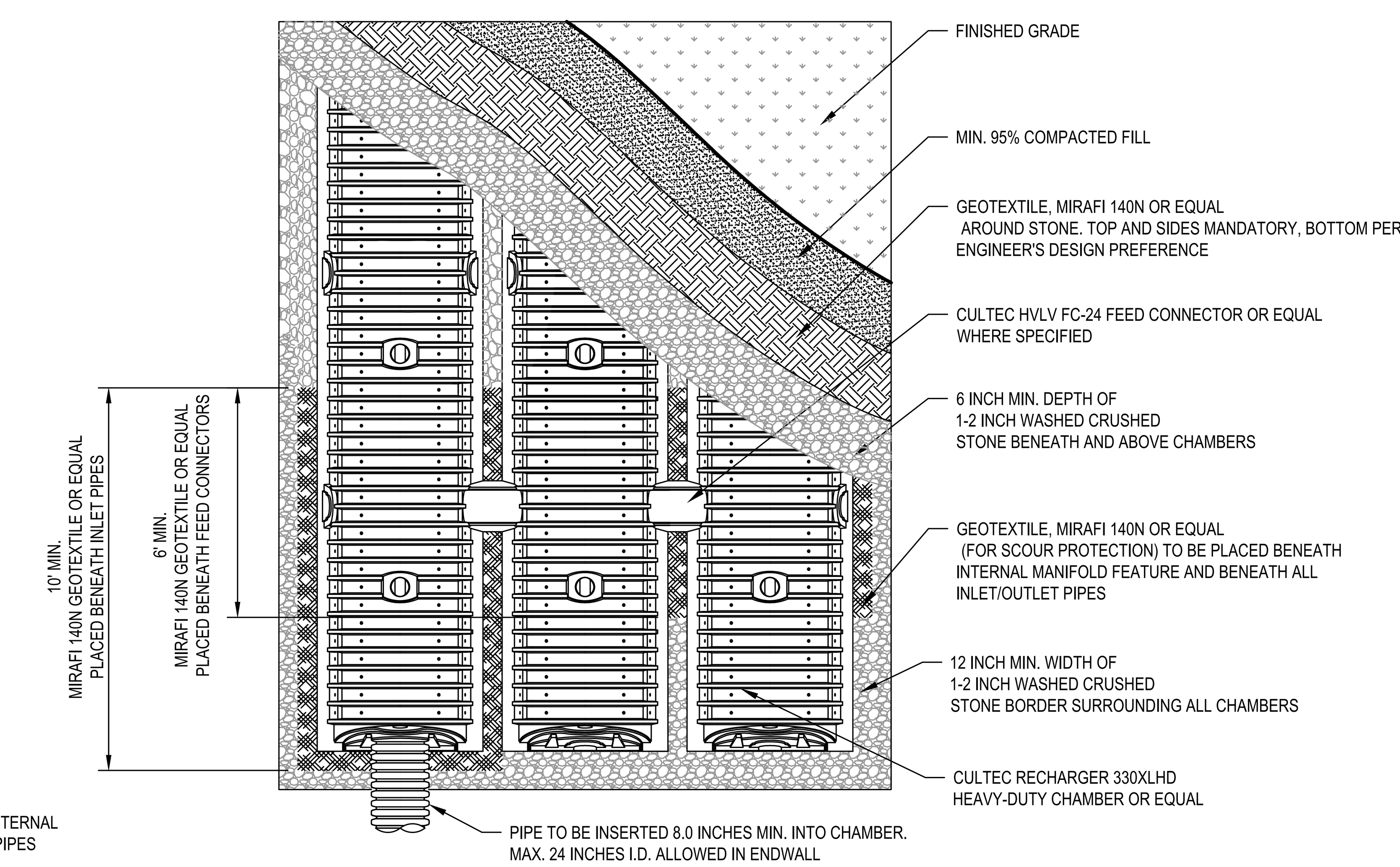
5 D02 HEADER PIPE DETAIL
NOT TO SCALE



4 D02 INFILTRATOR INTERNAL MANIFOLD
NOT TO SCALE



6 D02 INFILTRATOR CROSS SECTION-ENDWALL VIEW
NOT TO SCALE



7 D02 HEAVY DUTY INFILTRATOR PLAN VIEW-NON-TRAFFIC APPLICATIONS
NOT TO SCALE

No	Revision	Drawn	Job Manager	Project Director	Date
1	PRELIMINARY DESIGN				4/2017

Note: * indicates signatures on original issue of drawing or last revision of drawing

NOTES: UNDERGROUND FACILITIES, STRUCTURES, AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE SURVEYS AND RECORDS, AND THEREFORE THEIR LOCATIONS MUST BE CONSIDERED APPROXIMATE ONLY. THERE MAY BE OTHERS, THE EXISTENCE OF WHICH IS PRESENTLY NOT KNOWN. ANYONE USING UTILITY INFORMATION AND DATA PROVIDED HEREIN SHALL CALL DIG SAFE AT 811 SEVENTY TWO (72) HOURS, 3 BUSINESS DAYS IN ADVANCE TO VERIFY THE LOCATION OF UTILITIES PRIOR TO START OF CONSTRUCTION.

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Drawn	Designer	
Drafting Check	Design Check	
Approved (Project Director)		
Date		
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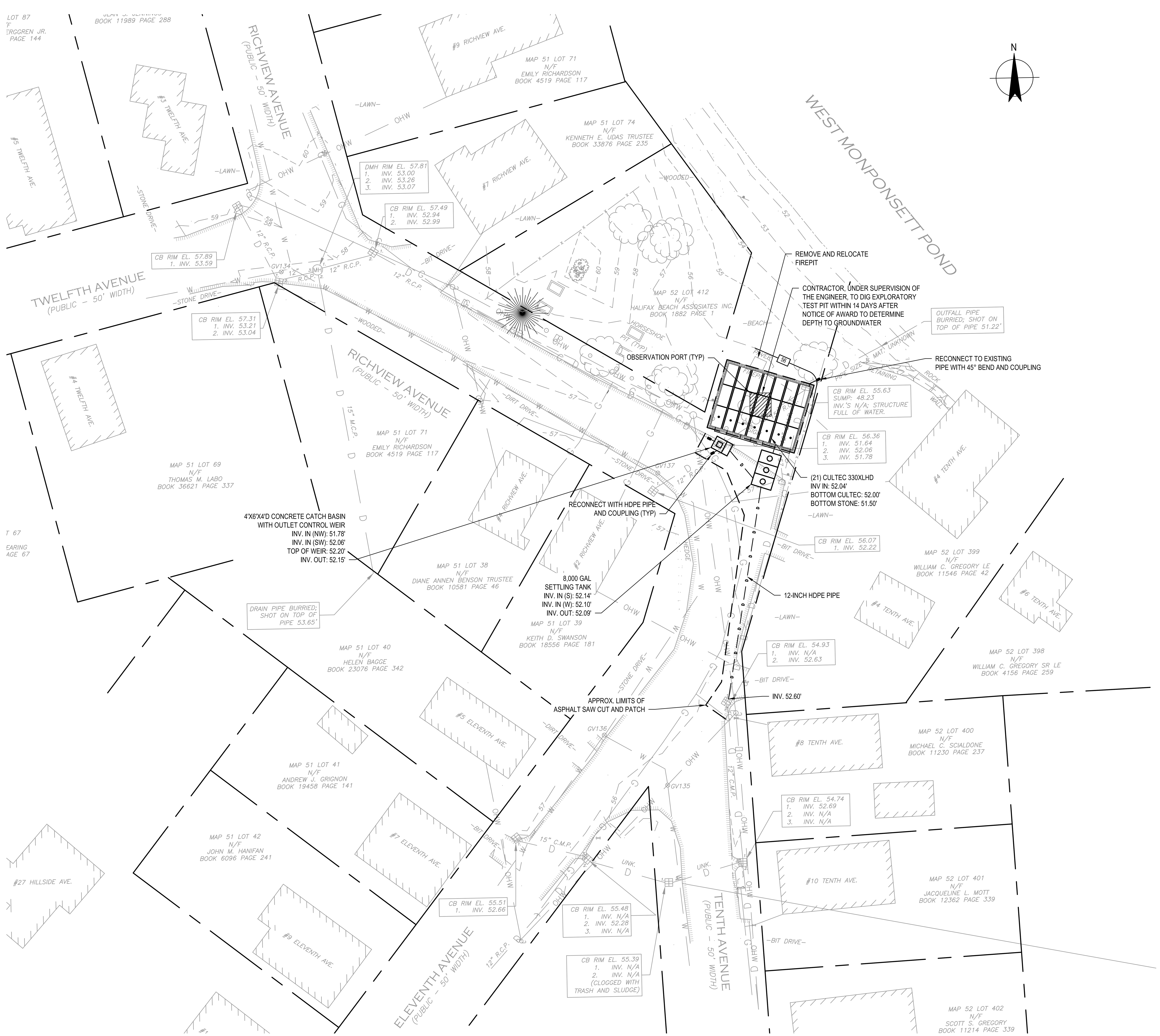
Client TOWN OF HALIFAX, MASSACHUSETTS
Project STORMWATER IMPROVEMENTS
Title CONSTRUCTION DETAILS - 2

Drawing No: 11110997-D02
Rev: 0

Plot Date: 21 April 2017 - 11:20 AM Plotted by: Craig Curtin Cad File No: G:\111\11110997 Stormwater Outfall Assessment for the East and West Monponsett Ponds\CADD\Drawings\Preliminary Designs\Detail\11110997-D02.dwg

BASIS OF DESIGN FOR OW-09
IMPERVIOUS DRAINAGE AREA: 46,000 SF
0.5" RUNOFF VOLUME: 1,917 CF
1" RUNOFF VOLUME: 3,833 CF
INFILTRATION AREA CAPACITY: 1,664 CF
NUMBER OF CHAMBERS: 21
TYPE OF CHAMBERS: CULTEC 330XLHD
SYSTEM STORES 43% OF THE 1" RUNOFF VOLUME



PROPOSED SITE PLAN OW-09 (AREA 1)
SCALE 1" = 20'

No	Revision	Drawn	Job Manager	Project Director	Date
1	PRELIMINARY DESIGN				4/2017

Note: * indicates signatures on original issue of drawing or last revision of drawing

0 10 20 30 40'
SCALE 1"=20' AT ORIGINAL SIZE

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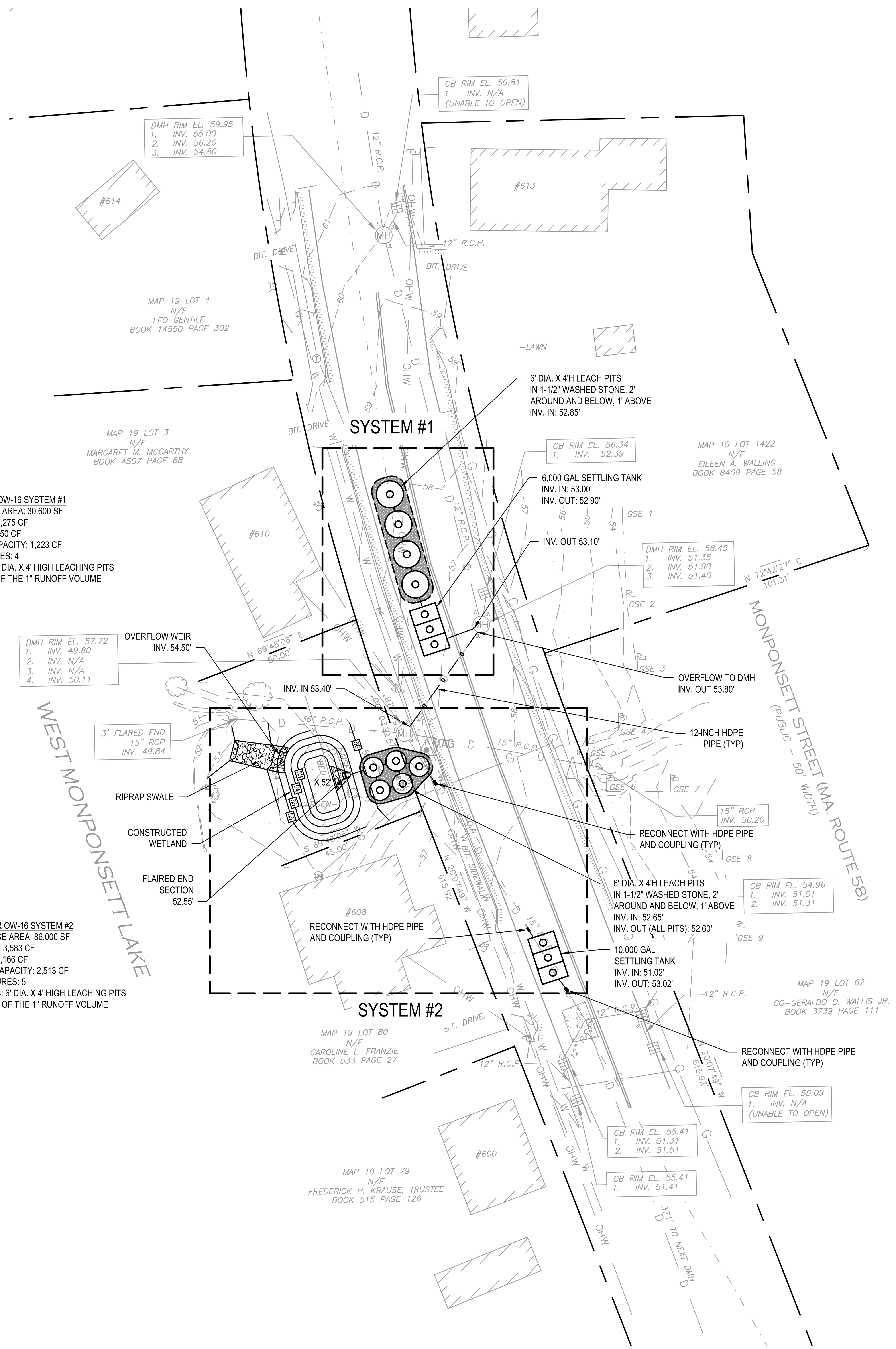
Client: **TOWN OF HALIFAX, MASSACHUSETTS**
Project: **STORMWATER IMPROVEMENTS**
Title: **PROPOSED SITE PLAN OW-09**

Original Size: Arch D
Drawing No: **11110997-C01**
Rev: 0

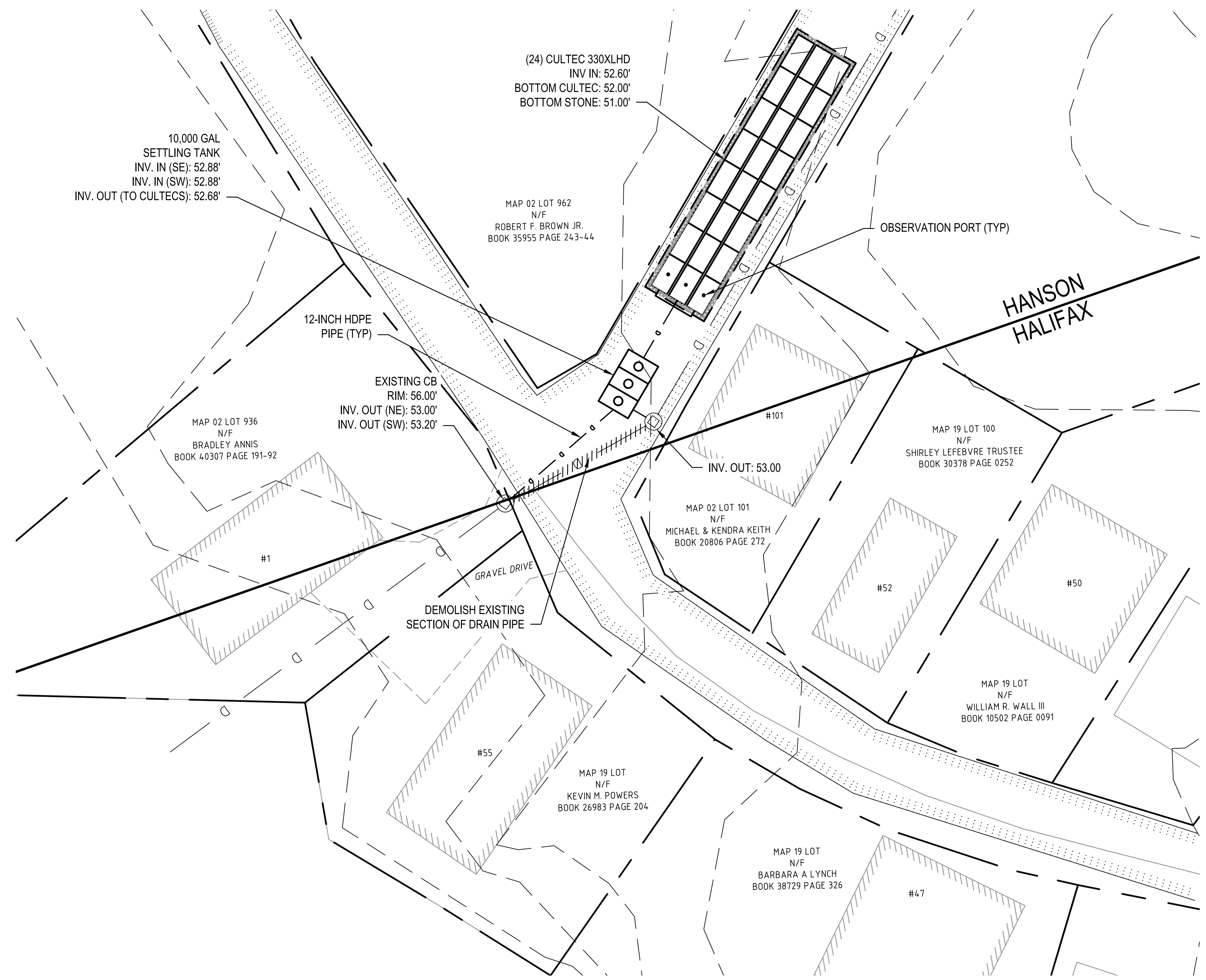
Plot Date: 21 April 2017 - 11:21 AM Plotted by: Craig Curtin Cad File No: G:\111\11110997 Stormwater Outfall Assessment for the East and West Monponsett Ponds\CADD\Drawings\Preliminary Designs\Civil\11110997-C01.dwg



BASIS OF DESIGN FOR OW-16 SYSTEM #1
IMPERVIOUS DRAINAGE AREA: 30,600 SF
0.5" RUNOFF VOLUME: 1,275 CF
1" RUNOFF VOLUME: 2,550 CF
INFILTRATION AREA CAPACITY: 1,223 CF
NUMBER OF STRUCTURES: 4
SIZE OF STRUCTURE: 6' DIA. X 4' HIGH LEACHING PITS
SYSTEM STORES 48% OF THE 1" RUNOFF VOLUME

BASIS OF DESIGN FOR OW-16 SYSTEM #2
IMPERVIOUS DRAINAGE AREA: 86,000 SF
0.5" RUNOFF VOLUME: 3,583 CF
1" RUNOFF VOLUME: 7,166 CF
INFILTRATION AREA CAPACITY: 2,513 CF
NUMBER OF STRUCTURES: 5
SIZE OF STRUCTURES: 6' DIA. X 4' HIGH LEACHING PITS
SYSTEM STORES 35% OF THE 1" RUNOFF VOLUME

PROPOSED SITE PLAN OW-16 (AREA 2)
SCALE 1" = 20'



PROPOSED SITE PLAN OW-19 (AREA 3)
SCALE 1" = 20'

BASIS OF DESIGN FOR OW-19
TOTAL DRAINAGE AREA: 504,000 SF
IMPERVIOUS DRAINAGE AREA: 70,000 SF
0.5" RUNOFF VOLUME: 2,917 CF
1" RUNOFF VOLUME: 5,833 CF
INFILTRATION AREA CAPACITY: 2,065 CF
NUMBER OF CHAMBERS: 24
TYPE OF CHAMBERS: CULTEC 330XLHD
SYSTEM STORES 35% OF THE 1" RUNOFF VOLUME

NOTES:

1. NO TOPOGRAPHIC INSTRUMENT SURVEY WAS PERFORMED.
2. ALL CONTOURS, FEATURES, AND STRUCTURES ARE FROM MASSGIS.
3. ELEVATIONS ARE BASED ON AN ASSUMED DATUM.

No	Revision Note: * indicates signatures on original issue of drawing or last revision of drawing	Drawn	Job Manager	Project Director	Date
1	PRELIMINARY DESIGN				4/2017

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SCALE 1"=20' AT ORIGINAL SIZE

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Client **TOWN OF HALIFAX, MASSACHUSETTS**
Project **STORMWATER IMPROVEMENTS**
Title **PROPOSED SITE PLAN OW-16 AND OW-19**

Original Size Arch D
Drawing No: **11110997-C02**
Rev: 0

Plot Date: 21 April 2017 - 11:21 AM Plotted by: Craig Curtin Cad File No: G:\111\11110997 Stormwater Outfall Assessment for the East and West Monponsett Ponds\CADD\Drawings\Preliminary Designs\Civil\11110997-C01.dwg