MASSACHUSETTS
watershed·based plans

WATERSHED-BASED PLAN

Spicket River Watershed

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Prepared For:

MassDEP
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Contents

Executive Summary

Introduction: The purpose of a Massachusetts Watershed-Based Plan (WBP)[1] 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 the Merrimack River Watershed Council with funding, input, and collaboration with the Massachusetts Department of Environmental Protection (MassDEP). As described in the Introduction, the following project partners and stakeholders met monthly and contributed to the WBP throughout the project: Groundwork Lawrence, Merrimack Valley Planning Commission (MVPC), City of Lawrence, City of Methuen, and Tighe & Bond.

The Spicket River is an 18-mile-long tributary of the Merrimack River, originating in Big Island Pond, New Hampshire, and ending in Lawrence, Massachusetts. The upper portion of the 74.5 square mile watershed is primarily rural, while the lower portion, which includes Lawrence, MA and Methuen, MA, is heavily urbanized. In 2013, the Spicket River Greenway, a 3.5 mile long "emerald bracelet", was opened to help improve river restoration and neighborhood revitalization. This plan intends to continue the work already invested in revitalizing the Spicket River as a natural resource in two of Massachusetts' prominent gateway cities.

Impairments and Pollution Sources:

Goals, Management Measures, and Funding: The primary goal of this WBP is to document the water quality of the Spicket River, analyze the data we collect to determine the source of pathogens and nutrients and understand the health of the system, and ultimately propose nature-based solutions to improve overall water quality in the system. The impacts of these efforts on the people and ecosystems within the Spicket River Watershed will be shared and expanded upon through education and outreach.

Public Education and Outreach: Public Education and Outreach are focused on assessing public perceptions of the Spicket River, including links between perceptions of attractiveness or how natural the Spicket River appears. A survey measured perceptions of the ecological state of the river and assessed resident's perceptions about flood protection or restoration needs. Several tabling events occurred to engage residents about the Watershed-Based Plan, both seeking input and answering questions about the goals and opportunities of the plan. Five videos about the Spicket River Watershed were produced and released on social media, and three articles on the plan were published in The Rambo, Eagle Tribune, Groundwork Lawrence's newsletter, and the Merrimack Valley Planning Commission's Newsletter. Two public meetings with the plan's resident-based Advisory Committee occurred to discuss the plan and gather community input to better the plan.

Implementation Schedule and Evaluation Criteria: Project activities will be implemented based on information from water quality monitoring, public education and outreach, land use and nutrient loading calculations, and implementation of BMPs. It is expected that continuous water quality monitoring will be used to evaluate improvements from BMPs over time, as well as establish concrete long-term load reduction goals. The overall goal of this WBP is to de-list this section of the Spicket River from the 303(d) list. The WBP will be re-evaluated and adjusted, as needed, once every five years.

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[1] The Massachusetts Watershed Based Plans tool is publicly available at this URL: https://prj.geosyntec.com/MassDEPWBP

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 the information in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency's (EPA'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 WBPs only for selected watersheds. Massachusetts Department of Environmental Protection's (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.

EPA 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 includes nine elements (a through i) in accordance with EPA Guidelines:

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

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

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

d) An **estimate of the amounts of technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, United States Department of Agriculture's (USDA'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 toward attaining water quality standards and, if not, the criteria for determining whether this WBP needs to be revised or, if a NPS total maximum daily load (TMDL) has been established, whether the TMDL needs to be revised.

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

Project Partners and Stakeholder Input

This WBP was developed by the Merrimack River Watershed Council (MRWC) with funding, input, and collaboration from the City of Methuen and Lawrence, Groundwork Lawrence, Tighe & Bond, and the Merrimack Valley Planning Commission (MVPC) and the Massachusetts Bays National Estuary Partnership (MassBays), using funds from EPA grant number 00A01085-0. Additionally, local residents were surveyed on their perception and knowledge of the Spicket River to identify concerns within the community and determine priority issues that the team of stakeholders could focus on (the survey is discussed in greater detail in Element E and the results are in Appendix C). This WBP was developed using funds from MassDEP's Section 604(b) grant program to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool.

Core project stakeholders included:

- Becky Zawalski, Water Quality Project Manager – Merrimack River Watershed Council (MRWC)
- Jose Tapia, Program Associate for Urban Resilience – Merrimack River Watershed Councill (MRWC)
- Susie Bresney, Massachusetts Water Resources Project Manager (Former) – Merrimack River Watershed Council (MRWC)
- Matthew Cranney, Massachusetts Water Resources Project Manager (Current) – Merrimack River Watershed Council (MRWC)
- Lauren Zielinski, New Hampshire Water Resources Project Manager (Former) – Merrimack River Watershed Council
- Cecelia Gerstenbacher, Environmental Program Manager – Merrimack Valley Planning Commission (MVPC)
- Mikayla Minor, GIS Analyst - Merrimack Valley Planning Commission (MVPC)
- Tennis Lilly, Climate Resiliency Program Manager – Groundwork Lawrence
- Brad Buschur, Project Director – Groundwork Lawrence
- Emily Scerbo, Vice President – Tighe & Bond
- Kayla Larson, Project Manager – Tighe & Bond
- Joe Cosgrove, Environmental Planner – City of Methuen
- William Hale, Water Commissioner – Lawrence Water & Sewer Department
- Daniel Lahiff, Supervisor – Lawrence Water & Sewer Department
- Meghan Selby, 604(b) Grant Coordinator – MassDEP

- Suzanne Flint, Quality Assurance Officer – MassDEP

This WBP is meant to be a living document. It should be reevaluated at least once every five years and adjusted as needed based on ongoing efforts (e.g., based on monitoring results, 319 funding, etc.). It is strongly recommended that a working group including additional stakeholders be established to meet at least biannually to implement and update this WBP, and track progress.

Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's Watershed-Based Plan Tool. Additional data sources were reviewed and are summarized in subsequent sections of the WBP, if relevant, as listed by Table 1.

Table 1: Supplemental Data Sources

Title / Description	Source	Date
Spicket River Water Quality Baseline	Groundwork Lawrence and MRWC	2014
Merrimack River Watershed Assessment Study – Phase III Final Monitoring Data Report	CDM Smith	2016
Water Quality in Bloody Brook and Searles Pond	MRWC	2022

Summary of Past and Ongoing Work

In 1967, the Spicket River was classified as Class C waterbody by the State of Massachusetts, and it was upgraded to a Class B waterbody in 1999 which states that surface waters must be fishable and swimmable. Historically, the Spicket River has struggled with metals, nutrients, and pathogens as pollutants, with pathogens remaining a recurring issue over the last 50 years. This is primarily due to the river's proximity to historically industrial uses and impervious surfaces, which have caused residual leaching and runoff, particularly when regulations were limited surrounding best practices in disposing of industrial waste and mitigating stormwater runoff. The river is still reconciling with this historic use pattern.

Spicket River Water Quality Report (Groundwork Lawrence and MRWC, 2014)

In 2013, Groundwork Lawrence collected data on the Spicket river for eight months for a variety of water quality variables, including phosphates, orthophosphates, nitrates, dissolved oxygen (DO), temperature, total dissolved Solids (TDS), conductivity, turbidity, and pH, while MRWC collected pathogen data with a focus on *E. coli*. After analysis, the Spicket River was shown to struggle with pathogens, as well as have issues with algal growth in certain segments due to an excess of phosphates.

Merrimack River Watershed Assessment Study – Phase III Final Monitoring Data Report (CDM Smith, 2016)

CDM Smith conducted dry weather tributary sampling in July of 2016 for a variety of water quality variables, including 5-day carbonaceous biological oxygen demand, chlorophyll-a, dissolved oxygen concentration and percent, temperature, total nitrogen, ammonia, total phosphorus, orthophosphates, pH, *E. coli*, *Enterococcus*, and fecal coliforms. After analysis, the Spicket River was found to have lower oxygen levels than other tributaries that feed into the Merrimack River; however, they were still within acceptable range and consistent with the Massachusetts standard. The study also found that phosphorus is the limiting nutrient for algal growth in the Spicket River.

Water Quality in Bloody Brook and Searles Pond (MRWC, 2022)

Searles Pond is a part of an 8.7-acre conservation parcel owned by the City of Methuen and is upstream of Bloody Brook, which runs in the front and backyards of residential and business properties in Methuen before going underground and exiting in Lawrence into the Spicket River. During the summer, Searles Pond often suffers from high levels of algal growth, and has also been found to contain high levels of bacteria, well above the Massachusetts standard for safe recreation.

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 Spicket River, a nearly 18-mile-long body of water, originates at Big Island Pond in Atkinson, New Hampshire, and flows through the towns of Hampstead, Derry, and Salem, passing through the Arlington Mill Reservoir and under highway I-93. It crosses into Massachusetts, where it makes its way through Methuen and Lawrence, through several dams and under State Route 213, before emptying into the Merrimack River. Three tributaries flow into the Spicket River: Harris Brook (NH), World End Brook (NH & MA), and Bloody Brook (MA). It flows through the Methuen Rail Trail and the Lawrence Spicket River Greenway, historical districts, and a flood control system near the mouth where it empties into the Merrimack River.

The Spicket River is a critically important resource for the Gateway cities of Methuen and Lawrence and functions as a wildlife habitat corridor, a recreation amenity, and focal area for the region's early industrial development within dense urban neighborhoods. Despite growing momentum to invest in the river corridor, the river is listed as impaired on the Section 303(d) list for debris, trash, copper, *E. coli,* and nutrients. In the Spicket River Water Quality Baseline Study (2014), 45% of *E. Coli* samples exceeded the MA single sample standard and Total Phosphorus levels exceeded EPA guidelines to control algal growth at 9 stations. High concentrations were linked to rainfall, indicating nonpoint source pollution. Cyanobacteria blooms have led to beach closures at the headwaters of the Spicket; and algae blooms behind dam impoundments are suspected of being cyanobacteria. Finally, and most critically, the Spicket River is a major contributor to pollutant loading in the downstream Merrimack River.

As Environmental Justice communities, Lawrence and Methuen have been historically under-resourced, have low per capita access to greenspace, and their populations carry a disproportionate burden of natural resource neglect. As climate change brings larger rainstorms, and with them, more run-off, the issues along the Spicket River are expected to worsen in an already climate-vulnerable community. This 604(b)-funded project focuses on *E. Coli*, Phosphorous and cyanobacteria monitoring, resulting in a comprehensive watershed-based plan (WBP) for the Spicket River. This project will fill a critical gap in water quality monitoring and will lead to the development of best management practices to improve the water quality of the Spicket, for people and wildlife alike.

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID):	Harris Brook ; Spicket River (MA84A-10) ; World End Brook ; Bloody Brook
Major Basin:	Merrimack
Watershed Area (within MA):	6805.4 (ac)

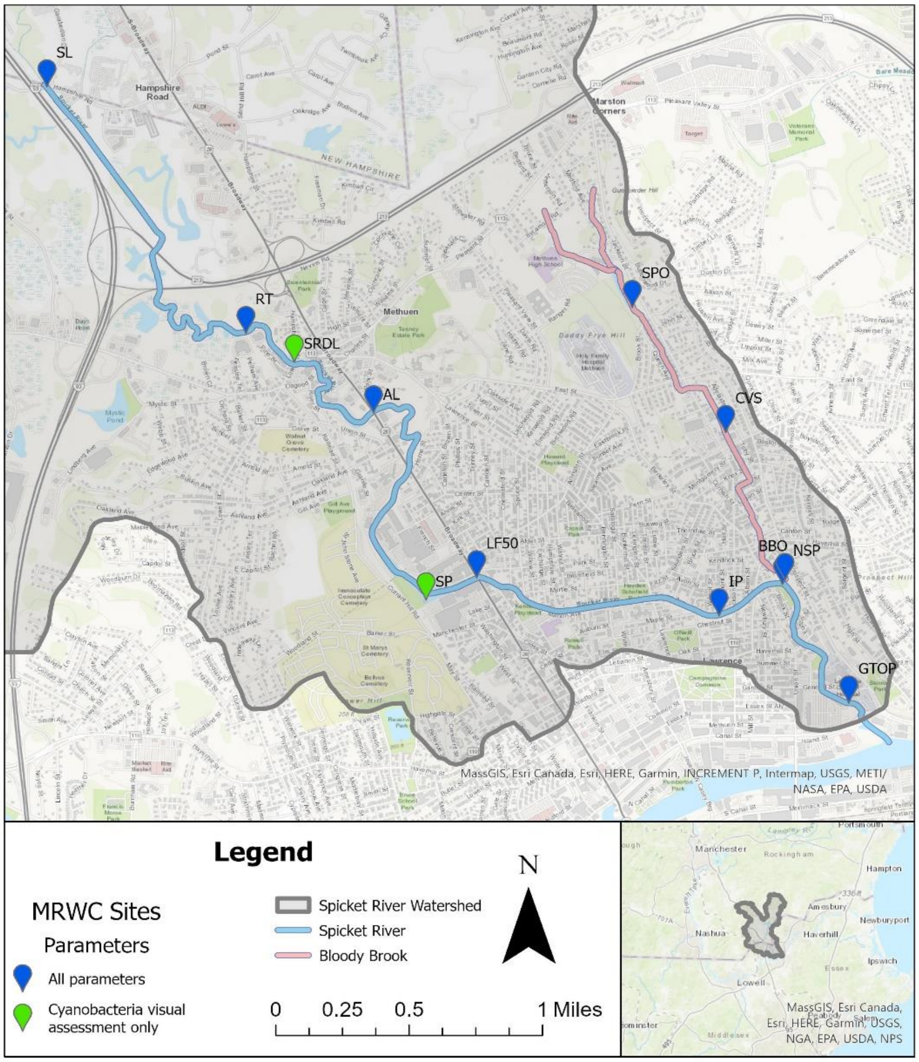

Figure A-1: Spicket River Watershed with MRWC Water Quality Sampling Sites (MRWC)

MassDEP Water Quality Assessment Report and TMDL Review

The following reports are available:

- Draft Pathogen TMDL for the Merrimack River Watershed
- Merrimack River Watershed 2004 Water Quality Assessment Report

The section below summarizes the findings of any available Water Quality Assessment Report and/or TMDL that relate to water quality and water quality impairments. Select excerpts from these documents relating to the water quality in the watershed are included below (note: relevant information is included directly from these documents for informational purposes and has not been modified).

Merrimack River Watershed 2004 Water Quality Assessment Report (MA84A-10 - Spicket River)
In 2004, MA DMF evaluated fish passage in the Merrimack River basin. American Shad has been observed at the mouth of the Spicket River, but the Spicket River Dam obstructs the passage of anadromous fish upstream. In 2003, CDM measured dissolved oxygen, temperature, and pH a total of 12 times and collected five total phosphorus and three chlorophyll-a (phytoplankton) samples at one site (T009) (See Special Note 2). Dissolved oxygen and pH measurements were slightly low on one occasion each. The total phosphorus concentrations ranged from 0.049 to 0.360 mg/L and the chlorophyll-a concentrations ranged from 0.7 to 7.4 ug/L. The Aquatic Life Use is not assessed (too limited data). An Alert Status is identified for this use due to elevated total phosphorus concentrations and the barrier to fish migration. 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 4). In 2003, CDM collected E. coli samples at one site (T009) (See Special Note 1). The geometric mean of the samples collected during the primary contact season was 9404 CFU/100ml. Based on this result violating the geometric mean criterion (126 CFU/100ml) for E. coli, the Primary Contact Recreational Use is assessed as impaired. Cause(s) of Impairment: Escherichia coli Source(s) of Impairment: Unspecified urban stormwater, Source Unknown In 2003, CDM collected E. coli samples at one site (T009) (See Special Note 1). The geometric mean of the samples was 9404 CFU/100ml. Based on this result violating the geometric mean criterion (630 CFU/100ml) for E. coli, the Secondary Contact Recreational Use is assessed as impaired. Cause(s) of Impairment: Escherichia coli Source(s) of Impairment: Unspecified urban stormwater, Source Unknown Insufficient data were available to assess the Aesthetics Use. **Report Recommendations:** Conduct additional bacteria monitoring to characterize the impairment and identify unknown sources. Conduct biological (macroinvertebrates) monitoring to evaluate the Aquatic Life Use. Conduct dissolved oxygen monitoring to evaluate diurnal variation

Additional Water Quality Data

Water quality sampling done on the Spicket River in 2014 by MRWC and 2016 by CDM Smith included sampling locations in Lawrence at Dr. Nina Scarito Park (NSP), and near the Greenway Trail at Oxford Park (GTOP), both of which were also monitored in 2022 and 2023. Results from prior studies showed elevated concentrations of pathogens and total phosphorus at certain times of the year. The water quality sampling done on Bloody Brook in 2022 included sampling locations at the outfall of Searles Pond (SPO), CVS (both in Methuen), and Bloody Brook Outfall (BBO) to the Spicket (in Lawrence) as part of an EOEEA Municipal Vulnerability Preparedness grant-funded project. Results from the prior study showed that SPO had the fewest unsafe levels of bacteria while BBO had the most unsafe levels, so SPO and CVS site locations were added to the 2023 study.

In the latest 2023 study, it was found that SPO had significantly higher total phosphorus levels than any other site monitored on the Spicket River or Bloody Brook. It was well over the state limit of 0.5 mg/L, as was the site at CVS, though it is worth it to note that while still high at the CVS location, the concentration of total phosphorus was significantly lower than Searles Pond most of the time. Samples collected at BBO were only able to be collected once in the 2023 monitoring season due to heavy rains making the site nearly inaccessible and dangerous for sample collection. However, on that one collection date, lab test showed nearly half the level of total phosphorus than at SPO and well below the EPA limit of safety. On average, total phosphorus shows to be highest in the middle of the summer, followed by the start of fall. Mid-autumn had the lowest amount of phosphorus during the course of this study.

Water Quality Data Gaps

Bloody Brook was a concern to us based on these data, as well as the fact that little information and data is known and available about the brook from where it goes underground at the CVS location and exits into the Spicket River at the BBO. Because testing was sporadic based on weather and safety concerns, more investigation is needed to determine the cause of the impairments and when it is most prevalent in the river.

Data from the 2023 study can be found in Appendix B and on MRWC's website.

Water Quality Impairments

Known water quality impairments, as documented in the Massachusetts Department of Environmental Protection (MassDEP) 2018/2020 Massachusetts Integrated List of Waters (MassDEP, 2021), are listed below. Impairment categories from the Integrated List are as follows:

Table A-2: 2018/2020 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-3: Water Quality Impairments (MassDEP 2021)
for Spicket River (MA84A-10, Integrated List Category 5)

Designated Use	Impairment Cause	Impairment Source
Aesthetic	Debris	Unspecified Urban Stormwater
	Trash	Unspecified Urban Stormwater
Fish Consumption	Ddt In Fish Tissue	Source Unknown
	Mercury In Fish Tissue	Source Unknown
Fish, other Aquatic Life and Wildlife	Benthic Macroinvertebrates	Channelization
	Benthic Macroinvertebrates	Loss Of Riparian Habitat
	Benthic Macroinvertebrates	Municipal Point Source Discharges

Designated Use	Impairment Cause	Impairment Source
	Benthic Macroinvertebrates	Unspecified Urban Stormwater
	Copper	Combined Sewer Overflows
	Copper	Unspecified Urban Stormwater
	Fish Passage Barrier	Dam Or Impoundment
	Nutrients	Combined Sewer Overflows
	Nutrients	Unspecified Urban Stormwater
	Physical Substrate Habitat Alterations	Channelization
	Physical Substrate Habitat Alterations	Loss Of Riparian Habitat
	Physical Substrate Habitat Alterations	Unspecified Urban Stormwater
Primary Contact Recreation	Debris	Unspecified Urban Stormwater
	Escherichia Coli (e. Coli)	Combined Sewer Overflows
	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
	Escherichia Coli (e. Coli)	Source Unknown
	Trash	Unspecified Urban Stormwater
Secondary Contact Recreation	Debris	Unspecified Urban Stormwater
	Escherichia Coli (e. Coli)	Combined Sewer Overflows
	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
	Escherichia Coli (e. Coli)	Source Unknown
	Trash	Unspecified Urban Stormwater

Pollutants are found in more urbanized areas of the watershed, of which the Massachusetts portion is mostly comprised. While non-point sources most likely come from the large amount of impervious surfaces within the watershed and can contributed to stormwater runoff, point source pollutants can come from Combined Sewer Overflows (CSOs). Fertilizers are suspected to be the highest contributor to high phosphorus concentrations. High pollutant loadings can be found in Element B.

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) or 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 (314 CMR 4.00, 2013) prescribe the minimum water quality criteria required to sustain a waterbody's designated uses. This watershed is a Class 'B' waterbody. The water quality goal for fecal coliform bacteria is based on the Massachusetts Surface Water Quality Standards.

Table A-4: Surface Water Quality Classification by Assessment Unit

Assessment Unit ID	Waterbody	Class
MA84A-10	Spicket River	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.).

Table A-5: Water Quality Goals

Pollutant	Goal	Source
Total Phosphorus (TP)	Total phosphorus should not exceed: --50 ug/L in any stream --25 ug/L within any lake or reservoir	Quality Criteria for Water (USEPA, 1986)
Bacteria	**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)

Note: *There may be more than one water quality goal for bacteria due to different Massachusetts Surface Water Quality Standards Classes for different Assessment Units within the watershed.*

Land Use and Impervious Cover Information

Land use information and impervious cover for Lawrence and Methuen is presented in the tables and figures below. The information compiled in 2016 differs in methodology from the 2005 data referenced in the previous plan and makes comparisons between the two datasets challenging. The 2005 Land Use Data was developed based on aerial photography interpreted by the University of Massachusetts Department of Forest Resources. The data are organized into several use categories: Forest, Residential, Commercial, and industrial, Agricultural, Wetlands and Water, Transportation, and Other.

The 2016 Land Use Dataset however was developed through a combination of the NOAA Coastal Change Analysis Program raster data procured nationally, multispectral satellite imagery, and lidar-based terrain elevation data to arrive at a new 19 class raster dataset. Not only does it describe more detailed land cover categories due to changes in interpretation and imagery resolution, but it also utilizes the recently created Statewide Parcel layer and associated DOR land use codes to intersect the land cover polygons based on the use code derived from the parcels. MVPC used the land use and land cover categories separately to create the community profile for each community due to the inability to recreate the categories of 2005 and the tendency to count land in the incorrect groupings when a compatibility crosswalk was created to reconcile the two.

Watershed Land Uses

Table A-6: Massachusetts Watershed Land Uses / Land Cover[1]

Land Use (ac)	Agriculture	Commercial	Industrial	Low Density Residential	Medium Density Residential	High Density Residential	ROW	Tax Exempt / Open Land	Water	Total Acres
Lawrence	0.00	59.27	40.89	78.97	6.19	329.18	211.01	309.94	15.83	1051.28
Methuen	64.61	383.25	194.32	2032.16	80.68	413.05	808.8	1767.05	93.41	5837.32
Land Cover (ac)	**Cultivated**	**Impervious**	**Forest**	**Residential**	**Open Land**	**Water**	**Wetland**	**Total Acres**	**% of Watershed**	
Lawrence	0.00	650.88	210.51	180.24	3.8	5.84	0.00	1051.27	15.26	
Methuen	65.36	1264.15	2883.69	900.37	75.4	104.42	543.96	5837.35	84.74	

Notes:
1) Total Spicket River Watershed measures approximately 6,888.6 acres

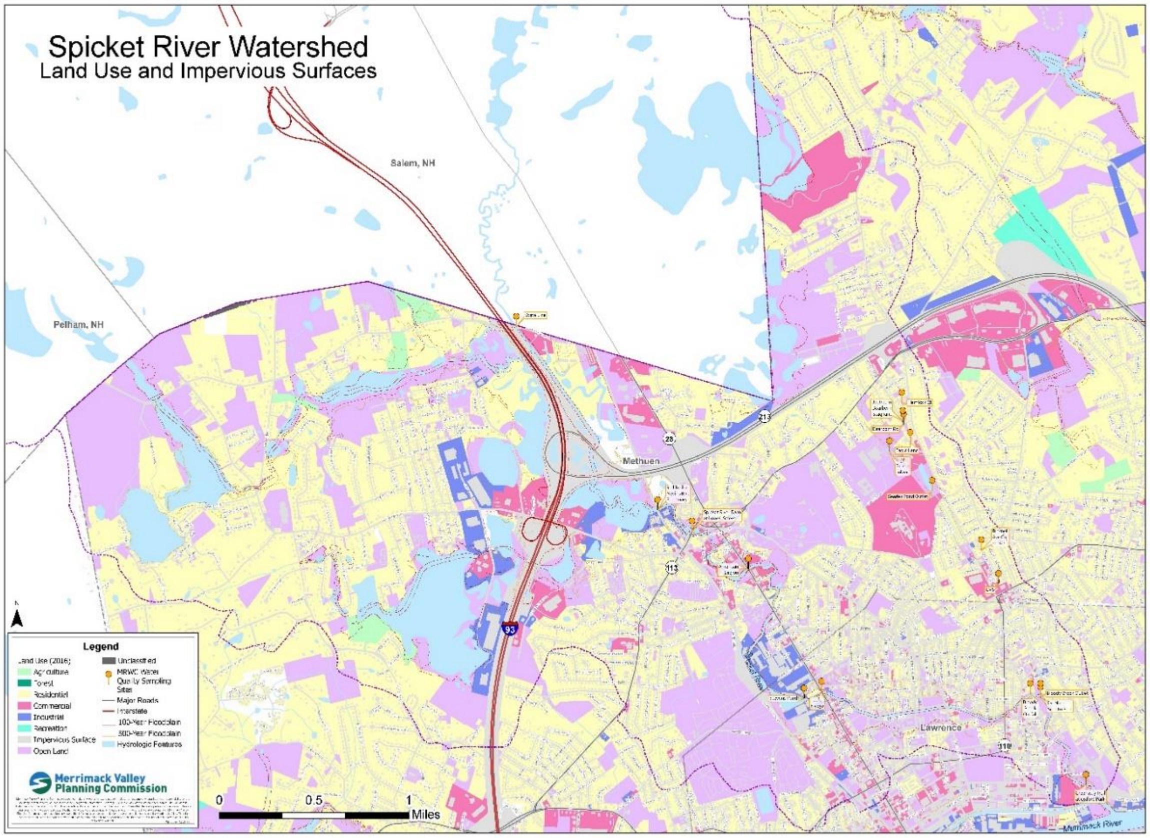

Figure A-2: Spicket River Watershed Land Use Map (MVPC)

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 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, 2016c) on the use of the Sutherland equations to predict relative levels of connection and disconnection based on the type of stormwater infrastructure within the **total impervious area (TIA)** of a watershed. Within each subwatershed, the total area of each land use was summed up and used to calculate the percent TIA.

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

	Estimated TIA (%)	Estimated DCIA (%)
Watershed	28	23.3

(Note: Values generated by Massachusetts Watershed-Based Plan Online Tool)

The relationship between TIA and water quality can generally be categorized as shown in **Table A-8** (Schueler et al. 2009):

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

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

Pollutant Loading

Geographic Information Systems (GIS) was used for the pollutant loading analysis. The land use data (MassGIS, 2009b) was intersected with impervious cover data (MassGIS, 2016) 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) 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 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 Total Nitrogen and Total Phosphorus were obtained from USEPA (USEPA, 2020) (see values provided in Appendix A) **Table A-9** presents the nitrogen loading Rates used to calculate TN, **Table A-10** presents the phosphorus loading rates used to calculate TP, and **Table A-11** presents the updated Phosphorus loading rate constants for the pervious land areas of the watershed based on soil types.

Table A-9: Estimated Pollutant Loading for Total Nitrogen

Nitrogen Source Category by Land Use	Land Surface Cover	Nitrogen Load Export Rate (lbs/ac/yr)	Nitrogen Load Export Rate (kg/ha/yr)
All Impervious Cover	Impervious	14.1	15.8
*Developed Land Pervious (DevPERV) – HSG A	Pervious	0.3	0.3
*Developed Land Pervious (DevPERV) – HSG B	Pervious	1.2	1.3
*Developed Land Pervious (DevPERV) – HSG C	Pervious	2.4	2.7
*Developed Land Pervious (DevPERV) – HSG C/D	Pervious	3.0	3.4
*Developed Land Pervious (DevPERV) – HSG D	Pervious	3.7	4.1

Notes: For pervious areas, if the hydrologic soil group (HSG) is known, use the appropriate value from this table. If the HSG is not known, assume HSG C/D conditions for the nitrogen load export rate.

Table A-10: Estimated Pollutant Loading for Total Phosphorus

Phosphorus Source Category by Land Use	Land Surface Cover	P Load Export Rate (lb/ac/yr)
Commercial and Industrial	Directly connected impervious	1.78
	Pervious	See*DevPERV
Multi-Family and High Density Residential	Directly connected impervious	2.32
	Pervious	See*DevPERV
Medium Density Residential	Directly connected impervious	1.96
	Pervious	See*DevPERV
Low Density Residential – “Rural”	Directly connected impervious	1.52
	Pervious	See*DevPERV
Highway	Directly connected impervious	1.95^
	Pervious	See*DevPERV
Forest	Directly connected impervious	1.52
	Pervious	0.13
Open Land	Directly connected impervious	1.52
	Pervious	See*DevPERV
Agriculture	Directly connected impervious	1.52
	Pervious	0.45

Phosphorus Source Category by Land Use	Land Surface Cover	P Load Export Rate (lb/ac/yr)
*Developed Land Pervious (DevPERV) – Hydrologic Soil Group A	Pervious	0.03
*Developed Land Pervious (DevPERV) – Hydrologic Soil Group B	Pervious	0.12
*Developed Land Pervious (DevPERV) – Hydrologic Soil Group C	Pervious	0.21
*Developed Land Pervious (DevPERV) – Hydrologic Soil Group D	Pervious	0.37

Table A-11: Estimated Pollutant Loading for Total Phosphorus based on Hydrological Soil Group

P Land Use Code Description	P Loading Export Rate (lb/ac/yr)				
	Pervious Area Soil Type				
	HSG A	HSG B	HSG C	HSG C/D	HSG D
Commercial	0.04	0.18	0.36	0.46	0.54
Industrial	0.04	0.18	0.36	0.46	0.54
High Density Residential	0.04	0.18	0.36	0.46	0.54
Medium Density Residential	0.04	0.18	0.36	0.46	0.54
Highway	0.04	0.18	0.36	0.46	0.54
Forest	0.11	0.14	0.19	0.21	.023
Open Land	0.04	0.18	0.36	0.46	0.54
Agriculture	0.07	0.29	0.6	0.76	0.91

Note: Values from Voorhees Memo (2014), Attachment C, Table C-1. Values converted from kg/ha/yr. to lb/ac/yr. and rounded to decimal places.

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

Table B-1 lists estimated pollutant loads for the following primary nonpoint source (NPS) pollutants: total phosphorus (TP), total nitrogen (TN), total suspended solids (TSS). These estimated loads are based on the pollutant loading analysis presented in Section 4 of Element A.

Water Quality Goals

Water quality goals for primary NPS pollutants are listed in **Table B-1** based on the following:

- TMDL water quality goals (if a TMDL exists for the water body);
- For all water bodies, including impaired waters that have a pathogen TMDL, the water quality goal for bacteria is based on the Massachusetts Surface Water Quality Standards (314 CMR 4.00, 2013) that apply to the Water Class of the selected water body.
- If the water body does not have a TMDL for TP, a default target TP concentrations is provided which is based on guidance provided by the USEPA in Quality Criteria for Water (1986), also known as the "Gold Book". Because there are no similar default water quality goals for TN and TSS, goals for these pollutants are provided in **Table B-1** only if a TMDL exists or alternate goal(s) have been optionally established by the WBP author.
- 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 the selected water body. 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:

a. For lakes and ponds, the estimate of annual TP loading is averaged across the entire watershed. However, a given lake or reservoir may have multiple tributary streams, and each stream may drain land with vastly different characteristics. For example, one tributary may drain a highly developed residential area, while a second tributary may drain primarily forested and undeveloped land. In this case, one tributary may exhibit much higher phosphorus concentrations than the average of all streams in the selected watershed.

b. 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 close 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."

c. If the calculated water quality goal is higher than the existing estimated total load; the water quality goal is automatically set equal to the existing estimated total load.

Table B-1: Pollutant Load Reductions Needed

Pollutant	Existing Estimated Total Load	Water Quality Goal	Required Load Reduction
Total Phosphorus	4042 lbs/yr	1664 lbs/yr	2378 lbs/yr
Total Nitrogen	29625 lbs/yr	--	--
Total Suspended Solids	541 ton/yr		
Bacteria	*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.*	Class B. **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.	Draft Pathogen TMDL for the Merrimack River Watershed The Merrimack River TMDL establishes indicator bacteria limits and outlines corrective actions to achieve that goal. At this time, there is no TMDL for the Spicket River. Recommended TMDL implementation measure include identification and elimination of prohibited sources such as leaky or improperly connected sanitary sewer flows and best management practices to mitigate storm water runoff volume. This report represents a TMDL for pathogen indicators (fecal coliform, E. coli, and enterococcus bacteria) in the Merrimack River watershed. Most of the bacteria sources are believed to be storm water related. Since accurate estimates of existing sources are generally unavailable, it is difficult to estimate the pollutant reductions for specific sources. For illicit sources, the goal is complete elimination (100% reduction).

(Note: Values generated by Massachusetts Watershed-Based Plan Online Tool)

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.

Creating Outfall Catchment Areas

Preparation:

MVPC completed the GIS analysis for the Spicket River Watershed Based Plan area and all the GIS components were performed in Esri's ArcGIS Pro 3.1 with the Hydrology tools within the Spatial Analyst extension. The objective was to delineate the outfall catchment areas within the Spicket River Watershed and rank the catchments based on specific water quality criteria then intersect those highest-ranking catchments with the parcels to identify sites across Methuen and Lawrence that could be ideal locations for infiltration retrofits. The GIS analysis was intended to provide a basis for priority investment areas and the top-ranking parcels have been verified for feasibility by the Tighe & Bond engineering team prior to final site selection.

To begin, MVPC culled down the stormwater, parcel, land use, etc. to the areas of Methuen and Lawrence within the Spicket River watershed. The Hydrology toolset requires a digital elevation model which we received from the state developed LiDAR dataset to start. The DEM needed to be hydrologically conditioned to robustly map the direction and accumulation of flow in the Spicket River project area using the Esri documentation for the framework of this process. In general, first the Flow Direction tool was used to attribute the direction of run off to each pixel in the DEM. The Sink tool was used to identify erroneous sinks in the data that would skew flow direction. The sinks were filled using the Fill tool until a smooth, hydrologically conditioned DEM that represented the morphology of the Spicket River Watershed area was created.

Delineating Catch Basin Catchment Areas

The conditioned DEM was put through the Flow Accumulation tool to create a raster dataset depicting areas where flow would pool. At this point, the locations where the water outlets, or pour points, needed to be identified before delineation. The mouth of the Spicket River was the first pour point to test the methodology against and using this as the outlet delineated a catchment area representative of the entire Spicket River watershed. When compared with the state delineated watershed it created a near identical polygon.

The pour points needed to delineate catchment areas for the catch basins are the catch basin points themselves since this is where the flow enters the stormwater system. The Watershed tool was run using the combined catch basin layer for the two cities as the pour points. The tool output individual "watersheds" or catchment areas for each catch basin using the Spatial Analyst extension.

Attributing Pipe Networks to Catch Basins

With the catch basin catchment areas delineated, the catchment areas needed to be attributed to the correct pipe network and associated outfall. MVPC utilized the [MAPC Stormwater Outfall Mapping methodology]() as a guide for this process, though it should be noted the Hydrology toolset was used in place of the catchment delineation process referenced.

A unique PIPESYS_ID was assigned to each pipe segment and the pipes were buffered according to diameter. Where no diameter was present a minimum of 2" assumption was used. The pipe buffers were dissolved into a multi-part polygon then exploded to isolate the individual pipe system polygons. The original pipe layer was spatially joined to the pipe polygons to carry over the attributes from the stormwater system, including the unique ID. The same was done for the outfalls and catch basins to associate them with the pipe network they were closest to. At this point, all the interconnected pipes shared a PIPESYS_ID and the associated catch basins and outfalls did as well. This did not produce a perfect result, which will be discussed more under "Considerations", but it allowed the majority of the catch basins within the project area to be associated correctly with the pipe and outfall features.

The last step to prepare the catchments for ranking was to dissolve all the catch basin catchment areas attributed to the same PIPESY_ID together. The results were the catchment areas for each of the outfalls.

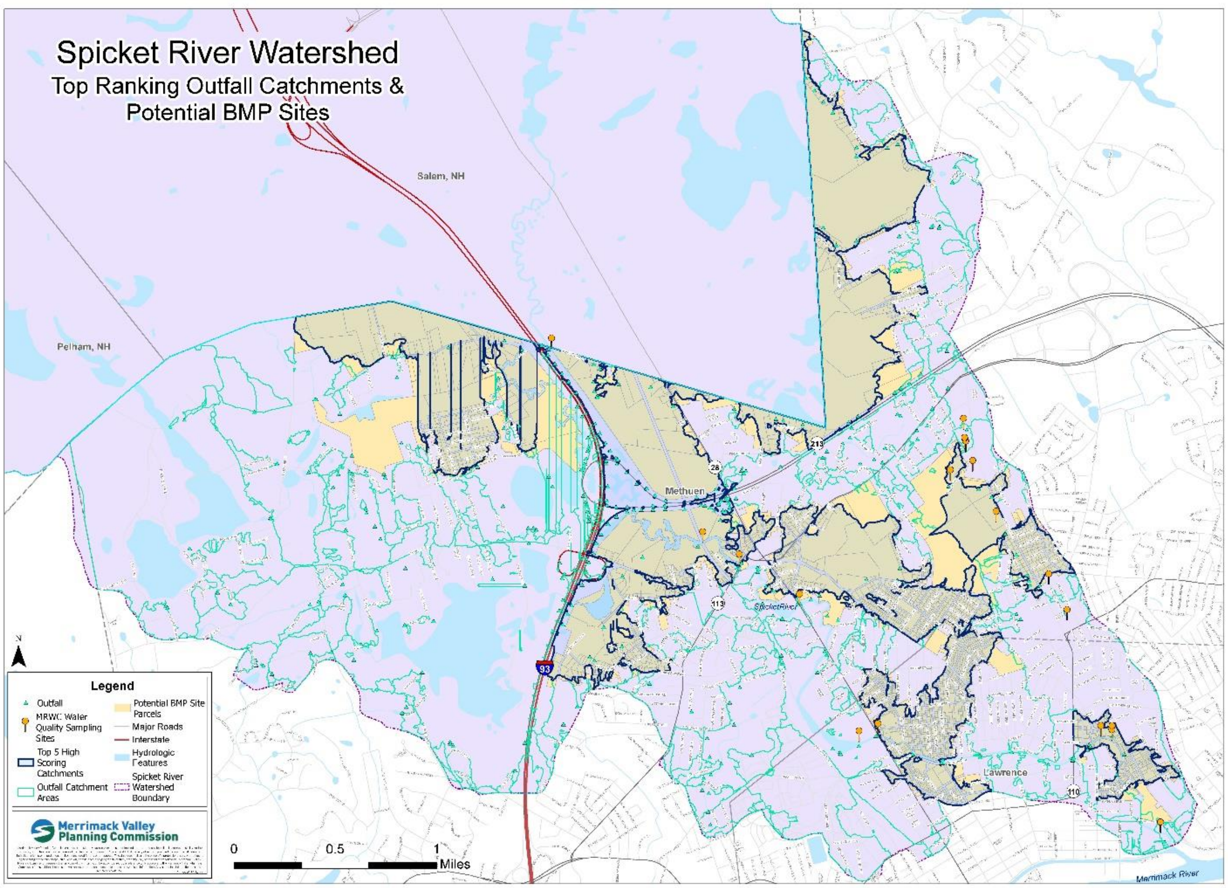

Figure C-1: Top Ranking Outfall Catchments and Potential BMP Sites (MVPC)

Scoring Outfall Catchment Areas

Calculating General Evaluation Criteria:

The catchment areas were now ready to be scored to determine which should be priority investment areas. MVPC used the criteria determined by the Spicket River Watershed Based Plan working group, based in the methodology developed for Nutrient Source Identification Methods in 2021 by the Neponset River Watershed Association to assign scores to each catchment area. The scoring criteria can be found in Table C-1.

Table C-1: Outfall Catchment Ranking and Scoring with Loading Criteria

GIS Layers and Point System for Initial Ranking and Screening of Outfall Catchments			
	Points	**Total Possible Points**	**Total Possible Score**
A or B hydrologic soil group	5.0 or 0	5	5
A/D or B/D hydrologic soil group	2.5 or 0		
MassGIS Drainage Areas sub-basins of waters designated as TMDL completed (Category 4a) or Impaired/Requiring a TMDL (Category 5) on the Massachusetts List of Integrated	5.0 or 0	5	5
Environmental Justice Areas, 2020	5.0 or 0	5	5
Impervious area larger than 1 acre	10	10	10
Impervious area 0.5 to 1 acre	5		
Impervious area less than 0.5 acre	2.5		
Localized flooding areas (FIRM)	5.0 or 0	5	5
Presence of Pollutants (AUL, Tier II, UST, GWDP, Brownfields)	5.0 or 0.0	5	5
Forested Area (less than 0.5 ac, 0.5-1 ac, more than 1 ac -inverse of impervious)	5.0, 2.5, 1.0	5	5
Presence of Green Stormwater Infrastructure already	5.0 or 0.0	5	5
Presence of MRWC Sampling Location	5.0 or 0.0	5	5
Outfall Catchment Phosphorus Loading lbs Per Year (Top 10%, 10-25%, 25-50%, Bottom 50%)	50.0, 35.0, 20.0, 5.0	50	50
Outfall Catchment Nitrogen Loading lbs Per Year (Top 10%, 10-25%, 25-50%, Bottom 50%)	50.0, 35.0, 20.0, 5.0	50	50
TOTAL		150	150

Calculating N and P Loading Rates for Outfall Catchments:

MVPC worked through the criteria above for each outfall catchment and scored the catchments appropriately. Most of the criteria above was assigned to a catchment area if it was present within the catchment or not. The loading rate and impervious surface criteria required additional land use analysis to attribute the appropriate score.

To calculate these items, MVPC used the EPA MS4 Permit for MA methodology for completing the Nutrient Source Identification Reports refined by the Neponset River Watershed Association and Pioneer Valley Planning Commission referenced in the methodology above. In 2016, the EPA released updated constants for the land use analysis which we used in this plan. Using EPA's methodology, MVPC intersected the 2016 Land Cover/Land Use data with the Soil Survey Geographic (SSURGO) Database available through MassGIS. The result was a base shapefile representing the different land cover/land use polygons and their associated soil types.

Included in the 2016 EPA Guidance were crosswalk data tables outlining the pollutant loading export rate to apply to a given parcel based on the intersection of land use class, land cover class. Crosswalk fields were added to the GIS to indicate which constants needed to be applied to each polygon for the loading rate calculations and the correct crosswalk value was input for each polygon type. Similarly, the loading rate constants for the PLER and NLER fields were added. Finally, the directly connected impervious area (DCIA) constants were calculated as well. The Calculate Geometry tool was used in conjunction with the Select by Attribute tool to isolate the impervious surface polygons, calculate the acres and finish the loading rates/DCIA based on the updated Sutherland Equations documented in EPA's latest methodology.

Selecting Parcels within Highest-Ranking Catchments:

Five outfall catchment areas rose to the top of the list with the highest score being 138.5 of 150 possible points. These five outfall areas represent portions of the stormwater system that would be impactful places to focus infiltration capacity building, but these areas covered a span of over 2,000 individual parcels. The list needed to be further cut down to a manageable subset for the Tighe & Bond field verification team to perform site suitability visits.

MVPC created a parcel layer representing all the parcels within the Spicket River Watershed and began systematically eliminating parcels based on individual criteria that would make specific sites ideal for investment. First, the parcels that were not municipally, commercially, or industrially used based on the DOR land use code were removed. This culled the list to 446 properties. Then the properties less than 0.5 acres were removed to isolate the larger acreage parcels and maximize implementation opportunities. A list of 115 properties remained.

The land use crosswalk completed for the loading rate calculations was revisited and reused at this point to rank the remaining parcels based on the presence of impervious surfaces on site Using a systematic ranking process in GIS allowed the team to significantly narrowed the focus of potential retrofit parcels to 115 properties. To further narrow in on the most advantageous sites for green infrastructure, a more manual approach was necessary to incorporate project goals and priorities not readily available in existing database layers. MVPC mapped the 115 sites alongside factors like the *E. Coli* concentration from the MRWC Sampling Sites, planned Complete Streets projects, concentrations of important sensitive populations like youth and elderly residents, as well as proximity to open space for considerations. These factors were determined by the shared collective of the Spicket River WBP Working Group.

A clear trend was emerging where the sites with the highest impervious surface present were often coincident with areas of high pollutant loads, classified Environmental Justice populations, and high visibility or social impact areas, where project investment would bring many direct and indirect benefits to the health of the Spicket River watershed. MVPC prepared a list of the top 10 sites with the most impervious surface present in each Lawrence and Methuen for a total of 20 sites. The top 20 selected sites are found in Table C-2.

Table C-2: Top Ranking Parcels by Community

City	Address	Owner	Assessed Lot Size	Impervious Surface Area (ac)	Parcel ID
Methuen	400 BROADWAY	MASS SOC FOR THE PREVENTION	49.67	4.81	610-123-44
Methuen	98 LINDBERG AVE	F W WEBB COMPANY	18.1333	10.62	514-146-27
Methuen	28 PELHAM AVE	28 PELHAM AVENUE REALTY LLC	22.94	3.24	612-124-88
Methuen	75 PLEASANT ST	METHUEN TOWN OF	26	7.79	712-41-123A
Methuen	436 BROADWAY	SHRI SWAMINE LLC	10.22	8.97	610-123-47A
Methuen	100 HOWE ST[3]	METHUEN TOWN OF	34.8	5.48	810-68B-47A
Methuen	144 HAMPSHIRE RD	FELLOWSHIP BIBLE CHURCH	26.01	3.13	310-125-13A
Methuen	70 EAST ST[2]	MPT OF METHUEN STEWARD LLC	72.3	17.70	814-41-22
Methuen	1 RANGER RD[1]	METHUEN TOWN OF	49.52	21.73	814-41-102A
Lawrence	150 ARLINGTON ST	LAWRENCE CITY OF	3.02	2.78	193-0-41
Lawrence	ALDER ST (JUNIPER ST)	LAWRENCE CITY OF	0.8815	0.43	171-0-109
Lawrence	150 BERKELEY ST	LAWRENCE HOME FOR AGED	11	1.43	132-0-1
Lawrence	LAWRENCE ST[4]	LAWRENCE CITY OF	64.54	1.01	173-0-53
Lawrence	58 ALDER ST	TARBOX SCHOOL	1.02	0.66	171-0-116
Lawrence	HAMPSHIRE ST (& AUBURN ST)	LAWRENCE HOUSING AUTHORITY	2.85	1.58	169-0-43
Lawrence	243 HAMPSHIRE ST	APOSTOLIC EXARCHATE	1.25	1.03	148-0-3
Lawrence	353 ELM ST[5]	LAWRENCE HOUSING AUTHORITY	1.31	0.93	147-0-26
Lawrence	REAR BROOK ST	LAWRENCE CITY OF	2.78	0.51	88-0-83
Lawrence	81 AUBURN ST	CENTRAL CATHOLIC HIGH SCHOOL	2.06	1.81	169-0-41
Lawrence	99 AUBURN ST	CENTRAL CATHOLIC HIGH SCHOOL	2.52	2.43	169-0-40
Lawrence	300 HAMPSHIRE ST	CENTRAL CATHOLIC HIGH SCHOOL	1.31	1.02	169-0-42
Lawrence	HAMPSHIRE ST	CENTRAL CATHOLIC	1.74	1.12	169-0-36
Lawrence	1 GENERAL ST	LAWRENCE GENERAL HOSPITAL	10.38	6.57	68-0-1

1) Methuen High School
2) Holy Family Hospital
3) Comprehensive Grammer School
4) Howard Playstead
5) Bennington Street

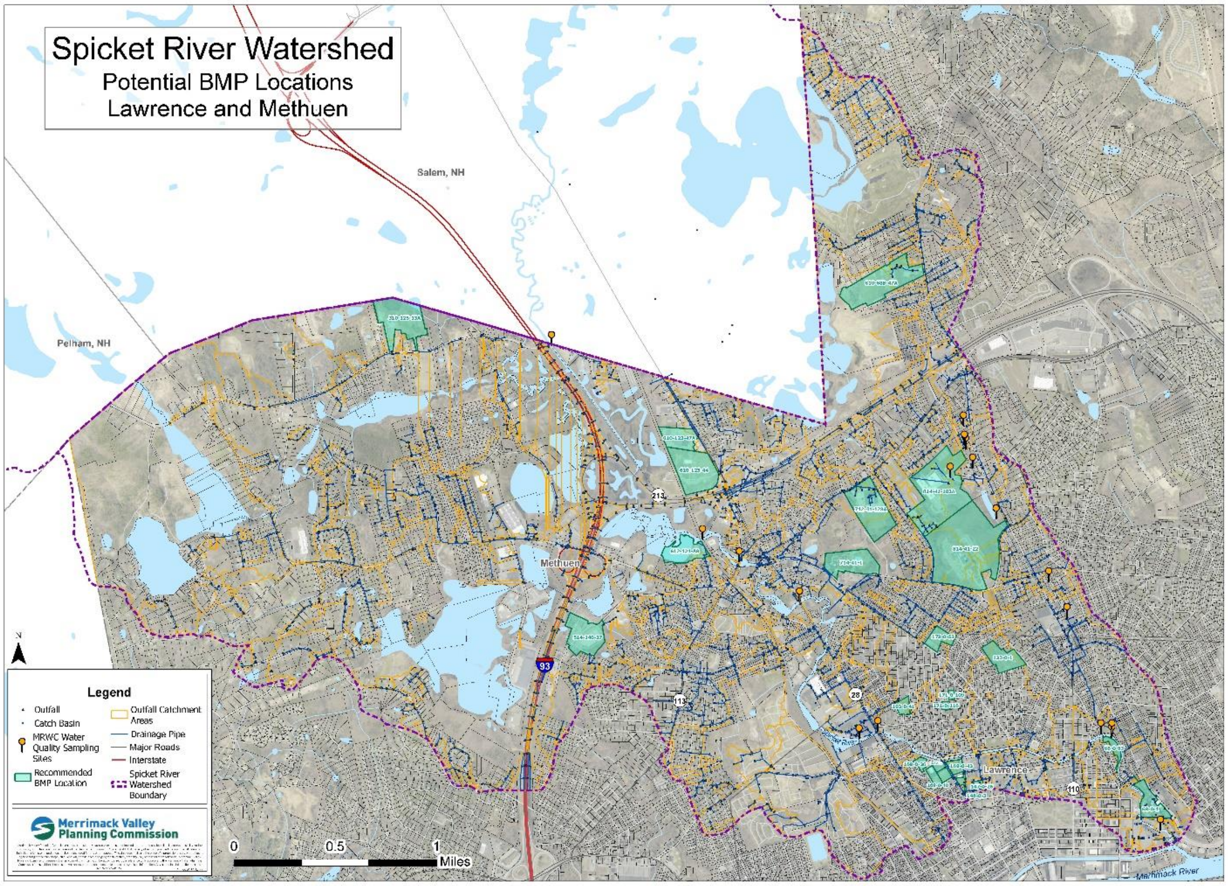

Figure C-2: Potential Lawrence and Methuen BMP Sites in the Spicket River Watershed (MVPC)

Considerations of Data Available

The GIS analysis conducted for the Spicket River Watershed Based Plan was completed using the best available inputs regarding the quality of the data. However, several of these datasets were incomplete or posed problematic elements that impacted the ability for the GIS to accurately map some of these factors.

The most important factor was the quality and completeness of the stormwater infrastructure data used to create the catch basin and outfall catchment areas. There were areas in Lawrence and Methuen that were not accurately mapped and would have required ground truthing the data to be sure the consequent pipe segments were attributed to the correct outfalls. While much of the watershed mapped as expected, when the PIPESY_ID was dissolved to individual outfall catchments there were major pockets around the I-93 corridor that did not appear complete and subsequently impacted the outfall catchments. This was most relevant for the highest-ranking catchment, ID 64 which abutted the New Hampshire boundary. Likely, this catchment area is larger than it should be due to the lack of individual catchments delineated around the corridor.

Similarly, the lack of stormwater infrastructure data available in New Hampshire means that the water upstream would not accurately be represented and is a contributing factor to this catchment area being so large.

This ultimately impacted the ranking to a certain degree. MVPC attempted to normalize the loading rate and impervious surface data over the entire acreage of the catchment area to account for how this nuance skewed the aggregations toward the larger catchment areas. However, this served to skew the data toward the artificially small catchment areas that were not likely delineated correctly due to the inaccuracies in the stormwater data inputs. Either way, more complete stormwater inputs would have been needed to reflect the status of the system more accurately.

Lastly, there were several criteria discussed within the working group that were better suited to be evaluated by experts within the community but should be discussed here for consideration. These criteria included right of way areas due to the inherent difficulty in identifying ownership without proper surveying, habitat connectivity given the general lack of specific data available, and proximity to forest because it was dependent on the site use whether proximity was a positive attribute or less forested areas were to be more highly considered.

Final Site Selections:

The Working Group relied on local knowledge of the group members to review each of the 20 top ranking sites. The local expertise provided insight into property ownership, recent and planned municipal projects, community needs, and preexisting stormwater flooding concerns. For instance, on certain parcel sites we were able to discuss if elimination of parking spaces would be an option to reduce impervious pavement, given the needs and priorities of the community. Through workshop meetings, the team collectively narrowed the 20 sites down to top 10 parcels for constructability and feasibility review.

Tighe & Bond visited the top-ranking sites in Methuen and Lawrence for a boots-on-the-ground exercise. An engineer accompanied by MRWC looked for site features at each site, to understand any constructability limitations, slope of ground surface and existing drainage patterns, availability of space, visibility to the public, and presence of existing stormwater treatment infrastructure. The site visits were the final step in narrowing down the potential sites for green infrastructure retrofits. Five sites in the Spicket River Watershed were selected to pursue further conceptual designs that could secure funding for implementation. Three of the sites are in Methuen: Methuen High School, Holy Family Hospital, and Methuen Comprehensive Grammar School; and two of the sites are in Lawrence: the Howard Playground and Bennington Street. Due to the urban nature of this watershed, BMPs were recommended which fit into already developed parcels, roadways, and parks to best serve communities while acknowledging space constraints. In general, the types of BMPs recommended include bioretention systems of varying shape and capacity, sediment forebays and basins in necessary locations to mitigate sedimentation within the bioretention areas, rain gardens, conveyance swales, and educational signage. BMPs were selected based on appropriate sizing relative to each parcel – for example, a small rain garden is suggested for a grassy strip in-between a roadway and sidewalk on Bennington Street in Lawrence, whereas sites such as the Comprehensive Grammar School in Lawrence require a substantial bioretention system equip with underground drainage pipes, a deep sump hooded catch basin, and sediment forebay. Appendix D includes additional information such as conceptual designs, summary “fact sheets”, opinion of probable construction costs (OPCCs) and pollutant loading reduction estimates for each of the five sites. These BMPs were determined to be the best fit within the Spicket River watershed to improve water quality and provide other impactful community benefits.

While five sites were prioritized for conceptual BMP design buildouts, additional structural and non-structural BMPs throughout the watershed will be required to substantially mitigate nutrient and bacteria inputs. Ultimately, the team aspires to see BMPs within the 20 priority sites identified through GIS land use analysis wherever feasible. It is likely that many BMP designs at these sites will be similar to those proposed for the top five parcels given that they maintain similar attributes. On larger parcels, we would anticipate continuing to see a variety of green infrastructure retrofits which provide greenery and aesthetic in the urban watershed, including but not limited to bioretention areas and rain gardens, porous pavement, vegetated filter strips, and water quality swales. BMPs will fit contour to the parcel in an appropriate area to collect ample non-point source pollution and may be accompanied by some gray infrastructure to convey additional stormwater to the BMPs and/or mitigate sedimentation. BMPs which require minimal maintenance will be favorably selected to be considerate of local Department of Public Works' capacity. On municipal properties, BMPs may include those identified within MVPC's 2022 MS4 Municipal Assistance Grant annual report, as well as Lawrence and Methuen's MS4 year 4 annual reports to the Department of Environmental Protection. Further, small and easily accessible BMPs like rain gardens, tree box filters, and rain collection systems will be encouraged at privately owned parcels to engage the widest audience and lower the barrier of entry for contributing to non-point source pollution reduction.

Beyond structural BMPs, non-structural BMPs should continue to be leveraged and expanded within the watershed to contribute to overall non-point pollution reduction. In the Massachusetts component of the watershed, both Methuen and Lawrence administer the MS4 permit, which includes not only a requirement to develop and work towards implementing structural BMPs, but to engage in robust educational outreach with a variety of stakeholders within the community as it relates to stormwater and on-point source pollution. Continuing to expand upon these campaigns within both cities and align them directly with active green infrastructure implementation projects would increase awareness for residents, developers, and industry. Methuen and Lawrence currently host a plethora of educational material on dog waste, fertilizer usage, and water conservation on their websites. This material could be expanded into a more robust educational campaign targeted at problem groups or parcels. Both Methuen and Lawrence also work with the community-based organization Groundwork Lawrence (GWL) to engage with community members and environmental justice groups. During the planning phase of this effort, GWL worked to disseminate surveys, table events, and attend public meetings regarding the Spicket River. As we move forward to the implementation of BMPs along the watershed, the cities will continue to work with GWL to ensure the public is involved in and aware of this work. Finally, the Merrimack River Watershed Council intends to continue exploring hot spot pollution areas throughout the watershed through continued water quality monitoring where funding permits. This monitoring will allow the project team to understand the impacts BMPs are having to the watershed, and identify new target areas to pursue.

Non-Structural BMPs

BMPs can also be non-structural and can include street sweeping, rain gardens, and tree planting to reduce TP loading. It is recommended that these municipalities evaluate and potentially optimized and the potential removals from ongoing activities be calculated in accordance with Element H & I. It is also recommended that ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as increased frequency of sweeping or number of trees and shrubs planted.

Other nonstructural BMPs could also include sewer maintenance to determine illicit sewer connections, municipal sewer maintenance, land use regulation revision, protection of open space, impervious cover reduction, adoption of good housekeeping practices, and public education and outreach (see Element E).

It is also noted that the majority of the watershed rests in New Hampshire, where additional non-structural BMPs could be implemented with bi-state cooperation. This, along with a watershed-based plan for the Spicket

River in New Hampshire, could help increase the total number of load reduction for the watershed as a whole for delisting from the 303(d) list.

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.

Table D-1 presents the funding needed to implement the management measures presented in this watershed plan. The table includes costs for structural, operation and maintenance activities, information/education measures, and monitoring/evaluation activities. The table also includes summary statistics of proposed BMPs, including potential pollutant load reductions.

Table D-1: Summary of Funding Needed to Implement the Watershed Plan.

Site	BMP Identification / Location	BMP Description	Drainage Area (ac)	Impervious Area (%)	Est. Load Reduction					Cost Estimates ($)				Site Specific Notes
					TN (lbs/yr)	TP (lbs/yr)	TSS (lbs/yr)	Bacteria % Removal	Bacteria # Coliform[4]	Capital[1]	O&M[3]	Technical Assistance[2]	Total	
	Structural BMPs (from Element C)													
1	Methuen High School, Methuen	Bioretention	1.29	43.4	10.0	1.05	252	94 %	3,800,000	$372,500	$3,000	$42,500	$418,000	Additional education and engagement opportunities.
2	Holy Family Hospital, Methuen	Bioretention (East)	0.52	57.7	5.0	0.56	126	94 %	2,100,000	$92,500	$3,000	$17,500	$113,000	Proximate to Searles Pond (identified by the MRWC to be discharging an elevated level of phosphorus).
		Bioretention (West)	0.94	79.8	9.9	0.97	270	33 %	261,000	$81,000	$3,000	$39,000	$123,000	
3	Bennington Street, Lawrence	Bioretention (North)	0.18	100	2.4	0.25	64	49 %	155,000	$130,000	$3,000	$50,000	$183,000	Pedestrian connection from the Rail Trail, added tree canopy cover, reduction of impervious areas, potential traffic calming.
		Bioretention (South)	0.20	100	2.3	0.22	64	22 %	27,000	$142,500	$3,000	$37,500	$183,000	
4	Howard Playground, Lawrence	Bioretention	3.33	0.6	5.5	0.57	163	97 %	10,100.000	$105,000	$3,000	$30,000	$138,000	Additional community engagement and activation opportunities.
5	Comprehensive Grammar School, Methuen	Bioretention	1.85	0.41	12.6	1.40	318	96 %	3,600,000	$130,000	$3,000	$80,000	$163,000	Total cost is based on the primary BMP proposed, excluding the alternative
				Sub-Total:	47.7	5.02	1,257	--	20,043,000	$1,053,500	$21,000	$246,500	$1,321,000	
	Information / Education (see Element E)													
--	Project Updates	Post project updates to website, including completed WBP	--	--	--	--	--	--	--	--	--	--	$0	
--	Signage	Create information signage for up to 3 BMPs	--	--	--	--	--	--	--	$3,000	--	--	$3,000	Costs for updating existing signage and additional signage not included in the BMP designs.
				Sub-Total:	--	--	--	--	--	$3,000	$0	$0	$3,000	
	Monitoring and Evaluation (see Element H/I)													
--	Sampling QAPP / SOPs	Write sampling QAPP and sampling plan	--	--	--	--	--	--	--	--	--	$5,000	$5,000	Estimated cost; cost will vary widely depending on level of detail.
--	Annual Water Quality Sampling	TBD	--	--	--	--	--	--	--	--	--	$12,000	$12,000	Extent of sampling program TBD – annual ballpark cost placeholder.
				Sub-Total:	--	--	--	--	--	--	--	$17,000	$17,000	
									TOTALS:	$1,353,500	$21,000	$263,500	$1,338,000	

General Notes

1) *Planning level capital costs for BMPs obtained from WBP Element C and/or professional judgement from past projects.*
2) *Technical assistance (i.e., engineering, permitting, and construction administration) based on site-specific evaluation and professional judgement.*
3) *Annual operation and maintenance estimated as a lump sum based on professional judgement from past projects. Actual costs may vary widely based on who performs the maintenance.*
4) *Estimated number of bacteria colonies removed per design storm (per guidance in the New England Stormwater Retrofit Manual, October 2022).*

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 team developing the Spicket River Watershed-Based Plan created public information and education strategy to raise awareness about the project and encourage public participation in the development of the plan. The team developed a targeted approach to reach residents of Methuen and Lawrence through surveys, tabling events, social media posts, articles in local newspapers, and the creation of a resident advisory committee. To help facilitate these activities, the team collaborated with Groundwork Lawrence, a resident-led community-based organization with a twenty-year track record of improving public health throughout Greater Lawrence. The overall goal of these efforts was to integrate the community into the planning effort, ensure community voices are included in plan development, and ensure the plan is well understood and received by the community once developed, and ensure successful and meaningful implementation in the future.

Step 2: Target Audience

The target audience focuses mainly on the residents of Methuen and Lawrence, and those interested in the health of the Spicket River in general. To reach these audiences, the team developed several engagement strategies. Special consideration was given to reaching residents of environmental justice residents. To this end, the team established an advisory committee comprised of Lawrence and Methuen residents who live within the watershed of the Spicket River, conducted surveys in English and Spanish within environmental justice neighborhoods with residents using the Spicket River Greenway and the Methuen Rail Trail (see Appendix C for the survey questions and results), and used local print and social media channels to promote the work. A central component to reaching the target audience was holding and recording a livestream of a public meeting in Methuen and Lawrence in multiple languages, then sharing a video of the meeting via Groundwork's socials.

Step 3: Outreach Products and Distribution

Groundwork Lawrence prepared the following products to raise awareness about the Watershed-Based Plan:

Survey

This survey assessed public perceptions of the Spicket River, including links between perceptions of how attractive or how natural the river appeared and perceptions of specific ecological conditions on the river. The public's perceived need for flood protection, river rehabilitation, level of engagement with the resource, and perceptions about impacts of nonpoint source pollution on the quality of the Spicket was also assessed. The study's results show that public perception of the river is complex and, in some ways, aligns well with available monitoring data collected from that river, but simultaneously reflects the public's lack of knowledge about non-point source pollution. Overall, 35 residents participated in the survey and nearly all of them had positive perceptions of pictures of green stormwater infrastructure examples. However, most residents also were unaware of several pollutants that caused issues in the Spicket River (flooding, CSOs, pet waste, and fertilizers) and future outreach activities should focus on addressing these knowledge gaps. The survey and results are presented in Appendix C.

Tabling at community events

Tabling at community events provided the opportunity to engage residents about a range of topics. The team used brochures, maps, and water quality data to provide a scaffold for conversations with residents at the following events:

a. Food Insecurity: This event brought together a broad range of community groups at the Lawrence Senior Center on October 25th, 2023. Our table had 39 unique visitors, eight of which provided contact information on our sign-up sheet, and 20 Spicket River WBP pamphlets were distributed.
b. Lawrence Farmers Market: A popular destination for many residents is the Lawrence Farmers Market on the Campagnone Common. The market runs all day and we tabled from 10:30AM to 2:00PM on October 25th, 2023, the peak visitation timeframe for the market. Our table had 9 unique visitors, two of which provided contact information on our sign-up sheet, and two Spicket River WBP pamphlets were distributed.
c. Methuen Farmers Market: A popular destination for many residents is the Methuen Farmers Market at the Nevins Library. The market runs all day and we tabled from 11:00AM to 2:00PM on October 27th, 2023. Our table had 42 unique visitors, 31 of which provided contact information on our sign-up sheet.

Two additional tabling events are scheduled to occur in January, 2024, after the submission of the Plan.

Social and Traditional Media

Content was created in the form of Spicket River Talk videos to reach more people and presented at the public meetings. The videos were also posted on various social media and presented the following information:

a. Present the team's efforts to prepare the Watershed-Based Plan and why it is needed.
b. Discuss the water quality sampling efforts and the pollutants impacting the river.
c. Review existing Green Stormwater Infrastructure in the cities of Methuen and Lawrence to develop support for efforts of the municipalities.
d. Promote the public meeting.
e. Review the public meeting and discuss next steps.

At the time of Plan submission, only the first video (a) was released. The other four videos are scheduled for completion and posting in late December 2023 and January 2024, after Plan submission. Topics of the remaining four (4) talk videos may change depending on timing, availability, and feedback from previous videos.

To raise awareness about the work, two articles were published in The Rumbo, Eagle Tribune, and a review of the plan was published in both Groundwork Lawrence's newsletter and MVPC's newsletter and on MRWC's website.

Resident Advisory Committee

To further integrate the community outreach, residents of the watershed were asked to serve on the Advisory Committee. This Committee met twice to learn about the water quality of the river, the pollutants of concern, and what the municipalities are doing to improve the health of the Spicket, offer their opinions on the plan and designs presented, and ultimately become champions of the plan. The members of this committee include:

- Jeovanny Rodriguez, a civil engineer and Lawrence City Councilor
- Milagros Puello, a Lawrence resident and engineer with the Town of Andover
- Jose Tapia, Lawrence resident, MRWC employee, and project associate
- Mike LaBonte, Methuen resident and water quality monitoring volunteer
- Chelsea Morel, Methuen resident and Secretary for the Methuen Rail Trail Alliance
- Tim Vermette, Methuen resident and President of the Methuen Rail Trail Alliance

Water Quality Monitoring Volunteers

In 2022, no volunteers were recruited for water quality monitoring and sampling was conducted by MRWC staff. Four volunteers were recruited by MRWC to assist with water quality monitoring during the 2023 sampling season. It is important to note that only two of the four volunteers were residents within the Spicket River Watershed; MRWC decided that volunteer assistance, regardless of residency, was needed to help complete the sampling for the season and opened the opportunity to those outside of the municipalities within the watershed.

Education and Outreach Moving Forward

As of the completion of this planning process, education, and outreach along the Spicket River has only just begun. This initial outreach allowed our team to garner initial citizen interest through our local advisory committee, understand community knowledge gaps through our survey, and begin educational campaigning through our social media presence and tabling events. Looking forward, the team envisions a twofold educational campaign to continue engaging local citizens in work along the Spicket. The first is centered around general education, and will consist of continued social media presence, engagement with community-based organizations, hosting of river walks, and attendance at community events. Educational messaging will be based after knowledge gaps as identified in the Spicket River user survey disseminated during this planning process. Garnering interest and excitement about work along the Spicket cannot be done overnight, and persistent education is expected to continue as the group moves from planning to implementation, with a special focus on educating river users and abutting residents.

Beyond general outreach upkeep, the group will look to develop specific outreach related to the BMPs proposed below. Several BMPs are intentionally proposed at public locations, such as the comprehensive grammar school in Methuen and Howard playstead in Lawrence. These are locations where communities gather and there are educational opportunities, especially for children. As we shift towards implementation in these public areas, the planning team will work closely with school and municipal staff to develop educational signage, create lesson plans and engagement opportunities for students around BMPs and non-point source education, and host site visit opportunities for municipal staff, school personnel, and the greater community as work gets underway. Additionally, the team hopes to engage local schools and municipal personnel to participate in rain garden planting days once the BMP infrastructure is ready, equip with educational handouts on stormwater and NPS developed by the group or provided by a third party.

Overall, the group looks forward to building out specific educational deliverables in forthcoming 319 and other implementation grant applications and is dedicated to continuing to provide a high level of community engagement on the effort.

Step 4: Evaluate Information/Education Program

To ensure the efforts to engage residents are effective, the team developed a range of outreach strategies to meet people where they are. Basic information was gathered to document the extent to which in-person engagement reached residents. The team found residents had questions about water quality issues, sources of nonpoint source pollution and how to reduce nonpoint source pollution and how to receive funding for nature-based infrastructure along the Spicket River. The public meetings held sought to address these issues and provide residents with the information needed to fully understand the goals of the plan.

Additional education programs and outreach products and events will be determined based on the BMPs installed and completed within the watershed. These will be continuously re-evaluated on a yearly basis to ensure that the public has full understanding and determine the best way to reach residents.

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.

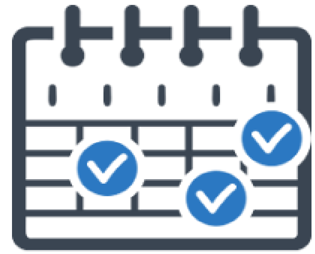

Table FG-1: Implementation Schedule and Interim Measurable Milestones [1]

Category	Action	Year(s)
Monitoring	Write Quality Assurance Project Plan (QAPP) for sampling and establish water quality monitoring program	2024
	Perform annual water quality sampling per Element H&I monitoring guidance	Annual
	Apply for state and federal funding to support water quality monitoring program	2024
Structural BMPs	Obtain funding and implement 1-2 additional BMPs from Appendix D	2025
	Obtain funding and implement 1-2 additional BMPs from Appendix D	2027
	Obtain funding and implement 1-2 additional BMPs from Appendix D	2029
Public Education and Outreach *(See Element E)*	Periodically post project updates to website, including completed WBP	Annual
	Continue ongoing implementation of previously completed outreach efforts (See Element D)	Annual
Adaptive Management and Plan Updates	Re-evaluate Watershed-Based Plan at least once every five (5) years and adjust, as needed, based on ongoing efforts (e.g., based on monitoring results, 319 funding, etc). – Next update, January 2028	2025
	Reach long-term goal to de-list section of watershed from 303(d) list for total phosphorus	2038

[1] 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 (MS4e) permit requirements. Stakeholders will perform tasks contingent on available resources and funding.

[2] Stakeholders include MRWC, MVPC, City of Methuen, City of Lawrence, and Groundwork Lawrence

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 below will be used to measure the effectiveness of the proposed management measures (described in Element C) in improving the water quality of the Spicket River.

Indirect Indicators of Load Reduction

Non-Structural BMPs

Potential load reductions from non-structural BMPs, such as street sweeping, catch basin cleaning, conserving riparian vegetation zones, revegetating native species, and decentralizing discharges, can be estimated from indirect indicators. These indicators may include miles swept, number and variety of species planted, acres conserved, etc. In Element C of this plan, it is recommended that potential pollutant removal from these ongoing activities be evaluated to see if potential improvements can be implemented to achieve higher pollutant load reductions such as less impervious surface. These ongoing activities, especially those required annually by the MS4 permit, should be evaluated for their current effectiveness, with potential recommendations made for efforts such as additional street sweeping and catch basin cleaning, higher levels of riparian buffer zone conservation in municipal wetland bylaws, specifications in bylaws regarding native species planting, and the like. While these BMPs do not reduce nutrient loading in an easily calculated way, they are nonetheless essential to the overall load reduction and general upkeep of the watershed. Load reductions from street sweeping and catch basin cleaning can be estimated according to Appendix F of the 2016 Massachusetts Small MS4 General Permit (Figure HI-1 and Figure HI-2).

Figure HI-1. Street sweeping calculation methodology

$$Credit_{sweeping} = IA_{swept} \times PLE_{IC\text{-}land\ use} \times PRF_{sweeping} \times AF \qquad \textbf{(Equation 2-1)}$$

Where:

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

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

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

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

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

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

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

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

Figure HI-2. Catch basin cleaning calculation methodology

$$Credit_{CB} = IA_{CB} \times PLE_{IC\text{-}land\ use} \times PRF_{CB} \qquad \textbf{(Equation 2-2)}$$

Where:

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

IA_{CB} = Impervious drainage area to catch basins (acres)

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

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

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

Frequency	Practice	PRF_{CB}
Semi-annual	Catch Basin Cleaning	0.02

Project-Specific Indicators

Number of BMPs installed and Pollution Reduction Estimates

Element C of this WBP recommends the installment of BMPs at 5 locations. The anticipated pollutant load reduction has been documented for each proposed BMP, where applicable. The number of BMPs installed will be tracked and quantified as part of this monitoring program. For example, if all recommended BMPs are installed, the anticipated *E. coli* load reduction is estimated to be a total of 20,043,000 coliforms, and the anticipated total phosphorus load reduction is estimated to be 5.02 pounds per year.

Direct Measurements

River Sampling

It is recommended to continue with the current monitoring plan, with MRWC to continue monitoring *E. coli* and total phosphorus bi-monthly from May through November. Water quality parameters such as temperature, pH, TSS, dissolved oxygen, salinity, and conductivity will also continue to provide additional data. It is recommended that, at a minimum, samples be taken at the Dr. Nina Scarito Park site, Greenway Trail at Oxford Park, and Bloody Brook Outfall where Bloody Brook enters the Spicket River. It is also recommended that the site at Searles Pond outlet and the CVS location on Bloody Brook remain a sampling location, as this is where the higher amounts of phosphorus have been observed and stream goes underground before exiting in the Spicket River. Since cyanobacteria blooms in the Spicket River are related with phosphorus, it is recommended that any blooms will be observed at the previous established sites at the Spicket River Dam at Lowell Street and Stevens Pond and submitted to BloomWatch if observed.

Water quality monitoring may continue to be performed through the established volunteer monitoring program to save on costs in accordance with established practices for MassDEP/s environmental monitoring for volunteers; however, it is noted that organization of volunteers would continue to require funding.

Adaptive Management

As discussed in Element B, the baseline monitoring, will be used to establish a long-term (i.e., 3 year) phosphorus load reduction goal (or other parameter(s) depending on results). Long-term goals will be re-evaluated once per year and adaptively adjusted based on additional monitoring results and other indirect indicators. If monitoring results and indirect indicators do not show improvement to the total phosphorus concentrations measured within the Spicket River, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

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Appendices

Appendix A – Pollutant Load Export Rates (PLERs)

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
AGRICULTURE, HSG A	0.45	7.14	2.6
AGRICULTURE, HSG B	0.45	29.4	2.6
AGRICULTURE, HSG C	0.45	59.8	2.6
AGRICULTURE, HSG D	0.45	91	2.6
AGRICULTURE, IMPERVIOUS	1.52	650	11.3
COMMERCIAL, HSG A	0.03	7.14	0.3
COMMERCIAL, HSG B	0.12	29.4	1.2
COMMERCIAL, HSG C	0.21	59.8	2.4
COMMERCIAL, HSG D	0.37	91	3.7
COMMERCIAL, IMPERVIOUS	1.78	377	15.1
FOREST, HSG A	0.12	7.14	0.5
FOREST, HSG B	0.12	29.4	0.5
FOREST, HSG C	0.12	59.8	0.5
FOREST, HSG D	0.12	91	0.5
FOREST, HSG IMPERVIOUS	1.52	650	11.3
HIGH DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.3
HIGH DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.2
HIGH DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.4
HIGH DENSITY RESIDENTIAL, HSG D	0.37	91	3.7
HIGH DENSITY RESIDENTIAL, IMPERVIOUS	2.32	439	14.1
HIGHWAY, HSG A	0.03	7.14	0.3
HIGHWAY, HSG B	0.12	29.4	1.2
HIGHWAY, HSG C	0.21	59.8	2.4
HIGHWAY, HSG D	0.37	91	3.7
HIGHWAY, IMPERVIOUS	1.34	1,480	10.5
INDUSTRIAL, HSG A	0.03	7.14	0.3
INDUSTRIAL, HSG B	0.12	29.4	1.2

Land Use & Cover[1]	PLERs (lb/acre/year)		
	(TP)	(TSS)	(TN)
INDUSTRIAL, HSG C	0.21	59.8	2.4
INDUSTRIAL, HSG D	0.37	91	3.7
INDUSTRIAL, IMPERVIOUS	1.78	377	15.1
LOW DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.3
LOW DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.2
LOW DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.4
LOW DENSITY RESIDENTIAL, HSG D	0.37	91	3.7
LOW DENSITY RESIDENTIAL, IMPERVIOUS	1.52	439	14.1
MEDIUM DENSITY RESIDENTIAL, HSG A	0.03	7.14	0.3
MEDIUM DENSITY RESIDENTIAL, HSG B	0.12	29.4	1.2
MEDIUM DENSITY RESIDENTIAL, HSG C	0.21	59.8	2.4
MEDIUM DENSITY RESIDENTIAL, HSG D	0.37	91	3.7
MEDIUM DENSITY RESIDENTIAL, IMPERVIOUS	1.96	439	14.1
OPEN LAND, HSG A	0.03	7.14	0.3
OPEN LAND, HSG B	0.12	29.4	1.2
OPEN LAND, HSG C	0.21	59.8	2.4
OPEN LAND, HSG D	0.37	91	3.7
OPEN LAND, IMPERVIOUS	1.52	650	11.3
[1]HSG = Hydrologic Soil Group			

(Note: Values generated by Massachusetts Watershed-Based Plan Online Tool)

Appendix B – Water Quality Results

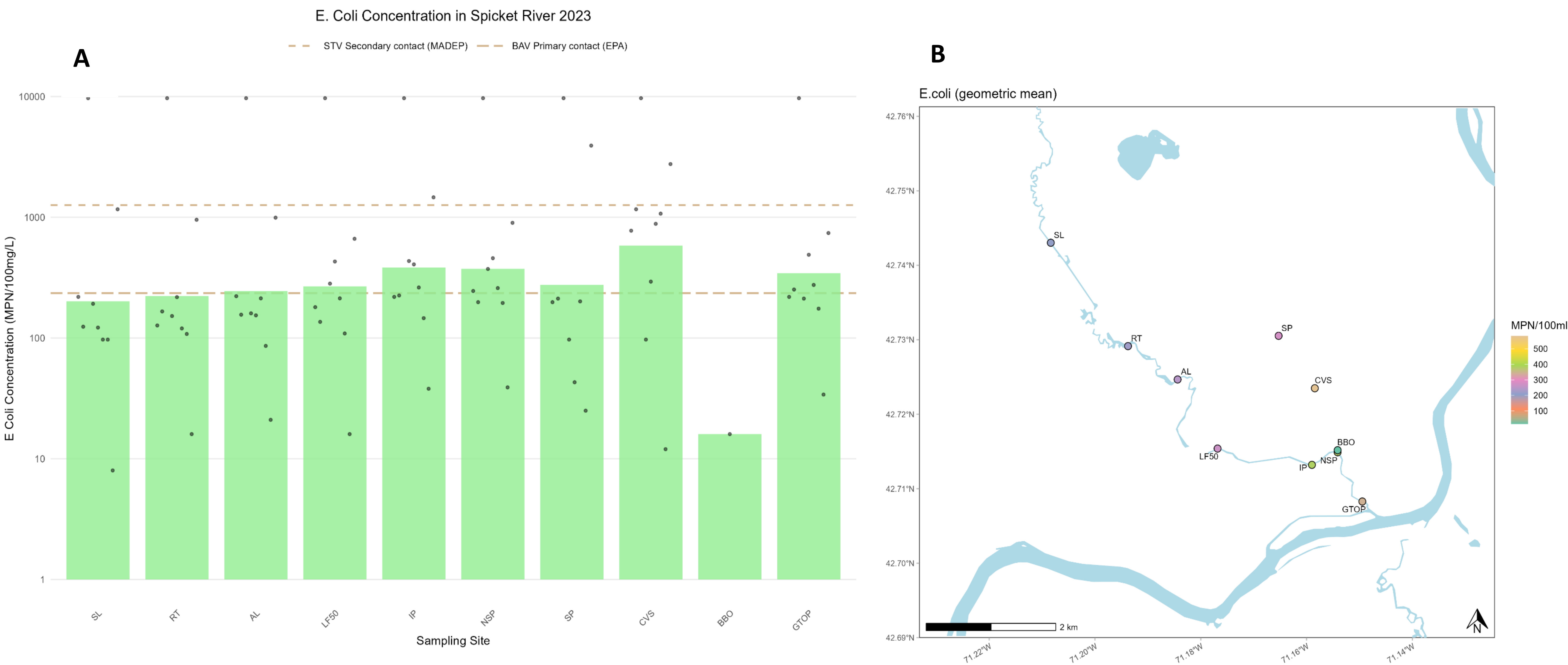


Figure 1: Average *E. coli* concentration results for Spicket River water quality sampling 2023. Figure 1A shows the MassDEP and EPA safe limits. Each dot represents a sampling date. Figure 1B shows average concentrations at each site in relation to its location within the watershed.

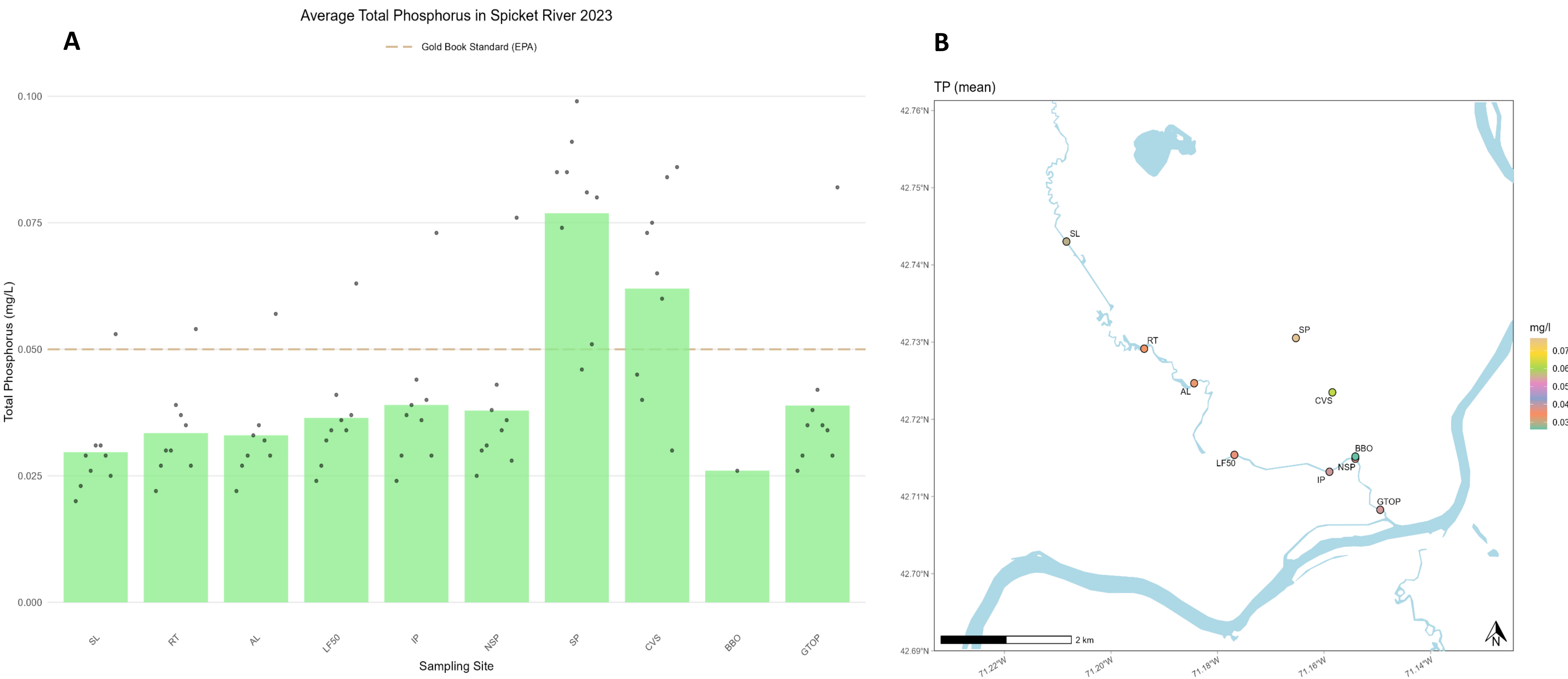


Figure 2: Average Total Phosphorus results for Spicket River water quality sampling 2023. Figure 2A shows the EPA safe limits. Each dot represents a sampling date. Figure 2B shows average concentrations at each site in relation to its location within the watershed.

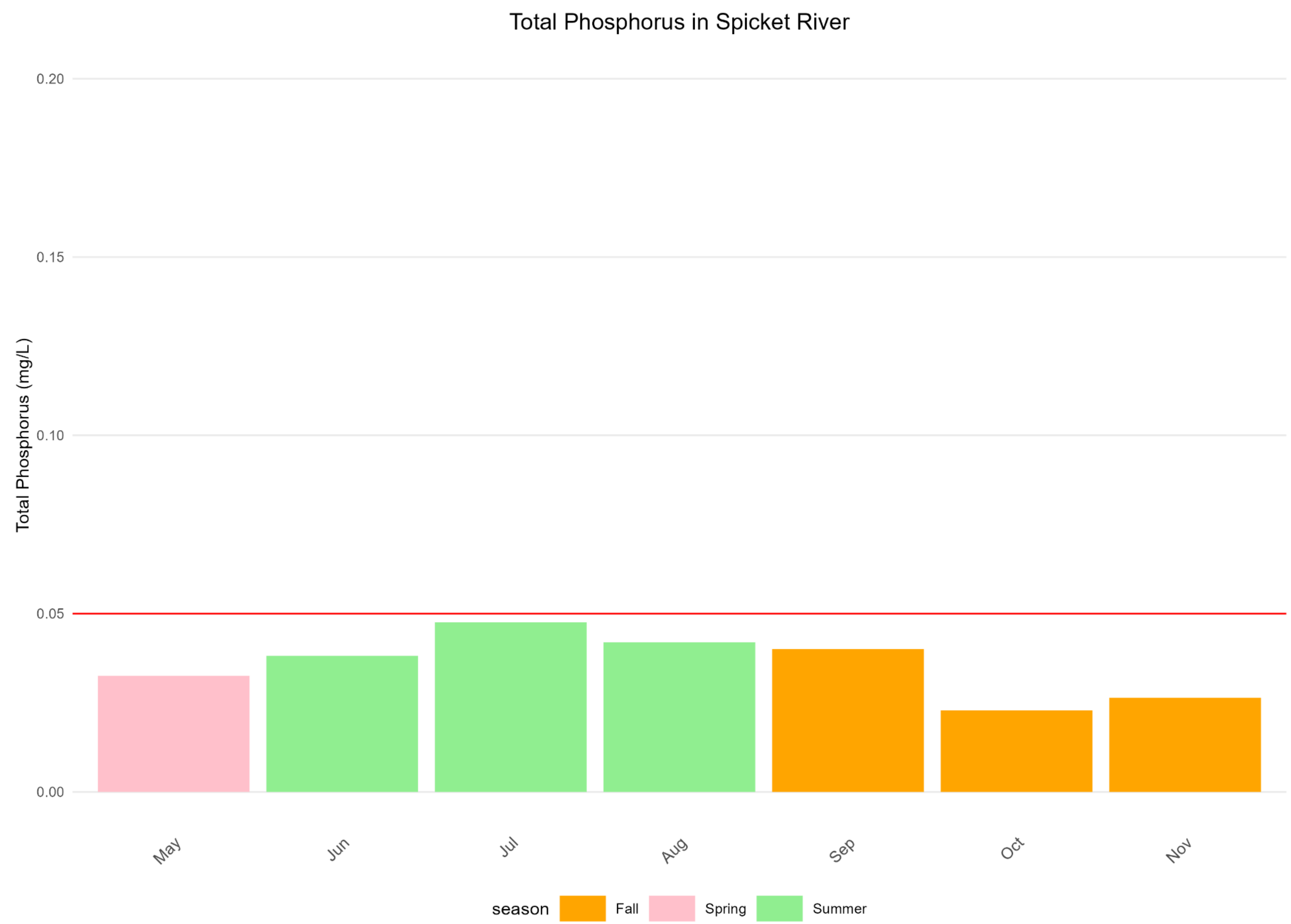


Figure 3: Average Total Phosphorus in the Spicket River for 2022 and 2023 sampling seasons separated by seasonality with the EPA safe limit shown. While under the state safe limit of 0.5 mg/L, it is important to note that this graph represents the average for each site in each month and that larger impacts to the watershed will occur from the smaller local scale concentrations of phosphorus.

Appendix C – Survey Questions and Results

Survey:

I. Introduction

The Spicket River Watershed Based Plan (WBP) is a project focused on gathering information and studying the Spicket River watershed, and developing projects that will improve water quality and the environmental health of the Spicket River. The Spicket River WBP is a partnership between the Merrimack River Watershed Council, the Merrimack Valley Planning Commission, Groundwork Lawrence, and the cities of Lawrence and Methuen. It's important that this project is guided by community input, and we want to understand the concerns of residents who live and work near the river, and who spend time on the Greenway and Rail Trail. By taking a few short minutes to answer these survey questions, you can help us be more responsive to residents and come up with projects that will benefit the community.

II. **Demographic Data.** We need to collect some basic information about you and your relationship to the river. Your responses are confidential, and we do not ask for personal identifying information.

a. Age
b. Gender
c. What city or town do you live in?
d. Greenway or Rail Trail use frequency
  - Less than once per week
  - Once per week
  - Several times per week
e. Primary Greenway or Rail Trail activity
  - Walking
  - Running
  - Dog walking
  - Biking

III. **Statements about River Condition.** Please tell us how strongly you agree or disagree with each of the following statements.

Scale: Strongly Agree (SA), Agree (A), Neither Agree nor Disagree (N), Disagree (D), Strongly Disagree (SD), Do Not Know (DK).

a. I like to look at the river while using the Greenway or Rail Trail
b. Flooding along the Spicket River is a problem
c. Combined Sewer Overflows along the Spicket River needs to be addressed
d. Pet waste is a water quality issue here
e. Chemical contamination such as pesticides or fertilizers is a water quality issue here

f. Runoff from streets, sidewalks, and buildings is a water quality issue here
g. Trash is a water quality issue here
h. Contamination from outdoor car washing is a water quality issue

IV. **Next, we're going to ask questions for you to rate the current conditions along the Spicket River. Please tell us about how you feel about the Spicket river, specifically the areas you frequent or are most familiar with, on a scale of 1 to 10, 1 being least favorable, 10 being most favorable.** Scale: 1 = It is terrible, to 10 = It is perfect

a. The overall attractiveness of the Spicket River
b. Quality of the vegetation/Green Space / Parkland along the banks of this section of the Spicket River
c. Quality of the water of the Spicket River
d. General environmental condition / appearance of the Spicket River

V. Level of Engagement.

a. Have you participated in a River of Park cleanup or attended an educational class/hike in the last 2 years?

Yes; I have participated in a stream or neighborhood cleanup.
Yes; I have attended an educational class or hike.
No

b. Have you communicated your environmental efforts with neighbors, friends, relatives, or other local groups?

c. Have you spoken to neighbors or local officials about your concerns about the Spicket River?

d. Would you be interested in participating in future events on the Spicket River such as clean ups, or guided walks?

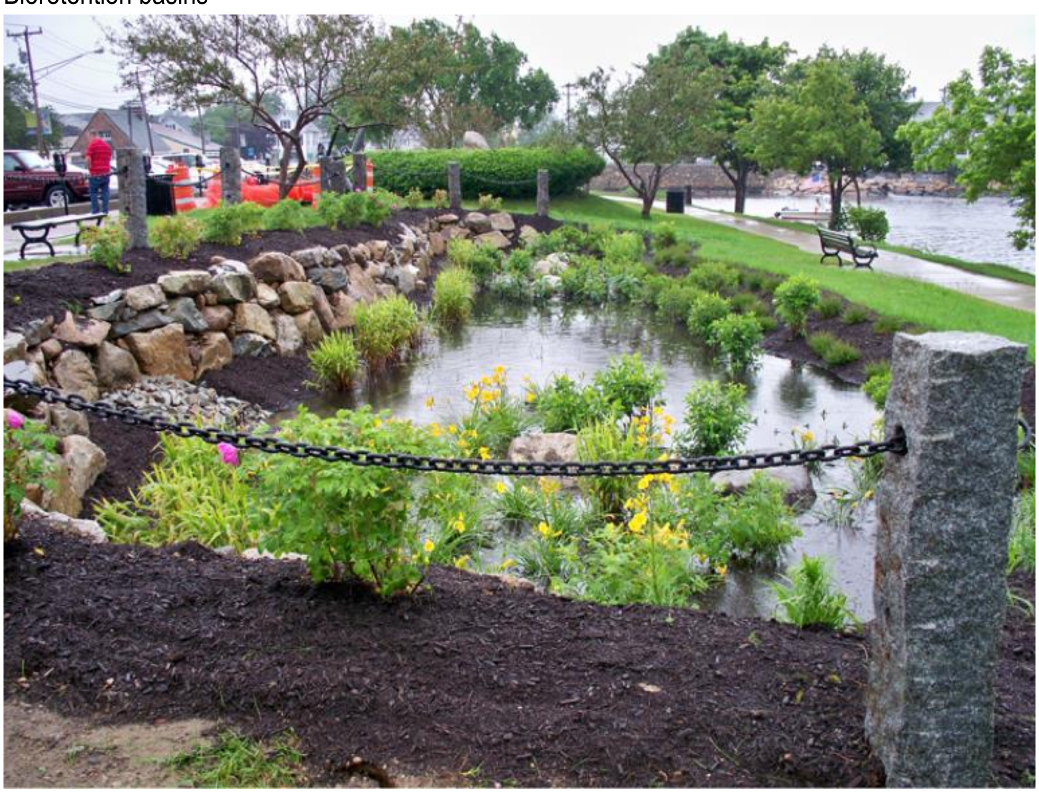
Below are examples of green stormwater infrastructure. This mimics natural systems by absorbing and treating stormwater close to where the rain falls. Stormwater can become polluted by contaminants on parking lots, pesticides and fertilizers on lawns, and soil eroded from bare ground. On a scale of 1-10, to what extent do you think this infrastructure is a good fit for your community? Scale: 1 = It is terrible, to 10 = It is perfect

a. Rain Garden

b. Green Streets

c. Bioswales

d. Bioretention basins



e. Trees

VII A. Are there any specific improvements or projects you would like to see in the Spicket River Watershed? (Open ended response)

B. Is there anything else you want us to know? (Open Ended response)

Thank you for participating in our survey, we appreciate your time today. Your responses are important and will help inform the creation of the WBP and future projects to improve the health of the Spicket River. If you want to learn more about the project, or stay informed about our progress, you can follow our work here (give participant leave-behind card).

Survey Results:

Groundwork Lawrence is pleased to submit the survey results for the Spicket River Watershed Based Plan.

The goal of the survey is to assess public perceptions of the Spicket River, including links between perceptions of attractiveness of how natural the Spicket River appears. The survey will also measure perceptions of the ecological state of the river as well as assessing residents' perceptions about flood protection or restoration needs.

The Spicket River Survey is comprised of 28 questions and responses were gathered in the month of August through 2 sessions interviews with Greenway users in Lawrence (at Immigrant Place Park) and Methuen (on the Methuen Rail Trail). Additional survey responses were collected from participants in a guided hike led by the Merrimack River Watershed Council. Most respondents (56%) were female, the median age of 51, and 20 of the 25 respondents lived in Methuen or Lawrence (57%).

Included with this submission is a spreadsheet containing all the survey responses in detail as well as a PDF with graphical representations of results. Generally, people utilized the greenway for walking or biking (a combined 29 of 35 responses) and had a favorable impression of the appearance of the greenway and river, though with some concerns. Of the 35 responses, 18 were from infrequent Greenway users or visitors to the river (less than once per week).

The responses from regular greenway users are likely more representative of WBP stakeholders. Some highlights of these responses are:

- 16 agree or strongly agree that flooding was a problem.
- Perceptions of environmental problems varied.
  - Only 8 agreed or strongly that flooding was a problem.
  - While 11 agreed or strongly agreed that Combined Sewer Outflows (CSO) were a problem, 7 did not know what CSOs were.
  - Pet waste (8), Chemical pollution (9) and Outdoor Car Washing (7) were the lowest ranking concerns.
  - Eleven respondents agreed or strongly agreed that stormwater runoff is a problem.
  - Floating trash is the top ranked concern with 15 responses agreeing or strongly agreeing.
- All the Nature Based Solutions were ranked highly by survey respondents.

Responses to the two open-ended questions elicited responses about the presence of homelessness, the need to do more to pick up trash in the river and remove invasive species. Respondents also suggested pollinator gardens, increasing tree canopy, access for boating, and public art installations:

- I think planting vegetation in the flood zones would have a positive impact the most. I'd love to see some pollinator gardens along the roadsides.
- Clean up debris in the river.
- More access for car top boats
- Incorporate some public art projects to highlight environmental concerns.
- Address litter, homelessness, transients, needles, fear of crime.
- Cleaning up the unhoused and trash will help beautifying it.
- Love the ideas of the planting of gardens and trees but would like to be sure they are native.
- There is a woman named Jenn Houle that has a pollinator art project, could be nice to see some of the painted butterflies along trails or have some more partnerships with groups like Greenbelt.

Spicket River Survey

35
Responses

10:58
Average time to complete

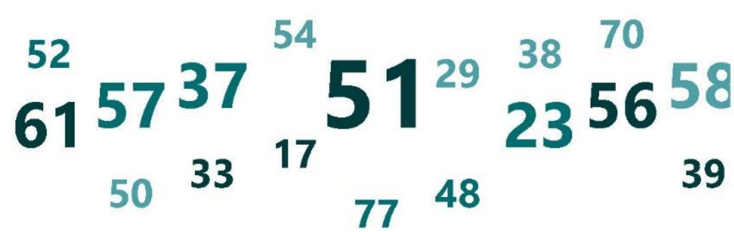
Active
Status

1. What is your age?

35
Responses

Latest Responses
"23"
"24"
"21"

3 respondents (**9**%) answered **51** for this question.



2. Gender

34
Responses

Latest Responses

"male"

"m"

"Male"

19 respondents (**56**%) answered **Female** for this question.

3. What city or town do you live in?

33
Responses

Latest Responses

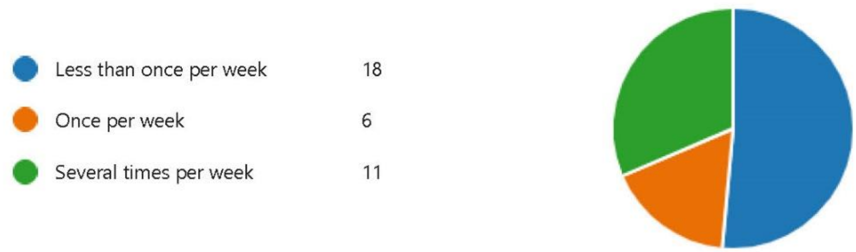
"Lawrence "

"Pelham, NH"

"Lawrence"

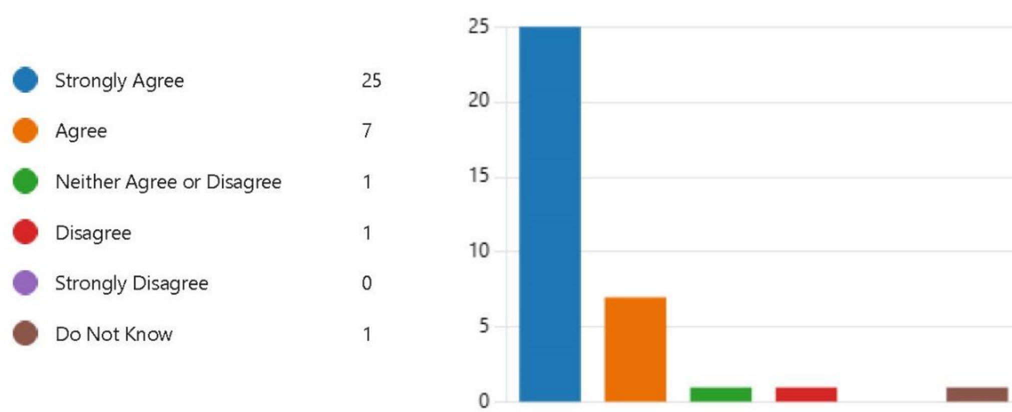
12 respondents (**36**%) answered **Methuen** for this question.

4. Greenway or Rail Trail use frequency



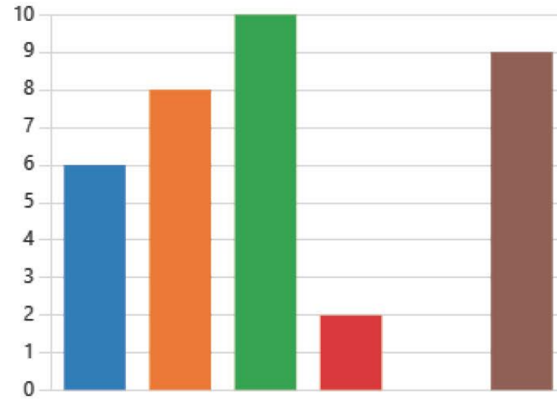
5. Primary Greenway or Rail Trail activity

6. I like to look at the river while using the Greenway or Rail Trail



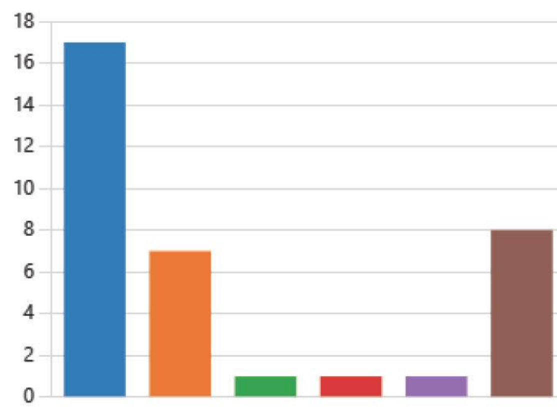
7. Flooding along the Spicket River is a problem

Strongly Agree	6
Agree	8
Neither Agree or Disagree	10
Disagree	2
Strongly Disagree	0
Do Not Know	9



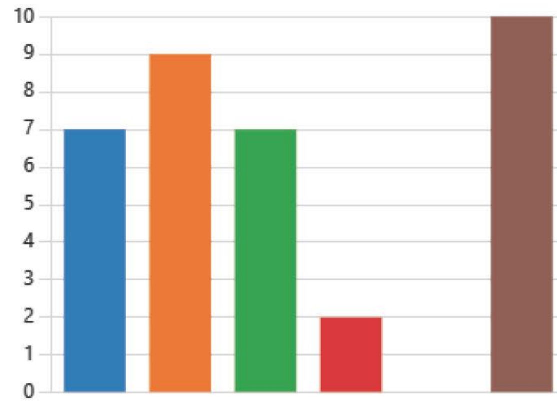
8. Combined Sewer Overflows along the Spicket River needs to be addressed

Strongly Agree	17
Agree	7
Neither Agree or Disagree	1
Disagree	1
Strongly Disagree	1
Do Not Know	8



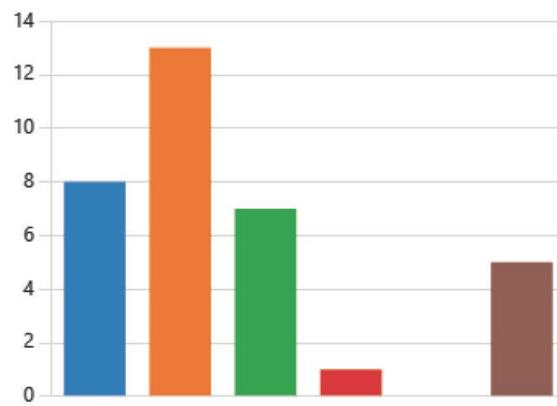
9. Pet waste is a water quality issue here

Strongly Agree	7
Agree	9
Neither Agree or Disagree	7
Disagree	2
Strongly Disagree	0
Do Not Know	10



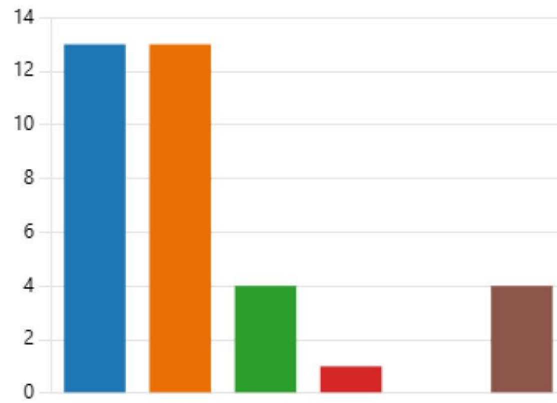
10. Chemical contamination such as pesticides or fertilizers is a water quality issue here

Strongly Agree	8
Agree	13
Neither Agree or Disagree	7
Disagree	1
Strongly Disagree	0
Do Not Know	5



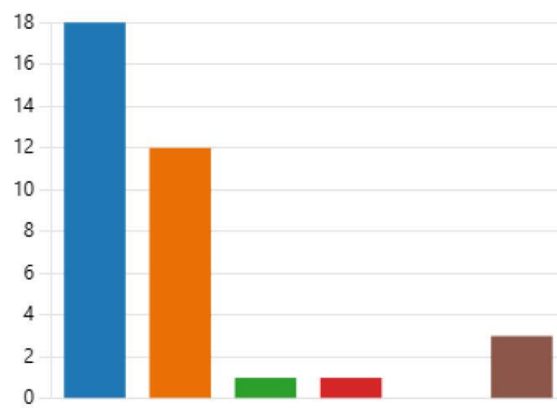
11. Runoff from streets, sidewalks, and buildings is a water quality issue here

Strongly Agree	13
Agree	13
Neither Agree or Disagree	4
Disagree	1
Strongly Disagree	0
Do Not Know	4



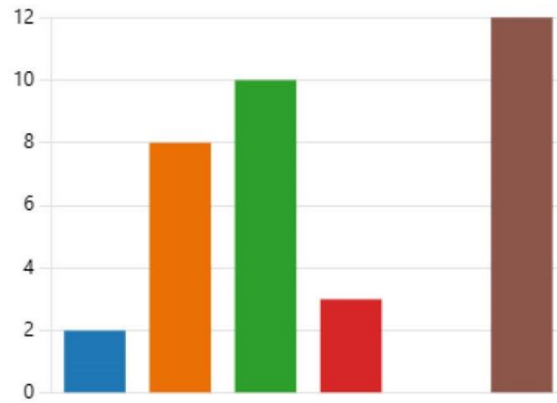
12. Trash is a water quality issue here

Strongly Agree	18
Agree	12
Neither Agree or Disagree	1
Disagree	1
Strongly Disagree	0
Do Not Know	3



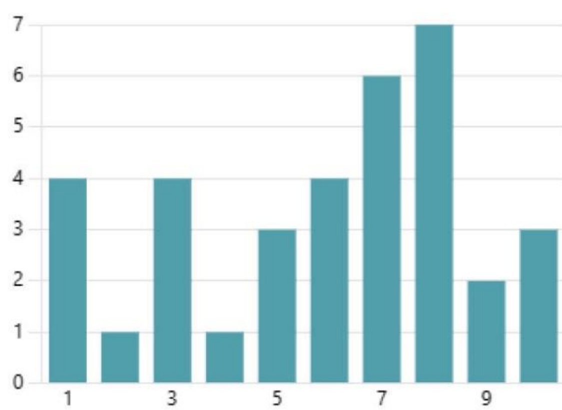
13. Contamination from outdoor car washing is a water quality issue

Strongly Agree	2
Agree	8
Neither Agree or Disagree	10
Disagree	3
Strongly Disagree	0
Do Not Know	12



14. The overall attractiveness of the Spicket River

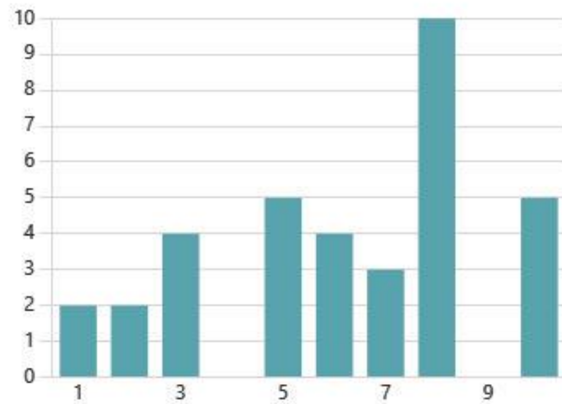
5.91
Average Rating



15. Quality of the vegetation/Green Space/Parkland along the banks of the Spicket River

6.23

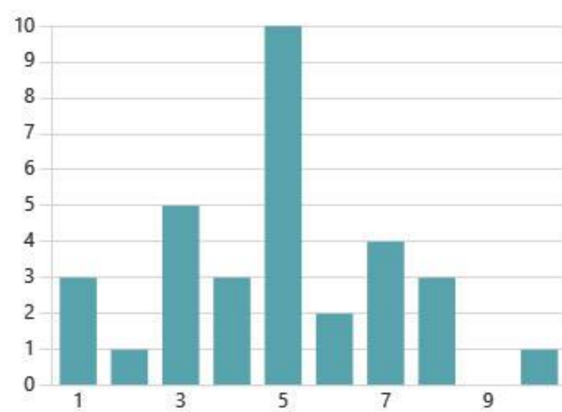
Average Rating



16. Quality of the water of the Spicket River

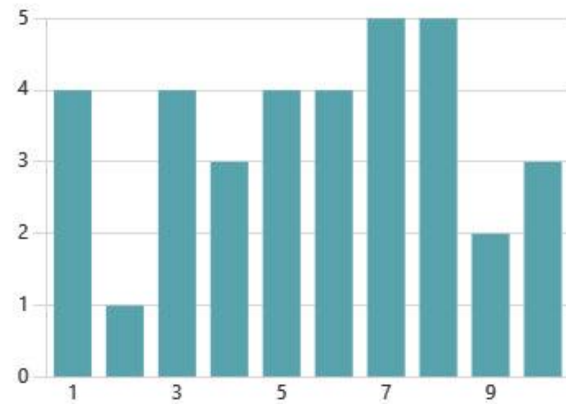
4.88

Average Rating



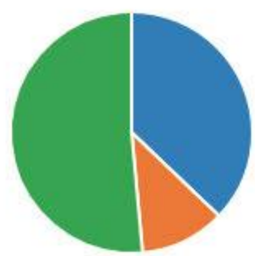
17. General environmental condition/appearance of the Spicket River

5.63
Average Rating



18. Have you participated in a River or Park cleanup or attended an educational class/hike in the last 2 years?

Yes; I have participated in a stre...	13
Yes; I have attended an educatio...	4
No	18



19. Have you communicated your environmental efforts with neighbors, friends, relatives, or other local groups?

Yes	17
No	18

20. Have you spoken to neighbors or local officials about your concerns about the Spicket River?

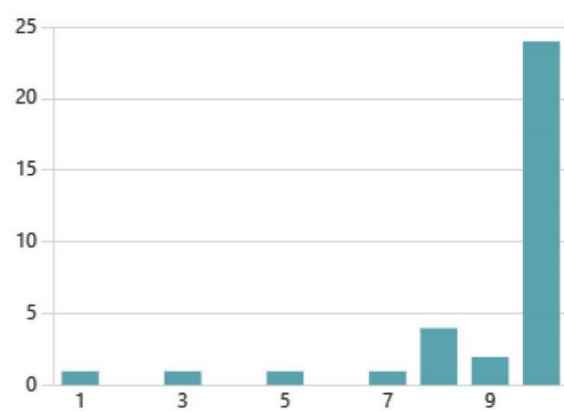
Yes	6
No	29

21. Would you be interested in participating in future events on the Spicket River such as clean ups, or guided walks?

Yes	29
No	6

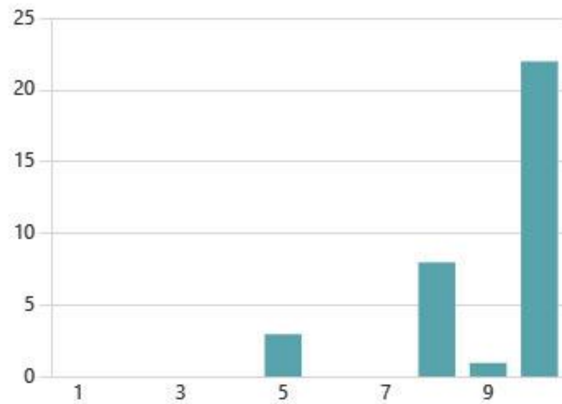
22. Rain Garden

9.00
Average Rating



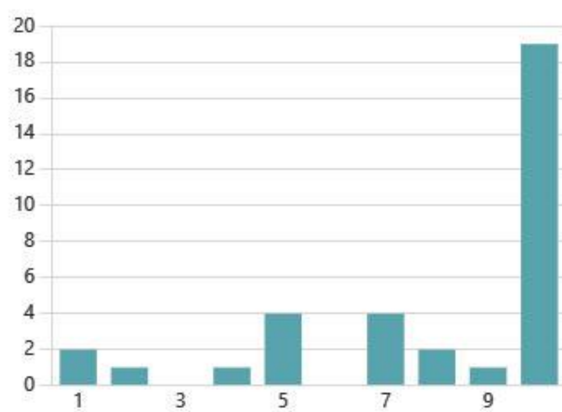
23. Green Streets

9.06
Average Rating



24. Bioswales

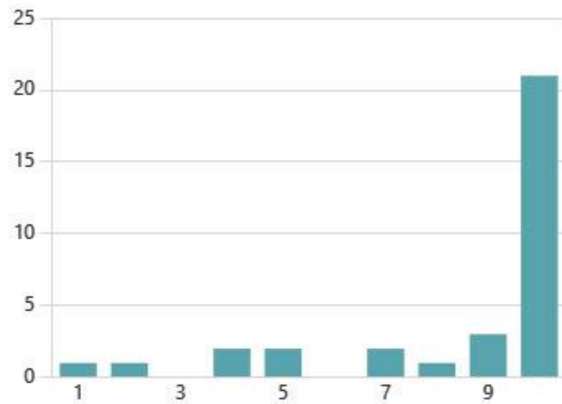
7.97
Average Rating



25. Bioretention Basins

8.48

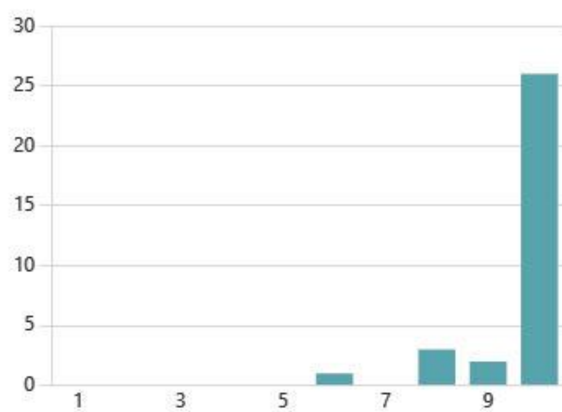
Average Rating



26. Trees

9.63

Average Rating



27. Are there any specific improvements or projects you would like to see in the Spicket River Watershed?

10
Responses

Latest Responses

"These things all look great but who will pay to maintain them? "

2 respondents (**20**%) answered **planting** for this question.

28. Is there anything else you want us to know?

11
Responses

Latest Responses

"Plant more trees."

"Have seen people throw trash into the river, seen people dump...

4 respondents (**36**%) answered **river** for this question.

Appendix D – BMP Conceptual Designs

Site 1: Methuen High School

Site Location: *1 Ranger Road, Methuen, Massachusetts*
BMP Type: Bioretention

Site Summary: Methuen Hish School serves grades 9 through 12. The property features a large educational building, tennis courts, various sports fields, and large parking and driveway areas throughout the site – a;; pf which characterize a site with a large amount of impervious area. Based on MassDEP's inventory of wetlands, there are wetlands at the northeast corner of the site. This site provides opportunity for public education and engagement due to the mix of educational and recreational use.

Proposed Improvement: The proposed retrofit improvement includes the construction of a bioretention system within a grassed area located between two drive aisles at the north end of the site, near the baseball fields. The existing grass area is unutilized, and proximate to a common footpath that would promote engagement of passerby. A raised footbridge is proposed to span the rain garden, complemented by educational signage, to promote public visibility and interaction regarding the benefits of green stormwater infrastructure. Sidewalk "foxhole" inlets are proposed to direct runoff to the bioretention system while providing pretreatment of TSS. After treatment, a level of exfiltration from the system is assumed, but an outlet control structure is proposed to measure possible flows from larger storm events. Flows ultimately discharge to wetland upstream of Searles Pond, a notable portion of the Spicket River Watershed.

Expected O&M: Inspect and remove trash monthly. Mow perimeter and accessible slopes and remove dead vegetation biannually. Monitor biannually to ensure proper function during and after storms biannually, and replace system media and vegetation only if/as needed.

Permitting: The proposed work would constitute a disturbance to the 100' Buffer Zone of a small adjacent wetland and, at a minimum, would require the filing of a Request for Determination of Applicability (RDA) with the Local Conservation Commission. As the work may be considered an expansion of an existing stormwater management system, a Notice of Intent (NOI) may not be required for the work (to be confirmed with the local Conservation Officer).

Parcel Ownership: City of Methuen

BMP Characteristics[1]	
Subcatchment Area (acres)	1.29
Impervious Area (acres)	0.56
BMP Footprint (ft^2)	2,500
BMP Volume (ft^3)	4,250
Estimated Pollutant Load Reduction[2]	
TP (lbs./yr.)	1.05
Bacteria (% removal)[3]	94%
Estimated Cost	
Planning-level Capital Cost	$415,000

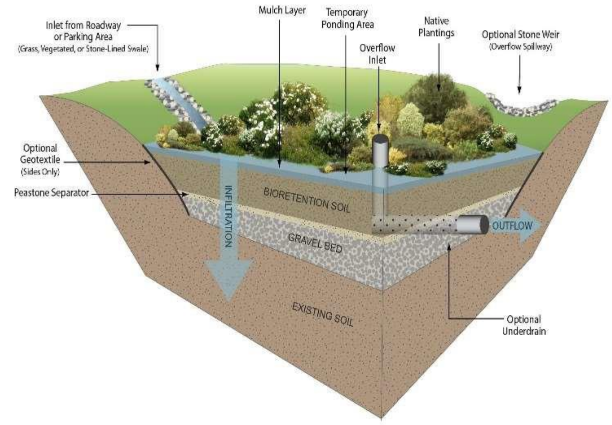
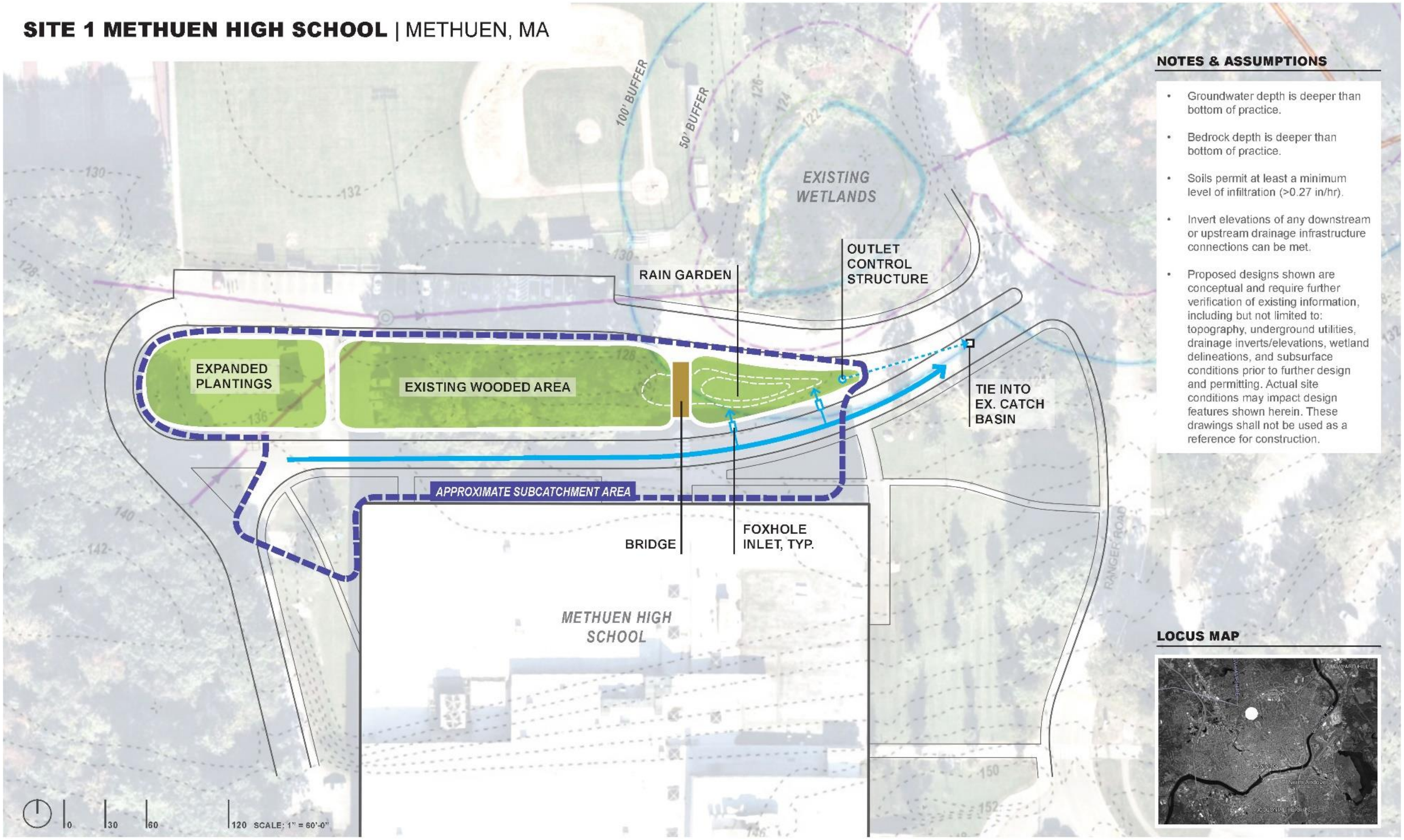


Figure 1: Example Bioretention Area
Source: A Clean Water Toolkit

Note that the capital cost shown represents the vision shown in the associated rendering, which includes a pedestrian footbridge, new concrete sidewalks around the entire turnaround area, and expanded plantings west of the basin (in addition to associated required demolition costs). Estimated cost includes construction, engineering & design (10%), construction administration ($12,500), and a 40% design and construction contingency. Estimated breakout cost for the footbridge, including design, construction, and contingency, is $65,000 (included under the $415,000 total). Operations and maintenance costs for a bioretention area of this type and size could be $3,000/year.

1. All values are approximate based on schematic sizing
2. Sizing characteristics and estimated pollutant load reductions based on established guidance from the EPA MA MS4 General Permit (effective July 1, 2018, with modification effective January 6. 2021), the Massachusetts Stormwater Handbook (Volume 2, Chapter 2: Structural BMP Specifications), and the New England Stormwater Retrofit Manual (last revised October 2022).
3. At this removal rate, there are an estimated 3.8 million colonies removed per design storm (per the New England Stormwater Retrofit Manual (last revised October 2022).

SITE 1 METHUEN HIGH SCHOOL | METHUEN, MA



NOTES & ASSUMPTIONS

- Groundwater depth is deeper than bottom of practice.
- Bedrock depth is deeper than bottom of practice.
- Soils permit at least a minimum level of infiltration (>0.27 in/hr).
- Invert elevations of any downstream or upstream drainage infrastructure connections can be met.
- Proposed designs shown are conceptual and require further verification of existing information, including but not limited to: topography, underground utilities, drainage inverts/elevations, wetland delineations, and subsurface conditions prior to further design and permitting. Actual site conditions may impact design features shown herein. These drawings shall not be used as a reference for construction.

LOCUS MAP

SITE 1 METHUEN HIGH SCHOOL | METHUEN, MA *EXISTING*

SITE 1 METHUEN HIGH SCHOOL | METHUEN, MA *POTENTIAL*

Site 2: Holy Family Hospital

Site Location: *70 East Street, Methuen, Massachusetts*

BMP Type: Bioretention

Site Summary: Holy Family Hospital is a general medical and surgical facility located in Methuen, Massachusetts, situated within a large 17.7 acres parcel that is characterized by meandering driveways and a large amount of paved parking areas surrounding the primary structure. The site is located just southwest of Searles Pond, which was identified by MRWC to be discharging an elevated level of phosphorus.

Proposed Improvement: The proposed retrofit improvements on this site include the construction of two (2) separate systems on different parts of the site. The first system, a bioretention cell preceded by a sedimentation forebay, is proposed along the eastern edge of a satellite parking area. The proposed system would serve to collect sheet runoff from this parking lot and provide treatment prior to discharge. After treatment, a level of exfiltration from the bioretention area is assumed, but an outlet control structure is proposed to monitor possible flows from larger storm events to an outlet at the bottom of the adjacent slope. The second BMP proposed includes a bioretention strip along the western portion of the site, along the edge of an existing parking area. Runoff from the associated subcatchment sheets across the parking lot directly into an adjacent wetland. The edge of the pavement is in disrepair, evidenced by various points of erosion and crumbling of the pavement and subbase. The proposed BMP would serve to collect the primarily impervious runoff and provide a level of treatment prior to discharge to the wetland. Overflow for this system would include a few different wide overflow spillways along the length of the system to discharge and dissipate potential flows from larger storm events.

Expected O&M: Inspect and remove trash monthly. Mow perimeter and accessible slopes and remove dead vegetation biannually. Monitor biannually to ensure proper function during and after storms biannually, and replace system media and vegetation only if/as needed.

Permitting: The proposed western bioretention strip would constitute a disturbance to the 100’ Buffer Zone to a wetland and would require, at a minimum, the filing of a Request for Determination of Applicability (RDA) with the Methuen Conservation Commission. However, a Notice of Intent (NOI) may be required due to required grading and excavation within the buffer zone for the installation of a new stormwater management BMP (*i.e.*, one that does not connect to existing systems). Consultation should be undertaken with the Methuen Conservation Office prior to filing to determine the appropriate permitting pathway.

Parcel Ownership: MPT of Methuen Steward, LLC

BMP Characteristics[1]	BMP #1 (East)	BMP #2 (West)
Subcatchment Area (acres)	0.52	0.94
Impervious Area (acres)	0.30	0.75
BMP Footprint (ft^2)	1,500	1,750
BMP Volume (ft^3)	1,500	1,000
Estimated Pollutant Load Reduction[2]		
TP (lbs./yr.)	0.56	0.97
Bacteria (% removal)[3]	94%	33%
Estimated Cost		
Planning-level Capital Cost	$110,000	$120,000

Estimated costs includes construction of the work, engineering & design ($12,500, each), permitting ($12,500 Eastern BMP, $21,500 Western BMP), construction administration ($5,000, each), and a 40% design and construction contingency (each). Operations and maintenance costs for a system of this type and size could be $3,000/year (each).

1. All values are approximate based on schematic sizing
2. Sizing characteristics and estimated pollutant load reductions based on established guidance from the EPA MA MS4 General Permit (effective July 1, 2018, with modification effective January 6. 2021), the Massachusetts Stormwater Handbook (Volume 2, Chapter 2: Structural BMP Specifications), and the New England Stormwater Retrofit Manual (last revised October 2022).
3. At this removal rate, there are an estimated 2.1 million colonies removed per design storm from the Eastern BMP, and 261,000 colonies removed per design storm from the Western BMP (per the New England Stormwater Retrofit Manual (last revised October 2022).

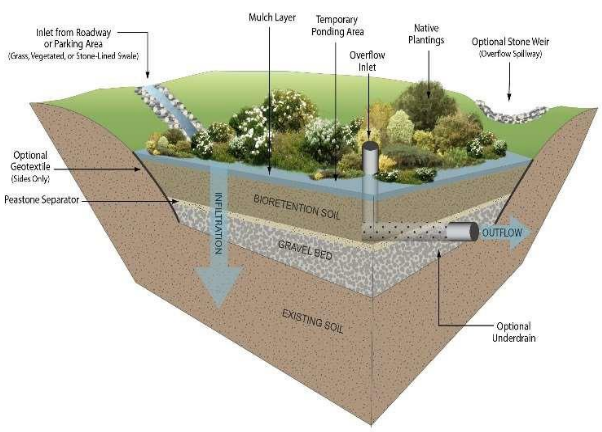
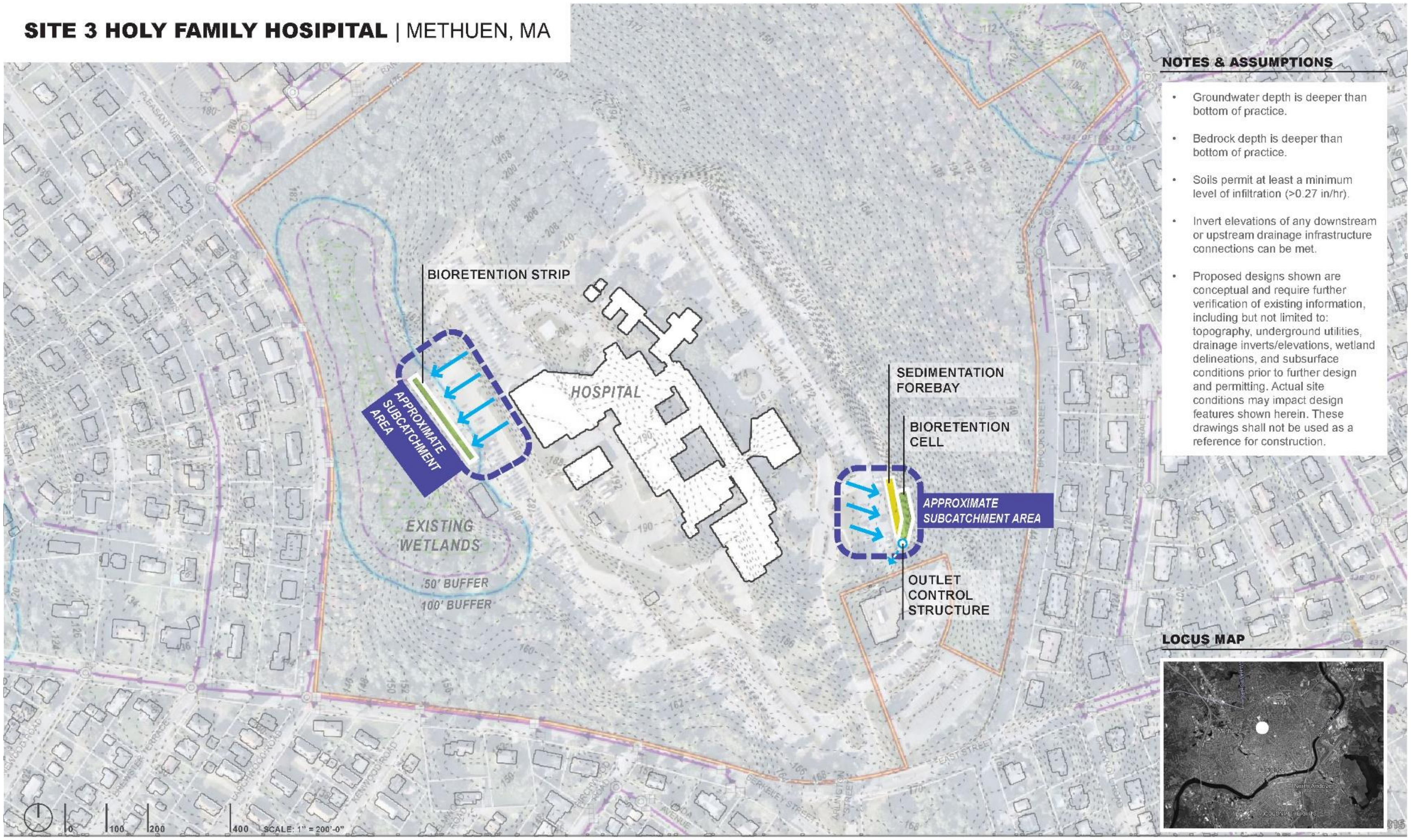


Figure 1: Example Bioretention Area
Source: A Clean Water Toolkit

SITE 3 HOLY FAMILY HOSPITAL | METHUEN, MA



NOTES & ASSUMPTIONS

- Groundwater depth is deeper than bottom of practice.
- Bedrock depth is deeper than bottom of practice.
- Soils permit at least a minimum level of infiltration (>0.27 in/hr).
- Invert elevations of any downstream or upstream drainage infrastructure connections can be met.
- Proposed designs shown are conceptual and require further verification of existing information, including but not limited to: topography, underground utilities, drainage inverts/elevations, wetland delineations, and subsurface conditions prior to further design and permitting. Actual site conditions may impact design features shown herein. These drawings shall not be used as a reference for construction.

LOCUS MAP

SPICKET RIVER WATERSHED RETROFIT
DECEMBER 2023

HALVORSON Tighe&Bond STUDIO Tighe&Bond

Site 3: Bennington Street

Site Location: *Bennington Street, Lawrence, Massachusetts*
BMP Type: Bioretention

Site Summary: Bennington Street is located in the center of downtown Lawrence, running north to south and spanning the Spicket River by means of a small bridge. Bennington Street in characterized by a varying road width and concrete sidewalks on both sides, with little to no relief of open green space. The Lawrence and Methuen Rail Trail intersects Bennington Street along the south edge of the Spicket River. This site presents an opportunity to provide a direct pedestrian connection from the Rail Trail to Plainsman Park, add tree canopy cover, reduce impervious areas, and provide potential traffic calming measures.

Proposed Improvement: The proposed retrofit improvements for this site include two (2) systems are either end of the project limits. The first BMP, to the north end, includes situating a rain garden in between the roadway and the sidewalk after implementing a curb realignment and roadway narrowing. Runoff from the impervious surfaces of Bennington Street would enter the rain garden via “rain garden turrets”, which permit shallow curbline entrances to BMPs while providing a level of pretreatment. After treatment, a minimum level of exfiltration from the system is assumed, and an outlet pipe is proposed to convey runoff to an adjoining stormwater basin under larger storm events. Flows ultimately discharge to the Spicket River, about 50 feet away. The second BMP, located at the south end of Bennington Street at its intersection with Chestnut Street, includes another rain garden built into a roadway narrowing upgrade along Chestnut Street. Flows enter the system similarly via a rain garden turret. A minimum level of exfiltration from the system is assumed, but an outlet control structure is proposed to convey potential flows from larger storms back into the closed drainage system under Chestnut Street. Additional curbline revisions and landscaped areas are proposed around the system.

Expected O&M: Inspect and remove trash monthly. Mow perimeter and accessible slopes and remove dead vegetation biannually. Monitor biannually to ensure proper function during and after storms biannually, and replace system media and vegetation only if/as needed.

Permitting: Work required for the northern BMP to the Spicket River would constitute a disturbance to the 100’ Buffer Zone, 200’ Riverfront Area, and Bordering Land Subject to Flooding (BLSF; *i.e.*, FEMA AW Flood Zone) associated with the Spicket River, requiring the filing of a Notice of Intent (NOI) with the Lawrence Conservation Commission. The proposed work would likely qualify as exempt for the Buffer Zone and Riverfront Area as the conversion of impervious surface to vegetation (310 CMR 10.02(b)(2)(f)), however, the project filing will need to demonstrate how the project meets BLSF performance standards (*e.g.*, no loss of flood storage capacity or habitat functions). The southern BMP may be considered part of the local BLSF buffer zone.

Parcel Ownership: City of Lawrence

BMP Characteristics[1]	BMP #1 (North)	BMP #2 (South)
Subcatchment Area (acres)	0.18	0.20
Impervious Area (acres)	0.18	0.20
BMP Footprint (ft^2)	600	300
BMP Volume (ft^3)	300	200
Estimated Pollutant Load Reduction[2]		
TP (lbs./yr.)	0.25	0.22
Bacteria (% removal)[3]	49%	22%
Estimated Cost		
Planning-level Capital Cost	$180,000	$180,000

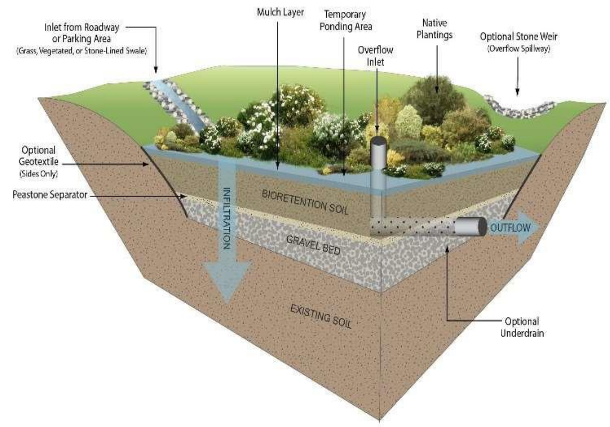
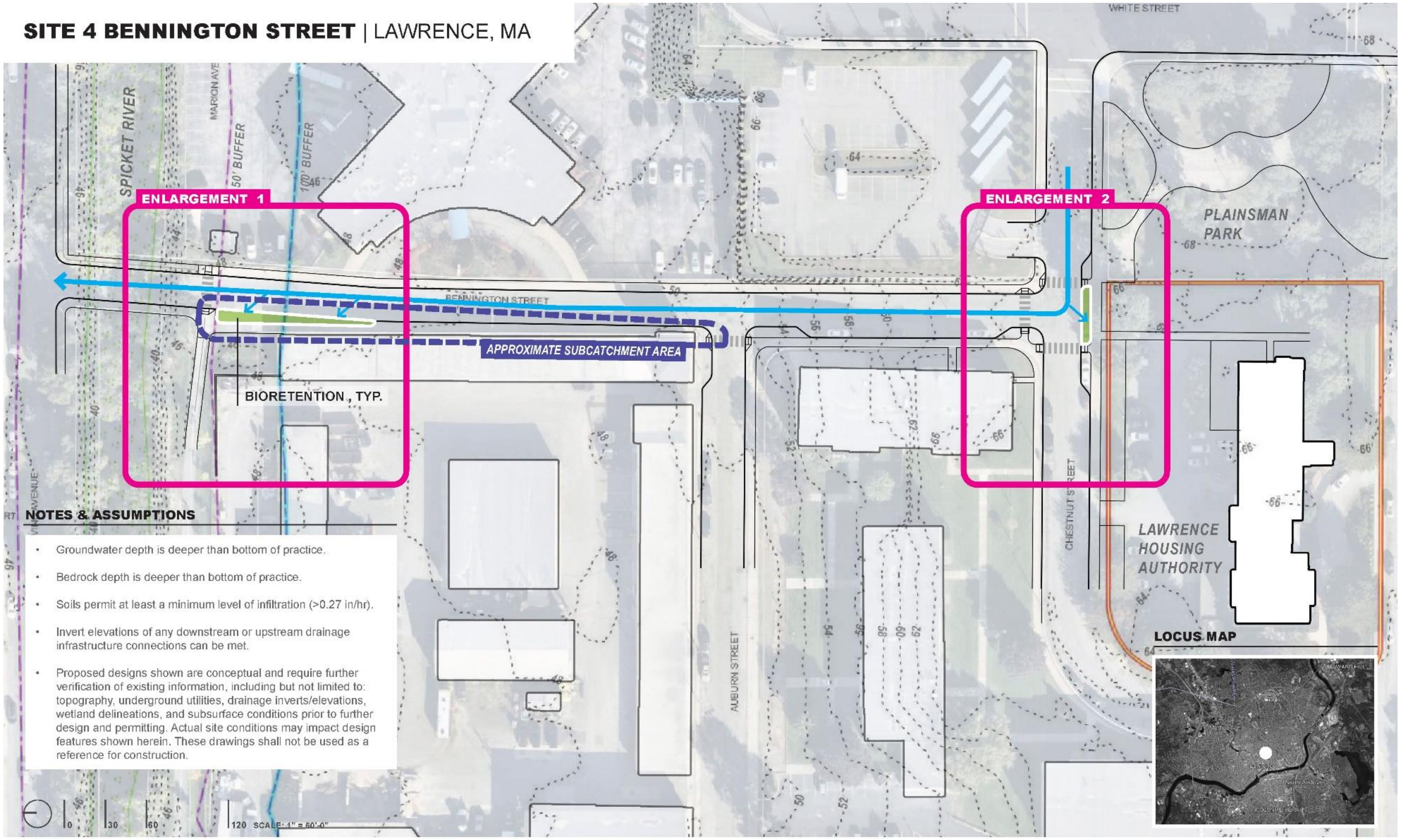


Figure 1: Example Bioretention Area
Source: A Clean Water Toolkit

Estimated cost includes construction of the work, engineering & design ($25,000, each), permitting ($20,000 Northern BMP, $7,500 Southern BMP), construction administration ($5,000, each), and a 40% design and construction contingency (each). Operations and maintenance costs for a system of this type and size could be $3,000/year (each).

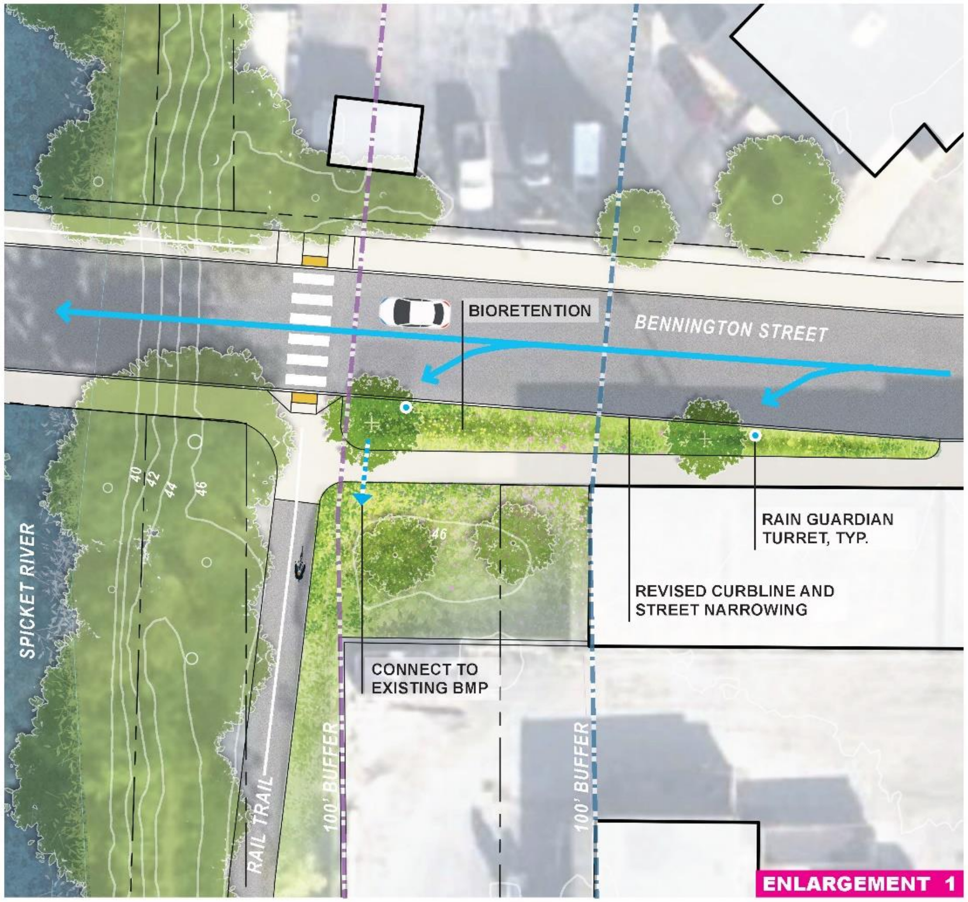
1. All values are approximate based on schematic sizing
2. Sizing characteristics and estimated pollutant load reductions based on established guidance from the EPA MA MS4 General Permit (effective July 1, 2018, with modification effective January 6. 2021), the Massachusetts Stormwater Handbook (Volume 2, Chapter 2: Structural BMP Specifications), and the New England Stormwater Retrofit Manual (last revised October 2022).
3. At this removal rate, there are an estimated 155,000 colonies removed per design storm from the Northern BMP, and 27,000 colonies removed per design storm from the Soouthern BMP (per the New England Stormwater Retrofit Manual (last revised October 2022).

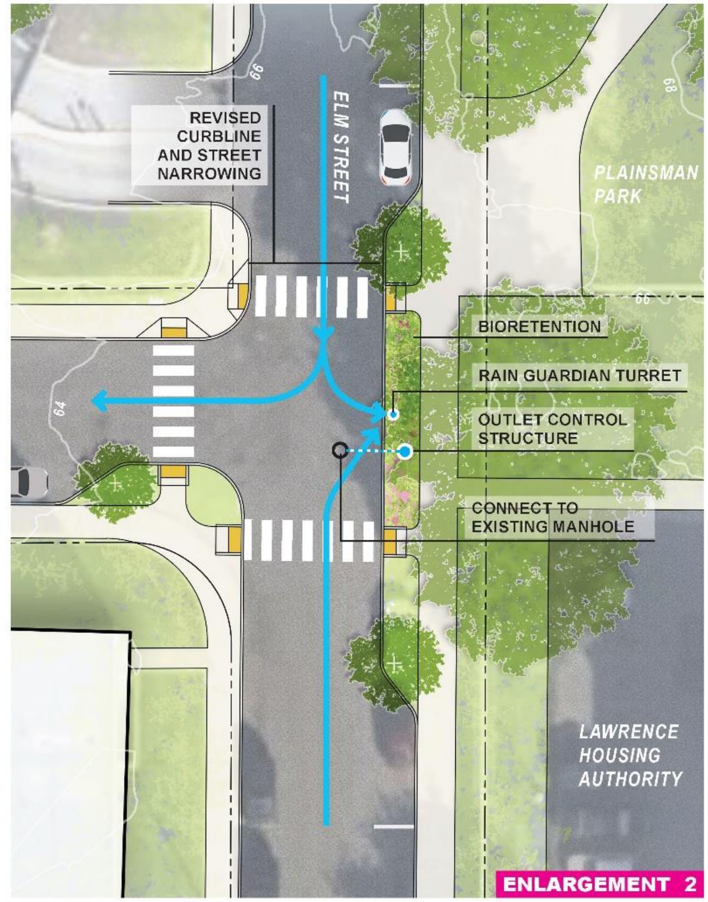
SITE 4 BENNINGTON STREET | LAWRENCE, MA



NOTES & ASSUMPTIONS

- Groundwater depth is deeper than bottom of practice.
- Bedrock depth is deeper than bottom of practice.
- Soils permit at least a minimum level of infiltration (>0.27 in/hr).
- Invert elevations of any downstream or upstream drainage infrastructure connections can be met.
- Proposed designs shown are conceptual and require further verification of existing information, including but not limited to: topography, underground utilities, drainage inverts/elevations, wetland delineations, and subsurface conditions prior to further design and permitting. Actual site conditions may impact design features shown herein. These drawings shall not be used as a reference for construction.





0 10 20 40 SCALE: 1" = 20'-0"

Site 4: Howard Playstead

Site Location: Lawrence Street, Lawrence, Massachusetts

BMP Type: Bioretention

Site Summary: Howard Playstead is a recreational park located across from the intersection of Lawrence Street and Hampshire Street in Lawrence, MA. It is characterized by baseball and softball fields, paved tennis and basketball courts, and a small recreational playground for children. Paved walks connect the various fields to one another, serving as an outdoor space for community engagement and recreation.

Proposed Improvement: The proposed retrofit improvement includes the construction of a bioretention system within a grassed area located between the existing tennis courts and the playground. The site-specific location was selected due to the breadth of its subcatchment area, proximity to existing closed drainage, and presence within a primary entrance to the site. As runoff from the upper ball fields sheets down the adjacent slope, some minor regrading is proposed to convey flows toward a set of stone weirs. The weird, in combination with complementary landscaping, add form to the primary function of a small sedimentation basin between weird prior to entering the bioretention cell. By adding educational signage, an opportunity is presented to provide a space functional to stormwater treatment and public engagement and education. After treatment, a level of exfiltration from the bioretention area is assumed, but an outlet control structure is proposed to meter possible flows from larger storm events to the downstream closed drainage system in Lawrence Street. Additionally. The City of Lawrence is potentially interested in resurfacing the existing courts. If these are to be resurfaced, grading could be sloped to the proposed conveyance swale and bioretention area, to further capture additional runoff and pollutant at this property.

Expected O&M: Inspect and remove trash monthly. Mow perimeter and accessible slopes and remove any dead vegetation biannually. Monitor to ensure proper function during and after storms biannually. Replace system media and vegetation only if/as needed.

Permitting: There are no permitting requirements anticipated for the proposed work at this site.

Parcel Ownership: City of Lawrence

Sizing Characteristics[1]	
Subcatchment Area (acres)	4.2
Impervious Area (acres)	0.2
BMP Footprint (ft^2)	1,800
BMP Volume (ft^3)	3,800
Estimated Pollutant Load Reduction[2]	
TP (lbs./yr.)	0.57
Bacteria (% removal)[3]	97%
Estimated Cost[3]	
Planning-level Capital Cost	$135,000

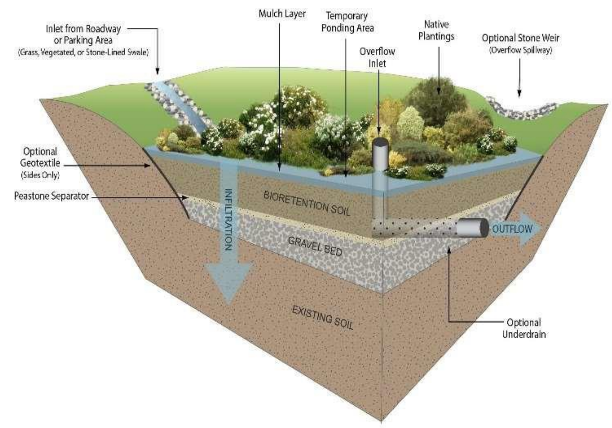
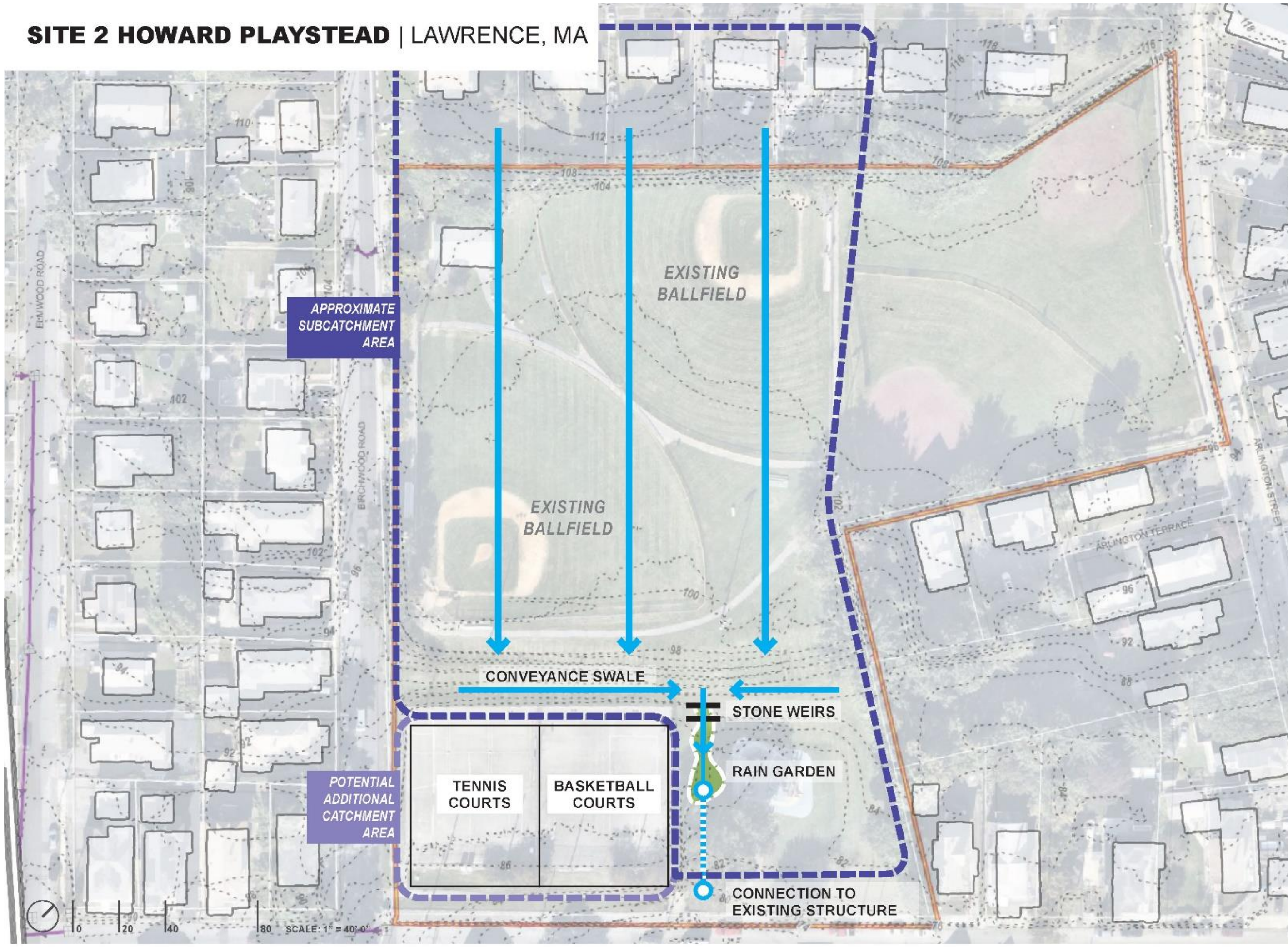


Figure 1: Example Bioretention Area
Source: A Clean Water Toolkit

Estimated cost includes construction of the work, engineering & design ($25,000), construction administration ($5,000), and a 40% design and construction contingency. Operations and maintenance costs for a bioretention area of this type and size could be $3,000/year.

1. All values are approximate based on schematic sizing
2. Sizing characteristics and estimated pollutant load reductions based on established guidance from the EPA MA MS4 General Permit (effective July 1, 2018, with modification effective January 6. 2021), the Massachusetts Stormwater Handbook (Volume 2, Chapter 2: Structural BMP Specifications), and the New England Stormwater Retrofit Manual (last revised October 2022).
3. At this removal rate, there are an estimated 10 million colonies removed per design storm (per the New England Stormwater Retrofit Manual (last revised October 2022).

SITE 2 HOWARD PLAYSTEAD | LAWRENCE, MA



NOTES & ASSUMPTIONS

- Groundwater depth is deeper than bottom of practice.
- Bedrock depth is deeper than bottom of practice.
- Soils permit at least a minimum level of infiltration (>0.27 in/hr).
- Invert elevations of any downstream or upstream drainage infrastructure connections can be met.
- Proposed designs shown are conceptual and require further verification of existing information, including but not limited to: topography, underground utilities, drainage inverts/elevations, wetland delineations, and subsurface conditions prior to further design and permitting. Actual site conditions may impact design features shown herein. These drawings shall not be used as a reference for construction.

LOCUS MAP


SPICKET RIVER WATERSHED RETROFIT
DECEMBER 2023
HALVORSON Tighe&Bond

SITE 2 HOWARD PLAYSTEAD | LAWRENCE, MA *POTENTIAL*

Site 5: Comprehensive Grammar School

Site Location: *100 Howe Street, Methuen, Massachusetts*

BMP Type: Bioretention

Site Summary: The Comprehensive Grammar School, serving pre-kindergarten through Grade 8, is situated within a parcel of approximately 34.8 acres located to the east of Stillwater Pond. Impervious area on-site includes the building footprint, driveway entrance, walkways, and parking lots. To the west of the school, there is open grass available for sports and student recreation. Based on MassDEP's inventory of wetlands, there are wetlands on-site on both the east and west sides of the school. This site provides opportunity for public education and engagement due to the mix of educational and recreational use.

Proposed Improvement: The proposed retrofit improvement includes the construction of a bioretention system within a grassed and wooded area north of the midpoint of the driveway entrance. Construction of additional underground drainage pipes could convey existing upstream underground drainiage from the driveway to the BMPs. A portion of both on and off-site grassed areas are expected to sheet down into the system. Additionally, installation of a deep-sump hooded catch basin in the south-eastern parking area is proposed to convey additional impervious area to the BMP. A sediment forebay will provide a small detention space for TSS to settle out of runoff prior to entering the bioretention cell. After treatment, a level of exfiltration from the system is assumed, but an outlet control structure is proposed to measure possible flows from larger storm events. Flows ultimately discharge to an on-site wetland south of the driveway area and installing a water quality unit for pretreatment. From there, flow will be directed to a bioretention basin along the northern property line, which can be designed to treat and infiltrate runoff before discharging it to an on-site wetland. This alternative design may be considered should further site investigation indicate conditions that would render the primary retrofit design infeasible.

Expected O&M: Inspect and remove trash monthly. Mow perimeter and accessible slopes and remove any dead vegetation biannually. Monitor to ensure proper function during and after storms biannually. Replace system media and vegetation only if/as needed.

Permitting: The proposed work may constitute a disturbance to the 100' Buffer Zone of a small adjacent wetland for connection to the existing closed drainage system. At a minimum, this would require the filing of a Request for Determination of Applicability (RDA) with the Local Conservation Commission. As the work may be considered an expansion of an existing stormwater management system, a Notice of Intent (NOI) may not be required for the work (to be confirmed with the local Conservation Officer).

Parcel Ownership: City of Methuen

Sizing Characteristics[1]	
Subcatchment Area (acres)	1.85
Impervious Area (acres)	0.76
BMP Footprint (ft^2)	2,000
BMP Volume (ft^3)	2,800
Estimated Pollutant Load Reduction[2]	
TP (lbs./yr.)	1.4
TSS (lbs./yr.)	318
Bacteria (% removal)[3]	96%
Estimated Cost	
Planning-level Capital Cost (Primary)	$130,000
Planning-level Capital Cost (Alternate)	$110,000

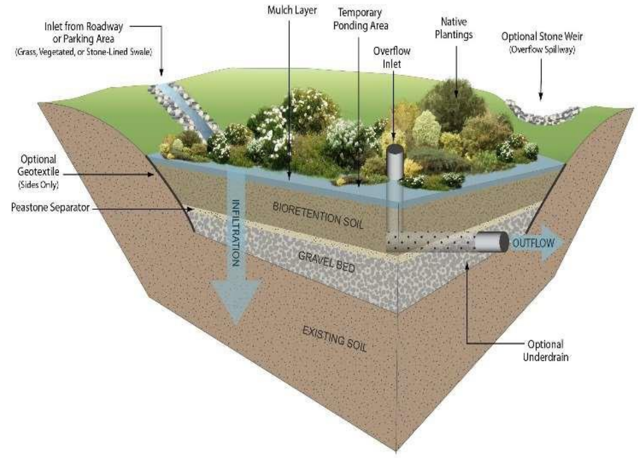


Figure 1: Example Bioretention Area
Source: A Clean Water Toolkit

Estimated cost includes construction of the work, engineering & design ($12,500, each), permitting ($12,500, each), construction administration ($5,000, each), and a 40% design and construction contingency (each). Operations and maintenance costs for a system of this type and size could be $3,000/year (each).

1. All values are approximate based on schematic sizing
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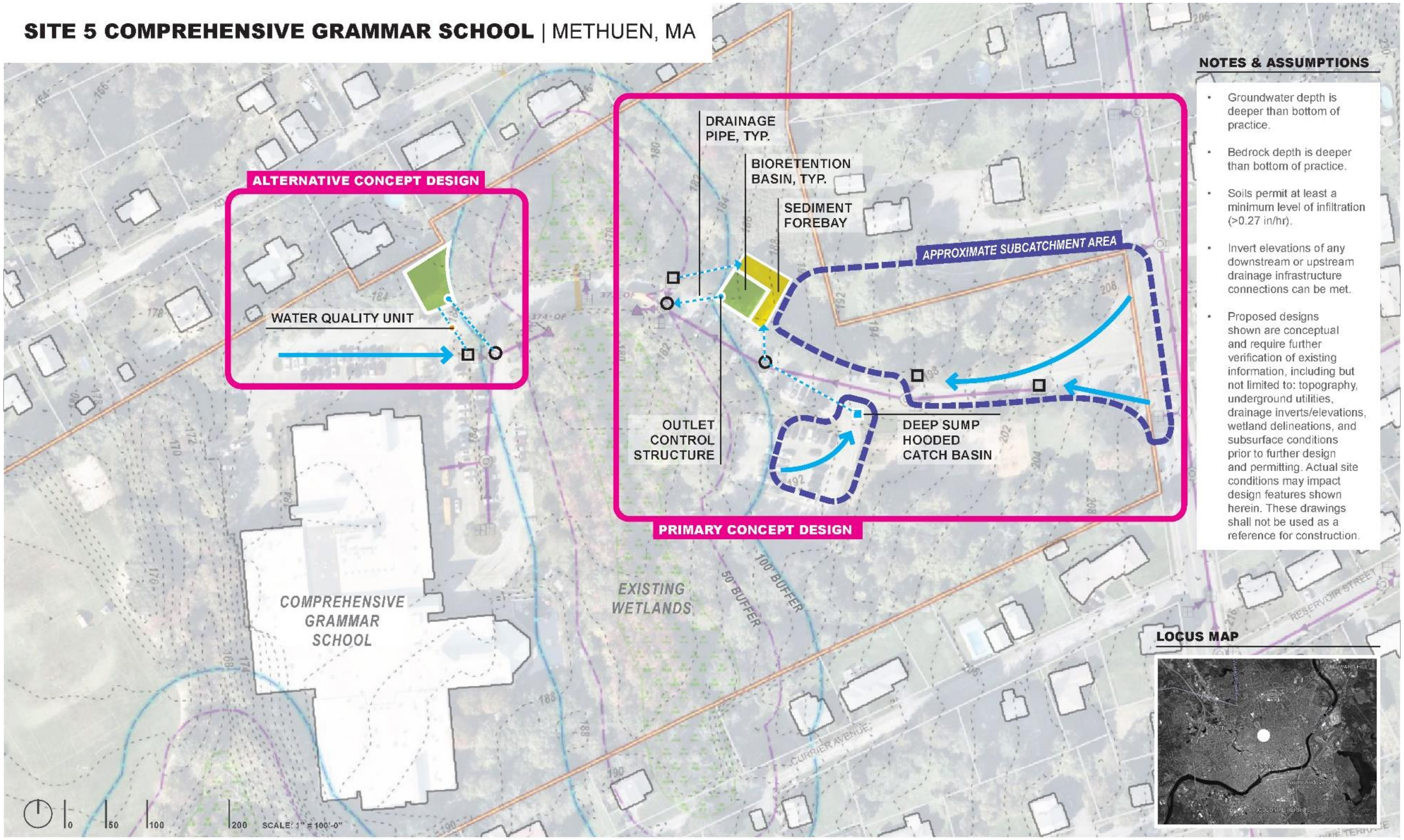
3. At this removal rate, there are an estimated 3.6 million colonies removed per design storm (per the New England Stormwater Retrofit Manual (last revised October 2022).

SITE 5 COMPREHENSIVE GRAMMAR SCHOOL | METHUEN, MA



NOTES & ASSUMPTIONS

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SPICKET RIVER WATERSHED RETROFIT
DECEMBER 2023

HALVORSON Tighe&Bond STUDIO Tighe&Bond