WATERSHED-BASED PLAN

STOUGHTON
Beaver Meadow Brook Watershed

March 2020

Prepared By:

Town of Stoughton
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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 Stoughton Engineering Department with funding, input, and collaboration with the Massachusetts Department of Environmental Protection (MassDEP).

The Beaver Meadow Brook watershed, located within the towns of Stoughton and Canton, is approximately 7.4 square miles (4,743 acres) and is a headwater of the approximately 130-square mile Neponset River watershed. Beaver Meadow Brook flows into Bolivar Pond and Forge Pond in Canton where it converges with Pequid Brook and Massapoag Brook and forms the East Branch of the Neponset River. This WBP focuses specifically on the Beaver Meadow Brook watershed within the Towns of Stoughton and Canton.

Impairments and Pollution Sources: Beaver Meadow Brook is listed under Category 5 of the Integrated List due to dissolved oxygen (DO) and *E. Coli*. The source of the DO impairment for Beaver Meadow Brook is currently unknown; however, stormwater has been identified as a priority concern by past MassDEP WBPs for the Neponset River watershed, by the Executive Office of Energy & Environmental Affairs' (EEA) Boston Harbor Watershed Assessment and Action Plan, and by the Neponset River TMDL (Town of Stoughton, 2018). A TMDL has been established for the Neponset River watershed for *E. Coli*, which (as of the 2016 revision of the Integrated List) is also applicable to the Beaver Meadow Brook watershed. According to the TMDL, the known and suspected sources for *E. Coli* in Beaver Meadow Brook are from illicit sewer connections, stormwater runoff and failing septic systems (MassDEP, 2002).

Monitoring data collected by the Citizens Water Monitoring Network, managed by the Neponset River Watershed Association, regularly tracks concentrations of DO, total phosphorus (TP), and *E. coli* at one sampling location located near the outlet of the Beaver Meadow Brook watershed. Results of this water quality monitoring from recent years (2013—2018) suggests that the stream has experienced elevated levels of TP (exceeding 50 µg/L) and fails to meet *E. Coli* water quality standards for swimming (exceeding a geometric mean of 126 colonies/100 ml). However, the 2013—2018 data also indicates that the stream has had healthy concentrations of DO (greater than 5 mg/L).

Goals, Management Measures, and Funding: Water quality goals for this WBP are focused on addressing the Neponset River Watershed Bacteria TMDL, listed DO impairments, and observed elevated concentrations of TP from ambient monitoring data. It is expected that these reductions will result in improvements to listed impairments throughout the study area. This WBP includes an adaptive sequence to establish and track specific water quality goals. First, an interim goal has been established to reduce phosphorus loading by 10 pounds in the next five years. From there, focus will be shifted to the long-term goal of delisting all assessment units within the study area based on adaptively adjusting goals based on ongoing monitoring results.

It is expected that goals will be accomplished primarily through 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. Structural BMPs will be implemented at Dawe Elementary per a Fiscal Year 2019 Section 319 grant. From there, additional planning and implementation is expected to be performed.

It is expected that 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 stormwater improvements and their anticipated benefits and to promote watershed stewardship. The Town of Stoughton and Neponset River Watershed Association aim 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, activity on online resources, 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 structural 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 interim goal of this WBP is to reduce land use-based phosphorus loading by 10 pounds by 2024. The long-term goal of this WBP is to de-list the all waterbodies within the study area from the 303(d) list. The WBP will be re-evaluated and adjusted, as needed, once every three years.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

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, 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 Beaver Meadow Brook watershed includes nine 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 watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), 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 watershed-based plan), 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, USDA's 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 watershed-based plan 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 Stoughton Engineering Department with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (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. Stoughton was a recipient of Section 319 funding in Fiscal Year 2019 to implement BMPs in the Beaver Meadow Brook watershed.

Core project stakeholders included:

- Craig Horsfall, Assistant Town Engineer – Stoughton Engineering Department
- Marc Tisdelle, Town Engineer – Stoughton Engineering Department
- Patrick Hogan – Neponset River Watershed Association (NepRWA)
- Matthew Reardon – MassDEP
- Jane Peirce – MassDEP

This WBP was developed as part of an iterative process. The Geosyntec project team collected and reviewed existing data from the Town of Stoughton. This information was then used to develop a preliminary WBP for review by core project stakeholders. A stakeholder conference call was then held to solicit input and gain consensus on elements included in the plan (e.g., water quality goals, public outreach activities, etc.). The WBP was finalized once stakeholder consensus was obtained for all elements.

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 Beaver Meadow Brook BMP Retrofit Project Section 319 Nonpoint Source Pollution Grant Program application (Town of Stoughton, 2018). Additional data sources were reviewed and are summarized in subsequent sections of this WBP, if relevant.

Summary of Past and Ongoing Work

Neponset River Watershed Association Citizen Water Monitoring Network (https://www.neponset.org/your-watershed/cwmn-data/)

The Citizen Water Monitoring Network (CWMN), led by the NepRWA has been collecting water quality data throughout the Neponset River Watershed since 1994. Refer to the website or Element A for more details.

Hot Spot Monitoring (https://www.neponset.org/projects/hot-spot-program/)

NepRWA conducts a Hot Spot Monitoring Program to assess water quality and locate pollution sources discharging to water bodies in the Neponset River watershed. The program primarily focuses on *E. coli* concentrations, but also monitors for other pollutants. The results of the monitoring are used to identify locations for follow-up investigation.

Mitigation and Minimization Alternatives to Improve Streamflow in the Neponset River Watershed (Town of Canton, 2016)

In 2016, the Town of Canton was awarded funding through the Sustainable Water Management Initiative Grant to perform a study to evaluate water management alternatives for improving streamflow in the Neponset River watershed, including areas within the Beaver Meadow Brook watershed. The study focused on estimates of water volumes available for mitigation, listing costs associated with mitigation measures, evaluating effectiveness of mitigation measures for improving streamflow, and comparison of costs and overall basin impacts. The study also identified and prioritized 128 sites for stormwater retrofits in the Neponset watershed, including three sites within the Beaver Meadow Brook watershed (one of which was located in Canton and two of which were located in Stoughton).

Watershed-based Plan, Canton, Pequit Brook and Beaver Meadow Brook Watersheds within the Town of Canton (Town of Canton et al., 2019)

The Town of Canton completed its own WBP for Pequit Brook and Beaver Meadow Brook watersheds. As detailed in the Fiscal Year 2018 Section 3

19 Nonpoint Source Pollution Grant application Pequit and Beaver Meadow Brook BMP Retrofit Project, submitted by the Town of Canton (Town of Canton, 2017), a swale and large bioretention cell were proposed at Devoll Field, in the Beaver Meadow Brook watershed (within Canton).

The Charles-Neponset Water Conservation and Groundwater Recharge Project (Dedham Westwood Water District, et. al., 2017)

The Charles-Neponset Water Conservation and Groundwater Recharge Project was a collaboration in 2017 between stakeholders for the Charles River and the Neponset River. The project had three primary objectives: 1) implement a water usage app for residents to increase water use efficiency; 2) identify and refine water supply pumping optimization scenarios; and 3) identify priority stormwater recharge retrofit opportunities. The Town of Stoughton was primarily involved in working towards the second and third objectives of the project.

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

The Beaver Meadow Brook watershed, located within the towns of Stoughton and Canton, is approximately 7.4 square miles (4,743 acres) and is a headwater of the approximately 130-square mile Neponset River watershed. Beaver Meadow Brook flows into Bolivar Pond and Forge Pond in Canton where it converges with Pequid Brook and Massapoag Brook and forms the East Branch of the Neponset River. This WBP focuses specifically on the Beaver Meadow Brook watershed within the Towns of Stoughton and Canton (delineated to the point where the stream intersects with Pleasant Street in Canton). **Table A-1** presents the general watershed information for Beaver Meadow Brook and **Figure A-1** includes a map of watershed boundary.

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID):	Beaver Meadow Brook (MA73-20)
Major Basin:	Neponset River
Watershed Area (within MA):	4742.8 (ac)

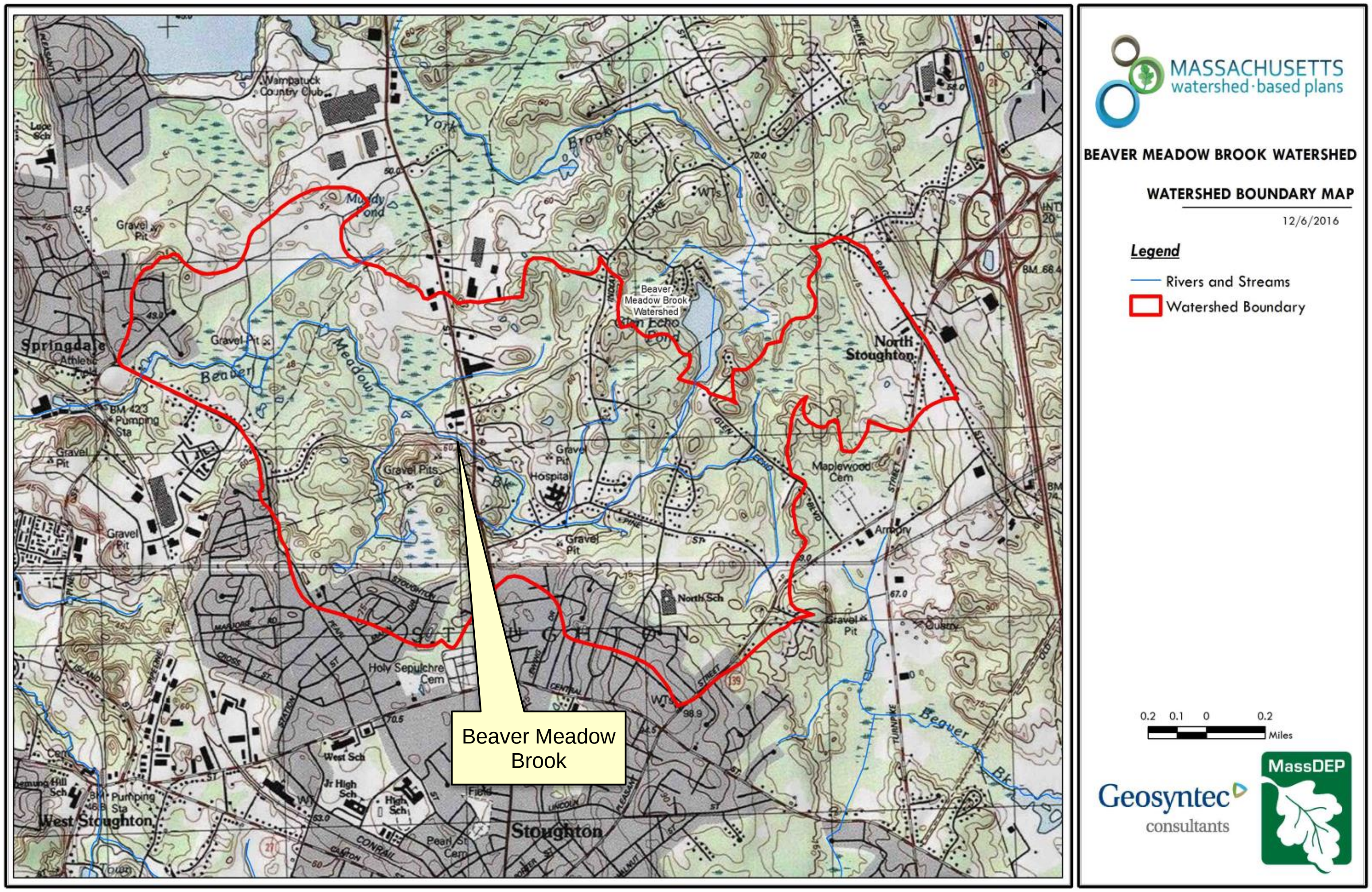

Figure A-1: Watershed Boundary Map

(MassGIS, 2007; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

MassDEP Water Quality Assessment Report and TMDL Review

The following reports are available:

- Neponset River Watershed 2004 Water Quality Assessment Report
- Total Maximum Daily Loads of Bacteria for Neponset River Basin

Select excerpts from the 2004 Water Quality Assessment Report relating to the water quality in the Beaver Meadow Brook watershed is included below (note: relevant information is included directly from these documents and has not been modified). Additional information on the TMDL for Bacteria in the Neponset River Basin is included in **Appendix A**.

Neponset River Watershed 2004 Water Quality Assessment Report (MA73-20 - Beaver Meadow Brook)
Aquatic Life Insufficient data were available to assess the Aquatic Life Use. **Fish Consumption** This waterbody does not have a site-specific fish consumption advisory. All applicable statewide fish consumption advisories issued by MA DPH due to mercury contamination apply to this waterbody (See Special Note 2). **Primary Contact** NepRWA collected E. coli samples at one site in 2007 and 2008. The annual geometric means of the samples collected at the site during the primary contact season were 49 CFU/100ml and 48 CFU/100ml. These results do not violate the geometric mean criterion (126 CFU/100ml) for E. coli. **Secondary Contact** NepRWA collected E. coli samples at one site in 2007 and 2008. The annual geometric means of the samples collected at the site were 49 CFU/100ml and 48 CFU/100ml. These results do not violate the geometric mean criterion (630 CFU/100ml) for E. coli. **Aesthetics** Insufficient data were available to assess the Aesthetic Use. **Report Recommendations** NA

Additional Water Quality Data

The NepRWA's Citizen Water Monitoring Network (CWMN) has been collecting water quality data throughout the Neponset River Watershed since 1994. Sampling sites are visited between May and October and are assessed for numerous parameters including TP, dissolved oxygen (DO), and *E. coli*.

The CWMN includes one sampling location ("BMB026") located directly downstream of the Beaver Meadow Brook watershed (See **Figure A-2**). Results between 2013—2018 at BMB026 indicated that Beaver Meadow Brook had concerning levels of TP in 2013—2016 and 2018 (exceeding 50 µg/L). Results also indicated that Beaver Meadow Brook had levels of *E. coli* greater than a geometric mean of 126 colonies/100 ml, which is not safe for swimming but less than a geometric mean of 630 colonies/100 ml, which is safe for boating. However, data collected between 2013 and 2018 indicated that the stream has recently sustained healthy concentrations of DO (greater than 5 mg/L). **Table A-2** presents the NepRWA CWMN data for BMB026 for 2013—2018.

Table A-2: Water Quality Data at Sampling Location BMB026
(Source: https://www.neponset.org/your-watershed/cwmn-data/)

Year	E. coli (Geometric Mean - colonies/100 ml)	Total Phosphorus (µg/L)	Dissolved Oxygen (mg/L)
2013	132	58	7.1
2014	492	69	6.3
2015	380	58	6.8
2016	138	51	6.7
2017	170	38	5.7
2018	498	51	6.7

There are also two additional sampling locations within the Beaver Meadow Brook watershed that are part of the NepRWA's Hotspot Program ("BMB-B" and "BMB_C"). *E. Coli* data was available for the two "hotspot" locations from 8/1/2018 (43.5 colonies/100 ml and 290 colonies/100 ml for BMB_B and BMB_C, respectively).

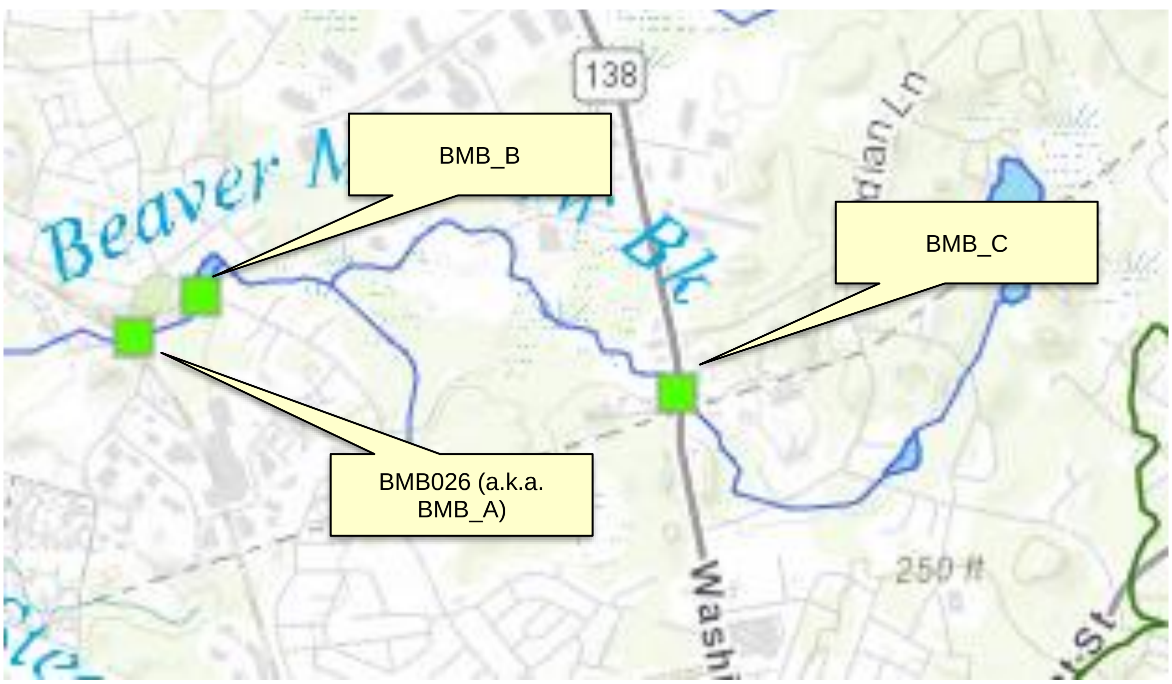

Figure A-2. CWMN Water Quality Monitoring Locations within the Beaver Meadow Brook Watershed
(Source: https://www.neponset.org/your-watershed/cwmn-data/)

Water Quality Impairments

Beaver Meadow Brook is listed under Category 5 of the Integrated List due to DO and *E. Coli*. The source of the DO impairment for Beaver Meadow Brook is currently unknown; however, stormwater has been identified as a priority concern by past MassDEP WBPs for the Neponset River watershed, by the Executive Office of Energy & Environmental Affairs' (EEA) Boston Harbor Watershed Assessment and Action Plan, and by the Neponset River TMDL (Town of Stoughton, 2018). A TMDL has been established for the Neponset River watershed for *E. Coli*, which (as of the 2016 revision of the Integrated List) is also applicable to the Beaver Meadow Brook watershed. According to the TMDL, the known and suspected sources for *E. Coli* in Beaver Meadow Brook are from illicit sewer connections, stormwater runoff and failing septic systems (MassDEP, 2002).

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
MA73-20	**Beaver Meadow Brook**	**5**	Fish, other Aquatic Life and Wildlife	Oxygen, Dissolved	Source Unknown, Discharges from Municipal Separate Storm Sewer Systems (MS4)
MA73-20	**Beaver Meadow Brook**	**5**	Primary Recreation Use	*E. Coli*	Source Unknown, Discharges from Municipal Separate Storm Sewer Systems (MS4)

Water Quality Goals

Water quality goals may be established for a variety of purposes, including the following:

a.) For **water bodies with known impairments**, a Total Maximum Daily Load (TMDL) is established by MassDEP and the United States Environmental Protection Agency (USEPA) as the maximum amount of the target pollutant that the waterbody can receive and still safely meet water quality standards. If the waterbody has a TMDL for total phosphorus (TP), total nitrogen (TN), or total suspended solids (TSS), that information is provided below and included as a water quality goal.

b.) For **water bodies without a TMDL for total phosphorus** (TP), a default water quality goal for TP is based on target concentrations established in the Quality Criteria for Water (USEPA, 1986) (also known as the "Gold Book"). The Gold Book states that TP should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir, nor 25 ug/L within a lake or reservoir. For the purposes of developing WBPs, MassDEP has adopted 50 ug/L as the TP target for all streams at their downstream discharge point, regardless of which type of water body the stream discharges to.

c.) Massachusetts Surface Water Quality Standards (MSWQS) (314 CMR 4.00, 2013) prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. Beaver Meadow Brook is a Class 'B' waterbody, as listed in **Table A-5**. The water quality goal for *E. Coli* is based on the MSWQS.

Table A-5: Surface Water Quality Classification by Assessment Unit ID

Assessment Unit ID	Waterbody	Class
MA73-20	Beaver Meadow Brook	B

d.) **Other water quality goals set by the community** (e.g., protection of high quality waters, in-lake phosphorus concentration goal to reduce recurrence of cyanobacteria blooms, etc.).

Refer to **Table A-6** for a list of water quality goals for TP, bacteria (*E. Coli*) and DO. It is expected that efforts to reduce TP loading will also result in improvements to the DO impairment in Beaver Meadow Brook. Excess TP can cause eutrophication which depletes dissolved oxygen. Effective management of TP can limit eutrophication and allow DO to naturally replenish (USEPA, 2015).

Table A-6: Water Quality Goals

Pollutant	Goal	Source
Total Phosphorus (TP)	Total phosphorus should not exceed: --50 ug/L in any stream	[Quality Criteria for Water (USEPA, 1986)]
Bacteria (*E. Coli*)	**Class B Standards** • 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 of samples 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)
Dissolved Oxygen (DO)	Dissolved oxygen saturation should not be less than 5 mg/L in warm water fisheries or less than 6 mg/L in cold water fisheries.	Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013)

Land Use Information

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

Watershed Land Uses

As summarized by **Table A-7**, land use in the Beaver Meadow Brook watershed is mostly forested (approximately 63 percent); approximately 21 percent of the watershed is residential; approximately 12 percent of the watershed is commercial or industrial; approximately 4 percent of the watershed is open land or water; and less than 0.5% percent is devoted to agriculture.

Table A-7: Watershed Land Uses

Land Use	Area (acres)	% of Watershed
Forest	2974.6	62.7
Medium Density Residential	522.1	11.0
Industrial	465.3	9.8
Low Density Residential	430.0	9.1
Open Land	175.0	3.7
Commercial	101.5	2.1
High Density Residential	55.7	1.2
Agriculture	9.6	0.2
Water	8.9	0.2
Highway	0.0	0.0

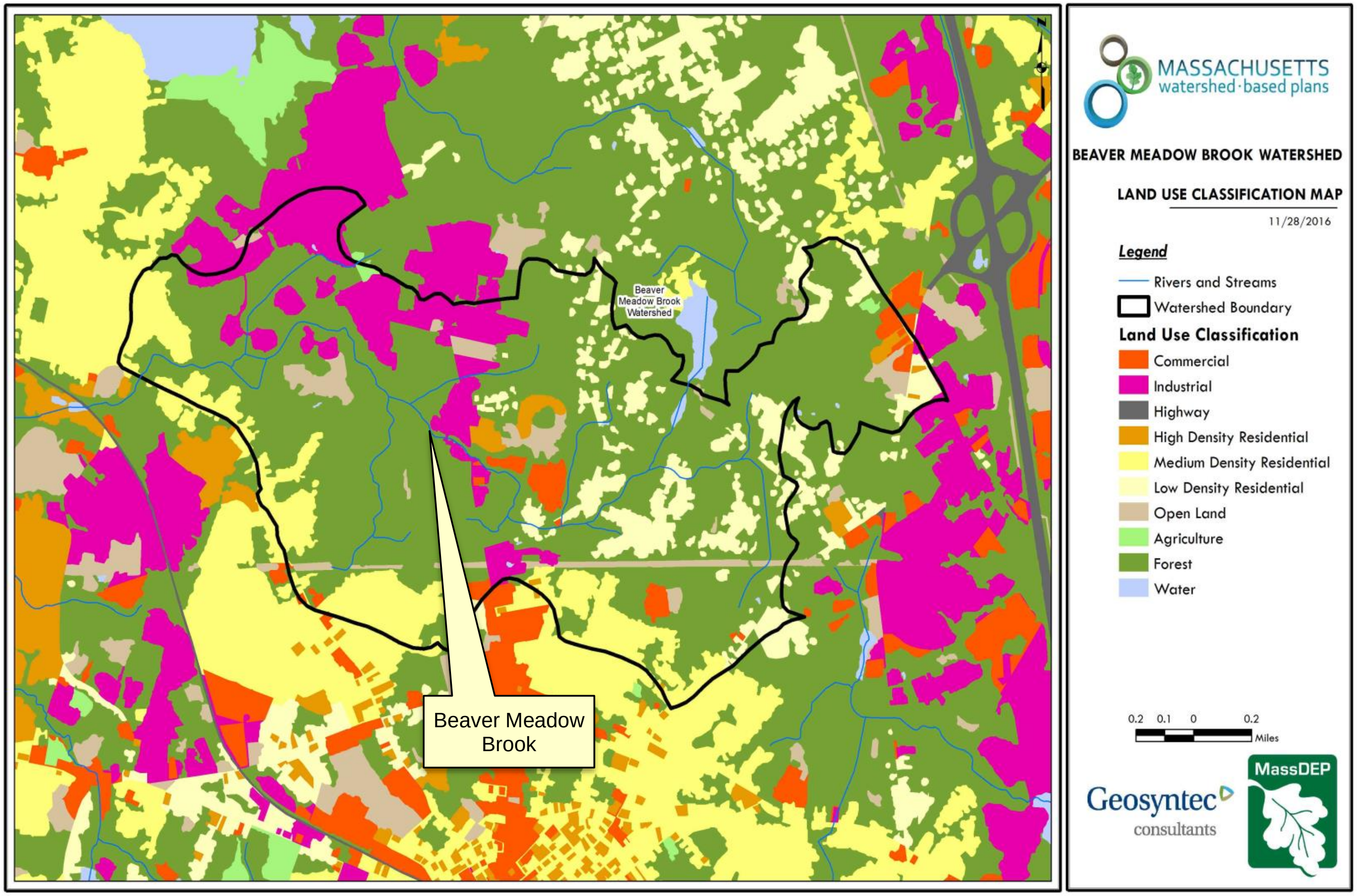

Figure A-3: Watershed Land Use Map

(MassGIS, 2007; 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 Beaver Meadow Brook watershed is concentrated in the northwestern portion of the watershed, as illustrated in **Figure A-4** 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 the watershed, the total area of each land use was summed and used to calculate the percent TIA (**Table A-8**).

Table A-8: TIA and DCIA Values for the Watershed

	Estimated TIA (%)	Estimated DCIA (%)
Beaver Meadow Brook Watershed	17	12.6

The relationship between TIA and water quality can generally be categorized as listed by **Table A-9** (Schueler et al. 2009). The TIA value for the watershed is 17%; therefore, tributaries and waterbodies can be expected to show fair to good water quality.

Table A-9: 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.

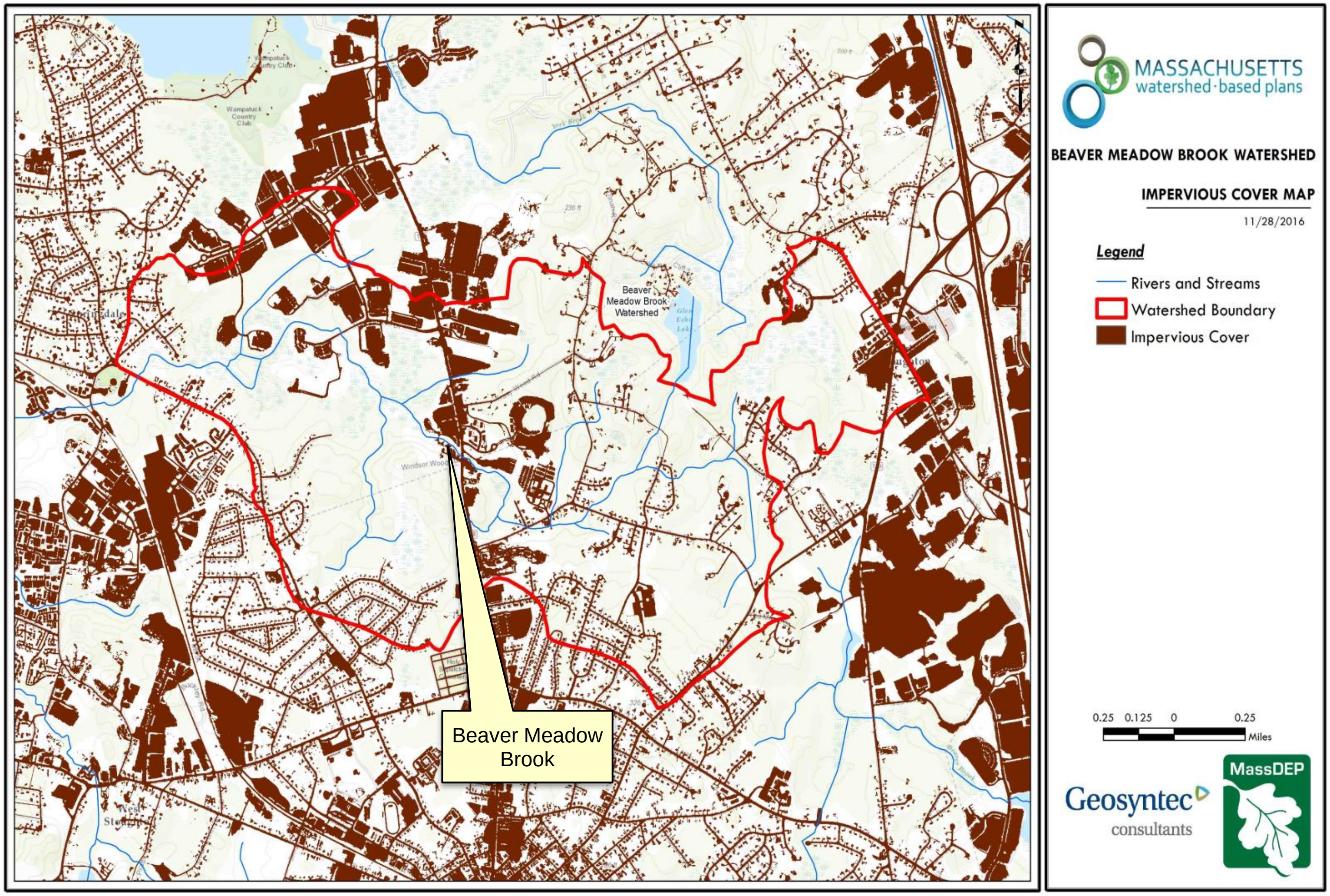

Figure A-4: Watershed Impervious Surface Map

(MassGIS, 2007; 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 C**) 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 to receiving waters within the study area is 1,595 pounds per year, as presented by **Table A-10**. The largest contributors of land use-based phosphorus load originate from areas designated as industrial (34% of the total phosphorus load) and forested (28% 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 and generally represent a “best case scenario” with regards to phosphorus loading, meaning that those portions of the watershed are unlikely to provide opportunities for nutrient load reductions through best management practices.

Table A-10: 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)
Industrial	547	4,687	58.65
Forest	443	2,346	96.45
Medium Density Residential	182	1,501	21.38
Low Density Residential	145	1,404	19.8
Commercial	121	1,037	12.97
Open Land	82	666	16.43
High Density Residential	71	462	6.98
Agriculture	5	29	0.36
Highway	0	0	0
TOTAL	1,595	12,133	233.01

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

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) (1,595 lbs/yr), total nitrogen (TN) (12,133 lb/yr), and total suspended solids (TSS) (233 tons/yr) were previously presented in Element A of this WBP. *E. coli* loading has not been estimated for this WBP, because there are no known PLERs for *E. coli*.

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 by Element A, water quality goals for this WBP are focused on addressing the Neponset River Watershed Bacteria TMDL, the listed dissolved oxygen impairment, and observed elevated concentrations of phosphorus from ambient monitoring data. A description of criteria for each water quality goal is described by **Table B-1**. Since it is not practical to estimate *E. coli* and DO 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 will also result in improvements to *E. Coli* and DO in Beaver Meadow Brook. Excess TP can cause eutrophication which depletes dissolved oxygen. Effective management of TP can limit eutrophication and allow DO to naturally replenish (USEPA, 2015).

The following adaptive sequence is recommended to establish and track water quality goals.

1. Establish an **interim goal** to reduce land use-based TP to Beaver Meadow Brook by 10 pounds over the next 5 years (by 2024) within the watershed.
2. Continue to maintain and expand, as feasible, the Citizen Water Monitoring Network (CWMN) in accordance with recommendations from Elements H&I. Use monitoring results to perform trend analysis to identify if proposed Element C management measures are resulting in improvements and to identify site candidates to be sampled as indicator sites.
3. Establish a **long-term goal** to reduce land use-based phosphorus by 178 pounds per year and to meet all applicable water quality standards over the next 20 years, leading to the delisting of Beaver Meadow Brook from the Integrated List.

Table B-1: Pollutant Load Reductions Needed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Total Phosphorus[1]	1,595 lbs/yr	1,417 lbs/yr	178 lbs/yr
Bacteria (*E. Coli*)[2]	*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. Data collected between 2013—2018 indicated that Beaver Meadow Brook had levels of E. coli ranging from a geometric mean of 132—498 colonies/100 ml.*	**Class B Standards** • 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 of samples from most recent 6 months shall not exceed 33 colonies/100 ml, and no single sample shall exceed 61 colonies/100 ml.	*75% - Concentration Based (goal is to reduce geometric mean to 126 colonies/100 ml or less)*
Dissolved Oxygen (DO)[3]	*MSWQS for DO are concentration standards (e.g., mg/L), which are difficult to predict based on estimated annual loading. However, data collected between 2013 and 2018 indicates that Beaver Meadow Brook has recently sustained healthy concentrations of DO (greater than 5 mg/L).*	Dissolved oxygen saturation should not be less than 5 mg/L in warm water fisheries or less than 6 mg/L in cold water fisheries.	*Concentration Based (2013—2018 data indicates achievement of water quality goal)*

Notes:

1. *According to the USEPA Gold Book, total phosphorus should not exceed 50 ug/L in any stream at the point where it enters any lake or reservoir. The water quality loading goal was estimated by multiplying this target maximum phosphorus concentration (50 ug/L) by the estimated annual watershed discharge for Beaver Meadow Brook. To estimate the annual watershed discharge, the mean flow was used, which was estimated based on United States Geological Survey (USGS) "Runoff Depth" estimates for Massachusetts (Cohen and Randall, 1998). Cohen and Randall (1998) provide statewide estimates of annual Precipitation (P), Evapotranspiration (ET), and Runoff (R) depths for the northeastern U.S. According to their method, Runoff Depth (R) is defined as all water reaching a discharge point (including surface and groundwater), and is calculated by: P - ET = R. A mean Runoff Depth R was determined for the watershed by calculating the average value of R within the watershed boundary. This method includes the following assumptions/limitations: The estimated existing loading value only accounts for phosphorus due to stormwater runoff. Other sources of phosphorus may be relevant, particularly phosphorus from on-site wastewater treatment (septic systems) within proximity to receiving waters. Phosphorus does not typically travel far within an aquifer, but in watersheds that are primarily unsewered, septic systems and other similar groundwater-related sources may contribute a significant load of phosphorus that is not captured in this analysis. As such, it is important to consider the estimated TP loading as "the expected TP loading from stormwater sources*
2. *For all waterbodies, including impaired waters that have a pathogen TMDL, the water quality goal for bacteria is based on the Massachusetts Surface Water Quality Standards (MSWQS) (314 CMR 4.00, 2013) that apply to the Water Class of the selected water body. See Appendix A for additional information from the Neponset River Watershed Bacteria TMDL.*
3. *Dissolved oxygen criteria are based on the Massachusetts Surface Water Quality Standards (MSWQS) (314 CMR 4.00, 2013).*

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 and Ongoing Management Measures

As detailed in the Fiscal Year 2018 Section 319 Nonpoint Source Pollution Grant application, Pequit and Beaver Meadow Brook BMP Retrofit Project, submitted by the Town of Canton (2017), a swale and large bioretention cell were proposed at Devoll Field, in the Beaver Meadow Brook watershed (within Canton). The BMP has been installed and it was estimated that this BMP will result in a combined load reduction of 364 lbs/yr for TSS, 2.7 lbs/yr for TP, and 26.0 lbs/yr for TN. This BMP was also presented in the Town of Canton Watershed-based Plan for "Pequit Brook and Beaver Meadow Brook Watersheds within the Town of Canton" (Town of Canton et al., 2019).

The Town of Stoughton was awarded funding through the Fiscal Year 2019 Section 319 Nonpoint Source Pollution Grant Program to install an infiltration basin at Dawe Elementary School, within the Beaver Meadow Brook watershed (within Stoughton). The Dawe Elementary School site provides the opportunity to capture and infiltrate runoff from a 25-acre drainage area that includes 6.5 acres of impervious cover. The location of the proposed infiltration basin is in the wooded area adjacent to Dawe Elementary School. A diversion structure within an upstream manhole will redirect a portion of the flow from the drainage area into the infiltration basin, which is sized to treat the one-inch storm. A proprietary separator will provide pretreatment upstream of the infiltration basin. A natural ledge slope, reinforced with rip rap, will provide three sides of the basin and a constructed earthen berm will act as the fourth. A crushed stone path will be constructed on top of the berm for inspection and maintenance access. The soils within the basin are a sandy loam with high hydraulic conductivity (See attached soil description for more detail). Informational signage will be installed beside the BMP with information about the infiltration basin and examples of actions individuals can take to reduce stormwater pollution. It is anticipated that this BMP will result in a combined annual load reduction of 8 lbs/yr of TP, 1,065 lbs/yr of TSS, and 61 lbs/yr of TN. Additional details on the Infiltration Basin design to be installed at Dawe Elementary School are included in **Appendix B.** The design plans for this BMP are currently being finalized and construction is planned in the Summer of 2020.

Future Management Measures

In 2016, the Town of Canton prepared a final report on Mitigation and Minimization Alternatives to Improve Streamflow in the Neponset River Watershed (Town of Canton, 2016), which identified and ranked 128 potential stormwater BMP retrofit sites. Three of the potential sites were located within the Beaver Meadow Brook watershed; these included the Devoll Field bioretention cell and the Dawe Elementary School infiltration basin, which are described above and currently in progress.

The report identified a third BMP opportunity site within the Beaver Meadow Brook watershed, which was also proposed at the Dawe Elementary School. The proposed BMP was to divert surface runoff from the parking lot and Coolidge Street to the open grass area in front of the school and into a rain garden or bioretention cell. This BMP concept was identified as a "good site" for BMP implementation. Future management measures in the Beaver Meadow Brook watershed will first focus on implementing this BMP at Dawe Elementary School. Once this option has been implemented and/or deemed infeasible for implementation upon further analysis, Stoughton may consider additional investigation with the following recommended general sequence to identify and implement future structural BMPs within the Beaver Meadow Brook watershed:

Structural BMPs

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 Element C BMP-selector tool of the MassDEP's Watershed-Based Planning Tool to help develop concepts. 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 nutrient and bacterial loading to Beaver Meadow Brook, 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 TSS, TN, and TP loading; as well as Illicit Discharge Detection and Elimination (IDDE) to reduce bacteria 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 Element HI. 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. For example, by implementing microbial source tracking protocols to track and eliminate bacteria sources at key outfalls to Beaver Meadow Brook.

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 proposed management measures in Stoughton presented in this watershed plan is based on estimates from the Beaver Meadow Brook BMP Retrofit Project Section 319 Nonpoint Source Pollution Grant Program application (Town of Stoughton, 2018). The total costs including design and permitting; construction of the structural BMPs;; and information/education measures is estimated at approximately $161,406, as detailed by **Table D-1**. Additionally, annual operation and maintenance costs were estimated to be approximately $2,900 per year (Dedham Westwood Water District et al., 2017) and existing monitoring costs at Station BMB026 are $1,500/year (which is paid by the Town of Canton).

Table D-1: Summary of Proposed BMP Costs

Task/Objective	Cost
Design and Permitting	$12,000
Construction	$129,900
O&M Plan	$520
Outreach and Technology Transfer	$15,666
Reporting and Project Management	$3,320
Total	**$161,406**

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. Neponset River stakeholders have previously been successful with and will continue to pursue securing grant funding through the Sustainable Water Management Initiative Grant Program and the Water Management Act Grant Program. Guidance is available to provide additional information on potential funding sources for nonpoint source pollution reduction efforts[1].

[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

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. Local students.

Step 3: Outreach Products and Distribution

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

1. Develop and post informational signs at proposed BMP locations and distribute educational mailings.
2. Develop public press releases and blog articles.
3. Conduct fifth-grade two-day classroom and outdoor educational programs at Dawe Elementary School.
4. Email updates and presentations to municipal officials.

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.

1. Track the number of educational mailings distributed.
2. Track number of webpage views and emails opened.
3. Record the number of students attending educational programs.

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 2022 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.

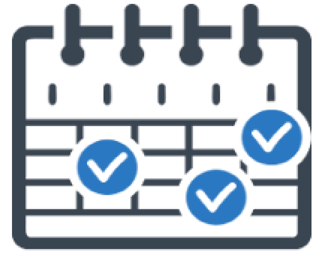

Table FG-1 provides a preliminary schedule for implementation of recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated in 2021, or as needed, based on ongoing monitoring results and other ongoing efforts.

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

Category	Action	Estimated Cost	Year(s)
Monitoring / Vegetation	Consider expanding or adjusting Citizen Water Monitoring Network to additional or alternative waterbodies / sampling locations as resources allow – see Element H&I for suggestions.		Annual
	Continue to perform volunteer water quality sampling and analysis		Annual
Structural BMPs	Document estimated pollutant removals from existing BMPs in the watershed (e.g., Devoll Field)		2019
	Complete installation of BMPs at Dawe Elementary School	$142,420	2020
	Obtain funding and implement 1-2 additional BMPs within the Beaver Meadow Brook watershed	$160,000	2022
	Obtain funding and implement 1-2 additional BMPs within the Beaver Meadow Brook watershed	$160,000	2024
	Obtain funding and implement 1-2 additional BMPs within the Beaver Meadow Brook watershed	$160,000	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)*	Periodically post project updates to website and blog profiles and send email updates to municipal officials	$5,000	Annual
	Develop and post informational signs at proposed BMP locations and conduct classroom education programs	$5,000	2020
	Develop and distribute educational mailings	$5,000	2020
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 2021		2022
	Reach interim goal to reduce land-based phosphorus by 10 pounds/year		**2024**
	Reach interim goal to reduce E. Coli concentrations to be equal to or less than a geometric mean of 126 colonies/100 ml		**2024**
	Reach long-term goal to de-list Beaver Meadow Brook from the 303(d) list		**2039**

[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 Beaver Meadow Brook.

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. Appendix F of the 2016 Massachusetts Small MS4 General Permit provides specific guidance for calculating phosphorus removal from these practices. 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**. Additionally, since there is a bacteria TMDL applicable to the watershed, it is recommended that IDDE efforts required by the NPDES Small MS4 Permit be tracked.

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

Where:

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

Frequency[1]	Sweeper Technology	$\text{PRF}_{\text{sweeping}}$
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:

$\text{Credit}_{\text{CB}}$	=	Amount of phosphorus load removed by catch basin cleaning (lb/year)
IA_{CB}	=	Impervious drainage area to catch basins (acres)
$\text{PLE}_{\text{IC-and use}}$	=	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 (i.e., under construction), and future BMPs will be tracked as BMPs are installed. For example, once ongoing BMPs are installed, the anticipated phosphorus load reduction to Beaver Meadow Brook watershed is estimated to be 10 pounds per year.

TMDL Criteria

TMDL requirements include the continuation of the NepRWA's CWMN monitoring program during both wet and dry weather. In addition, the TMDL requires development of a detailed monitoring plan and sampling associated with illicit discharge detection.

Direct Measurements

Direct measurements are generally expected to be performed in accordance with existing monitoring activities by the NepRWA's CWMN, as summarized below, along with additional recommendations to supplement sampling[3]. The CWMN includes a core sampling site, "BMB026", which is located directly downstream of the outlet of the Beaver Meadow Brook watershed (within Canton). This location is sampled regularly. The CWMN also has two additional "hot spot" sites, within the Beaver Meadow Brook watershed, which are sampled based on anticipated needs. These hot spot sites are located at the intersection of Beaver Meadow Brook with Pleasant Street in Canton (BMB_B) and in Beaver Meadow Brook directly downstream of the Stoughton/Canton town line ("BMB_C").

River Sampling

Continue regular sampling of sampling site BMB026 in accordance with the CWMN. Since sampling site BMB_C exhibited heightened levels of E. Coli during the most recent sampling event in August, 2018 (186 colonies/100 ml) and this location is located approximately ½-river mile downstream of the proposed BMP at Dawe Elementary School, more frequent sampling (in accordance with the CWMN program) is recommended at this location.

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 and bacteria concentrations, as well as other indicators (e.g., dissolved oxygen) measured within the watershed, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

[3] A full explanation of the CWMN, including sampling frequencies, parameters, and locations is provided at this link: https://www.neponset.org/your-watershed/cwmn-data/.

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Appendices

Appendix A – Excerpts from Neponset River Bacteria TMDL (MassDEP, 2002)

Total Maximum Daily Loads of Bacteria for Neponset River Basin (MA73-20 - Beaver Meadow Brook)
Problem Assessment Extensive water quality data are available for the Neponset River and tributaries. In 1994 the Massachusetts Department of Environmental Protection (MADEP), in cooperation with several other state agencies and citizen monitoring groups, initiated a comprehensive assessment of the Neponset River Basin. The results of this work identified that numerous waterbody segments, including lakes and ponds, in the Neponset River Basin were not attaining the State's water quality standards. The most pervasive water quality problem identified was, and remains, due to excessive levels of fecal coliform indicator bacteria. Since the 1994 study, the Neponset River Watershed Association (NepRWA), a non-profit organization, has collected annual water quality data at numerous locations throughout the basin. Beginning in 1996, all of NepRWA's monitoring activities have been conducted according to EPA approved Quality Assurance Project Plans (QAPP) developed by NepRWA. Establishing a QAPP represents a significant accomplishment by NepRWA that has resulted in the collection of credible data used to identify waterbody segments that do not attain water quality standards, and identify specific pollutant sources requiring control measures. The following figures (originally Figures 4 and 5 of the "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) provide the locations of MADEP (1994) and the NepRWA (1997 through 1999) sampling stations, respectively.

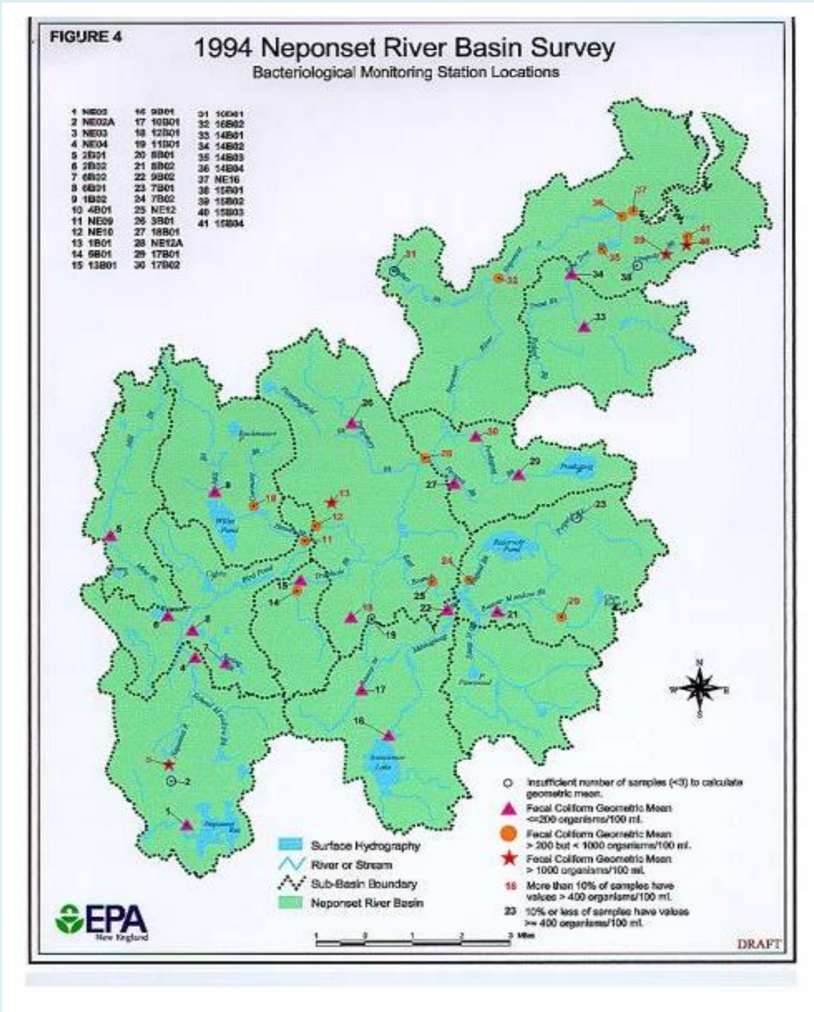


FIGURE 4
1994 Neponset River Basin Survey
Bacteriological Monitoring Station Locations
Insufficient number of samples (<3) to calculate geometric mean.
Fecal Coliform Geometric Mean <=200 organisms/100 ml.
Fecal Coliform Geometric Mean > 200 but < 1000 organisms/100 ml.
Fecal Coliform Geometric Mean > 1000 organisms/100 ml.
More than 10% of samples have values > 400 organisms/100 ml.
10% or less of samples have values >= 400 organisms/100 ml.
Surface Hydrography
River or Stream
Sub-Basin Boundary
Neponset River Basin
EPA
New England
DRAFT

Fecal Contamination of the Neponset River Basin

The NepRWA annual water quality monitoring program and the 1994 MADEP monitoring efforts provide an extensive bacterial monitoring coverage through out the basin. Between 1997 and 1999, NepRWA established and monitored 57 surface water stations, and MADEP monitored 41 stations for bacteria in 1994. The locations of the MADEP and NepRWA (1997-1999) bacteria monitoring stations are provided in the figures above (originally Figures 4 and 5 of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002), respectively, illustrating the extensive coverage of the monitoring programs. Individual data may be found in The Neponset River Watershed, 1994 Resource Assessment Report, dated October 1995 and the NepRWA annual monitoring reports. The figures illustrate the extent of non-attainment of the fecal coliform standards in the Neponset River and tributaries. Monitoring stations are depicted where the geometric means exceed 200 organisms per 100 ml and/or where more than 10 % of the samples have values exceeding 400 organisms per 100ml. For the NepRWA stations (1997 –1999), Figure 5 indicates the highest geometric mean of the three years. As indicated, the entire length of the Neponset River, starting near Route 1 in Foxborough downstream to the estuary, and several tributaries do not meet the fecal coliform standards. Also, numerous tributaries were found to be in non-attainment. Exceedences of the fecal coliform criteria were observed at 60% of the NepRWA stations for one or more years, and at 51% of the 1994 MADEP stations. The high percentage of NepRWA stations exceeding fecal coliform criteria is not surprising, considering that, to aid in source identification efforts, NepRWA targeted its monitoring activities in areas with known or suspected problems.

The following tables (originally Tables 4 through 7 of the "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) present the calculated geometric means and percent of samples exceeding 400 organisms per 100 ml for each location in 1994, 1997, 1998, and 1999.

TABLE 1994 DEP
NEPONSET RIVER SURVEY
FECAL COLIFORM

STATION ID	STATION LOCATION	NO. OF SAMPLES COLLECTED	GEOMETRIC MEAN	% OF SAMPLES > 400 (cfu/100 ml)
NE02	Neponset River, outlet of Crackrock Pond, Foxborough	3	36	33
NE02A	Neponset River, Route 1, Foxborough	2	-	0
NE03	Neponset River, Summer Street, Walpole	4	1544	100
NE04	Neponset River, South Street, Walpole	3	47	0
2B02	Mine Brook, Mill Pond Road, Walpole	3	<20	0
2B01	Mine Brook, Elm Street, Medfield	3	106	0
6B01	Spring Brook, off Route 27, near playground, Walpole	2	23	0
6B02	Spring Brook, Washington Street, Walpole	3	34	0
NE09	Hawes Brook, Washington Street, Norwood	3	212	33
4B01	Germany Brook, Inlet Ellis Pond, Nichol Street, Norwood	3	410	67
1B02	Mill Brook, inlet Pettee Pond off Clearwater Drive, Brook Street, Westwood	3	92	0
NE10	Neponset River, Pleasant Street Bridge, Norwood	3	855	100
1B01	Meadow Brook, off Meadow Brook Road/Pleasant Street, Norwood	4	85,225	100
5B01	Traphole Brook, Cooney Street, Walpole	3	298	33
12B01	Unnamed Traphole tributary, Union Street and Edge Hill Road, Sharon	3	99	33
13B01	Unnamed Traphole tributary, Union Street, Walpole	3	108	0
11B01	Unnamed Neponset tributary, Edge Hill Road, Sharon	1	-	0
NE12	East Branch Neponset River, Neponset Street, Canton	3	300	0
9B02	Massapoag Brook, Walnut Street off Washington Street, Canton	3	20	0
10B01	Beaver Brook, Upland Road, Sharon	3	78	0
9B01	Massapoag Brook, outlet of Massapoag Lake, Sharon (Cedar, East & Massapoag Street)	3	58	0
7B02	Pequid Brook, Sherman Street, Canton	3	203	33
7B01	Pequid Brook, York Street, Canton	1	-	0
8B02	Beaver Meadow Brook, Pine Street, Canton	3	54	0
8B01	Beaver Meadow Brook, Route 138, Canton	3	288	67
3B01	Purgatory Brook, Route 1 near Everett Street, Norwood	3	154	33
NE12A	Neponset River, Dedham Street Bridge, Canton	3	456	33
18B01	Pecunit Brook, Elm Street, Canton	3	43	0
17B02	Ponkapoag Brook, Elm Street, Canton	3	199	33
17B01	Ponkapoag Brook, Washington Street, Canton	3	56	0
16B02	Mother Brook, Hyde Park Avenue, Hyde Park	4	204	25
16B01	Mother Brook, Washington Street, Dedham	2	-	50
14B04	Pine Tree Brook, Central Avenue, Milton Village	3	420	67
14B03	Pine Tree Brook, Central Avenue, Milton	3	768	67
14B02	Pine Tree Brook, Blue Hills Parkway, Milton	3	113	0
14B01	Pine Tree Brook, Unquity Road and Harland Street, Milton	3	90	0
NE16	Neponset River, downstream of Baker Dam, Adams Street, Milton/Boston line	3	593	67
15B04	Gulliver Creek, Christopher Avenue, Milton	3	512	67
15B03	Unquity Brook, Adams Street, Milton	2	-	0
15B02	Unquity Brook, Brook Road, Milton	2	-	100
15B01	Unquity Brook, Gun Hill Street off Randolph Avenue, Milton	1	-	0

STATION ID	STATION LOCATION	NO. OF SAMPLES COLLECTED	GEOMETRIC MEAN	% OF SAMPLES > 400 (cfu/100 ml)
SMB001	School Meadow Brook at Pine Street, Walpole	6	5	0
SMB013	School Meadow Brook at Washington Street, Walpole	6	123	16.7
SPB008	Spring Brook at Washington Street, Walpole	6	11	0
SPB012	Spring Brook at Stone Street, Walpole	6	7	0
GEB008	Germany Brook at Sycamore Drive, Westwood	6	30	0
GEB020	Germany Brook at inlet of Ellis Pond, Norwood	5	961	80
NER075	Neponset River at Hollingsworth and Vose Dam, Walpole	5	33	0
HAB002	Hawes Brook at Walpole Street, Norwood	6	42	16.7
HAB006	Hawes Brook at Railroad Bridge/Endean Park, Norwood	6	771	83.3
HAB010	Hawes Brook at Washington Street, Norwood	5	651	80
MEB001	Meadow Brook at Sunnyside Road, Norwood	6	9432	100
MEB006	Meadow Brook at Dean Street, Norwood	5	1278	60
THB008	Traphole Brook at High Plain Street, Sharon	2	51	50
THB020	Traphole Brook at Coney Street, Walpole	6	87	16.7
THB026	Traphole Brook at Sumner Street, Norwood	6	141	16.7
NER095	Neponset River at Neponset Street, Canton	4	224	50
MOB001	Mother Brook at Route One Dam, Dedham	6	123	33.3
MOB010	Mother Brook at Bussey Street, Dedham	4	74	0
MOB020	Mother Brook at River Street, Hyde Park/Boston	3	391	33.3
NER130	Neponset River at Green Lodge Street, Canton	4	92	0
NER150	Neponset River at Paul's Bridge, Milton	4	89	0
NER165	Neponset River at Dana Avenue, Hyde Park/Boston	3	655	100
NER175	Neponset River at Truman Parkway, Mattapan/Boston	1	110	0
NER185	Neponset River at Ryan Playground, Mattapan/Boston	6	1168	83.3
PTB012	Pine Tree Brook at Unquity Road, Milton	5	168	0
PTB022	Pine Tree Brook at Canton Avenue, Milton	5	194	20
PTB035	Pine Tree Brook at Brook Road, Milton	6	418	50
PTB047	Pine Tree Brook at Eliot Street, Milton	5	645	80
UNB002	Unquity Brook at Randolph Avenue, Milton	5	668	60
UNB009	Unquity Brook at Brook Road, Milton	5	76	0
UNB016	Unquity Brook at Squantum Street, Milton	6	1533	100
NER200	Neponset river at Adams Street Bridge, Milton/Boston Line	6	523	66.7

TABLE 1997 NEPONSET RIVER FECAL COLIFORM DATA

TABLE 1998 NEPONSET RIVER SURVEY FECAL COLIFORM DATA							
Station ID	Station Description	Dry Weather Geometric Mean	No. of Dry Samples	Wet Weather Geometric Mean	No. of Wet Samples	Overall Geometric Mean	Overall % > 400 cfu/100ml)
NER021	Neponset River at Sumner Street, Walpole	132	6	247	4	170	10
MIB060	Mine Brook at Mill Pond Road, Walpole	10	6	12	4	11	0
NER075	Neponset River at Hollingsworth and Vose Dam, Walpole	71	6	93	3	78	0
GEB020	Germany Brook at inlet of Ellis Pond, Norwood	169	3	1111	4	495	57
HAB006	Hawes Brook at Railroad Bridge/Endean Park, Norwood	290	5	571	4	392	67
HAB010	Hawes Brook at Washington Street, Norwood	156	5	1212	4	388	44
MEB001	Meadow Brook at Sunnyside Road, Norwood	7573	6	9813	4	8400	100
MEB006	Meadow Brook at Dean Street, Norwood	1574	6	3812	4	2242	90
NER130	Neponset River at Green Lodge Street, Canton	158	6	314	4	208	20
EAB010	East Branch at Neponset Street, Canton	269	5	617	4	389	44
NER150	Neponset River at Paul's Bridge, Milton	119	5	825	4	281	44
NER165	Neponset River at Dana Avenue, Mattapan	265	6	718	4	395	50
NER178	Neponset river at Monponset Street, Mattapan	184	4	1259	2	349	33
NER185	Neponset River at Ryan Playground	607	5	1202	4	822	44
PTB022	Pine Tree Brook at Canton Avenue, Milton	117	6	307	4	172	30
PTB028	Pine Tree Book at Blue Hill Parkway, Milton	128	4	474	4	246	50
PTB035	Pine Tree Brook at Brook Road, Milton	218	5	562	3	311	38
UNB002	Unquity Brook at Randolph Avenue, Milton	309	6	2424	4	704	50
UNB014	Unquity Brook at Adams Street, Milton	109	4	1849	4	449	50
UNB016	Unquity Brook at Squantum Street, Milton	487	6	4491	4	1293	60
NER200	Neponset River at Adams Street Bridge, Milton	179	4	1060	4	436	50
NER215	Neponset river at Granite Avenue, Milton	634	5	648	4	640	33

TABLE 1999 NEPONSET RIVER FECAL COLIFORM DATA				
STATION ID	STATION LOCATION	NO. OF SAMPLES COLLECTED	GEOMETRIC MEAN	% OF SAMPLES > 400 (cfu/100 ml)
PUB022	Purgatory Brook at Rte. 1A, near Everett St., Westwood	4	257	25
NER125	Neponset River at Dedham St. Bridge, Canton	4	164	0
PEB008	Pecunit Brook at Elm St., Canton	4	90	0
POB024	Ponkapoag Brook at Washington St., Canton	4	15	0
NER150	Neponset River at Paul's Bridge, Milton	3	94	0
MOB001	Mother Brook At Route One Dam, Dedham	4	358	50
NER165	Neponset River at Dana Avenue, Hyde Park/Boston	4	197	25
NER185	Neponset River at Ryan Playground, Mattapan/Boston	4	338	50
PTB028	Pine Tree Brook at Blue Hill Parkway, Milton	4	71	0
PTB035	Pine Tree Brook at Brook Road, Milton	5	125	0
PTB047	Pine Tree Brook at Central Ave., Milton	4	259	25
NER200	Neponset River at Adams Street Bridge, Milton	4	469	50
UNB002	Unquity Brook at Randolph Avenue, Milton	7	972	71
UNB014	Unquity Brook at Adams Street	5	309	40
UNB016	Unquity Brook at Squantum Street, Milton	3	452	67
NER002	Neponset River at Outlet of Crackrock Pond, Walpole	3	7	0
NER040	Neponset River at South St., Walpole	3	185	0
MIB037	Mine Brook at Elm St., Medfield	4	125	25
SMB013	School Meadow Brook at Washington Street, Walpole	4	173	0
SPB016	Spring Brook at Rte. 27, Walpole	4	165	0
NER075	Neponset River at Hollingsworth and Vose Dam, Walpole	4	55	0
MLB024	Mill Brook at inlet of Petee's Pond, Westwood	4	84	25
WIP001	Willett Pond, northern site, Walpole	4	53	0
WIP002	Willett Pond, Southern Site, Walpole	4	17	0
WIP003	Willett Pond, Eastern site, Walpole	4	11	0
GEB020	Germany Brook at inlet of Ellis Pond, Norwood	4	93	0
HAB002	Hawes Brook at Walpole Street, Norwood	4	60	0
HAB006	Hawes Brook at Railroad Bridge/Endean Park, Norwood	3	117	0
HAB010	Hawes Brook at Washington Street, Norwood	3	238	0
NER080	Neponset River at Pleasant St. Bridge, Norwood	4	152	0
MEB001	Meadow Brook at Sunnyside Road, Norwood	4	4086	100
THB020	Traphole Brook at Coney Street, Walpole	4	65	0
BEB013	Beaver Brook at Upland Road, Sharon	4	39	0
MPB009	Massapoag Brook at outlet Lake Massapoag, Sharon	4	101	25
MPB088	Massapoag Brook at Walnut St., Canton	2	-	0
SHB021	Steep Hill Brook, at Central St, & West St., Stoughton	4	69	0
BMB026	Beaver Meadow Brook at Pine St., Canton	4	166	0
PQB040	Pequit Brook at Sherman St., Canton	4	184	25
EAB010	East Branch at Neponset St., Canton	4	188	25

Consistent with the Water Quality Standards for fecal coliform, data are summarized and presented in terms of a geometric mean, which is often used as a measure of central tendency for bacteria data. Review of these data reveal that many of the same segments continuously exceed standards indicating the presence of relatively consistent bacteria sources. These data clearly illustrate the impacts of urbanization on ambient bacteria levels since the more developed areas of the watershed typically have the higher bacteria levels. By contrast, low fecal coliform levels are observed in the less developed subwatersheds (i.e., Mine Brook). These data are useful for estimating the natural background contribution for both dry and wet weather conditions.

The majority of the existing data represent dry weather conditions. These data are valuable for identifying dry weather sources of bacteria such as leaking sewers and illicit sewer connections, but are limited for assessing the overall quality of surface waters because there are also impacts associated with wet weather sources. NepRWA was successful in monitoring four wet weather events during the 1998 sampling season. These data are extremely useful to begin documenting the magnitude of wet weather impacts, and give a more complete assessment of the waterbodies during all weather and flow conditions. To illustrate the relative magnitudes of dry and wet weather bacteria levels, the 1998 data table (originally Table 6 of the "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) provides separate geometric means for dry and wet weather conditions. As expected, the wet weather geometric means are typically significantly greater than the dry weather geometric means reflecting the inputs of wet weather sources such as storm water runoff and the flushing of materials from piped drainage systems.

Also, the 1997 data are particularly informative because they are representative of drought-like conditions when river flows and the pollutant assimilative capacity were very low. Comparison of the 1997 and 1998 dry weather geometric means reveals that, for most stations, the 1997 dry weather geometric means are notably higher than the 1998 dry weather geometric means.

Stream Base Flow and In-Stream Fecal Coliform Levels
The Neponset River Basin fecal coliform data illustrate the relationship between stream base flow quantity and in-stream bacteria concentrations. As stream base flow (flow in stream channel during dry weather conditions) declines bacteria concentrations typically increase. This relationship is due primarily to the fact that stream base flow is composed mostly of ground water flow entering the stream channel.

The very low concentrations of bacteria in ground water due to the natural filtering action of the soil matrix through which ground water flows effectively dilutes bacterial wastes from other sources that may be entering the stream during dry weather conditions. Individual bacteria data collected from the Meadow Brook system in Norwood clearly illustrate this relationship.
Small urbanized watershed systems like Meadow Brook are particularly vulnerable to declining base flows following extended dry weather conditions. In the case of Meadow Brook the highly impervious cover of the watershed and the presence of an antiquated sewer system which carries sanitary sewage and ground water infiltration out of the basin to the MWRA's Deer Island Wastewater Treatment Facility contribute to reduced base flow. The high percentage of impervious cover in the watershed significantly reduces the opportunity for rainwater to percolate into the ground and recharge ground water which in turn recharges stream base flow. Instead much of the rainfall is converted to storm water runoff which quickly passes out of the system.
The importance of maintaining and restoring stream base flow through protecting and enhancing ground water recharge to protect and improve water quality as well as effectively manage municipal storm water will be discussed in the TMDL implementation section of this document.

Identification of Fecal Coliform Bacteria Sources
Largely through the efforts of the NepRWA, the stream teams (citizen monitoring groups active in several subwatersheds of the Neponset River watershed), and MADEP field staff, numerous point and nonpoint sources of fecal contamination have been identified. The following table (originally Table 8 of “Total Maximum Daily Loads of Bacteria for Neponset River Basin” report, 2002) summarizes the river segments impaired due to measured fecal coliform contamination and identifies suspected and known sources. Dry weather sources include leaking sewer pipes, storm water drainage systems (illicit connections of sanitary sewers to storm drains), and failing septic systems. Wet weather sources include storm water runoff and sanitary sewer overflows.

Table : Summary of Fecal Coliform Contamination in the Neponset River Watershed

Location	Known and Suspected Sources
Upper Neponset River	Storm water runoff and failing septic systems and
Hawes and Germany Brooks	Illicit sewer connections, sanitary sewer overflows, and storm water runoff.
East Branch Neponset River, Pequid & Beaver Meadow Brooks	Illicit sewer connections, storm water runoff, and failing septic systems.
Steep Hill Brook	Illicit sewer connections, storm water runoff, and failing septic systems.
Middle Neponset River and Meadow Brook	Leaking sewers, illicit sewer connections, storm water runoff, and failing septic systems.
Traphole Brook	Illicit sewer connections, storm water runoff, and failing septic systems.
Purgatory Brook	Illicit sewer connections, sanitary sewer overflows, storm water runoff, and failing septic systems.
Ponkapoag Brook	Illicit sewer connections, storm water runoff, and failing septic systems.
Lower Neponset River	Illicit sewer connections and storm water runoff.
Mother Brook	Illicit sewer connections and storm water runoff.
Pine Tree Brook	Sanitary sewer overflows, illicit sewer connections, storm water runoff, and failing septic systems.
Neponset River Estuary, Unquity & Gullivers Brooks	Illicit sewer connections, sanitary sewer overflows, storm water runoff, and failing septic systems.

The NepRWA has effectively used its monitoring program to identify bacteria sources and initiate the implementation of necessary controls. For example, the elevated fecal coliform levels in Meadow Brook have been traced to leaking sewers with under-drains that transport sewage to the storm drainage system and to Meadow Brook. Norwood has corrected portions of the faulty sewer system and obtained additional funding to continue repair work.

There are no permitted point source discharges of fecal coliform within the Neponset River Basin. However, a number of nonpoint and non-permitted point pollutant sources do exist. Nonpermitted point sources include piped storm water drainages systems and sanitary sewer overflows. Possible nonpoint sources include, diffuse storm water runoff, leaking sewers, and failing or inadequate septic systems depending on the nature of the discharge to surface waters (discrete or diffuse).

It is difficult to provide accurate quantitative estimates of fecal coliform contributions from the various sources in the Neponset River Basin because many of the sources are diffuse and intermittent, and extremely difficult to monitor or accurately model. Therefore, a general level of quantification according to source category is provided. This approach is suitable for the TMDL analysis because it indicates the magnitude of the sources and illustrates the need for controlling them. Additionally, many of the sources (failing septic systems, leaking sewer pipes, sanitary sewer overflows, and illicit sanitary sewer connections) are prohibited because they indicate a potential health risk and, therefore, must be eliminated. However, estimating the magnitude of overall bacteria loading (the sum of all contributing sources) is achieved for wet and dry conditions using the extensive ambient data available that define baseline conditions.
Leaking sewer pipes, illicit sewer connections, sanitary sewer overflows (SSOs), and failing septic systems represent a direct threat to public health since they result in discharges of partially treated or untreated human wastes to the surrounding environment. Quantifying these sources is extremely speculative without direct monitoring of the source because the magnitude is directly proportional to the volume of the source and its proximity to the surface water. Typical values of fecal coliform in untreated domestic wastewater range from 104 to 106 MPN/100ml.

Illicit sewer connections into storm drains result in direct discharges of sewage via the storm drainage system outfalls. The existence of illicit sewer connections to storm drains is well documented in many urban drainage systems, particularly older systems that may have once been combined. In collecting information to support its Municipal Storm Water NPDES Permit application, the Boston Water and Sewer Commission (BWSC) identified and eliminated fiftyseven illicit connections within the Neponset Basin during 1994 and 1995 (MADEP, 1995).

Since 1997 BWSC has corrected nine illicit connections eliminating an estimated 12,550 gallons per day of sanitary sewage from the storm drainage system and there are two additional illicit connections that have been assigned to a contract for repair (BWSC, 2000). It is probable that numerous other illicit sewer connections exist in storm drainage systems serving the older developed portions of the basin. Monitoring of storm drain outfalls during dry weather is needed to document the presence or absence of sewage in the drainage systems. NepRWA has been active in monitoring storm drain outfalls that has led to the identification of several illicit connections. All communities in the Neponset Basin are subject to the Storm water Phase II Final Rule that will require the development and implementation of an illicit discharge detection and elimination plan.

Storm water runoff is another significant contributor of fecal coliform pollution. During rain events, fecal matter from domestic animals and wildlife are readily transported to surface waters via the storm water drainage systems and/or overland flow. The natural filtering capacity provided by vegetative cover and soils is dramatically reduced as urbanization occurs because of the increase in impervious areas (i.e., streets, parking lots, etc.) in the watershed.

Extensive storm water data have been collected and compiled both locally and nationally in an attempt to characterize the quality of storm water. Bacteria are easily the most variable of storm water pollutants, with concentrations often varying by factors of 10 to 100 during a single storm. The following table (originally Table 9 and 10 of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) summarizes wet weather sampling results of five storm drain outfalls in the Neponset River Basin and provides observed ranges of fecal coliform in storm water from different land uses during two storms monitored in the Wachusett Reservoir.

Table Wet Weather Storm Drain Sampling – Neponset River Basin (1) (MA DEP, 2000)

Land Use Category	Fecal Coliform	Enterococcus	E. Coli
	Organisms / 100 ml		
Residential	< 16 – 25,000	340 – 70,000	<16 – 4,000
Forest/Urban Open	410 – 31,000	2,500 – 45,000	41 – 22,000
Commercial	16 – 5,600	120 – 2,300	<16 – 1,200
Industrial	600 – 3,600	880 – 11,000	130 – 3,000

(1) Grab samples collected for four storms between September 15, 1999 and June 7, 2000.

Table Wachusett Reservoir Storm Water Sampling MDC-CDM Wachusett Storm Water Study (June 1997)

Land Use Category	Fecal Coliform Bacteria (1) Organisms / 100 ml
Agriculture, Storm 1	110 - 21,200
Agriculture, Storm 2	200 - 56,400
"Pristine" (not developed, forest), Storm 1	0 - 51
"Pristine" (not developed, forest), Storm 2	8 - 766
High Density Residential (not sewered, on septic systems), Storm 1	30 - 29,600
High Density Residential (not sewered, on septic systems), Storm 2	430 - 122,000

Considering this variability, storm water bacteria concentrations are difficult to accurately predict. Caution must be exercised when using values from single wet weather grab samples to estimate the magnitude of bacteria loading because it is often unknown whether the sample is representative of the "true" mean. To gain an understanding of the magnitude of bacterial loading from storm water and avoid overestimating or underestimating bacteria loading, event mean concentrations (EMC) are often used. Typical storm water event mean densities for various indicator bacteria are provided in the following tables (originally Table 11 and 12 of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002). These EMCs illustrate that storm water bacteria concentrations from certain land uses (i.e., residential) are typically at levels sufficient to cause water quality problems.

NepRWA has begun to quantify the magnitude and extent of fecal contamination in the Neponset Basin during wet weather conditions. With the exception of two sampling stations, Mine Brook (MIB060) and the Neponset River at Hollingsworth and Vose (NER075), excessive levels of fecal coliform were observed at all stations highlighting the need for improved storm water management. The extent of urbanized land cover in the Neponset Basin in conjunction with the fecal coliform EMCs in the following tables (originally Tables 11 and 12 respectively of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002), supports the assertions that storm water runoff is a significant cause contributing to the non-attainment of designated uses, and that reductions of wet weather bacteria sources are warranted. However, since wet weather data in the Neponset Basin remains limited, a progressive implementation of the TMDL is proposed to address wet weather bacteria sources. This approach requires estimating the pollutant reductions necessary to meet water quality standards using the best available information and allows controls to be implemented while additional data are collected.

Table: Storm Water Event Mean Bacteria Concentrations (2)
The Lower Basin of the Charles River

Land Use Category	Fecal Coliform Bacteria (Organisms / 100 ml)	Enterococcus Bacteria (Organisms / 100 ml)
Single Family Residential	2,845 – 93,950	5,456 – 86,679
Multifamily Residential	2,185 – 30,624	3,176 – 49,405
Commercial	682 – 27,670	2,134 – 35,489

(2) Event Mean Densities for eight storms sampled during 2000 by USGS.

Table: Storm Water Event Mean Fecal Coliform Concentrations (3)

Land Use Category	Fecal Coliform Bacteria (3) Organisms / 100 ml
Single Family Residential	37,000
Multifamily Residential	17,000
Commercial	16,000
Industrial	14,000

(3) Derived from NURP study event mean concentrations and nationwide pollutant buildup data

Septic systems designed, installed and maintained in accordance with 310 CMR 15.000: Title 5, are not significant sources of fecal coliform bacteria. Studies demonstrate that wastewater located four feet below properly functioning septic systems contain on average less than one fecal coliform bacteria organism per 100 ml (Ayres Associates, 1993). Failed or non-conforming septic systems, however, can be a major contributor of fecal coliform to the Neponset River and tributaries. Wastes from failing septic systems enter surface waters either as direct overland flow or via groundwater. Wet weather events typically increase the rate of transport of pollutant loadings from failing septic systems to surface waters because of the wash-off effect from runoff and the increased rate of groundwater recharge.

TMDL Information

Pathogen (MA73-20)

Total Maximum Daily Load Development

Section 303 (d) of the Federal Clean Water Act (CWA) requires states to place water bodies that do not meet the water quality standards on a list of impaired waterbodies. The CWA requires each state to establish Total Maximum Daily Loads (TMDLs) for listed waters and the pollutant contributing to the impairment(s). TMDLs determine the amount of a pollutant that a waterbody can safely assimilate without violating the water quality standards. Both point and nonpoint pollution sources are accounted for in a TMDL analysis. Point sources of pollution (those discharges from discrete pipes or conveyances) receive a wasteload allocation (WLA) specifying the amount of pollutant each point source can release to the waterbody. Nonpoint sources of pollution (all sources of pollution other than point) receive a load allocation (LA) specifying the amount of a pollutant that can be released to the waterbody by this source. In accordance with the CWA, a TMDL must account for seasonal variations and a margin of safety, which accounts for any lack of knowledge concerning the relationship between effluent limitations and water quality. Thus:

TMDL = WLAs + LAs + Margin of Safety
Where:
WLA = Waste Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future point source of pollution.
LA = Load Allocation which is the portion of the receiving water's loading capacity that is allocated to each existing and future nonpoint source of pollution.

FECAL COLIFORM TMDL

Loading Capacity

The pollutant loading that a waterbody can safely assimilate is expressed as either mass-per-time, toxicity or some other appropriate measure (40 C.F.R. § 130.2(i)). Typically, TMDLs are expressed as total maximum daily loads. However, MADEP believes it is appropriate to express bacteria TMDLs in terms of concentration because the fecal coliform standard is also expressed in terms of the concentration of organisms per 100 ml. Since source concentrations may not be directly added, the previous equation does not apply. To ensure attainment with Massachusetts' water quality standards for bacteria, all sources (at their point of discharge to the receiving water) must be equal to or less than the standard. Expressing the TMDL in terms of daily loads is difficult to interpret given the very high numbers of bacteria and the magnitude of the allowable load is dependent on flow conditions and, therefore, will vary as flow rates change. For example, a very high number of bacteria are allowable if the volume of water that transports the bacteria is high too. Conversely, a relatively low number of bacteria may exceed water quality standard if flow rates are low. For all the above reasons the TMDL is simply set equal to the standard and may be expressed as follows:

TMDL = Fecal Coliform Standard = WLA(p1) = LA(n1) = WLA(p2) = etc.
Where:
WLA(p1) = allowable concentration for point source category (1)
LA(n1) = allowable concentration for nonpoint source category (1)
WLA(p2) = allowable concentration for point source category (2) etc.

For Class B surface waters the fecal coliform TMDL includes two components: (1) the geometric mean of a representative set of fecal coliform samples shall not exceed 200 organisms per 100 ml; and (2) no more than 10 % of the samples shall exceed 400 organisms per 100 ml. For Class SB surface Waters the fecal coliform TMDL is more restrictive to protect the shellfish use goal and also includes two components: (1) the geometric mean of a representative set of fecal coliform samples shall not exceed 88 organisms per 100 ml; and (2) no more than 10 % of the samples shall exceed 260 organisms per 100 ml.

The goal to attain water quality standards at the point of discharge is environmentally protective, and offers a practical means to identify and evaluate the effectiveness of control measures. In addition, this approach establishes clear objectives that can be easily understood by the public and individuals responsible for monitoring activities. Also, the goal of attaining standards at the point of discharge minimizes human health risks associated with exposure to pathogens because it does not consider losses due to die-off and settling that are known to occur.

Wasteload Allocations (WLAs) and Load Allocations (LAs)

Although, there are no permitted discharges of fecal coliform into the Neponset River and its tributaries, direct storm water discharges from numerous storm drainage systems occur. Piped discharges are, by definition, point sources regardless of whether they are currently subject to the requirements of NPDES permits. Therefore, a WLA set equal to the fecal coliform standard will be assigned to the portion of the storm water that discharges to surface waters via storm drains.

WLAs and LAs are identified for all known source categories including both dry and wet weather sources for Class B and SB segments within the Neponset River Basin. Establishing WLAs and LAs that only address dry weather bacteria sources would not ensure attainment of standards because of the significant contribution of wet weather bacteria sources to fecal coliform criteria exceedences. Illicit sewer connections and deteriorating sewers leaking to storm drainage systems represent the primary dry weather point sources of bacteria, while failing septic systems and possibly leaking sewer lines represent the nonpoint sources. Wet weather point sources include discharges from storm water drainage systems, sanitary sewer overflows (SSOs) and, until recently, combined sewer overflows (CSOs). Wet weather nonpoint sources primarily include diffuse storm water runoff.

The following table (originally Table 13 of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002) presents the fecal coliform bacteria WLAs and LAs for the various source categories. Source categories representing discharges of untreated sanitary sewage to receiving waters are prohibited, and therefore, assigned WLAs and LAs equal to zero. There are two sets of WLAs and LAs, one for Class B waters and the other for Class SB waters. The WLA and LA for storm water discharging to the lower fresh water portion of the Neponset River (Boston, Milton and Quincy) is set equal to the fecal coliform standard for SB waters in order to ensure that standards for restricted shellfish harvesting are met in the estuary.

Fecal Coliform Waste Load Allocations (WLAs) and Load Allocations (LAs) for the Neponset River and Identified Tributary Streams

Surface Water Classification	Bacteria Source Category	WLA (organisms per 100 ml)	LA (organisms per 100 ml)
B	Illicit Discharges to Storm Drains	0	N/A
B	Leaking Sanitary Sewers	0	0
B	Failing Septic Systems	N/A	0
B	Storm Water Runoff	GM $\leq$ 200 90% $\leq$ 400	GM $\leq$ 200 90% $\leq$ 400
B	Sanitary Sewer Overflows	0	0
SB	Illicit Discharges to Storm Drains	0	N/A
SB	Failing Septic Systems	N/A	0
SB	Storm Water Runoff (Boston, Milton and Quincy)	GM $\leq$ 88 90% $\leq$ 260	GM $\leq$ 88 90% $\leq$ 260
SB	Sanitary Sewer Overflows	0	0
SB	Combined Sewer Overflows	0	N/A

GM means geometric mean
N/A means not applicable

The TMDL should provide a discussion of the magnitudes of the pollutant reductions needed to attain the goals of the TMDL. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For the illicit sources, the goal is complete elimination (100% reduction). However, overall wet weather bacteria load reductions can be estimated using typical storm water bacteria concentrations, and the magnitude of the wet weather data observed in the Neponset Basin. This information indicates that two to three orders of magnitude (99 to 99.9%) reductions in storm water fecal coliform loadings will be necessary, especially in the developed areas draining to small tributaries.

In addition, overall reductions needed to attain water quality standards can be estimated using the extensive ambient fecal coliform data that are available from the Neponset Basin. Using ambient data is beneficial because it provides more realistic estimates of existing conditions and the magnitude of cumulative loading to the surface waters. Reductions are calculated using data from both wet weather conditions and combined wet and dry conditions and are presented in the following table (originally Table 14 of "Total Maximum Daily Loads of Bacteria for Neponset River Basin" report, 2002). Data from 1998 are used since it includes the greatest number of observations at a given location and includes the most wet weather observations. Examining wet weather data separately provides estimates of the magnitude of reductions from all sources during wet weather conditions. As indicated before, bacteria reductions of one to two orders of magnitude are needed to attain water quality standards. For example, when viewing the data in the table below at station MEB001 it would take a 98.9% reduction in fecal coliform during wet weather conditions to meet water quality standards. The 90% observation listed in the table means that 90% of the samples collected at that station fall below the value of 35,000 organisms per 100 ml. That value would have to be reduced to 400 organisms per 100 ml to meet water quality standards criteria (or stated another way a reduction of 98.9 % would be necessary).

Table: Estimates of Fecal Coliform Loading Reductions to the Neponset River and Tributaries			
Station	**MEB001**	**UNB002**	**NER185**
Wet Weather Geo. Mean	9813	2424	1202
% reduction (1)	**98**	**92**	**83**
Overall Geo. Mean	8,400	704	822
% reduction (1)	**98**	**72**	**76**
90 % observation	35,000	3,500	58,000
% reduction (2)	**98.9**	**88.6**	**99.3**

(1) Geometric mean to be less than or equal to 200 organisms per 100 ml.
(2) No more than 10 % of the samples shall exceed 400 organisms per 100 ml.

Margin of Safety

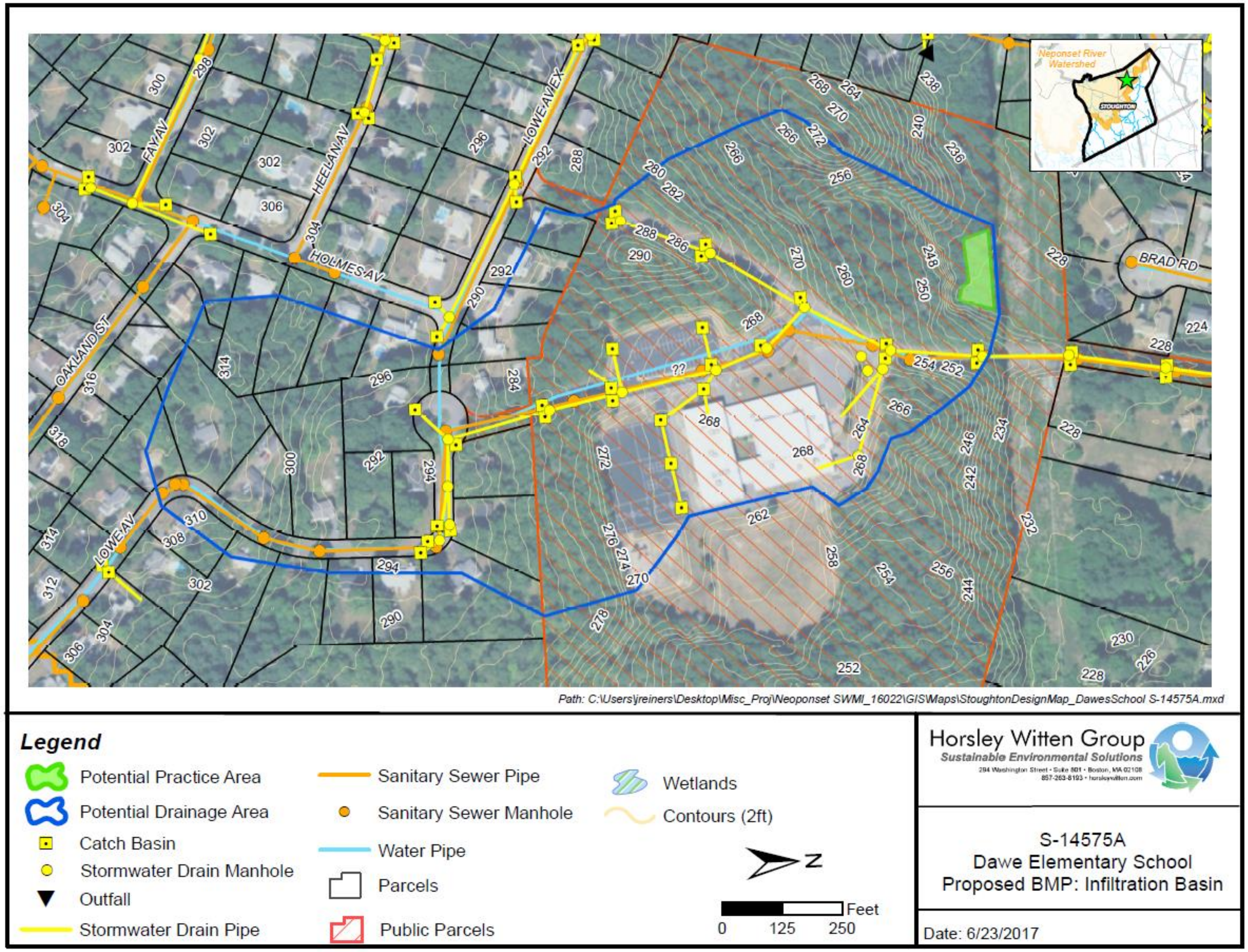
For this analysis, margin of safety is implied. First, the TMDL does not account for mixing in the receiving waters and assumes that zero dilution is available. Realistically, influent water will mix with the receiving water and become diluted provided that the influent water concentration does not exceed the TMDL concentration. Second, the goal of attaining standards at the point of discharge does not account for losses due to die-off and settling that are known to occur.

Seasonal Variability

TMDLs must also account for seasonal variability. This TMDL has set WLAs and LAs for all known and suspected source categories equal to the fecal coliform criteria independent of seasonal conditions. This will ensure the attainment of water quality standards regardless of seasonal and climatic conditions. Any controls that are necessary will be in place throughout the year, and, therefore, will be protective of water quality year-round.

Appendix B – Proposed BMPs (Town of Stoughton, 2018)

Proposed BMP Locus Map



Proposed BMP Drainage Area

Dawe Elementary School — Infiltration Basin

Site Description

The wooded parcel chosen for this retrofit site is located off of North School Drive, and is part of the Joseph R. Dawe Jr. Elementary School property. Currently, runoff from the existing 25-acre drainage area is piped through a series of catch basins and manholes located in North School Drive. The drainage area includes approximately 6.5 acres of impervious area.

The existing soil at the site consists of fine loamy sand and large boulders. Both soil test pits at this site were excavated to 10-feet with no groundwater observed.

Proposed Concepts

The proposed retrofit includes directing the first 1 inch of runoff from impervious surfaces in the upgradient drainage area to an existing wooded depression for infiltration and water quality treatment. The retrofit involves installing a diversion manhole in North School Drive to direct the smaller water quality rain event through a proprietary stormwater pre-treatment unit and a small sediment forebay before discharging to the existing wooded depression. Larger flows would bypass the infiltration area and continue in the existing drainage network. A berm would be constructed on the north side of the depression adjacent to the existing utility easement to create the necessary storage. All work is proposed outside the utility easement. A proposed emergency overflow spillway is provided in the berm to alleviate unforeseen conditions. The majority of the depression has been left undisturbed to create a more natural infiltration area.

A crushed granite walking path is provided along the top of the berm for inspection and maintenance purposes, and as a possible location for educational outreach to the community or the neighboring Dawe Elementary School.

Practice Sizing/Design Considerations

The natural infiltration area is designed to collect the first inch of runoff from the 6.5 acres is impervious cover in the drainage area, which is approximately 25 acres. The water quality volume is estimated to be 24,000 cubic feet. The berm on the natural infiltration area ranges from 1 to 5 feet in height to hold the water quality volume.

Pollutant Removal

The majority of the infiltration area will be natural woodland, which will also allow for attenuation of total nitrogen (TN), total phosphorus (TP) and bacteria in the topsoil and subsoil. The potential pollutant reductions for an infiltration basin are 50-60% of TN, 60-70% of TP, 80% of total suspended solids (TSS) (includes pretreatment) (Massachusetts Stormwater Handbook (2008)), and 95% of bacteria (Rhode Island Stormwater Design and Installation Standards Manual (RI Manual),2015). The pretreatment proprietary stormwater units are typically designed to remove 80% to 90% of the TSS.

Maintenance Considerations

Infiltration basins are expected to have monthly and semi-annual maintenance. The pretreatment unit should be inspected and clean every other month and after every major storm event. During the first few months of operation, the infiltration basin should be inspected after every major storm to ensure it is stabilized and functioning properly. At least twice a year, the buffer area, side slopes and basin bottom should be mowed and all trash and debris should be removed along with grass clippings and accumulated organic matter.

Proposed BMP Project Description (page 1 of 3)

Project costs

The construction of this site is expected to cost approximately $95,700. An additional $41,000 has been added to include an estimated 12% fee for final engineering design and permitting and a 30% contingency. Long-term annual operation and maintenance costs are likely to be about 3% of the construction costs, or $3,000 annually.

Next steps

- Obtain feedback from relevant Town departments and the school;
- Discuss operations and maintenance changes by converting the catch basins to manholes;
- Consider a potential partnership with the school and/or local residents to implement and/or maintain the practice;
- Investigate the slope on the upgradient side of the infiltration basin to determine if stabilization is necessary;
- Identify tree species in location of proposed infiltration basin to determine extent of clearing needed;
- Advance the engineering design for permitting and construction; and
- Develop educational programs for the school to help learn about stormwater and the benefits of stormwater practices.

Retrofit ID	Drainage Area (ac)	% Impervious	Design Treatment Volume (cf)[a]	Practice Area Required (sf)[b]	Practice Area Available (sf)[c]
Infiltration Basin	25	27	24,290	8,100	8,300

a) Design Water Quality Volume: V_{WQ} (cf) = (1 inches)(A_{IMP})/(12 inches/foot), where A_{IMP} = Impervious Area (in square feet)

b) Practice Area Required is calculated based on practice-specific design assumptions.

c) Practice Area Available is estimated from available mapping with limited field verification. Actual practice area may be adjusted as needed during pre-construction.

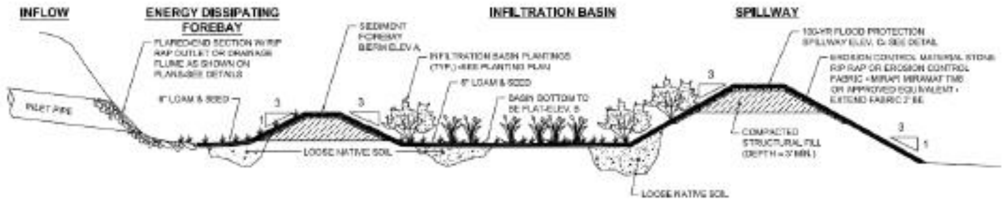
Site Photos

Existing depression in wooded area (proposed infiltration basin location)

North School Drive (Approximate Location of Diversion Manhole)

Proposed BMP Project Description (page 2 of 3)

Typical Infiltration Basin Detail



TYPICAL SECTION THROUGH INFILTRATION BASIN
NOT TO SCALE

Example of an Infiltration Basin

Appendix C – 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			