MASSACHUSETTS
watershed·based plans

WATERSHED-BASED PLAN

Shawsheen River Watershed

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City of Lawrence
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Executive Summary

Introduction:

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts's 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 in partnership with the Merrimack Valley Planning Commission and support from consultants Horsley Witten, with funding, input, and collaboration with the Massachusetts Department of Environmental Protection (MassDEP).

This WBP was prepared for the Lower Shawsheen River, which is a tributary of the Merrimack River. The part of the mainstem of the Shawsheen covered by this plan begins in Tewksbury, and runs through Andover, Lawrence and North Andover, before emptying at its confluence with the Merrimack River on the Lawrence – North Andover town line. This WBP specifically focuses on best management practices and measures for the Lower Shawsheen River. The lower segment of the watershed was selected for this plan to provide a more focused area for project prioritization, and to ensure water quality sampling would capture the effects of the Ballardvale Dam in Andover. The total area of the Shawsheen River watershed is approximately 48,226.7 acres and the river is 26 miles long. The watershed is a mostly suburban and urban watershed, with its boundaries including both rural and heavy urbanized areas.

Impairments and Pollution Sources:

The Shawsheen River is listed on the 2018/2020 Massachusetts 303(d) Integrated List of Waters (MassDEP, 2021) as a Category 5 Impaired Waterbody being impaired in the following parameters: Dissolved oxygen, physical substrate, habitat alterations, sedimentation/siltation, *E. coli* from MS4 systems, fecal coliform from MS4 systems, turbidity, benthic macroinvertebrates, chloride, and dewatering. The possible pollution sources most notably originate from urban stormwater runoff, however, can specifically be attributed to potential illicit storm sewer connections, industrial or commercial site stormwater discharge, highway/road/bridge runoff, animal feeding operations, channelization, and discharge from MS4 systems.

The Merrimack River Watershed Council has created a Sampling and Analysis Plan (SAP) which can be found in the **Appendix C**. This SAP included sampling for pathogens, *E. coli*, turbidity, as well as basic physical and chemical parameters such as temperature, pH, total dissolved solids, conductivity and dissolved oxygen. This work was done to help inform the decisions and contents of this WBP.

For the purposes of this WBP, Total Phosphorus is listed as the primary pollutant. The Total Phosphorus load reductions needed to achieve water quality goals are outlined in **Element B**.

Goals, Management Measures, and Funding:

The primary goals of this project are to reduce phosphorous loading from suburban runoff to improve water quality and ultimately remove the waterbody from the 303(d) list. In addition, project partners and stakeholders look to educate and empower local residents to minimize nutrient and pollutant runoff on their properties and build relations and local knowledge to enable future Best Management Practice (BMPs) implementation projects. These goals will be accomplished primarily through the installation of structural BMPs to capture runoff and the implementation of non-structural BMPs, including watershed education. Potential BMP implementation projects identified in **Element C** will help accomplish these goals by reducing run off, filtering and storing pollutants, and encouraging a more proactive stewardship of the Shawsheen River watershed. It is expected that funding for management measures will be obtained from a variety of sources including Section 319 Grant Funding.

Public Education and Outreach:

The goals of public education and outreach are to provide information about proposed stormwater improvements and their anticipated benefits and to promote watershed stewardship. Outreach to local residents, municipal staff, and recreators will educate and inspire future local action to ensure the preservation of the watershed region.

Implementation Schedule and Evaluation Criteria:

Projects will be implemented based on the goals in **Element H-I**, which cover monitoring, implementation of structural BMPs, public education and outreach activities, and periodic updates to the WBP. It is recommended that continuous water quality monitoring be used to evaluate improvements from the BMPs over time, as well as establish concrete long term load reduction goals and monitor the success of this WBP. The overall goal if this WBP is to de-list the watershed from the 303(d) list. Should funding be available, the WBP will be re-evaluated and adjusted as needed once every five years.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds and present 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 Lawrence, The Town of Andover, North Andover and Tewksbury, Groundwork Lawrence, the Merrimack Valley Planning Commission (MVP), the Shawsheen River Watershed Association (SRWA), and Engineering Firm and the Massachusetts Bay National Estuary Partnership (MassBays), using finds from EPA grant number 00A01085-0. This WBP was developed using MassDEP's Watershed-Based Planning Tool.

Core project stakeholders included:

- Becky Zawalski, Water Quality Program Manager (Former) – Merrimack River Watershed Council (MRWC)
- Jose Tapia, Water Quality Project Manager – Merrimack River Watershed Council (MRWC)
- Matthew Cranney, Water Resources Program Manager – Merrimack River Watershed Council (MRWC)
- Cecelia Gerstenbacher, Environmental Program Manager (Former) – Merrimack Valley Planning Commission (MVPC)
- Adrienne Lennon, Environmental Program Manager - Merrimack Valley Planning Commission (MVPC)
- Macklen Wier, Environmental Planner - Merrimack Valley Planning Commission (MVPC)
- Stephen Lopez, GIS/ IT Program Manager – Merrimack Valley Planning Commission (MVPC)
- Sarah Reny, GIS Analyst - Merrimack Valley Planning Commission (MVPC)
- William Hale, Water and Sewer Commissioner – Lawrence Water & Sewer Department
- Dan Lahiff, Supervisor- Lawrence Water & Sewer Department
- Jose Medina, Water and Sewer Supervisor – City of Lawrence
- Abigail Mahoney, Conservation Agent – Town of Tewksbury
- Joe Fontaine, Conservation Agent (Former) – Town of Tewksbury
- Alex Lowder, Community/ Economic Development Planner – Town of Tewksbury
- Amy Maxner, Conservation Administrator – Town of North Andover

- Justine Fox, Conservation Field Inspector (Former) – Town of North Andover
- Joyce Losick-Yang, Director of Sustainability and Energy – Town of Andover
- Robert Douglas, Director of Conservation – Town of Andover
- Michael Murray, Conservation Land Manager – Town of Andover
- Brian Henderson, Board President – Shawsheen River Watershed Association (SRWA)
- Tennis Lilly, Climate Resiliency Program Manager – Groundwork Lawrence
- Brad Buschur, Project Director – Groundwork Lawrence
- Jasper Sha, Environmental Analyst IV, Quality Assurance Analyst, Watershed Planning Program – 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. The data sources listed below primarily focused on planning and infrastructure, while relatively little water quality and sampling work was performed previously by the municipalities. To address these gaps in water quality data, MRWC conducted a sampling program during the watershed-based planning process. This sampling protocol can be found in **Appendix C**.

Table 1: Supplemental Data Sources

Title / Description	Source	Date
Andover Municipal Vulnerability Preparedness Plan	Town of Andover	2019
Restoring Aquatic Habitats through Dam Removal	Abbott et al.	2022
Sampling and Analysis Plan (SAP) For the Shawsheen River Water Sampling 2023	MRWC	2023
Sampling and Analysis Plan (SAP) For the Shawsheen River Water Sampling 2024	MRWC	2024
Shawsheen River Master Plan	Town of Andover	Ongoing

Summary of Past and Ongoing Work

As an historic river in a region that has seen many shifting land uses, the Shawsheen has been exposed to pollutants from a variety of sectors. Its industrial past continues to affect its water quality and quantity, as seen by the presence of defunct mill infrastructure on the river, stream channelization, and possible sewer discharges. As a river on Massachusetts' 303(d) list of impaired waters, the Shawsheen has been identified as a water body requiring a Total Maximum Daily Load (TMDL). The municipalities in the lower Shawsheen watershed have worked to implement stormwater infrastructure that could help make the river fishable and swimmable again, and as seen below, much of the prior work done surrounding non-point source pollution on the Shawsheen has been done on the municipal level.

Andover Municipal Vulnerability Preparedness (MVP) Plan (Town of Andover, 2019)

In 2019, the Town of Andover produced an MVP plan, focused on addressing the effects of climate change and other risks. The highest-priority risks identified by the plan were flooding and extreme weather events. The number-one recommendation put forward by the plan was to "undertake a strategic program of land acquisition and adaptation along waterways to provide flood storage and reduce the impacts of larger storm events and increased runoff." The recommendations and findings of the Shawsheen Watershed Based plan can complement this goal by providing further recommendations for reducing the effects of increased runoff.

Restoring Aquatic Habitats through Dam Removal (Abbott et al., 2022)

This study analyzed the relationship of dam characteristics and their thermal impacts at all three dams along the Shawsheen River in Andover prior to the removal of the lower two dams in 2017. This study used data from 2014 to 2016, examining upstream and downstream conditions of the three dams. Among the three, the still-standing Ballardvale Dam had the greatest impact on thermal conditions, which was attributed to the size and width of its impoundment. It found that the Ballardvale Dam had a "relatively small but persistent warming effect" and "negatively impacted stream DO [dissolved oxygen] regimes in the Shawsheen River, potentially affecting sensitive fish and macroinvertebrate taxa."

Sampling Analysis Plans for the Shawsheen River Water Sampling, 2023-2024 (Merrimack River Watershed Council, 2023, 2024)

MRWC's sampling program on the Shawsheen River was conducted from 2023 to 2024 to inform the development of this Shawsheen River Watershed-based Plan, as well as collect baseline water quality data upstream and downstream of the Ballardvale Dam prior to its removal. The results of MRWC's Shawsheen River Sampling are found in **Appendix B** and the full text of the SAPs can be found in **Appendix C**. The sampling program provided a baseline of water quality in the Shawsheen that could be used in the future to assess the impact of BMPs, prioritize areas for stormwater infrastructure and wetland restoration work, and assess the effect of the Ballardvale Dam on water quality.

Shawsheen River Master Plan (Town of Andover, Ongoing)

The Shawsheen River Master Plan is an initiative by the Town of Andover to provide a unified vision for the future of the Shawsheen River mainstem in the Town. The plan will synthesize findings and goals from community engagement initiatives, historical preservation, Andover's comprehensive plan, and disaster preparedness under Andover's Municipal Vulnerability Plan (outlined above).

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 Shawsheen River is a 26.7 mile-long tributary of the Merrimack River. The Shawsheen River has its headwater in the town of Bedford, and it flows north through the towns of Billerica, Wilmington, Tewksbury, Andover, and empties at its confluence with the Merrimack River in the City of Lawrence. The river watershed is approximately 48,226.7 acres in size and encompasses all or part of 12 Massachusetts municipalities. This watershed supports a population of approximately 250,000 people.

The Shawsheen River watershed encompasses a diverse mix of urban, suburban, and natural landscapes, serving as a vital green corridor within one of Massachusetts' more developed regions. In cities like Lawrence, home to a significant environmental justice population, urbanization has intensified challenges such as water pollution, environmental contamination, erosion, and sedimentation. For Lawrence, the Shawsheen River remains an invaluable resource, functioning as a wildlife habitat corridor, a recreational amenity, and a focal point of the region's early industrial history, particularly within its densely populated neighborhoods. Also located within the watershed, near the headwaters of the Shawsheen River, is the Hanscom Air Force Base in Bedford.

The historic use of the river and its watershed mirrors that of the Merrimack River: Heavy developmental use with a specific focus on industrial mills along the river which helped the surrounding area become the communities they are today. Today, remnants of the industrial history are still apparent along the river; notably in the presence of dams and canals. There are trails and parks, such as the Shawsheen River Reservation, located along several sections of the river, and preservation efforts are carried out by the Shawsheen River Watershed Association. Approximately 4.5% of the watershed area is covered by wetlands or open water.

The Shawsheen River has been identified by the Massachusetts Department of Environmental Protection as an impaired water body, and is listed under the Clean Water Action Section 303(d) Impaired Water Bodies List for bacteria. The Shawsheen River faces common impairments such as nutrient pollution, bacteria levels, sedimentation and turbidity, and aquatic barriers. The Shawsheen is vulnerable to catastrophic flooding, as was the case in the 2006 Mother's Day Floods. As a result of more intense rainfall, an increase in pollutant loading has degraded water quality and alienated community members from this natural resource. This project focuses on Total Phosphorous reduction, resulting in a comprehensive watershed-based plan (WBP) for the Shawsheen 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 Shawsheen, for people and wildlife alike.

Table A-1: General Watershed Information

Watershed Name (Assessment Unit ID):	Beaver Brook ; Content Brook (MA83-09) ; Elm Brook (MA83-23) ; Elm Brook (MA83-24) ; Heath Brook ; Hussey Brook ; Jones Brook ; Kiln Brook (MA83-10) ; Long Meadow Brook (MA83-11) ; McKee Brook ; Meadow Brook (MA83-12) ; Rogers Brook (MA83-04) ; Sandy Brook (MA83-13) ; Shawsheen River (MA83-01) ; Shawsheen River (MA83-08) ; Shawsheen River (MA83-17) ; Shawsheen River (MA83-18) ; Shawsheen River (MA83-19) ; Spring Brook (MA83-14) ; Strong Water Brook (MA83-07) ; Unnamed Tributary (MA83-15) ; Unnamed Tributary (MA83-16) ; Unnamed Tributary (MA83-20) ; Unnamed Tributary (MA83-21) ; Vine Brook (MA83-06) ; Webb Brook (MA83-22)
Major Basin:	Shawsheen River
Watershed Area (within MA):	48226.7 (ac)

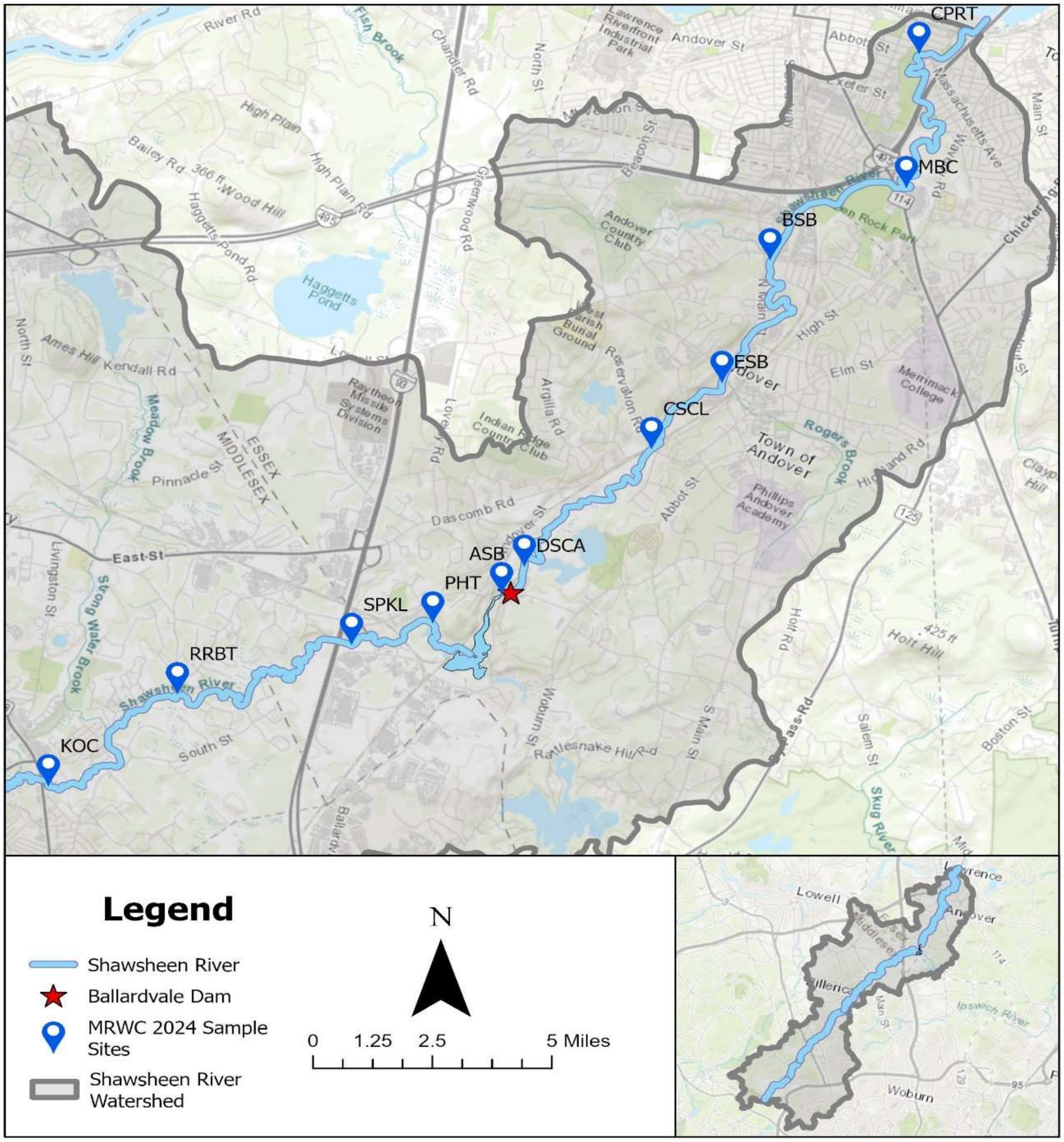

Figure A-1: Shawsheen River Watershed with MRWC Water Quality Sampling Sites (MRWC)

MassDEP Water Quality Assessment Report and TMDL Review

The following reports are available:

- Shawsheen River Watershed 2000 Water Quality Assessment Report

The following section has been moved to Appendix D. This section, titled “Water Quality Assessment Reports”, 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 in Appendix D (note: relevant information is included directly from these documents for informational purposes and has not been modified). This section has been moved due to the extent of the reports.

Historical and current Technical Memoranda (TM) produced by the MassDEP Watershed Planning Program are available here: Water Quality Technical Memoranda | Mass.gov and are organized by major watersheds in Massachusetts. Most of these TM present the water chemistry and biological sampling results of WPP monitoring surveys. The TM pertaining primarily to biological information (e.g., benthic macroinvertebrates, periphyton, fish populations) contain biological data and metrics that are currently not reported elsewhere. The data contained in the water quality TM are also provided on the "Data" page (Water Quality Monitoring Program Data | Mass.gov). Many of these TM have helped inform Clean Water Act 305(b) assessment and 303(d) listing decisions.

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)

Assessment Unit ID	Waterbody	Integrated List Category	Designated Use	Impairment Cause	Impairment Source
MA83-01	**Shawsheen River**	**5**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Source Unknown
MA83-01	**Shawsheen River**	**5**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Unspecified Urban Stormwater
MA83-01	**Shawsheen River**	**5**	Fish, other Aquatic Life and Wildlife	Physical Substrate Habitat Alterations	Source Unknown

MA83-01	**Shawsheen River**	**5**	Fish, other Aquatic Life and Wildlife	Sedimentation/siltation	Source Unknown
MA83-01	**Shawsheen River**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-01	**Shawsheen River**	**5**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-04	**Rogers Brook**	**4A**	Fish, other Aquatic Life and Wildlife	Physical Substrate Habitat Alterations	Channelization
MA83-04	**Rogers Brook**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-04	**Rogers Brook**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Illicit Connections/hook-ups To Storm Sewers
MA83-04	**Rogers Brook**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	On-site Treatment Systems (septic Systems And Similar Decentralized Systems)
MA83-04	**Rogers Brook**	**4A**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-04	**Rogers Brook**	**4A**	Primary Contact Recreation	Fecal Coliform	Illicit Connections/hook-ups To Storm Sewers
MA83-04	**Rogers Brook**	**4A**	Primary Contact Recreation	Fecal Coliform	On-site Treatment Systems (septic Systems And Similar Decentralized Systems)
MA83-06	**Vine Brook**	**5**	Aesthetic	Turbidity	Sand/gravel/rock Mining Or Quarries
MA83-06	**Vine Brook**	**5**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Baseflow Depletion From Groundwater Withdrawals
MA83-06	**Vine Brook**	**5**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Source Unknown
MA83-06	**Vine Brook**	**5**	Primary Contact Recreation	Turbidity	Sand/gravel/rock Mining Or Quarries
MA83-06	**Vine Brook**	**5**	Secondary Contact Recreation	Turbidity	Sand/gravel/rock Mining Or Quarries
MA83-07	**Strong Water Brook**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-07	**Strong Water Brook**	**4A**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)

MA83-08	**Shawsheen River**	**5**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Source Unknown
MA83-08	**Shawsheen River**	**5**	Fish, other Aquatic Life and Wildlife	Physical Substrate Habitat Alterations	Channelization
MA83-08	**Shawsheen River**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-08	**Shawsheen River**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Industrial/commercial Site Stormwater Discharge (permitted)
MA83-08	**Shawsheen River**	**5**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-08	**Shawsheen River**	**5**	Primary Contact Recreation	Fecal Coliform	Industrial/commercial Site Stormwater Discharge (permitted)
MA83-09	**Content Brook**	**5**	Fish, other Aquatic Life and Wildlife	Benthic Macroinvertebrates	Source Unknown
MA83-09	**Content Brook**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-10	**Kiln Brook**	**4A**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-11	**Long Meadow Brook**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-11	**Long Meadow Brook**	**4A**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-11	**Long Meadow Brook**	**4A**	Secondary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-13	**Sandy Brook**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-13	**Sandy Brook**	**4A**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-13	**Sandy Brook**	**4A**	Secondary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)

MA83-15	**Unnamed Tributary**	**5**	Fish, other Aquatic Life and Wildlife	Chloride	Highway/road/bridge Runoff (non-construction Related)
MA83-15	**Unnamed Tributary**	**5**	Fish, other Aquatic Life and Wildlife	Dewatering	Baseflow Depletion From Groundwater Withdrawals
MA83-15	**Unnamed Tributary**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Animal Feeding Operations (nps)
MA83-15	**Unnamed Tributary**	**5**	Primary Contact Recreation	Fecal Coliform	Animal Feeding Operations (nps)
MA83-17	**Shawsheen River**	**5**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Source Unknown
MA83-17	**Shawsheen River**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-17	**Shawsheen River**	**5**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-18	**Shawsheen River**	**5**	Fish, other Aquatic Life and Wildlife	Dissolved Oxygen	Source Unknown
MA83-18	**Shawsheen River**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-18	**Shawsheen River**	**5**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-19	**Shawsheen River**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-19	**Shawsheen River**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Illicit Connections/hook-ups To Storm Sewers
MA83-19	**Shawsheen River**	**4A**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-19	**Shawsheen River**	**4A**	Primary Contact Recreation	Fecal Coliform	Illicit Connections/hook-ups To Storm Sewers
MA83-20	**Unnamed Tributary**	**5**	Fish, other Aquatic Life and Wildlife	Chloride	Highway/road/bridge Runoff (non-construction Related)
MA83-21	**Unnamed Tributary**	**4A**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-22	**Webb Brook**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate

					Storm Sewer Systems (ms4)
MA83-22	**Webb Brook**	**5**	Secondary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-24	**Elm Brook**	**5**	Fish, other Aquatic Life and Wildlife	Physical Substrate Habitat Alterations	Channelization
MA83-24	**Elm Brook**	**5**	Fish, other Aquatic Life and Wildlife	Sedimentation/siltation	Unspecified Urban Stormwater
MA83-24	**Elm Brook**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-24	**Elm Brook**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Industrial/commercial Site Stormwater Discharge (permitted)
MA83-24	**Elm Brook**	**5**	Primary Contact Recreation	Escherichia Coli (e. Coli)	Source Unknown
MA83-24	**Elm Brook**	**5**	Primary Contact Recreation	Fecal Coliform	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-24	**Elm Brook**	**5**	Primary Contact Recreation	Fecal Coliform	Industrial/commercial Site Stormwater Discharge (permitted)
MA83-24	**Elm Brook**	**5**	Primary Contact Recreation	Fecal Coliform	Source Unknown
MA83-24	**Elm Brook**	**5**	Secondary Contact Recreation	Escherichia Coli (e. Coli)	Discharges From Municipal Separate Storm Sewer Systems (ms4)
MA83-24	**Elm Brook**	**5**	Secondary Contact Recreation	Escherichia Coli (e. Coli)	Industrial/commercial Site Stormwater Discharge (permitted)
MA83-24	**Elm Brook**	**5**	Secondary Contact Recreation	Escherichia Coli (e. Coli)	Source Unknown

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
MA83-01	Shawsheen River	B
MA83-04	Rogers Brook	B
MA83-06	Vine Brook	B
MA83-07	Strong Water Brook	B
MA83-08	Shawsheen River	B
MA83-09	Content Brook	B
MA83-10	Kiln Brook	B
MA83-11	Long Meadow Brook	B
MA83-12	Meadow Brook	B
MA83-13	Sandy Brook	B
MA83-14	Spring Brook	B
MA83-15	Unnamed Tributary	B
MA83-16	Unnamed Tributary	B
MA83-17	Shawsheen River	B
MA83-18	Shawsheen River	B
MA83-19	Shawsheen River	B

MA83-20	Unnamed Tributary	B
MA83-21	Unnamed Tributary	B
MA83-22	Webb Brook	B
MA83-23	Elm Brook	B
MA83-24	Elm Brook	B

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

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** • Primary contact recreation: For E. coli, geometric mean of samples collected within any 90-day or smaller period shall not exceed 126 cfu/100 mL, and no more than 10% of all such samples shall exceed 410 cfu/100 mL. For enterococci, geometric mean of all samples collected within any 90-day or smaller period shall not exceed 35 cfu/100 mL, and no more than 10% of all such samples shall exceed 130 cfu/100 mL. o Waters adjacent to any public or semi-public beach, at a location used for bathing and swimming purposes or waters impacted by combined sewer overflows (CSO) or publicly owned treatment works (POTW) discharges: For E. coli, geometric mean of samples collected within any 30-day or smaller period shall not exceed 126 cfu/100 mL, and no more than 10% of all such samples shall exceed 410 cfu/100 mL. For enterococci, geometric mean of all	Massachusetts Surface Water Quality Standards (MassDEP, 2022)

	samples collected within any 30-day or smaller period shall not exceed 35 cfu/100 mL, and no more than 10% of all such samples shall exceed 130 cfu/100 mL.

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 is presented in the tables and figures below. Land use source data is from 2005 and was obtained from MassGIS (2009b). The data set was developed based on aerial photography interpreted by the University of Massachusetts Department of Forest Resources. The data are organized into several use categories: Agriculture, Commercial, Forest, High Density Residential, Highway, Industrial, Low Density Residential, Medium Density Residential, Open Land, and Water.

Table A-6: Watershed Land Uses

Land Use	Area (acres)	% of watershed
Agriculture	478.73	1
Commercial	3379.84	6.8
Forest	21790.32	43.6
High Density Residential	1994.32	4
Highway	3946.52	7.9
Industrial	1991.5	4
Medium Density Residential	8592.73	17.2
Open Land	7160.7	14.3
Water	640.9	1.3

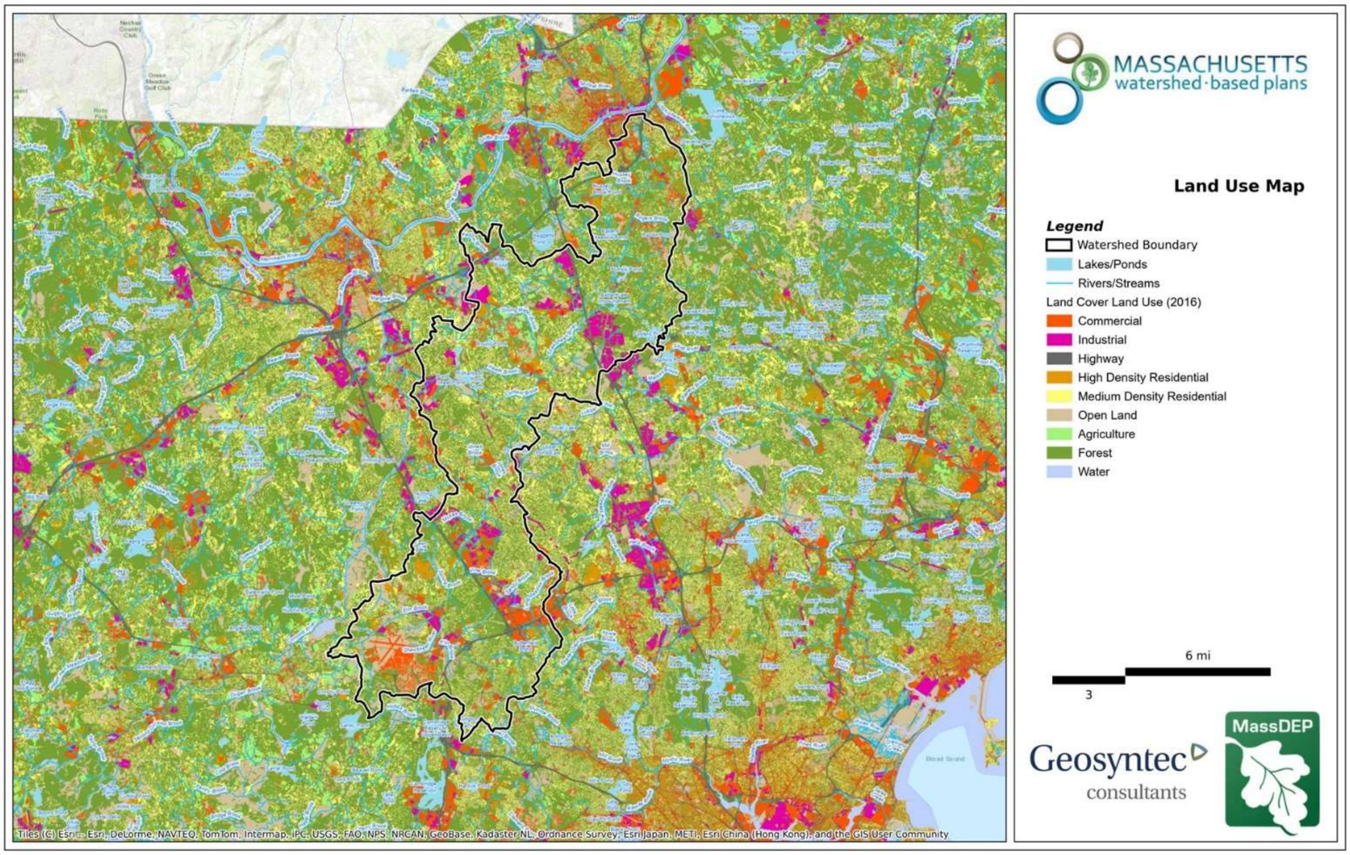

Figure A-2: Watershed Land Use Map Figure A-3: Watershed Land Use Map (MassGIS, 2007; MassGIS, 2019; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Watershed Impervious Cover

There is a strong link between impervious land cover and stream water quality. Impervious cover includes land surfaces that prevent the infiltration of water into the ground, such as paved roads and parking lots, roofs, basketball courts, etc.

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

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

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

	Estimated TIA (%)	Estimated DCIA (%)
Watershed	21.1	14.6

(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.

Watershed Impervious Cover Analysis

The Shawsheen River Watershed is a diverse watershed with both heavy industrial and forested land use. The watershed's impervious areas that are directly connected (DCIA) is estimated at 14.6%, while its Total Impervious Area is at 21.1%. Both of these numbers reflect clear signs of degradation. Stream bank erosion, channel widening, and stream habitat degradation have all been confirmed along the Shawsheen. Historically, the Shawsheen River floods with the Merrimack River, with one notable occurrence being the 2006 Mother's Day Flood. This flooding creates issues for the watershed such as ecosystem damage, as well as urban and community disruption. In addition to increased stormwater runoff, impervious surfaces can carry higher levels of pollutants into the water system, such as trash debris, chemicals, lawn fertilizer, and pet/animal waste. In addition to an analysis of current stormwater infrastructure, trash management and pet waste reduction practices have been attempted and are recommended to be continued in the future.

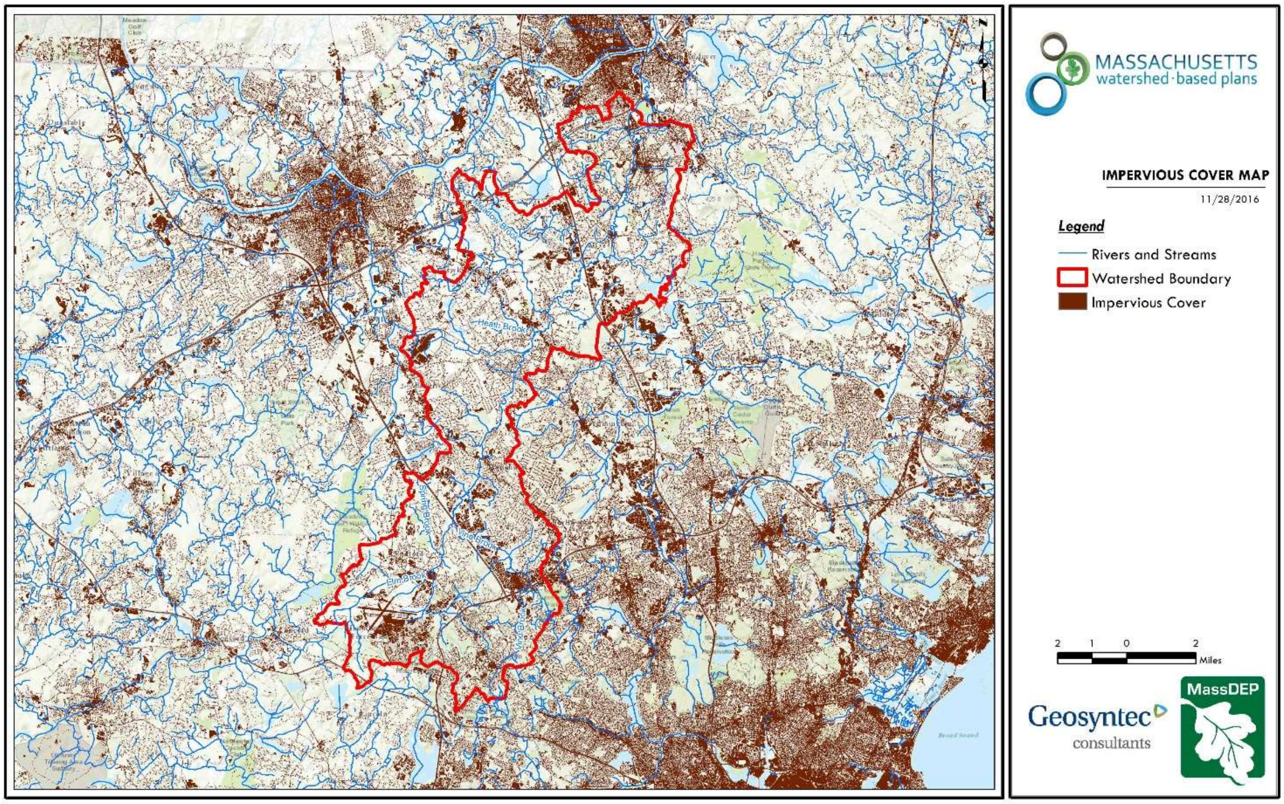

Figure A-3: Watershed Impervious Surface Map (MassGIS, 2007; MassGIS, 2009b; MassGIS, 1999; MassGIS, 2001; USGS, 2016)

Pollutant Loading

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

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

Pollutant loading for key nonpoint source pollutants in the watershed was estimated by multiplying each land use/cover type area by its pollutant load export rate (PLER) 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 TN, TP and TSS were obtained from USEPA (USEPA, 2020; UNHSC, 2018, Tetra Tech, 2015) (see values provided in Appendix A). **Table A-9** presents the estimated land-use based TN, TP and TSS pollutant loading in the watershed.

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

Use Type	Pollutant Loading[1]		
	Total Phosphorus (TP) (lbs/yr)	Total Nitrogen (TN) (lbs/yr)	Total Suspended Solids (TSS) (tons/yr)
Agriculture	219	1,285	8.70
Commercial	4,933	41,670	524.52
Forest	3,182	13,742	380.45
High Density Residential	1,933	12,515	189.40
Highway	5,964	42,770	2,213.13
Industrial	2,109	18,003	226.57
Medium Density Residential	6,086	46,066	695.13
Open Land	1,306	12,536	205.29
TOTAL	25,734	188,587	4,443.20

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

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

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

Estimated Pollutant Loads

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	25734 lbs/yr	12335 lbs/yr	13399 lbs/yr
Total Nitrogen	188587 lbs/yr		
Total Suspended Solids	4443 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** • Primary contact recreation: For E. coli, geometric mean of samples collected within any 90-day or smaller period shall not exceed 126 cfu/100 mL, and no more than 10% of all such samples shall exceed 410 cfu/100 mL. For enterococci, geometric mean of all samples collected within any 90-day or smaller period shall not exceed 35 cfu/100 mL, and no more than 10% of all such samples shall exceed 130 cfu/100 mL. o Waters adjacent to any public or semi-public beach, at a location used for bathing and swimming purposes or waters impacted by combined sewer overflows (CSO) or publicly owned treatment works	TMDL for Shawsheen River TMDL Summary: Water quality data collected in the watershed show that bacteria concentrations routinely exceed the State water quality standard. Current bacterial source categories address in the TMDL include: 1) illicit sewer connections, 2) sewer line leaks, 3) septic systems, and 4) urban stormwater runoff. Reductions from sewer breaks and illicit sewer connections will be required to achieve compliance with water quality standards. 'Good housekeeping' practices are recommended to mitigate stormwater runoff until pollution sources can be identified.

		(POTW) discharges: For E. coli, geometric mean of samples collected within any 30-day or smaller period shall not exceed 126 cfu/100 mL, and no more than 10% of all such samples shall exceed 410 cfu/100 mL. For enterococci, geometric mean of all samples collected within any 30-day or smaller period shall not exceed 35 cfu/100 mL, and no more than 10% of all such samples shall exceed 130 cfu/100 mL.

(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.

Background and Summary of Work

MVPC and MRWC collaborated on the GIS analysis of the Shawsheen watershed-based plan. An analysis of parcels for potential BMP suitability was performed to identify parcels that could be ideal for stormwater infiltration retrofits. This analysis was performed on the Shawsheen watershed communities of Andover, Lawrence, North Andover, and Tewksbury. The GIS analysis was intended to provide a basis for priority investment areas and the top-ranking parcels need to be verified for feasibility by the Horsley Witten engineering team before final site selections can be made. MVPC consulted with Horsley Witten Group to ensure the GIS methodology of analysis for identifying parcels is sufficient for this unique watershed. MVPC performed a similar watershed analysis on the Spicket River in 2022-2023, and the evaluation criteria and methodology from that analysis were modified for the Shawsheen watershed. The following documentation outlines data, methodology, scoring criteria, top ranking parcels, and considerations.

Methodology

The following workflow was performed in ArcGIS Pro 3.3.2. Extraneous steps such as creation of the project file, geodatabases, maps, and layouts were excluded from this procedure. The steps below were performed to quantify acreage or presence of data within the community parcels that fell within the four Shawsheen watershed communities. MVPC and Horsley Witten Group consultants reviewed the stormwater infrastructure data available for the four Shawsheen watershed communities. It was determined that due to data incompleteness and inaccuracies of outfalls, catchments, and pipe networks, scoring entire parcels would be more appropriate for identifying priority investment areas. Right-of-way (ROW) and fee simple owned (FEE) parcels were treated separately due to the length and shape of ROW polygons.

The FEE parcels were evaluated for property ownership, presence of wetlands, hydrologic soil groups, environmental justice areas, impervious areas, flood zone areas, existing pollutant sites, forested areas, and existing Green Stormwater Infrastructure.

At the recommendation of Horsley Witten, MVPC expanded their scoring to include ROWs. Once FEE parcels were evaluated and scored, ROW parcels were analyzed using a similar analysis. ROW parcels were entirely impervious surfaces, therefore impervious surface scores were not assigned to each polygon as this would skew the total score and ranking recommendation. GIS analysts took parcels for each community from MVPC's parcels database and merged ROW parcels together. They were clipped to Shawsheen watershed of the 4 communities. Spatial data for roads was extracted from the MassGIS Roads database and the roads' centerline shape was added to the analysis map. The following instructions were followed to unsplit lines and create points on line intersections. How To: Create Points on Line Intersections in ArcGIS Pro (esri.com). This was performed to break up the large ROW parcels into smaller segments by intersection and road name. Once road lines were split by intersections, road lines were buffered to the approximate size of the existing ROW parcels. The buffer road lines layer were spatially joined to the ROW parcels. The result was a multi-feature polygon with ROW parcels identified by LOC IDs and street names. The ROW sites were then scored using the criteria outlined in Table C-3.

FEE and ROW parcels were scored using their respective tables below (**Table C-1** and **Table C-2)**. The scoring evaluation criteria were developed from the Spicket River Watershed Based Plan documentation, with Horsley-Witten Group consultation. Each parcel within the watershed was evaluated based on 16 different criteria accounting for the parcel ownership, hydrologic soil groups, impervious surfaces, and a variety of other criteria. (See Table C-1 for layers used). A weighted importance was also assigned to each criterion, which reflected the weighted importance of the criterion (e.g., a criterion with a multiplier of 3 had greater weight on the overall prioritization of the parcel than a criterion with a multiplier of 1); and the weighted scores for all the criteria were then summed for each parcel to calculate a total BMP priority score.

Table C-1 presents the criteria, indicator type, metrics, scores, and multipliers that were used for the FEE parcels. Parcels with total scores above 38.5 are recommended for further investigation for BMP implementation suitability. **Table C-2** shows the scoring matrix used for the ROW parcels. **Figure C-1** presents the resulting BMP Hotspot Map for the watershed. This analysis solely evaluated individual parcels for BMP implementation suitability and likelihood for the measures to perform effectively within the parcel's features. This analysis does not quantify the pollutant loading to these parcels from the parcel's upstream catchment. When further evaluating a parcel's BMP implementation suitability and cost-effectiveness of BMP implementation, the existing pollutant loading from the parcel's upstream catchment and potential pollutant load reduction from BMP implementation should be evaluated.

GIS data used for **Figure 1: Top Ranking Parcels Map** analysis included:

- Soils (A or B)
- 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 Integrate
- Environmental Justice Areas 2020
- Impervious Area
- Localized Flooding Areas (FIRM)
- Activity and Use Limitation (AUL)
- Pollutants Underground Storage Tank (UST)
- Forested Areas
- Green Stormwater Infrastructure)

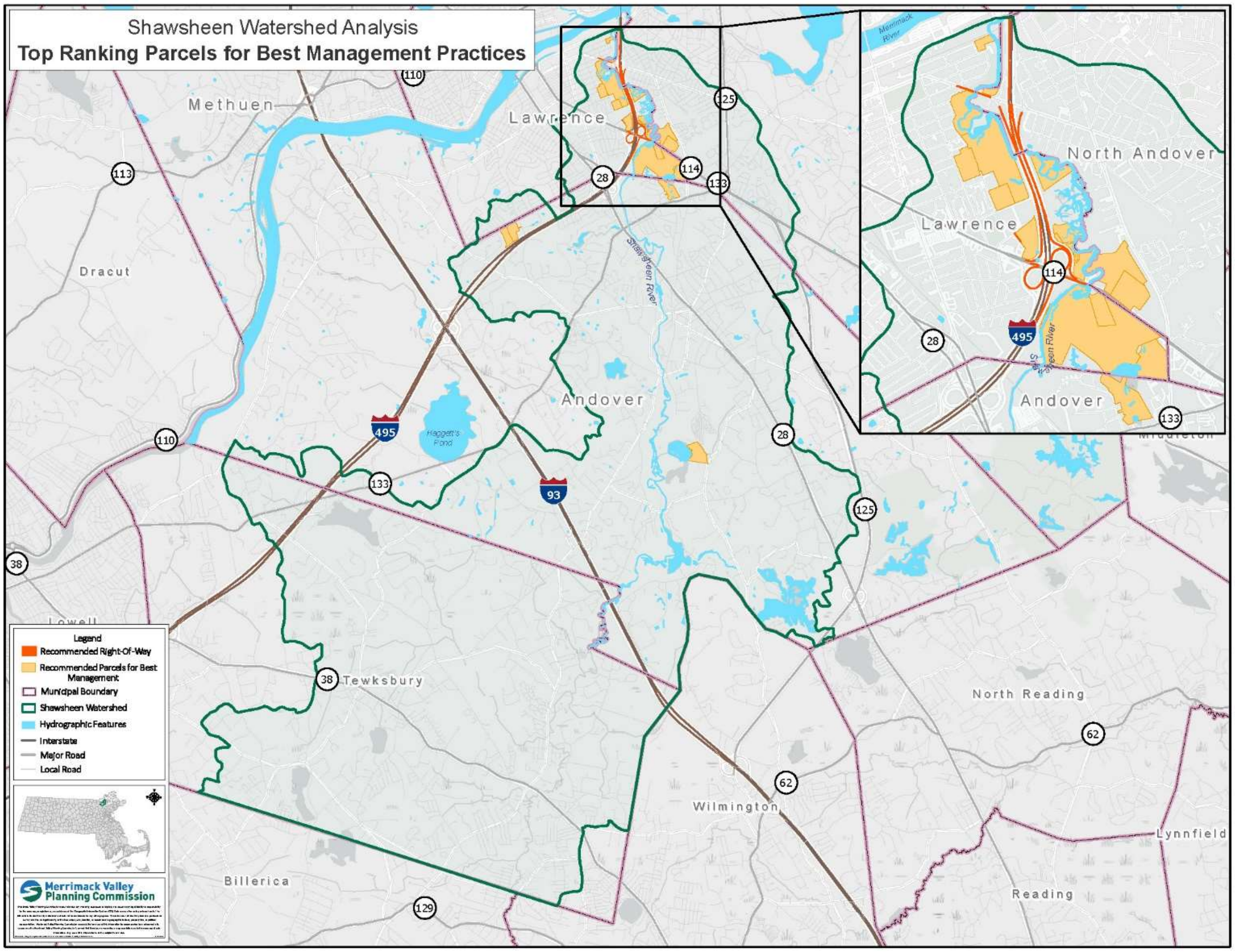

Figure C-1: Top Ranking Parcels Map: *(Soils (A or B) MassGIS Drainage Areas sub-basins of waters designated as TMDL completed (Category 4a) or Impaired/Requiring a TMDL (Category 5) on the Massachusetts List of Integrate, Environmental Justice Areas 2020, Impervious Area, Localized Flooding Areas (FIRM), Activity and Use Limitation (AUL), Pollutants Underground Storage Tank (UST), Forested Areas, Green Stormwater Infrastructure)*

Table C-1: GIS Layers and Point System for Initial Ranking of FEE Parcels

GIS Layers and Point System for Initial Ranking of FEE Parcels				
General evaluation criteria - all of outfall catchment area	Points	Total Possible Points	Weighing Importance	Total Possible Score
Parcel Ownership (Private)	1	5	1	5
Parcel Ownership (Municipal)	5			
Parcel Ownership (State)	2.5			
Parcel Ownership (Nonprofit)	2.5			
Parcel within 100 ft buffer of water features	5.0 or 0	5	1	5
A or B hydrologic soil group	5.0 or 0	5	1	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	1	5
Environmental Justice Areas, 2020	5.0 or 0	5	1	5
Impervious area larger than 1 acre	10	10	1	10
Impervious area 0.5 to 1 acre	5			
Impervious area less than 0.5 acre	2.5			
Located within a flood zone (FIRM)	5.0 or 0	5	1	5
Presence of Pollutants (AUL, UST)	5.0 or 0.0	5	1	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	1	5
Presence of Green Stormwater Infrastructure already	5	5	1	5
TOTAL		55		55

Table C-2: Matrix for ROW Scoring

GIS Layers and Point System for Initial Ranking of ROW Parcels				
General evaluation criteria - all of outfall catchment area	Points	Total Possible Points	Weighing Importance	Total Possible Score
Water Parcel (100 ft buffer intersect)	5.0 or 0	5	1	5
A or B hydrologic soil group	5.0 or 0	5	1	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 Integrated List of Waters	5.0 or 0	5	1	5
Environmental Justice Areas, 2020	5.0 or 0	5	1	5
Localized flooding areas (FIRM)	5.0 or 0	5	1	5
Presence of Pollutants (AUL, Tier II, UST, GWDP, Brownfields)	5.0 or 0.0	5	1	5
Presence of Green Stormwater Infrastructure already	5	5	1	5
TOTAL		35		35

Considerations of Data Available:

The GIS analysis conducted for the Shawsheen 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 element to consider in this recommendation of parcels is that stormwater infrastructure was not considered in the evaluation of parcel recommendations. The stormwater infrastructure data that was available for the 4 communities was not sufficient for providing catch basin and outfall catchment areas due to incomplete or erroneous features. Including and considering stormwater infrastructure data could have erroneously skewed subsequent parcel weighting.

Another important element to consider in this recommendation of parcels is that the data was acquired from MassGIS. Though the repository from the state is helpful and comprehensive for the state of Massachusetts, accuracy of the data may vary due to age of last update or creation methodologies.

Lastly, the ROW recommendations were developed using MassDOT roads data. This roads dataset is inherently challenging to identify ownership without proper surveying or communication with municipalities and the state. ROWs are polygons within each municipality's parcel geodatabase, but often do not accurately reflect the conditions true to the ground.

FEE and ROW Parcel Ranking

Parcels with the highest score from the evaluation criteria were selected. These top thirty FEE and ROW parcels were selected out of 18,000 parcels identified and evaluated from the 4 communities within the Shawsheen watershed. The highest-ranking parcels were evaluated and given to Merrimack River Watershed Council for further analysis.

Compilation of Highest-Scoring Sites:

Following a presentation of the GIS methodology to the stakeholder committee, a high-priority parcel packet was produced to guide the final selection of sites to be nominated for BMPs. The packet contained maps of each municipality's highest scoring sites and a brief description of the methodology used, and detailed views of the parcels under consideration.

MVPC's initial GIS analysis brought forward 30 parcels and 30 ROW segments to be considered as high-priority. Following conversations between MRWC, MVPC, and Horsley Witten, several groups of sites were struck or added to the plan. Firstly, the list of 30 parcels and 30 ROW segments was expanded to include any sites that scored equal to the 30th-highest-scoring site in each list. At the recommendation of Horsley Witten, interstate highways and sites that were predominately undeveloped forest or wetland were removed from the list. Horsely Witten also recommended several sites that were not the highest scorers, but were likely to be good locations for BMP implementation, based on the firm's professional experience. **Table C-3 Priority Parcels, Scored,** and **Table C-4: Priority Roads, Scored,** show the highest-scoring parcels and roads, respectively, presented in the packet. Notes are included for the six additional sites identified by Horsley Witten. Interstate highway segments and ramps were among the highest-scoring roads according to the evaluation criteria. However, they were not presented to the advisory or stakeholder committees, nor were considered for specific BMP recommendations, as the projects included in this plan were chosen for implementation at the local level. They are included in **Table C-4** in gray for reference by future transportation projects.

Table C-3: Priority Parcels, Scored:

All Communities - Parcels Scored																												
Site Name	Municipality	Parcel ID	Parcel Ownership	LOC_ID	Assessed Lot Size	Sum Impervious Area ACRES	Sum Forest Area ACRES	Sum Soils A_B Area ACRES	Sum Soils AD_BD Area ACRES	Sum EnvJustice Area ACRES	Sum FIRM Area ACRES	Sum IL Water Area ACRES	Count of AUL Points	Count of UST Points	Count of Grn Infr Str Points	Impervious Area Score	Forest Area Score	A or B Soils Scores	AD or BD Soils Score	EnvJust Score	FIRM Score	Pollutants Score	Green Infrstr Score	IL Subbasins Score	Parcel Ownership Score	Waterfront Parcel Score	Total Parcel Score	Notes
Pomps Pond Park	**Andover**	118-6	Municpal	F_750969_3056303		1.85	19.36	19.25			1.41	21.91	0	0	1	10	1	5	0	0	5	0	5	5	5	5	**41**	
Frye Circle	**Andover**	37-57	State	F_750596_3068111		2.344632	1.678876	4.891863	<Null>	<Null>	0.000008	4.891861	0	0	0	10	1	5	0	0	5	0	0	5	5	5	**36**	Addition by Horsley Witten
Bowling Green Soccer Field	**Andover**	36-91A	Municpal?	F_750351_3070087		0.045709	0.384641	0.951892	<Null>	<Null>	1.131419	1.131419	0	0	0	5	5	5	0	0	5	0	0	5	5	5	**35**	Addition by Horsley Witten
Parking Lot at Bartlet St and Park St	**Andover**	39-101		F_753590_3064556		1.354792	0.119552	<Null>	<Null>	<Null>	0.650131	1.483175	0	0	2	10	5	0	0	0	5	0	5	5	5	0	**35**	Addition by Horsley Witten
Andover Town Offices, Senor Center, Youth Center, Doherty Middle School	**Andover**	39-173		F_754317_3063592		7.140169	1.615005	6.537994	0.511582	<Null>	0	16.55687	0	0	0	10	1	5	2.5	0	0	0	0	5	5	5	**33.5**	Addition by Horsley Witten
Andover High School	**Andover**	72-54	Public	F_749220_3064211		24.14759	36.98012	63.00582	21.84469	<Null>	0	88.93865	0	0	0	10	1	5	2.5	0	0	0	0	5	5	0	**28.5**	Addition by Horsley Witten
Lawrence High School	**Lawrence**	40-0-1	Municpal	M_229086_937962	5.74	5.13	0.18	0.94			0.00	6.04	0	0	0	10	5	5	0	5	5	0	0	5	5	5	**45**	
South Lawrence East Elementary	**Lawrence**	61-0-50	Municpal	M_228895_938267	11.14	7.08	0.20	7.77			0.13	7.77	0	0	0	10	5	5	0	5	5	0	0	5	5	5	**45**	
Shawsheen Park	**Lawrence**	42-0-1	Municpal	M_229125_938239	29	2.60	12.48	26.08	1.34	30.86	15.13	30.86	0	0	0	10	1	5	2.5	5	5	0	0	5	5	5	**43.5**	
Shawsheen Road/ Costello Park	**Lawrence**	63-0-67	Municpal	M_228966_938649	6.94	0.77	7.88	6.00	4.08	10.20	8.54	10.20	0	0	1	2.5	1	5	2.5	5	5	0	5	5	5	5	**41**	
Chickering St Lot	**Lawrence**	39-0-4	Private	M_229159_937660	6.9	7.26	0.28	0.82		8.16	4.80	8.16	0	0	0	10	5	5	0	5	5	0	0	5	1	5	**41**	
River Pointe Apartments	**Lawrence**	18-0-1	Private	M_229600_936952	7.13	4.63	1.67	0.39	0.71	7.30	0.09	7.30	0	0	0	10	1	5	2.5	5	5	0	0	5	1	5	**39.5**	
Holiday Inn Plaza	**Lawrence**	19-0-5	Private	M_229614_937376	4.29	2.36	1.36	0.75	2.10	4.13	4.13	4.13	0	0	0	10	1	5	2.5	5	5	0	0	5	1	5	**39.5**	
Andover Park Apartments	**Lawrence**	1-0-1	Private	M_229913_936482	16.56	6.33	7.01	7.99	3.29	16.69	3.75	16.69	0	0	0	10	1	5	2.5	5	5	0	0	5	1	5	**39.5**	
Holiday Inn Plaza, Parking Lot	**Lawrence**	19-0-7	Private	M_229507_937354	0.28	0.08	0.09	0.09	0.18	0.27	0.27	0.27	0	0	0	5	5	5	2.5	5	5	0	0	5	1	5	**38.5**	
Den Rock Park	**Lawrence**	3-0-1	Municpal	M_229294_936920	80.75	0.09	74.38	57.49	10.47	78.42	20.72	78.42	0	0	0	5	1	5	2.5	5	5	0	0	5	5	5	**38.5**	
30 Massachusetts Ave	**North Andover**	002.0-0005-0	Private	M_229207_938753	1.12	1.34	0.13	0.23		0.00	1.47	1.47	0	0	0	10	5	5	0	5	5	0	0	5	1	5	**41**	
North Andover Mall	**North Andover**	026.0-0006-0	Private	M_229783_937232	19.3	7.67	9.11	1.17	3.43	19.03	18.73	19.03	0	0	0	10	1	5	2.5	5	5	0	0	5	1	5	**39.5**	
North Andover Mall	**North Andover**	027.0-0027-0	Private	M_229853_937025	12.74	11.22	0.75	0.11		12.69	12.54	12.69	0	0	0	10	2.5	5	0	5	5	0	0	5	1	5	**38.5**	
25 Margate St	**North Andover**	022.0-0131-0	Private	M_229782_937758	0.54	0.04	0.46	0.52	0.01	0.52	0.000001	0.52	0	0	0	5	5	5	2.5	5	5	0	0	5	1	5	**38.5**	
26 Delucia Way	**North Andover**	022.0-0135-0	Private	M_229782_937796	0.68	0.10	0.39	0.79	0.01	0.79	0.02	0.79	0	0	0	5	5	5	2.5	5	5	0	0	5	1	5	**38.5**	
447 Waverly Rd	**North Andover**	026.0-0011-0	Private	M_229784_937697	0.34	0.08	0.23	0.33	0.02	0.34	0.02	0.34	0	0	0	5	5	5	2.5	5	5	0	0	5	1	5	**38.5**	
Albert E. Thomson Elementary School	**North Andover**	015.0-0049-0	.	M_229904_938490	1.99	1.932645	0.164472	3.091999	<Null>	3.091998	0	3.091998	0	0	0	10	5	5	0	5	0	0	0	5	5	0	**35**	Addition by Horsley Witten
Saunders Recreational Area	**Tewksbury**	86-40	Municpal	M_224034_927711		1.62	1.11	7.84	2.09		1.80	9.93	0	0	0	10	1	5	2.5	0	5	0	0	5	5	5	**38.5**	
Tewksbury Public Schools Complex	**Tewksbury**	47-40	Municpal	M_221408_928809		6.94	10.99	10.54	6.99		5.93	25.64	0	0	0	10	1	5	2.5	0	5	0	0	5	5	5	**38.5**	
Carnation Drive Apartments	**Tewksbury**	47-66	Municpal	M_221476_929131		2.27	1.17	3.70	2.04		1.56	5.74	0	0	0	10	1	5	2.5	0	5	0	0	5	5	5	**38.5**	
Village Landing	**Tewksbury**	48-39-MAIN	Private	M_221339_929264		2.24	0.16	0.99	1.42		1.82	2.55	0	0	0	10	5	5	2.5	0	5	0	0	5	1	5	**38.5**	
Box Car Blvd Lot	**Tewksbury**	76-16-MAIN	Private	M_223488_929750		1.74	0.05	1.92	0.00		0.17	1.93	0	0	0	10	5	5	2.5	0	5	0	0	5	1	5	**38.5**	

Table C-4: Priority Road Segments, Scored:

All Communities Road Segments Scored - w/ Interstates in Gray																			
Street Name	Municipality	LOC_ID	Sum Soils A_B Area ACRES	Sum Soils AD_BD Area ACRES	Sum IL Water Area ACRES	SumEnvirJustce Area ACRES	Summarized Area in ACRES	Count of Polygons	Point_Count_AUL	Point_Count_UST	ScorePollutants	ScoreWaterfrontParcel	ScoreABSoils	ScoreADBDSoils	ScoreEnvJust	ScoreFirm	ScoreILSubbasins	ScoreGrnInfStr	TotalScore
WINTHROP AVENUE	Lawrence	M_227064	0.08	0	0.60	0.00	0.60	1	1	1	2	5	5	0	5	5	5	0	**27**
MASS AVE	Lawrence and North Andover	M_227064	0.44	0	0.83	0.00	0.83	4	1	0	1	5	5	0	5	5	5	0	**26**
MASS AVE		M_232992	0.44	0	0.83	0.00	0.83	4	1	0	1	5	5	0	5	5	5	0	**26**
BLUE STAR MEMORIAL HIGHWAY	Lawrence	M_227064	1.20	0	1.20	0.00	0.24	2	0	0	0	5	5	0	5	5	5	0	**25**
BLUE STAR MEMORIAL HIGHWAY	Lawrence	M_229300	1.20	0	1.20	0.00	0.24	2	0	0	0	5	5	0	5	5	5	0	**25**
BLUE STAR MEMORIAL HIGHWAY	Lawrence	M_227064	1.50	0	1.63	0.01	0.52	2	0	0	0	5	5	0	5	5	5	0	**25**
BLUE STAR MEMORIAL HIGHWAY	Lawrence	M_227064	1.20	0	1.20	0.00	0.00	1	0	0	0	5	5	0	5	5	5	0	**25**
BLUE STAR MEMORIAL HIGHWAY	Lawrence	M_229300	1.20	0	1.20	0.00	0.00	1	0	0	0	5	5	0	5	5	5	0	**25**
BLUE STAR MEMORIAL HIGHWAY	Lawrence	M_232992	1.20	0	1.20	0.00	0.00	1	0	0	0	5	5	0	5	5	5	0	**25**
BREWSTER STREET	Lawrence	M_227064	0.02	0	0.69	0.00	0.41	1	0	0	0	5	5	0	5	5	5	0	**25**
RAMP-RT 114 TO RT 495 NB	Lawrence	M_227064	0.11	0	0.33	0.00	0.33	1	0	0	0	5	5	0	5	5	5	0	**25**
RAMP-RT 114 TO RT 495 NB	Lawrence	M_227064	1.69	0	1.69	0.01	0.43	2	0	0	0	5	5	0	5	5	5	0	**25**
RAMP-RT 114 TO RT 495 NB	Lawrence	M_227064	1.19	0	1.23	0.00	0.04	1	0	0	0	5	5	0	5	5	5	0	**25**
RAMP-RT 495 SB TO RT 114 EB	Lawrence	M_227064	1.36	0	1.36	0.01	0.38	1	0	0	0	5	5	0	5	5	5	0	**25**
RAMP-RT 495 SB TO RT 114 EB	Lawrence	M_227064	0.20	0	0.20	0.00	0.03	1	0	0	0	5	5	0	5	5	5	0	**25**
RAMP-RT 495 SB TO RT 114 EB	Lawrence	M_227064	0.20	0	0.20	0.00	0.03	1	0	0	0	5	5	0	5	5	5	0	**25**
RAMP-RT 495 SB TO RT 114 WB	Lawrence	M_227064	1.66	0	1.82	0.01	0.67	1	0	0	0	5	5	0	5	5	5	0	**25**
RAMP-RT 495 SB TO RT 114 WB	Lawrence	M_227064	0.89	0	0.92	0.00	0.04	1	0	0	0	5	5	0	5	5	5	0	**25**
WINTHROP AVENUE	Lawrence and North Andover	M_227064	1.50	0	1.50	0.01	0.82	3	0	0	0	5	5	0	5	5	5	0	**25**
WINTHROP AVENUE		M_227064	0.20	0	0.20	0.00	0.18	1	0	0	0	5	5	0	5	5	5	0	**25**
WINTHROP AVENUE		M_227064	0.43	0	0.77	0.00	0.25	2	0	0	0	5	5	0	5	5	5	0	**25**
WINTHROP AVENUE		M_232992	0.43	0	0.77	0.00	0.25	2	0	0	0	5	5	0	5	5	5	0	**25**
WINTHROP AVENUE		M_227064	0.43	0	0.77	0.00	0.26	2	0	0	0	5	5	0	5	5	5	0	**25**
WINTHROP AVENUE		M_232992	0.43	0	0.77	0.00	0.26	2	0	0	0	5	5	0	5	5	5	0	**25**

Final Site Selection:

In the November 4th meeting of the Technical Advisory Committee, the committee members were shown the parcel packet and nominated sites based on hydrologic improvements, feasibility, and educational/social benefits. Committee members nominated 1 site in each of the towns of Andover, North Andover, and Tewksbury, and 2 sites in Lawrence. Two sites were chosen for Lawrence instead of one, as a high amount sites identified as high-priority in GIS analysis were along the Lower Shawsheen in Lawrence. The members of the Advisory Committee were given the opportunity to vote on sites in their town of residence, plus any of the other towns for which they felt able to make an informed nomination.

In the November 14th meeting of the Shawsheen Stakeholder Committee, the packet was again presented, along with the nominations and feedback from the advisory committee. The stakeholder committee then made the final selection of sites to be visited by Horsley Witten on their field day, narrowing the sites to just 5.

During Horsley Witten's field day on November 20th, Thomson Elementary School in North Andover was exchanged for Atkinson School, also in North Andover. This was done at the recommendation of North Andover Public Schools staff and due to the determination that Thomson School was less suited for BMP implementation than Atkinson School. Horsley Witten proposed BMPs for each site visited on their field day. The proposed BMPs, presented in **Table C-5** below.

Proposed Management Measures:

Before the field day, Horsley Witten used data including drainage and utility plans, aerial imagery, and GIS mapping of wetland resource areas, hydrologic soil groups, topography, land uses, land ownership, impervious surfaces, and water, sewer, and drainage infrastructure to assess characteristics and priorities for each site. During the field day at each site, three Horsley Witten engineers, MRWC and MVPC staff met with town and city DPW, water and sewer, and school district staff. Engineers assessed different parts of each site for BMP implementation. The full text of Horsley Witten's memo summarizing their findings from their observations in the field can be found in the appendix.

Following site visits, Horsley Witten developed green infrastructure recommendations that could improve stormwater conditions, reduce erosion, reduce pollution, and educate and encourage individuals to adopt beneficial practices for the river. Structural BMPs included in this plan include bioswales and wet swales, tree trenches, other bioretention areas, and permeable pavements. Non-structural components recommended to be implemented include stabilization of eroding banks, invasive species management, development of educational gardens, trash management and education programs, and tree plantings.

Table C-5 below lists each location with a proposed management measure and the additions recommended to improve conditions at that site. Locations in the table below were visited during the field day, though each property visited may contain multiple locations with recommended management measures.

Table C-5: Proposed Management Measures

Site Name	Existing Conditions	Proposed Solutions	Other Notes
Andover High School North Parking Lot	Existing grass island in the parking lot north of Andover High School. Raised garden bed for pollinator garden created and maintained by students.	Add inlets on upgradient side of island. Create depressed bioretention area in island, possibly with overflow structure to drainage network or flow in-flow out system. Work with students to transplant pollinator plants into bioretention area, add native plants, and integrate living lab/educational elements.	Parking lot drains down to island.
Andover High School East Parking Lot Island	Large asphalt parking lot east of Andover High School with closed drainage system and no stormwater treatment or trees. One way in and out. Tight backing out of east parking stalls. Old light poles in middle of center parking stalls.	Regrade parking lot and install bioswale/infiltration tree trench as center parking island running west to east. Move light poles, replace with modern solar lighting. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-3 and A-4.	Parking lot will likely be updated as part of high school renovations.
Andover High School East Parking Lot	Large asphalt parking lot east of Andover High School with closed drainage system and no stormwater treatment or trees. Grass island at bottom of parking lot.	Add surface inlets to island, create a bioretention area in the island with connection to drainage system. Possibly add chambers. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-2 and A-4.	If planning to repave parking lot, think about gutter lines.
Andover High School Tennis Courts	Paved strip between Andover High School east parking lot and tennis courts. No trees or shade. The spectators have requested shade structures.	Regrade lot and direct runoff from south edge into infiltration tree trench along tennis court. Plant trees that provide shade and are suitable for tennis courts. Design with hardscape permeable surface above trench and around tree wells for tennis spectators. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-2 and A-3.	
Andover High School Moraine St	Paved parking spaces along Moraine St south of Andover High School. Slope to east drops 6-7 ft to vegetated area. Invasive species present (Bittersweet). Runoff currently overtops asphalt berm in corner of the last parking space or continues down Moraine St.	Install a catch basin inlet at back corner of last parking space to convey runoff toward a new forebay and wet swale at bottom of slope. Design forebay to overflow to a wet swale and then out to wetland. Include invasive species management in design.	
Andover High School South Parking Lot West End	Large paved parking lot to southeast of Andover High School. Minimal landscape islands and no trees in parking lot. One oil-water separator shown on site plan. Multiple closed drainage systems discharge into wetland south of the parking lot.	Construct infiltration tree trenches within existing grassed landscape island and along southwest shoulder of parking lot. Connect to existing catch basins. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network.	
Costello Park	Three catch basins on Shawsheen Rd discharge through an 8-inch pipe at a granite headwall in Costello Park. Runoff continues along an informal swale down to and across the paved river trail. Pedestrians walk along the flow path to the river trail.	Construct an infiltrating bioretention basin with sediment forebay at the existing outfall. Formalize a pedestrian path around the bioretention basin to the river trail.	

Shawsheen Rd Street Trees	No trees or tree lawn on west side of Shawsheen Rd, Lawrence. Wide sidewalk (~8 ft) and wide road (~40 ft) with a parking lane and two travel lanes that are not striped. Dense residential neighborhood with Costello Park across the street. Stakeholders noted problems with fast driving and inconsistent sidewalks (missing in some areas).	Reconfigure right of way with addition of tree lawn and street trees along west side of Shawsheen Rd. Integrate with Safe Routes to School sidewalk and bike lane improvements.	This road is on the list for a future Safe Routes to School grant application.
Shawsheen Rd Litter	Litter all along Shawsheen Rd, particularly in section between Farnham St and E Boxford St near South Lawrence East Elementary School.	Focus trash management efforts on this neighborhood, including cleanups, education, and trash and recycling bins with lids. Beautify and formalize parking and path areas to encourage stewardship.	
Outfall @ S Lawrence East School	60-inch outfall into channel to Shawsheen River. Severe erosion, scouring under outfall structure and banks up to ~4-5 ft height. Channel ~ 400 ft to river. Flowing despite dry weather, fed by natural springs and pond at old railyard.	Stabilize outfall structure and channel banks and bottom. Add energy dissipation at outfall and along channel. Integrate upstream detention storage as part of Grafton St culvert improvements.	Planned culvert replacement/upsizing in upper catchment from Grafton St, Winthrop Ave area could increase peak flow at outfall unless detention storage is added.
S Lawrence East School Low Point	Low point along asphalt path behind South Lawrence East Elementary School. Erosion within lawn areas on both sides of path, sand accumulation on path.	Grade in swales and depressions on both sides of path to infiltrate runoff and prevent erosion. Revegetate eroding areas.	
S Lawrence East School Parking Lot	Steep, paved parking lot with green islands and trees, located south of South Lawrence East Elementary School. Drains to catch basin.	Construct infiltration tree trench in northeast corner of parking lot. Pipe catch basins in parking lot and driveway into tree trench. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network.	
Shawsheen Park Parking Lot	Large paved parking lot with no grassed islands or trees. Catch basin in northeast corner. Sediment accumulation indicates ponding runoff. Lawn and paved path to the east.	Install paved inlet at northeast corner of parking lot to divert runoff into sediment forebay and bioretention basin in lawn and path area. Reroute paved path around bioretention basin. Integrate living lab/educational elements into design.	
Atkinson School Front Lawn	Rooftop runoff ponds in front of North Andover Atkinson Elementary School building, likely due to flat terrain and lack of drainage (possibly high groundwater as well). School recently experienced flooding into building.	Create dry swale/soil filter along front of building with underdrain and yard drain to direct runoff away from building, filter roof runoff, and improve drainage.	
Atkinson School Parking Lots	Runoff from paved parking lots at North Andover Atkinson Elementary School flows northwest to two catch basins on Beacon Hill Blvd and overland into large open green space.	Original proposal was to construct a bioretention basin in the open green space. Based on redevelopment plans for the proposed North Andover Recreation Complex, a bioretention basin may not be feasible. Instead, consider permeable pavement or subsurface chambers under the parking lot, staying within the Atkinson Elementary School parcel and outside the limit of work for the Recreation Complex.	If Recreation Complex design plans change, consider bioretention basin in open green space.

Livingston St Recreation Area Parking Lot	Large paved parking lot at Livingston St Recreation Area in Tewksbury. Deteriorating asphalt and sediment accumulation at low point indicate ponding. Sediment berm at low point prevents runoff from draining out of parking lot. Fallen headwall in adjacent lawn may have been an inlet for parking lot runoff. Parking lot is heavily used during spring-fall and maintained during winter.	Remove sediment berm and install paved flume to direct runoff out of parking lot toward lawn. Construct sediment forebay and bioretention area to treat parking lot runoff. Design basin as shallow depression with gentle side slopes and mowable grass to allow green space to still be used by summer camps.	
Livingston St	Multiple catch basins along Livingston St connect into closed drainage system that outfalls to unnamed stream.	Construct infiltration tree trenches within right-of-way, connect to existing catch basins. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network. Consider including tree trench installation as part of planned Livingston St sidewalk upgrades.	Designs are in progress for sidewalk improvements along Livingston St.
Saunders Recreation Area Unnamed Stream	Runoff from gravel parking lot at Saunders Recreation Area flows overland toward unnamed stream to south. Stream is channelized through a wetland. Narrow vegetated buffer around stream with invasive plants. Mowed grass between vegetated buffer and parking lot. Drivers often park on lawn. Parking lot is heavily used during football season and Town has no plans to pave it.	Manage invasive plants along the stream. Widen stream buffer by planting native species within existing mowed lawn area. Install "Do Not Mow - Naturalized Area" and "No Parking" signs.	

Additional BMPs:

While the recommendations in the table above represent an opportunity to make effective progress on improving the Shawsheen's water quality, additional structural and non-structural management practices will be required to improve the health of the river to the point that it is fishable and swimmable again. Municipalities may look to the proposed solutions in Table C5 for a non-exhaustive list of stormwater retrofits that could be implemented elsewhere. In creating new structural BMPs, landowners should understand how their stormwater flows to the Shawsheen, and site their control measures for maximum pollution and stormwater control. 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.

Additional non-structural BMPs recommended by this plan include street sweeping, rain gardens and tree planting at sites not already included above. 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 municipalities engage in acquisition of wetlands and riparian areas for the purposes of conservation and restoration. The Town of Andover has already included acquisition of these lands as its top priority in its Municipal Vulnerability Preparedness plan. In implementing this plan, all municipalities can look to restore wetlands and floodplains to a natural state of water collection and filtration.

Community-wide educational and outreach programs similar to those described in **Element E**: **Public Information and Education** could improve water quality metrics through increasing the involvement of individuals and communities in improving the health of the Shawsheen watershed. Education and stewardship programs such as those conducted by Groundwork Lawrence in **Element E** are recommended to continue. Education and public outreach can help individuals play an active role in the restoration of the Shawsheen River through learning to implement small-scale BMPs wherever possible.

It is noted that the impact of non-point source pollution from the upper Shawsheen is not addressed in this plan. Future planning and sampling efforts in the southern half of the watershed could reveal additional BMPs that are even more effective at improving the health of the river than those recommended by this plan. Future work in the municipalities of Bedford, Billerica, Burlington, and Lexington could lead to a more unified approach to stormwater and non-point source pollution management across the whole watershed.

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. It is expected that implementation of these BMPs will play a significant role in decreasing phosphorus loading to the Shawsheen River.

A combination of town and city resources, reliance on the Merrimack Valley Planning Commision, and outside engineering or procured consultant services will be utilized to complete the projects included in the plan.

Potential funding sources might include:

- Section 319 Nonpoint Source Competitive Grant Program
- Municipal Vulnerability Preparedness (MVP) Action Grant Program (if the Town/City is eligible to apply)
- Town/City Capital Funds
- Hazard Mitigation Grants
- Volunteer time for public outreach and monitoring
- Municipal Assistance Grants
- DER Grants

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

Site	Site Location	SCM Description	Drainage Area (ac)	Impervious Area (%)	TN[1] (lbs/yr)	TP[1] (lbs/yr)	TSS[1] (lbs/yr)	Bacteria % Removal[2]	Bacteria[2] (E. coli Billion CFU/yr)	Construction[3]	Design & Permitting[3]	O&M[3]	Post-Installation Monitoring	Total Life-Cycle Cost[4]	Site Specific Notes
Structural BMPs (See Element C)															
					Estimated Load Reduction					Cost Estimates ($)					
A-2, A-3, A-4	Andover High School east parking lot	Parking lot island bioswale, trees, infiltration tree trench, and bioretention basin	1.4	100%	20.7	2.4	519.8	98%	12	$302,000	$53,000	$3,000	$600	$415,600	
A-6	Andover High School south parking lot, west end	Parking lot infiltration tree trenches	0.8	80%	9.6	1.1	242.6	98%	5	$141,000	$35,000	$3,000	$600	$236,600	
L-1	Costello Park, Lawrence	Bioretention basin, formalized pedestrian path	2.1	50%	13.8	2.1	444.4	90%	1,630	$80,000	$24,000	$3,000	$600	$164,600	
L-6	South Lawrence East School parking lot	Parking lot infiltration tree trenches	0.7	50%	5.3	0.6	136.5	83%	3	$41,000	$7,000	$3,000	$600	$108,600	
L-7	Shawsheen Park parking lot, Lawrence	Parking lot bioretention basin	0.4	100%	5.5	0.6	138.6	100%	3	$76,000	$14,000	$3,000	$600	$150,600	
NA-2	Atkinson School parking lot, North Andover	Parking lot subsurface infiltration chambers	0.4	100%	6.2	0.7	155.9	98%	3	$84,000	$15,000	$3,000	$600	$159,600	
T-2	Livingston Street, Tewksbury	Streetscape infiltration tree trenches	0.6	100%	8.3	0.9	213.3	83%	4	$63,000	$21,000	$3,000	$600	$144,600	
				Sub-Total:	69.5	8.4	1851.2	--	1660.2	$787,000	$169,000	$21,000	$4,200	$1,380,200	
Education and Outreach (See Element E)															
--	Annual Education and Outreach Activities	Includes stakeholder and community engagement, surveys and continuing education around the plan												$50,000	Cost may vary depended on education and outreach needs
--	Signage	To be installed at BMP implementation sites												$3,000	
				Sub-Total:	--	--	--	--	--	--	--	--		$53,000	
Monitoring and Evaluation (See Element H/I)															
--	Sampling QAPP / SOPs	Write sampling QAPP and sampling plan	--	--	--	--	--	--	--	--	--	--		$5,000	Estimated cost, cost will vary widely depending on level of detail
--	Annual Water Quality Sampling	TBD	--	--	--	--	--	--	--	--	--	--		$30,000	Cost is ballpark placeholder; program costs could vary widely depending on resources available.
				Sub-Total:	--	--	--	--	--	--	--	--		$35,000	
									TOTALS:	$787,000	$169,000	$21,000		$1,415,200	

Notes

1 TN, TP, and TSS load reductions estimated using methodology from the MA MS4 Permit Appendix F Attachment 3 and EPA Region 1 BMP Accounting and Tracking Tool

2 Bacteria load reduction estimated using methodology from Tisbury MA (2019) Planning Level GI SCM Performance Curves for Estimating Cumulative Reductions in SW-Related Indicator Bacteria

3 Planning-level costs estimated using EPA Region 1 (2016) Methodology for Developing Cost Estimates for Opti-Tool and best professional judgement. Expressed in 2024 dollars. Costs are only for SCMs and do not include additional site work. Estimates are meant for comparison and prioritization and should not be used as the basis for specific funding requests or project budgeting.

4 Life-cycle cost represents the capital and O&M costs over a 20-year life span.

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 Shawsheen 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 Lawrence along the Shawsheen corridor 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 Lawrence, and those interested in the health of the Shawsheen 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, Andover, North Andover, and Tewksbury residents who live within the watershed of the Shawsheen River, conducted surveys in English and Spanish within environmental justice neighborhoods, and used local print and social media channels to promote the work. A central component to reaching the target audience was the holding of a public meeting in 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

An open house was held on October 5th, 2024. This meeting included a survey of the attendees. This survey assessed public perceptions of the Shawsheen 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 Shawsheen 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.

Community events

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. Two engagement events were planned and held for residents living near the river. The first engagement event was held on July 24th, at 6 PM and included a walk along the Shawsheen Greenway.
b. The second was planned and held on August 15th at 6 PM and was an open house with structured discussions.

Groundwork Lawrence created a walking group with residents living next to Costello Park. The walking group walked four times during the reported period with an additional two more walks planned.

Social and Traditional Media

- To advance the Shawsheen River Watershed Based Plan GWL has completed two videos:
    - The first video focused on work along the Shawsheen corridor in Lawrence highlighting efforts to clean up a large volume of dumped trash (furniture, tires, and other bulky debris), efforts to restore the riverbank and urban forest along the corridor, and introduced the watershed based plan.
    - The second video used a stormwater outfall at the Shawsheen to highlight ways resident/youth action has improved the health of the river. About 10 years ago, high levels of bacteria were being discharged from the outfall and Lawrence HS students from an urban ecology class played an important role in elevating the issue. The video continued introducing the Shawsheen Watershed Based Plan.

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. Promote the public meeting.
d. Review the public meeting and discuss next steps.

To raise awareness about the work, an article in both English and Spanish was published in The Rumbo, the bilingual news publication of the Merrimack Valley. This article focused on nonpoint source pollution and acknowledged the City's success in receiving an award from the state to develop the Blue Merrimack Green Lawrence project- the first step towards mitigating CSOs in Lawrence.

Groundwork Lawrence also created a door hanger leave behind draft, coordinated with staff for an Earth Day Walk with Lawrence city staff and elected officials to promote the plan and stormwater improvements.

Resident Advisory Committee

To further integrate the community outreach, residents of the watershed were asked to serve on the Advisory Committee. This Committee met three times 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 Shawsheen, offer their opinions on the plan and designs presented, provide local insight into the final BMP locations, and ultimately become champions of the plan. The members of this committee include:

- Frank Surillo, City of Lawrence
- Tennis Lilly, Lawrence Conservation Commission
- Jon Honea, Shawsheen River Herring Count
- William McDowell, Merrimack College Associate Professor of Biology
- Helen Pickard, Friends of North Andover Trails
- James "Jay" Dowd, North Andover Historical Commission
- Mily Puello, Greater Lawrence Sanitary District
- Laurie Hartwick, Shawsheen River Watershed Association
- Robert Marsh, Shawsheen River Watershed Association
- Tom Braunchaud, Tewksbury
- Meghan Tenhoff, Northern Middlesex Council of Governments (NMCOG)

Advisory committee members were selected to bring expertise and background to the team to help determine the best locations for BMPs after a GIS analysis was completed and review the final draft of the plan for comments before its submission to MassDEP. In May, the advisory committee received an overview of the plan's progress results of the water quality monitoring up to that point. They provided suggestions on how to increase public engagement and the optimal siting of water quality monitoring locations. In September, the advisory committee received an update on the water quality sampling results and were informed of the hiring of Horsley Witten. In November, the advisory committee reviewed a packet of the 32 highest-scoring sites in MVPC's GIS analysis and nominated sites in each town to be prioritized for BMP implementation. The plan's first draft was sent out to the advisory committee before the plan was submitted to DEP. No comments or recommendations were received.

Water Quality Monitoring Volunteers

From May to November 2024, MRWC volunteers assisted in collecting samples water quality monitoring and sampling. All but one of the volunteers were residents of the Shawsheen River Watershed. Volunteers monitored *E. coli* and *enterococcus* concentrations at eleven sites on the mainstem of the Shawsheen river. The results of MRWC's Shawsheen water quality monitoring program can be found in **Appendix B.**

Education and Outreach Moving Forward

As of the completion of this planning process, education, and outreach along the Shawsheen River has only just begun. This initial outreach allowed our team to garner initial citizen interest through our local advisory committee 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 Shawsheen. 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. Garnering interest and excitement about work along the Shawsheen 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. 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. These educational activities not only look to garner interest around the water resource but also educate the public around the specifics of non-point source pollution. Educational opportunities may include workshops around reducing nutrients in runoff, and the harmful effects of bacteria in the water system.

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

Information and education efforts and how they will be evaluated.

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	Obtain funding and write Quality Assurance Project Plan (QAPP) for sampling and establish water quality monitoring program	2025
	Perform annual water quality sampling per Element H&I monitoring guidance	Annual starting 2026
	Perform seasonal water quality testing downstream and within sites of BMP implementation and other infrastructure improvements to determine their impact	As needed
	Perform seasonal water quality testing upstream and downstream of the Ballardvale Dam to determine the impact of removal	Contingent on dam's removal
Structural BMPs	Obtain funding and implement 1-2 additional BMPs from Table C-5	2026
	Obtain funding and implement 1-2 additional BMPs from Table C-5	2028
	Obtain funding and implement 1-2 additional BMPs from Table C-5	2030
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	2026

	efforts (e.g., based on monitoring results, 319 funding, etc). – Next update, January 2029	
	Reach long-term goal to de-list section of watershed from 303(d) list	2039

[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 (MS4) permit requirements. Stakeholders will perform tasks contingent on available resources and funding.

[2] Stakeholders include MRWC, MVPC, SRWA, City of Lawrence, Town of Tewksbury, Town of North Andover, Town of Andover, 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 Shawsheen 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

$Credit_{CB} = IA_{CB} \times PLE_{IC\text{-}land\ use} \times PRF_{CB}$ **(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 installation of BMPs at 19 unique locations across six parcels and two roads. 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 1660.2 billion coliforms per year. Anticipated reduction of total phosphorous (TP) is 8.4 pounds/year, and anticipated reduction of total nitrogen (TN) is 69.5 pounds/year.

Direct Measurements

River Sampling

It is recommended to continue with the current monitoring plan, with MRWC to continue monitoring *E. coli* bi-monthly from May through November. Water quality parameters such as temperature, pH, TSS, dissolved oxygen, salinity, conductivity, and turbidity will also continue to provide additional data.

Currently, funding does not exist to continue the sampling program. However, if funding were to be made available to MRWC or another applicable organization, continued monitoring of the parameters listed above could be pursued.

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) bacteria 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 bacteria concentrations measured within the Shawsheen River, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly.

A group of stakeholders associated with the established Shawsheen River advisory committee is recommended to be created and guided by the Merrimack Valley Planning Commission with participation from the Merrimack River Watershed Association as capacity allows. This stakeholder group will implement recommendations from this WBP and track overall progress. The group will continue to prepare an annual progress report for project-specific indicators and direct measurements as they relate to established water quality goals; and will provide an indication of ongoing efforts and overall next steps. Each municipality referenced in this document is encouraged to secure its own funding to support project development and completion. The Merrimack Valley Planning Commission will continue to provide technical assistance, support municipalities in drafting grant applications for implementation, and assist with project evaluation and plan revisions throughout its lifespan.

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Water Quality Assessment Reports

"*Shawsheen River Watershed 2000 Water Quality Assessment Report*

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
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

Appendix B – Water Quality Monitoring Results

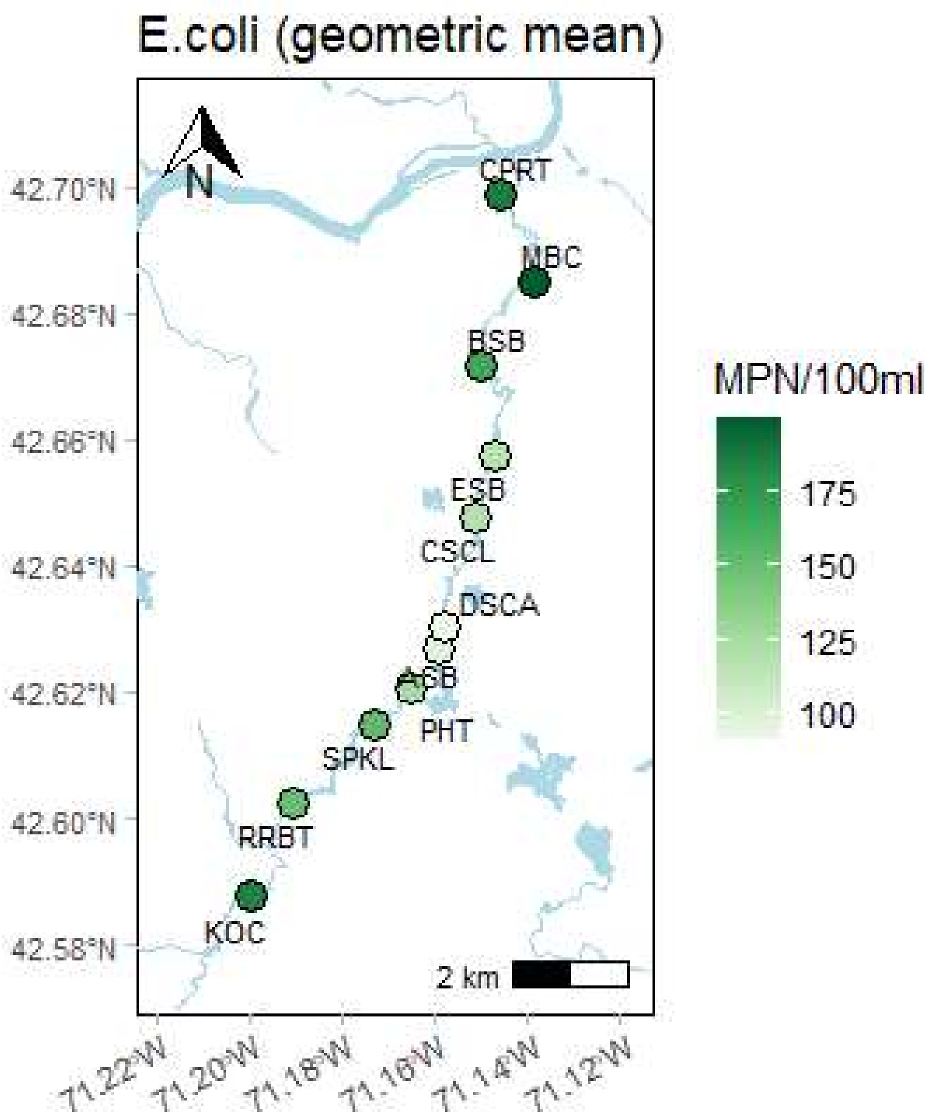
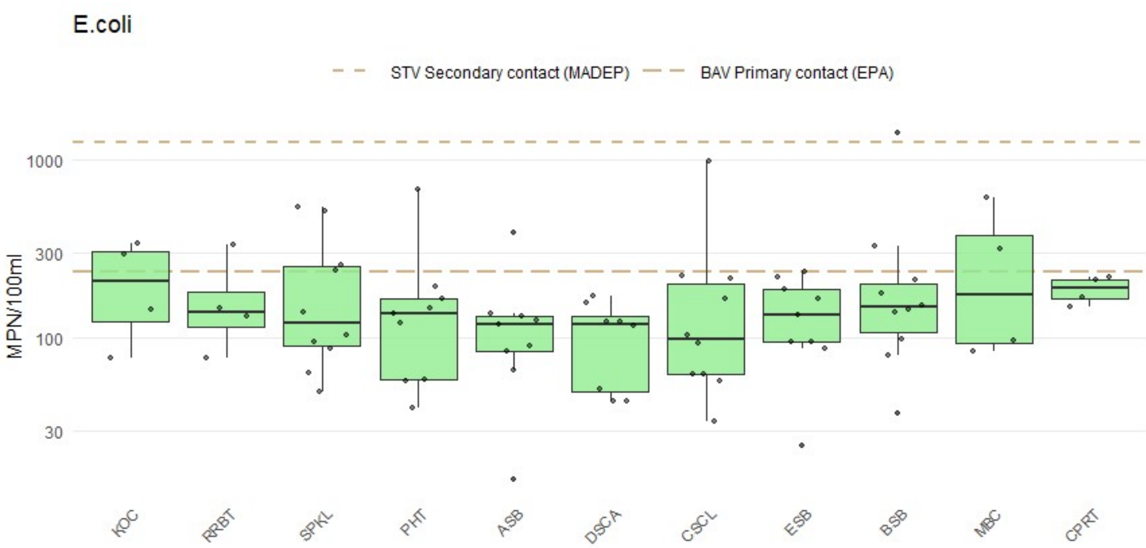


Figure 1: A spatial graph of the average *Escherichia coli* concentrations at the 13 sampling sites of the Shawsheen throughout the sampling project.

Figure 2: Boxplots displaying the average concentration of *Escherichia coli* by sampling site, including Primary and Secondary recreational contact limits.



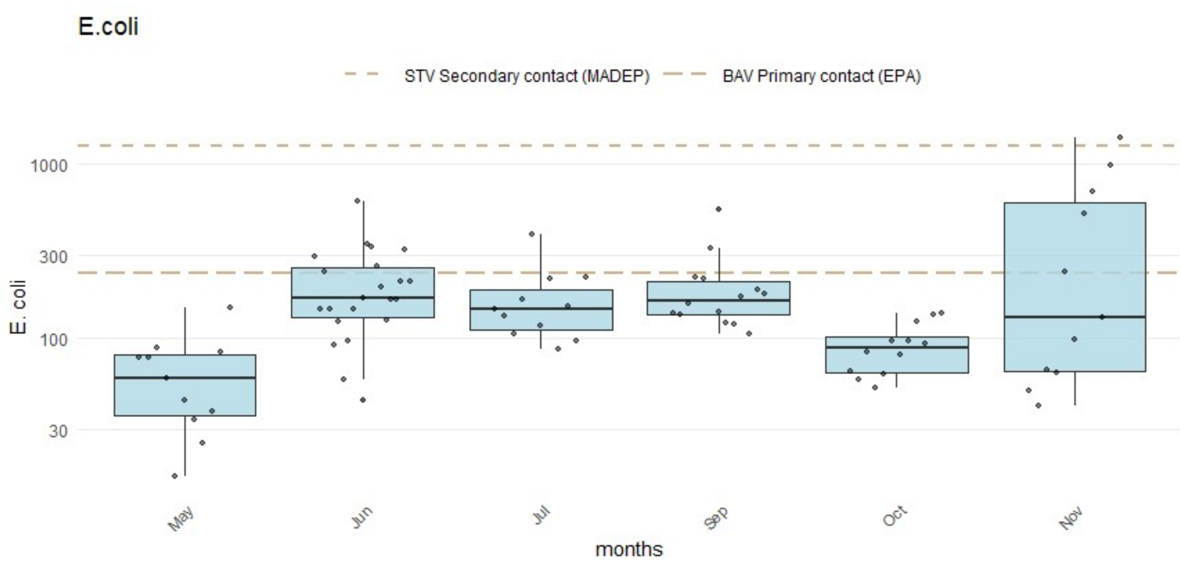


Figure 3: Boxplots displaying the average concentration of *Escherichia coli* in the sampling area of the Shawsheen by month, including Primary and Secondary recreational contact limits.

Figure 4: A spatial graph of the average Dissolved Oxygen readings at the 13 sampling sites of the Shawsheen throughout the sampling project.

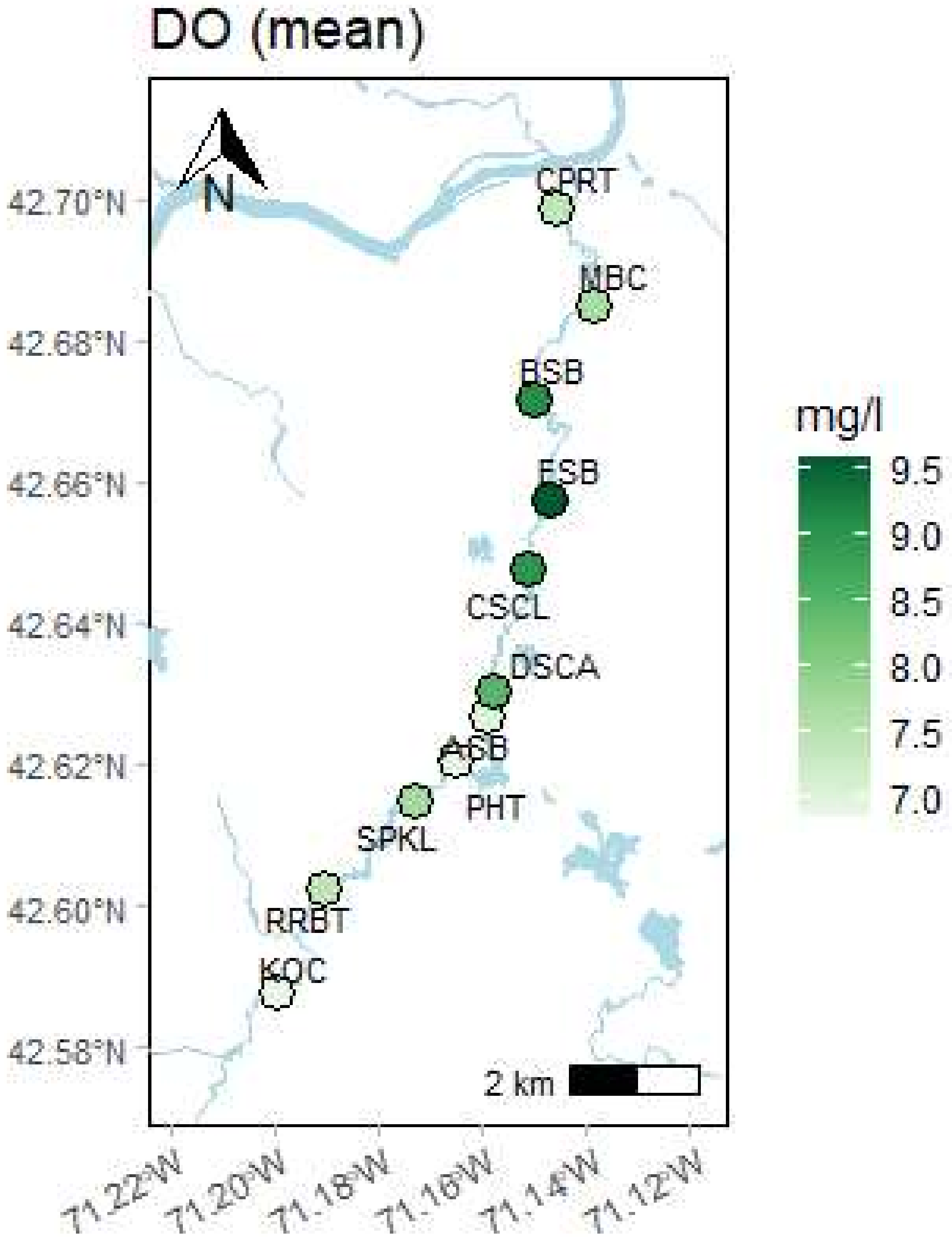
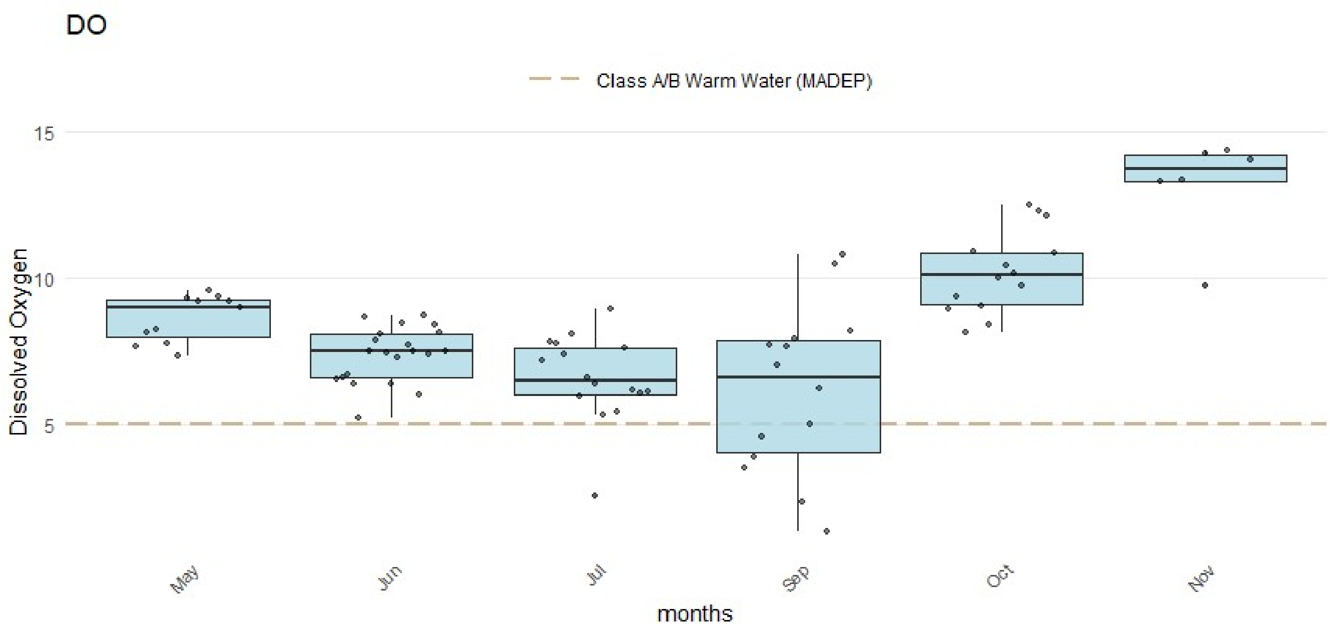


Figure 5: Boxplots displaying the average Dissolved Oxygen content by month in Milligrams per Liter, including the lower limit of dissolved oxygen readings to fall within the MADEP Warm Water Fisheries designation.



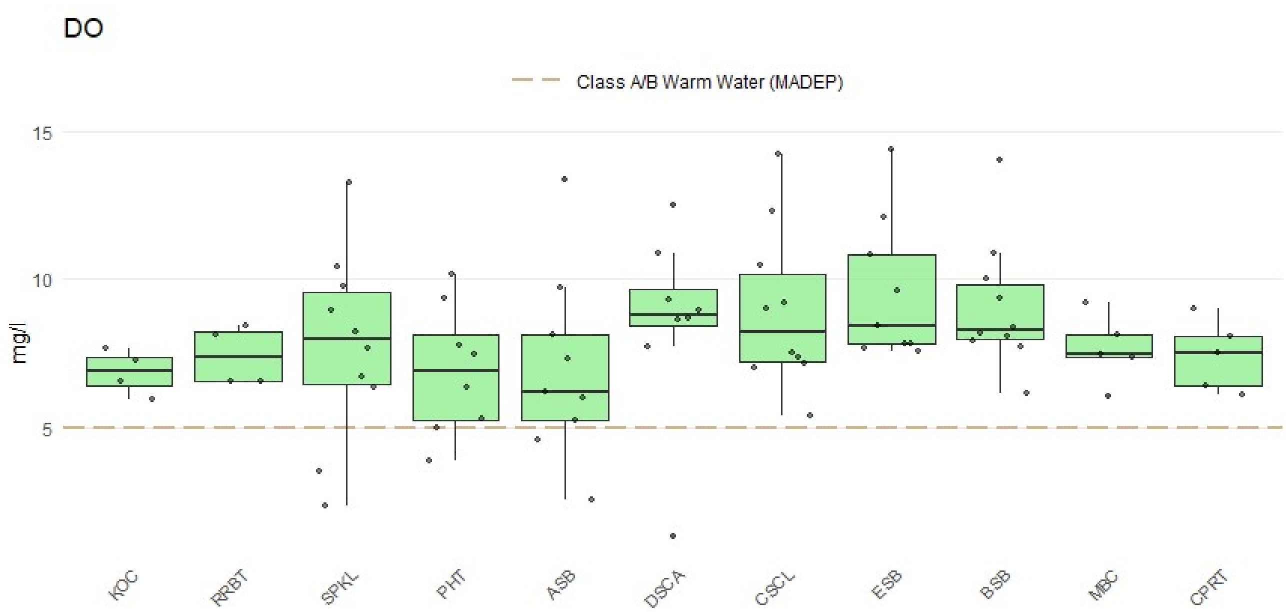


Figure 6: Boxplots displaying the average Dissolved Oxygen content by sampling site in Milligrams per Liter, including the lower limit of dissolved oxygen readings to fall within the MADEP Warm Water Fisheries designation.

Appendix C – Sampling and Analysis Plans

Sampling and Analysis Plan (SAP)
For the
Shawsheen River Water Sampling 2023

By the
Merrimack River Watershed Council
60 Island Street, Suite 246
Lawrence, MA 01840

1. Introduction

This Sampling Analysis Plan (SAP) for the Shawsheen River has been developed by the Merrimack River Watershed Council (MRWC), with assistance from Nashoba Analytical in Ayer, MA and has been reviewed by partners at the EPA and Massachusetts Department of Environmental Protection (DEP) (see Table 1 for SAP distribution list). The sampling program aims to identify areas of high concern for pathogens (*E. coli*), and turbidity (measured by secchi disc), as well as basic physical and chemical parameters (temperature, pH, total dissolved solids, conductivity, and dissolved oxygen measured in-situ using a handheld meter). These parameters will allow us to better understand where high loads of bacteria and nutrients are coming from. This work will inform a watershed-based plan for the Shawsheen River that will propose targeted best management practices for mitigating non-point source pollution in the watershed. The sampling will follow the *Quality Assurance Project Plan (Adoption Form Revision 11, June 22, 2020) Merrimack River Water Monitoring Program Approval for 2020-2025,* which includes sample collection Standard Operating Procedures and field readings that do not require laboratory analysis, except where otherwise noted in this SAP.

Table 1: SAP Distribution List:

Name	Org.	Email	Phone	Role
Becky Zawalski	MRWC	becky@merrimack.org	(978) 655-4742 x 709	Project Manager
Jose Tapia	MRWC	jose@merrimack.org	(978) 376-1475	Program Assistant
Cece Gerstenbacher	MVPC	cgerstenbacher@mvpc.org	(978) 374-0519 x 34	QA Officer
Suzanne Flint	Mass DEP	suzanne.flint@mass.gov	(508) 688-5062	Quality Assurance Analyst
Meghan Selby	Mass DEP	meghan.selby@mass.gov	(508) 767-2893	Watershed Planning Program

Note: The above-mentioned project staff and any staff and volunteers they oversee are responsible for following the procedures outlined in this SAP and in the appropriate SOPs.

2. Project Organization and Background

MRWC is a nonprofit organization with an office in Lawrence, MA and Concord, NH. MRWC has a dedicated base of volunteers and supporters throughout the watershed in MA and NH who support water quality monitoring and data collection. MRWC water quality monitoring, shoreline cleanups and stewardship events are rooted in community need for a healthy river and universal access to green space. MRWC has a strong partnership network that leverages resources and relationships to build a strong social and environmental safety net for vulnerable communities in our watershed.

As the "*Voice of the Merrimack,*" MRWC is extremely concerned about the limited, inconsistent, and less than cohesive knowledge of water quality in the Merrimack River and its tributaries, including the Shawsheen River in North Andover and Lawrence, Massachusetts.

The Shawsheen River is vulnerable to catastrophic flooding, as was the case with the infamous 2006 Mother's Day Floods. As a result of more intense rainfall, an increase in pollutant loading has degraded water quality and alienated community members from this natural resource. We have identified a lack of community involvement, inter-municipal collaboration, and technical analysis of multi-benefit solutions that target flooding and water quality. Comprehensive watershed-based planning can address these issues by a) developing detailed analysis, b) identification of remediations and c) to prepare municipalities and communities for project implementation.

The Shawsheen River Watershed has a total drainage area of approximately 78 square miles, including approximately 60 miles of named rivers and streams, and encompassing all or part of 12 Massachusetts' municipalities. The watershed supports a population of approximately 250,000 people. The mainstem of the Shawsheen River flows for approximately 25 miles, losing 70 feet in elevation from its headwaters at Hanscom Military Base to its confluence with the Merrimack River in Lawrence.

The river is listed as impaired on the Section 303(d) list for *E. coli* and Fecal Coliforms, Dissolved Oxygen, physical substrate habitat alterations, and sedimentation/siltation. The Ballardvale Impoundment in the Shawsheen River in the town of Andover is listed for mercury in fish tissue, aquatic plants, and non-native aquatic plants. The town of Andover is considering purchasing and removing the Ballardvale Dam. Monitoring water quality upstream and downstream of the dam prior to its removal will be beneficial in establishing a baseline as it relates to pollutants, sediments, and flood impacts removal may have.

The town of Andover is already working extensively on the Shawsheen River. They have proposed a Shawsheen Master Plan that is intended to provide documentation for the future vision of the Shawsheen River, as well as build public interest and input on future projects. Through the town's MVP Action Grant, their Master Plan project will assess and prioritize areas to improve the resiliency of the Town, the Shawsheen and the Merrimack watersheds. This MassBays-funded project focuses on *E. coli*, and dissolved oxygen, and turbidity monitoring, resulting in a comprehensive watershed-based plan (WBP) for the Shawsheen 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 Shawsheen, for people and wildlife alike.

3. Project Description/Objective

The goal of this water quality monitoring study is to document the water quality of the Shawsheen River, analyze the data we collect to determine the source of pathogens and nutrients and understand the health of the system, and ultimately get a baseline for water quality prior to dam removal. The impacts of these efforts on the people and ecosystems within the Shawsheen River Watershed will be shared and expanded upon through education and outreach. Our monitoring includes three main tasks:

- Collect grab samples for *E. coli* from all sites in the Shawsheen River biweekly at all primary sites to assess when, where, and how often concentrations exceed recommended federal and state limits.
- Collect several field parameters (temperature, pH, total dissolved solids, conductivity, salinity, and dissolved oxygen) using calibrated field probes biweekly at all primary sites.
- Use a secchi disc biweekly at all primary sites to determine turbidity to help assess siltation.

Details of data to be collected at part of these three tasks are outlined in Table 2, while a detailed sampling design is included in the following section.

Table 2: Analytes/Water Quality Measurements

Analysis	**Measurement**	**Parameter**	**Units**	**Ranges/Reporting Levels**
Laboratory	Biology	E. coli	MPN/100 mL	Reporting level: 4
In-situ measurement	NA	Dissolved Oxygen	mg/L, %	Range: 0-50mg/L, 0-500%
In-situ measurement	NA	Conductivity	mS/cm	0-200

In-situ measurement	NA	Salinity	ppt	0-70
In-situ measurement	NA	Total Dissolved Solids	g/L	0-100
In-situ measurement	NA	Temperature	Degrees C	-5 – 45
In-situ measurement	NA	pH		0-14
In-situ measurement	NA	Turbidity		Clear and colorless

Notes:

- The matrix is aqueous, freshwater
- For in-situ measurements, the following QAPP will be followed: MRWC Merrimack River Water Monitoring Program QAPP 6/22/20
- For laboratory analysis of the samples, see Table 13 for SOP and methods

The big picture project is outlined in Table 3, with individual sampling days and data to be collected each sampling day further described in detail in the following section.

Table 3: Project Timeline

Task	**Date**	**Participants**
Sampling	September 2023 – November 2023	Zawalski, Tapia
Project Deliverables Due	Within 30 days of sample receipt	Nashoba Analytical Laboratory, Zawalski, Tapia

Note: Project dates may be subject to change based on field conditions, timing of SAP approval and availability of materials for sample collection.

The MRWC project team who will carry out sample and data collections throughout this project, along with their roles and responsibilities are outlined in Table 4. The project team differs from MRWC Merrimack River Water Monitoring Program QAPP 6/22/2020.

Table 4: Project personnel, roles, and responsibilities

Personnel name and title	**Project Role**	**Responsibilities**
Becky Zawalski Project Manager	• Project Manager • QA Manager • Data Analysis Manager • Field staff	• Overall management of administrative and technical work of the monitoring • Review of procedures and data generated including reports to ensure adherence to QAPP/SAP. • Collect data in the field with MRWC staff or volunteers • Support data analysis and interpretation

	• Field Coordinator • Data Manager	• Planning and coordination of field monitoring, coordination of volunteer assignments and scheduling • Delivers samples to the lab • Oversight of proper sample handling/ preservation and chain of custody forms • Review of data collection, entry, and management for QA/QC • Lead on data analysis and interpretation
Jose Tapia Program Assistant	• Equipment Manager • Field staff	• Preparation of field equipment • Assists in data collection in the filed with MRWC staff or volunteers • Trains volunteers on a needed basis
Cece Gerstenbacher Environmental Program Coordinator	• QA Officer	• Verifies data was entered without errors • Ensures that all elements of the project follow QA procedures in the QAPP

4. Sampling Design

Sampling locations were selected to provide data upstream and downstream of the Ballardvale Dam to determine a baseline of water quality prior to the dam's removal. Monitoring activities will occur biweekly at each site from September 2023 – November 2023. Table 5 shows the sampling schedule for 2023 and the estimated time that the samples will be analyzed by MRWC volunteers using MRWC's IDEXX machine the same day they are collected and read 24 hours after incubation. However, volunteer capacity is not guaranteed, and in the event that the samples cannot be analyzed in-house, they will be delivered to Nashoba Analytical Laboratory in Ayer, Massachusetts. Samples will be collected between 9 am and 1 pm (suitable times for volunteers) and will be delivered to the lab within the required hold time by 2 pm. Samples will be collected despite weather conditions and data will be analyzed at the end of the sampling period by categorizing based on recent rain events with data from the nearest gauge. Because this is a two-year project, data will be analyzed at the end of this year and sampling design, timing of sampling, and the need for data during certain weather events will be revisited in preparation for a 2024 SAP and sampling starting spring of 2024.

All in-situ measurements, turbidity, collection of grab samples for *E. coli*, and monitoring will occur at all primary sites. Table 6 outlines the details of each sample and measurements to be collected. Table 7 and Figure 1 show the sampling locations, and at which site all data will be collected.

The stations will be located with a smart phone equipped with GPS, photos, and additional information to ensure samples are collected at the same location for each sampling event. An MRWC staff member will accompany no more than 2 community members to all sites to ensure all field protocols and data are complete and accurately recorded in the field data sheet. Any additional field observations and notes will also be recorded in the field data sheet (see Appendix).

Table 5: Sample Receipt Dates

Date	Day of the week	Approximate arrival time to the lab:
9/13/23	Wednesday	2:00 PM
9/27/23	Wednesday	2:00 PM
10/11/23	Wednesday	2:00 PM
10/25/23	Wednesday	2:00 PM
11/8/23	Wednesday	2:00 PM
11/22/23	Wednesday	2:00 PM

Note: Sample dates may be subject to change based on field conditions, timing of SAP approval and availability of materials for sample collection

Table 6: Sampling and Analytical Summary Table

Parameter	Samples per event	Name of Analytical Laboratory	Analytical Methods/SOP	Container	Preservation	Maximum Holding Time
E. coli	7 samples +1 blank	Nashoba Analytical/ MRWC IDEXX	Coliert-18: 9221B.2–2006	Screwcap: w/ Sodium Thiosulfate 120mL	1-6˚C	6 Hours
Parameter	**Readings per event**	**Equipment Analytical Methods/SOP**				
Dissolved Oxygen	7 readings	YSI 556 Handheld Multiparameter Instrument				
Conductivity	7 readings	YSI 556 Handheld Multiparameter Instrument				
Salinity	7 readings	YSI 556 Handheld Multiparameter Instrument				
Total Dissolved Solids	7 readings	YSI 556 Handheld Multiparameter Instrument				
Temperature	7 readings	YSI 556 Handheld Multiparameter Instrument				
pH	7 readings	YSI 556 Handheld Multiparameter Instrument				
Turbidity	7 readings	Secchi Disk				

Notes:

1. One duplicate will be collected for *E. coli* each sampling event. The site where the duplicate is collected will rotate each sampling event.
2. Analytical results needed within 30 days after sampling, unless otherwise stated.
3. Samples will be prepared and incubated by MRWC volunteers and/or staff using the MRWC IDEXX machine on the day of sampling event. They will be read 24 hours after entering the incubator and the results recorded. In the event that no volunteers are available and/or staff does not have the capacity to perform the analysis in house, then samples will be delivered at Nashoba Analytical on the day of sampling event.
4. Equipment and/or bottle blanks shall be collected for each sampler (at least once per sampling study), bottle lot number, and equipment used.

Table 7: Shawsheen River Sample Collection Sites

Site ID	Site Name	Latitude (deg min)	Longitude (deg min)	**Parameters** (*E. coli*, field parameters, secchi disk measurement for turbidity)	Site Description	Upstream or Downstream of Dam
SPKL	Shawsheen Pines Kayak Launch	42.614878	-71.172967	All Parameters	Stream bank site[1], at launch site below steps	Upstream
PHT	Pole Hill Trail	42.6206016	-71.1648111	All Parameters	Stream bank site[1] at trail	Upstream
ASB	Andover Street Bridge	42.626543	-71.158643	All Parameters	Bridge site[2] on downstream side before dam	Upstream
DSCA	Dale Street Conservation Area	42.630289	-71.1578133	All Parameters	Stream bank site[1] at canoe launch point	Downstream
CSCL	Central Street Canoe Launch	42.647575	-71.150717	All Parameters	Stream bank site[1] at canoe launch upstream of bridge	Downstream
ESB	Essex Street Bridge	42.65726	-71.14686	All Parameters	Bridge site[2] on downstream portion of bridge where there is a gap between the bridge and the pipe	Downstream
BSB	Balmoral Street Bridge	42.671572	-71.149483	All Parameters	Bridge site[2] on upstream side of bridge	Downstream

1. At stream bank and outfall sites, all samples will be collected directly in the sample bottles by hand. Monitors will carefully wade into the stream without stirring up bottom sediments to collect flowing water upstream of where they are standing.
2. At bridge sites, samples will be collected in a basket with a weight at the bottom and a mason jar attached. This is the same apparatus used in the MRWC water quality monitoring program on the Merrimack River. The *E. coli* sample will be collected by pouring sample water from the jar attached to the basket into the sterile sample bottle.

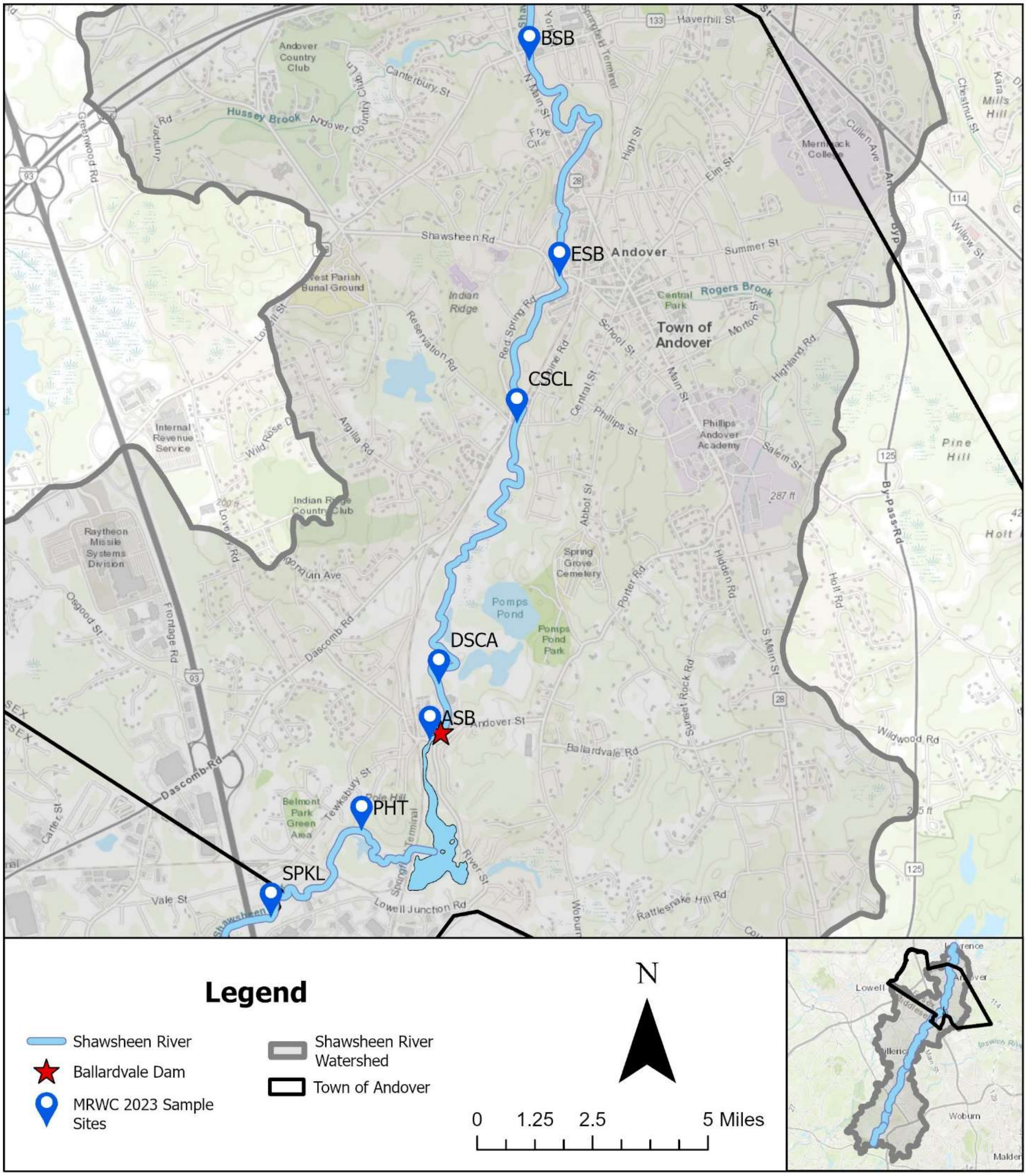


Figure 1: Map of monitoring locations

5. Equipment Needs

A full list of equipment needed for each sampling day is listed below. One deviation from the MRWC Merrimack River Water Monitoring Program QAPP 6/22/2020 is the use of a YSI Multiparameter Instrument to collect in-situ field data as opposed to a Hach Pocket Pro 2+ Tester in combination with a HI9146 Portable Dissolved Oxygen Meter. The reasoning is that the YSI instrument allows for all parameters to be read at the same time, which allows for more streamlined sampling. Calibration, maintenance inspection and testing of all equipment will adhere to Section 15, 16, and 17 of the previously mentioned QAPP.

- Bacteria sample bottles with thiosulfate
- YSI 556 Multiparameter Instrument
- pH 7.01 calibration standard
- Conductivity 1409 calibration standard
- DI water and spray bottle
- Pens/markers
- C batteries
- Field sheets
- Chain of Custody forms
- Cooler with ice/icepacks
- Ziplock bags
- Disposable gloves
- Bridge sample grabber
- Secchi disk

6. Data Management and QA/QC

This study and sample and data collection adhere to all quality control measures outlined in Section 14 of the *MRWC Merrimack River Water Monitoring Program QAPP 6/22/2020*. Documentation and record keeping of collected data will adhere to Section 9 in the previously mentioned QAPP, and data management in this study will adhere to Section 19 in the above previously mentioned QAPP. Instrument calibration will adhere to Section 16 in the previously mentioned QAPP, as well as include a post-calibration immediately following sampling. Field data will be collected using the field data sheet included in the Appendix.

Sampling and Analysis Plan (SAP)
For the
Shawsheen River Water Sampling 2024

By the
Merrimack River Watershed Council
60 Island Street, Suite 246
Lawrence, MA 01840

Introduction

This Sampling Analysis Plan (SAP) for the Shawsheen River has been developed by the Merrimack River Watershed Council (MRWC) and has been reviewed by partners at the EPA and Massachusetts Department of Environmental Protection (DEP) (see Table 1 for SAP distribution list). The sampling program aims to identify areas of high concern for pathogens (*E. coli*), and turbidity (measured by lab analysis), as well as basic physical and chemical parameters (temperature, pH, total dissolved solids, conductivity, and dissolved oxygen measured in-situ using a handheld meter). These parameters will allow us to better understand where high loads of bacteria and nutrients are coming from. This work will inform a watershed-based plan for the Shawsheen River that will propose targeted best management practices for mitigating non-point source pollution in the watershed. The sampling will follow the *Quality Assurance Project Plan (Adoption Form Revision 11, June 22, 2020) Merrimack River Water Monitoring Program Approval for 2020-2025,* which includes sample collection Standard Operating Procedures and field readings that do not require laboratory analysis, except where otherwise noted in this SAP.

Table 8: SAP Distribution List:

Name	**Org.**	**Email**	**Phone**	**Role**
Becky Zawalski	MRWC	becky@merrimack.org	(978) 655-4742 x 709	Project Manager
Jose Tapia	MRWC	jose@merrimack.org	(978) 655-4742 x 707	Program Analyst
Cece Gerstenbacher	MVPC	cgerstenbacher@mvpc.org	(978) 374-0519 x 34	QA Officer
Jasper Sha	Mass	Jasper.sha@mass.gov	(857) 274-0905	Quality Assurance

	DEP			Analyst
Tom Faber	EPA	Faber.Tom@epa.gov	(617) 918-8672	EMT Technical Lead
Maura Gould	EPA	Gould.Maura@epa.gov	(617) 918-8673	EMT Project Lead
Jack Parr	EPA	Paar.Jack@epa.gov	(617) 918-8604	Biology Lab Lead
Lauren Light	EPA	Light.Lauren@epa.gov	(61) 918-8319	Chemist
Paul Toompas	EPA	Toompas.Apostolos@epa.gov	(617) 918-8682	Chemistry Analyst
Holly Westbrook	EPA	Westbrook.Holly@epa.gov	(617) 918-8303	Chemistry Analyst

Note: The above-mentioned project staff and any staff and volunteers they oversee are responsible for following the procedures outlined in this SAP and in the appropriate SOPs.

7. Project Organization and Background

MRWC is a nonprofit organization with an office in Lawrence, MA and Concord, NH. MRWC has a dedicated base of volunteers and supporters throughout the watershed in MA and NH who support water quality monitoring and data collection. MRWC water quality monitoring, shoreline cleanups and stewardship events are rooted in community need for a healthy river and universal access to green space. MRWC has a strong partnership network that leverages resources and relationships to build a strong social and environmental safety net for vulnerable communities in our watershed.

As the "*Voice of the Merrimack,*" MRWC is extremely concerned about the limited, inconsistent, and less than cohesive knowledge of water quality in the Merrimack River and its tributaries, including the Shawsheen River in North Andover and Lawrence, Massachusetts.

The Shawsheen River is vulnerable to catastrophic flooding, as was the case with the infamous 2006 Mother's Day Floods. As a result of more intense rainfall, an increase in pollutant loading has degraded water quality and alienated community members from this natural resource. We have identified a lack of community involvement, inter-municipal collaboration, and technical analysis of multi-benefit solutions that target flooding and water quality. Comprehensive watershed-based planning can address these issues by a) developing detailed analysis, b) identification of remediations and c) to prepare municipalities and communities for project implementation.

The Shawsheen River Watershed has a total drainage area of approximately 78 square miles, including approximately 60 miles of named rivers and streams, and encompassing all or part of 12 Massachusetts' municipalities. The watershed supports a population of approximately 250,000 people. The mainstem of the Shawsheen River flows for approximately 25 miles, losing

70 feet in elevation from its headwaters at Hanscom Military Base to its confluence with the Merrimack River in Lawrence.

The river is listed as impaired on the Section 303(d) list for *E. coli* and Fecal Coliforms, Dissolved Oxygen, physical substrate habitat alterations, and sedimentation/siltation. The Ballardvale Impoundment in the Shawsheen River in the town of Andover is listed for mercury in fish tissue, aquatic plants, and non-native aquatic plants. The town of Andover is considering purchasing and removing the Ballardvale Dam. Monitoring water quality upstream of the dam in Tewksbury and downstream of the dam in Andover, North Andover, and Lawrence prior to its removal will be beneficial in establishing a baseline as it relates to pollutants, sediments, and flood impacts removal may have on the Shawsheen and the Merrimack River.

The town of Andover is already working extensively on the Shawsheen River. They have proposed a Shawsheen Master Plan that is intended to provide documentation for the future vision of the Shawsheen River, as well as build public interest and input on future projects. Through the town's MVP Action Grant, their Master Plan project will assess and prioritize areas to improve the resiliency of the Town, the Shawsheen and the Merrimack watersheds. This MassBays-funded project focuses on *E. coli*, and dissolved oxygen, and turbidity monitoring, resulting in a comprehensive watershed-based plan (WBP) for the Shawsheen River including Andover, North Andover, Tewksbury, and Lawrence. 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 Shawsheen, for people and wildlife alike.

8. Project Description/Objective

The goal of this water quality monitoring study is to document the water quality of the Shawsheen River, analyze the data we collect to determine the source of pathogens and nutrients and understand the health of the system, and get a baseline for water quality prior to dam removal. The impacts of these efforts on the people and ecosystems within the Shawsheen River Watershed will be shared and expanded upon through education and outreach. Our monitoring includes three main tasks:

- Collect grab samples for *E. coli* from all sites in the Shawsheen River biweekly at all primary sites to assess when, where, and how often concentrations exceed recommended federal and state limits.
- Collect several field parameters (temperature, pH, total dissolved solids, conductivity, salinity, and dissolved oxygen) using calibrated field probes biweekly at all primary sites.
- Collect water samples for turbidity from all sites in the Shawsheen River biweekly at all primary sites to assess suspended solids for sedimentation.

Details of data to be collected at part of these three tasks are outlined in Table 2, while a detailed sampling design is included in the following section.

Table 9: Analytes/Water Quality Measurements

Analysis	Measurement	Parameter	Units	Ranges/Reporting Levels
Laboratory	Biology	E. coli	MPN/100 mL	Reporting level: 4
Laboratory	Chemistry	Turbidity	NTU	0.3 NTU
In-situ measurement	NA	Dissolved Oxygen	mg/L, %	Range: 0-50mg/L, 0-500%
In-situ measurement	NA	Conductivity	mS/cm	0-200
In-situ measurement	NA	Salinity	ppt	0-70
In-situ measurement	NA	Total Dissolved Solids	g/L	0-100
In-situ measurement	NA	Temperature	Degrees C	-5 – 45
In-situ measurement	NA	pH	NA	0-14

Notes:

- The matrix is aqueous, freshwater
- For in-situ measurements, the following QAPP will be followed: MRWC Merrimack River Water Monitoring Program QAPP 6/22/20
- For laboratory analysis of the samples, see Table 13 for SOP and methods

The big picture project is outlined in Table 3, with individual sampling days and data to be collected each sampling day further described in detail in the following section.

Table 10: Project Timeline

Task	Date	Participants
Sampling	May 2024 – September 2024	Zawalski, Tapia
Project Deliverables Due	Within 30 days of sample receipt	Paar, Gould, Zawalski, Tapia

Note: Project dates may be subject to change based on field conditions, timing of SAP approval and availability of materials for sample collection.

The MRWC project team who will carry out sample and data collections throughout this project, along with their roles and responsibilities are outlined in Table 4. The project team differs from MRWC Merrimack River Water Monitoring Program QAPP 6/22/2020.

Table 11: Project personnel, roles, and responsibilities

Personnel name and title	Project Role	Responsibilities
Becky Zawalski Project Manager	• Project Manager • QA Manager • Data Analysis Manager • Field staff • Field Coordinator • Data Manager	• Overall management of administrative and technical work of the monitoring • Review of procedures and data generated including reports to ensure adherence to QAPP/SAP. • Collect data in the field with MRWC staff or volunteers • Support data analysis and interpretation • Planning and coordination of field monitoring, coordination of volunteer assignments and scheduling • Delivers samples to the lab • Oversight of proper sample handling/ preservation and chain of custody forms • Review of data collection, entry, and management for QA/QC • Lead on data analysis and interpretation
Jose Tapia Program Analyst	• Equipment Manager • Field staff	• Preparation of field equipment • Assists in data collection in the filed with MRWC staff or volunteers • Trains volunteers on a needed basis
Cece Gerstenbacher Environmental Program Coordinator	• QA Officer	• Verifies data was entered without errors • Ensures that all elements of the project follow QA procedures in the QAPP

9. Sampling Design

Sampling locations were selected to provide data upstream and downstream of the Ballardvale Dam to determine a baseline of water quality prior to the dam's removal. Monitoring activities will occur biweekly at each site from May 2023 – September 2023. Table 5 shows the sampling schedule for 2024 and the estimated time that the samples will arrive at the EPA Region 1 Laboratory in North Chelmsford, Massachusetts. Samples will be collected between 8 am and 1 pm (suitable times for volunteers) and will be delivered to the lab within the required hold time by 2 pm. Samples will be collected despite weather conditions and data will be analyzed at the end of the sampling period by categorizing based on recent rain events with data from the nearest gauge.

All in-situ measurements, turbidity, collection of grab samples for *E. coli*, and monitoring will occur at all primary sites. Table 6 outlines the details of each sample and measurements to be collected. Table 7 and Figure 1 show the sampling locations, and at which site all data will be collected.

The stations will be located with a smart phone equipped with GPS, photos, and additional information to ensure samples are collected at the same location for each sampling event. An MRWC staff member will train volunteers in the proper protocol and review data from all sites to ensure all field protocols and data are complete and accurately recorded in the field data sheet. Any additional field observations and notes will also be recorded in the field data sheet (see Appendix).

Table 12: Sample Receipt Dates

Date	Day of the week	Approximate arrival time to the lab:
5/21/24	Tuesday	2:00 PM
6/4/24	Tuesday	2:00 PM
6/17/24	Monday	2:00 PM
7/2/24	Tuesday	2:00 PM
7/16/24	Tuesday	2:00 PM
7/30/24	Tuesday	2:00 PM
8/13/24	Tuesday	2:00 PM
8/27/24	Tuesday	2:00 PM
9/10/24	Tuesday	2:00 PM
9/24/24	Tuesday	2:00 PM

Note: Sample dates may be subject to change based on field conditions, timing of SAP approval and availability of materials for sample collection

Table 13: Sampling and Analytical Summary Table

Parameter	Samples per event	Name of Analytical Laboratory	Analytical Methods/SOP	Container	Preservation	Maximum Holding Time
E. coli	11 samples +1 blank	NERL Biology	9221B	Screwcap: w/ Sodium Thiosulfate 120mL	1-6˚C	6 Hours
Turbidity	11 samples + 1 blank + 1 duplicate	NERL Chemistry	LSBSOP-TURB7	Wide-Mouth HDPE Packers with Closure, 250 mL	<4°C	48 hours
Parameter	**Readings per event**	**Equipment Analytical Methods/SOP**				
Dissolved Oxygen	11 readings	YSI 556 Handheld Multiparameter Instrument				
Conductivity	11 readings	YSI 556 Handheld Multiparameter Instrument				
Salinity	11 readings	YSI 556 Handheld Multiparameter Instrument				
Total Dissolved Solids	11 readings	YSI 556 Handheld Multiparameter Instrument				
Temperature	11 readings	YSI 556 Handheld Multiparameter Instrument				
pH	11 readings	YSI 556 Handheld Multiparameter Instrument				

Notes:

5. One duplicate will be collected for Turbidity each sampling event. The site where the duplicate is collected will rotate each sampling event.
6. Analytical results needed within 30 days after sampling, unless otherwise stated.
7. Due to the wide range of *E. coli* concentration that can occur from two samples collected in the same location at the same time, or a single sample split into two bottles for analysis, the EPA NERL biology lab lead has advised that this can make duplicate sampling misleading. As a result, a duplicate *E. coli* sample will not be collected for each sampling event.
8. Samples will be delivered at New England Regional Lab on day of sampling event.
9. Equipment and/or bottle blanks shall be collected for each sampler (at least once per sampling study), bottle lot number, and equipment used. Turbidity blanks will be collected the first 2-3 sampling events only.

Table 14: Shawsheen River Sample Collection Sites

Site ID	**Site Name**	**Latitude (deg min)**	**Longitude (deg min)**	**Parameters** (***E. coli*, field parameters, secchi disk measurement for turbidity**)	**Site Description**	**Upstream or Downstream of Dam**
KOC	Knights of Columbus	42.587449	-71.199270	All Parameters	Stream bank site[1], at end of trail behind building	Upstream
RRBT	Railroad Bed Trail	42.602298	-71.190248	All Parameters	Bridge site[1] at trail across from Lowe Street	Upstream
SPKL	Shawsheen Pines Kayak Launch	42.614878	-71.172967	All Parameters	Stream bank site[1], at launch site below steps	Upstream
PHT	Pole Hill Trail	42.6206016	-71.1648111	All Parameters	Stream bank site[1] at trail	Upstream
ASB	Andover Street Bridge	42.626543	-71.158643	All Parameters	Bridge site[2] on downstream side before dam	Upstream
DSCA	Dale Street Conservation Area	42.630289	-71.1578133	All Parameters	Stream bank site[1] at canoe launch point	Downstream
CSCL	Central Street Canoe Launch	42.647575	-71.150717	All Parameters	Stream bank site[1] at canoe launch upstream of bridge	Downstream
ESB	Essex Street Bridge	42.65726	-71.14686	All Parameters	Bridge site[2] on downstream portion of bridge where there is a gap between the bridge and the pipe	Downstream

Site ID	Site Name	Latitude (deg min)	Longitude (deg min)	**Parameters** (*E. coli*, field parameters, secchi disk measurement for turbidity)	Site Description	Upstream or Downstream of Dam
BSB	Balmoral Street Bridge	42.671572	-71.149483	All Parameters	Bridge site[2] on upstream side of bridge	Downstream
MBC	Market Basket Culvert	42.684759	-71.138218	All Parameters	Shore site[1] on the downstream portion of where the culvert empties into the Shawsheen	Downstream
CPRT	Costello Park Shawsheen River Trail	42.698649	-71.145822	All Parameters	Shore site[1] upstream of the Massachusetts Ave bridge	Downstream

3. At stream bank and outfall sites, all samples will be collected directly in the sample bottles by hand. Monitors will carefully wade into the stream without stirring up bottom sediments to collect flowing water upstream of where they are standing.
4. At bridge sites, samples will be collected in a basket with a weight at the bottom and a mason jar attached. This is the same apparatus used in the MRWC water quality monitoring program on the Merrimack River. The *E. coli* sample will be collected by pouring sample water from the jar attached to the basket into the sterile sample bottle. Jars are rinsed with Deionized (DI) water before and after each collection.

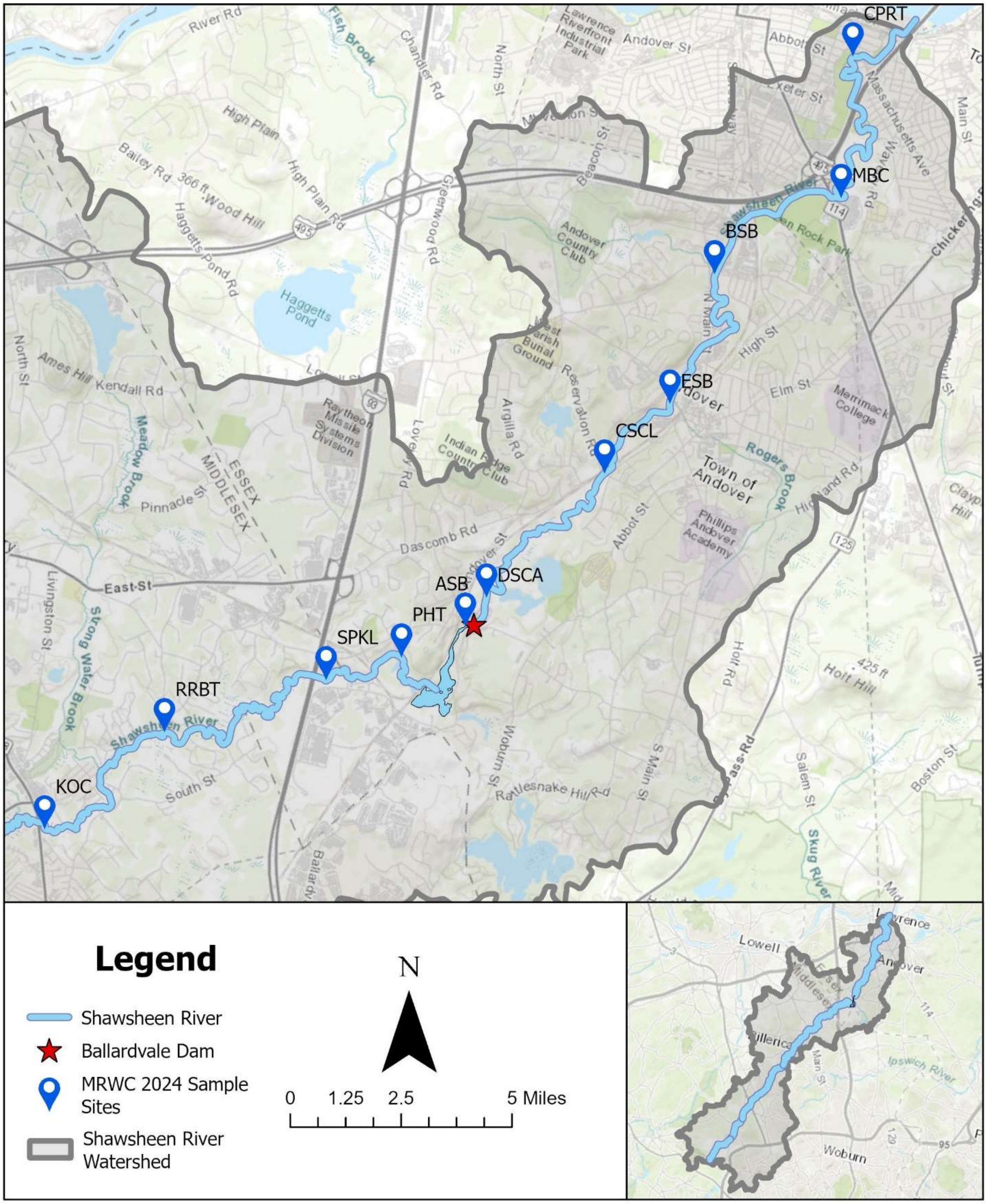


Figure 2: Map of monitoring locations

10.Equipment Needs

A full list of equipment needed for each sampling day is listed below. One deviation from the MRWC Merrimack River Water Monitoring Program QAPP 6/22/2020 is the use of a YSI Multiparameter Instrument to collect in-situ field data as opposed to a Hach Pocket Pro 2+ Tester in combination with a HI9146 Portable Dissolved Oxygen Meter. The reasoning is that the YSI instrument allows for all parameters to be read at the same time, which allows for more streamlined sampling. Each YSI instrument is calibrated at least 24 hours prior to sample collection using pH and conductivity standards, and the barometric pressure for Dissolved Oxygen. Post-sampling calibration occurs after each sampling event adhering to Section 14 of the previously mentioned QAPP, while calibration, maintenance inspection, and testing of all equipment will adhere to Sections 15, 16, and 17. Calibration logs are kept as far back as December 2021 for each machine, with maintenance inspection occurring after each sampling event. Calibration and inspection documentation can be found in the Appendix.

- Bacteria sample bottles with thiosulfate
- Turbidity bottles
- YSI 556 Multiparameter Instrument
- pH 7.01 calibration standard
- Conductivity 1409 calibration standard
- DI water and spray bottle
- Pens/markers
- C batteries
- Field sheets
- Chain of Custody forms
- Cooler with ice/icepacks
- Ziplock bags
- Disposable gloves
- Bridge sample grabber

11.Data Management and QA/QC

This study and sample and data collection adhere to all quality control measures outlined in Section 14 of the *MRWC Merrimack River Water Monitoring Program QAPP 6/22/2020*. Documentation and record keeping of collected data will adhere to Section 9 in the previously mentioned QAPP, and data management in this study will adhere to Section 19 in the above previously mentioned QAPP. Instrument calibration will adhere to Section 16 in the previously mentioned QAPP, as well as include a post-calibration immediately following sampling. Field data will be collected using the field data sheet included in the Appendix. Data will be reviewed and uploaded to EPA's Water Quality Exchange (WQX) upon project completion.

Appendix D – Water Quality Assessment Reports

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-07 - Strong Water Brook)

AQUATIC LIFE
Biology
DFWELE conducted fish population sampling at two locations in this segment - upper end of Mohawk Drive and Birchwood Road and 200 meters upstream of Mohawk Drive in Tewksbury - using a backpack shocker in July 2000. A total of 137 fish, representing nine species, were collected. The samples were dominated by fallfish and American eel, while redbreast sunfish, pumpkinseed, and redfin pickerel were abundant. Other species present, including bluegill, chain pickerel, largemouth bass, and white sucker, were represented by few individuals. The fish assemblage was a mix of macrohabitat generalists and fluvial specialists/dependants (Richards 2003).

Too little data are available to assess the status of the Aquatic Life Use, therefore, it is not assessed.

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Middle Shawsheen Stream Team collected fecal coliform bacteria data (Table16) during the months of June through September 1998 (seven sampling events for station SWB2.0 and eight sampling events for station SWB3.3) from two sites along this segment (MRWC 1998). Two of the seven sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 60 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at one station from Strong Water Brook (Appendix A, Table A4):
• SW01 is located upstream from Shawsheen Street bridge, Tewksbury, MA.
The fecal coliform bacteria counts at SW01 were 50 cfu/100 mls in August and 90 cfu/100 mls in September.

Based on elevated fecal coliform bacteria levels (geometric means greater than 200 cfu/100 mls and >25% of the samples exceeded 400 cfu/100 mls at the upstream sampling station) the Primary Contact Recreational Use is assessed as impaired for the entire length of this segment. The Secondary Contact Recreational Use is assessed as support. Although sources are currently unknown, land-use practices in this subwatershed include some agricultural activity and the town of Tewksbury is currently serviced primarily by on-site septic systems (MADEP 2002).

The drainage area of this segment is approximately 9.75 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Forest 35%
Residential 31%
Open Land 11%

The MRWC and the Northern Middlesex Council of Governments presented a planning level, environmental impacts analysis that was conducted for three subwatersheds in the Shawsheen Watershed - Strong Water Brook, Content Brook, and Pinnacle Brook. The goal of the study was to evaluate potential impacts to water quality and quantity, based on expected future development, and to recommend BMPs to minimize future impacts and maximize protection of watershed functions. A watershed model was used to evaluate potential water-related impacts that are expected with future development (MRWC 2001a). Based on the current conditions of the subwatersheds and results of the watershed modeling MRWC proposed that future developments meet the following watershed goals: reduce stormwater pollutant loads, maintain groundwater recharge and quality, protect stream channels, prevent increased overbank flooding, and safely convey extreme floods.

Report Recommendations:

• Review recommendations from the environmental impacts analysis final report presented by the MRWC (MRWC 2001a).
• Continue to monitor bacteria levels to help implement Phase II stormwater requirements.
• Additional monitoring (e.g., habitat quality) should be conducted to assess the status of the Aquatic Life Use.
• A shoreline survey should be conducted to document aesthetic quality of Strong Water Brook.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-10 - Kiln Brook)

AQUATIC LIFE USE
Biology
DFWELE conducted fish population sampling at one location in this segment - downstream of Maguire Street Bridge in Bedford - using a backpack shocker in July 2000. A total of 24 fish, representing four species, were collected. Redfin pickerel dominated the fish community. Other species present (American eel, chain pickerel, and swamp darter) were represented by a few individuals. The fish assemblage consisted of macrohabitat generalists (Richards 2003).

Too little information is available to assess the Aquatic Life Use.

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Upper Shawsheen Stream Team collected fecal coliform bacteria data during the months of June through September 1998 (eight sampling events) from one station along this segment (MRWC 1998). A total of eight bacteria samples were collected and the fecal coliform counts ranged from 100 cfu/100 mls to 5,800 cfu/100 mls. The geometric mean of the fecal coliform bacteria data is 464 cfu/100 mls. Fifty percent of the samples exceeded 400 cfu/100 mls and one sample exceeded 2,000 cfu/100 mls. Two of the eight sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

Based on elevated fecal coliform bacteria levels, the Primary Contact Recreational Use is assessed as impaired for the entire length of this segment. The Secondary Contact Recreational Use is assessed as support. However, it is identified with an Alert Status because of one elevated fecal coliform bacteria count (2,000 cfu/100 mls).

The drainage area of this segment is approximately 4.2 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 46%
Forest 24%
Open Land 12%

A portion of Kiln Brook drains a large wetland area. In this area there is an old (abandoned) town of Lexington landfill, which has been under suspicion that the leachate affects the water quality in the area of Kiln Brook (Dunn 2003a).

Report Recommendations:
• Continue to monitor bacteria levels in Kiln Brook to identify and remediate sources of contamination.
• A shoreline survey should be conducted to document aesthetic quality of Kiln Brook.
• Conduct groundwater and surface water monitoring to study the potential affects from the abandoned landfill in Lexington.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-14 - Spring Brook)

AQUATIC LIFE USE
Biology
DFWELE conducted fish population sampling at one location in this segment - downstream of Route 62 Bridge in Bedford - using a backpack shocker in July 2000. A total of 87 fish, representing six species, were collected. The samples were dominated by redfin pickerel and golden shiner, while American eel, and banded sunfish were abundant. Two other species, largemouth bass and swamp darter were represented by a few individuals. The fish assemblage was a mix of macrohabitat generalists and fluvial specialists/dependants (Richards 2003).

Too little data are available to assess the status of the Aquatic Life Use, therefore, it is not assessed.

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Upper Shawsheen Stream Team collected fecal coliform bacteria data (Table 11) during the months of June through September 1998 from two sites along this segment (MRWC 1998).
Two of the seven sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 49 of Water Quality Assessment Report]

Based on elevated fecal coliform bacteria levels (geometric mean greater than 200 cfu/100 mls and 43% of the samples exceeded 400 cfu/100 mls at the upstream sampling station) the Primary Contact Recreational Use is assessed as impaired for the entire length of this segment. It should be noted, however, that the downstream sampling station location (SB 2.3, Route 62, Bedford) did not have elevated fecal coliform bacteria levels. The Secondary Contact Recreational Use is assessed as support.
The drainage area of this segment is approximately 2.3 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 42%
Forest 31%
Open Land 15%

Report Recommendations:
• Additional monitoring (e.g., habitat quality) should be conducted to assess the status of the Aquatic Life Use.
• Continue to monitor bacteria levels to help implement Phase II stormwater requirements.
• A shoreline survey should be conducted to document aesthetic quality of Spring Brook.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-04 - Rogers Brook)

AQUATIC LIFE USE
Habitat and flow
A 0.6-mile reach of Rogers Brook is culverted under the downtown section of Andover.

The physical alteration (underground/culverted) of the stream channel has resulted in a reduction of habitat available for aquatic life. The Aquatic Life Use is, therefore, assessed as impaired for a 0.6-mile reach of this segment. The remaining 0.7-mile reach of Rogers Brook is not assessed for the Aquatic Life Use.

PRIMARY AND SECONDARY CONTACT RECREATION

The MRWC and the Upper Shawsheen Stream Team collected fecal coliform bacteria data (Table 20) during the months of June through September 1998 (eight sampling events) from two sites along this segment (MRWC 1998). Two of the eight sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 74 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at two stations from Rogers Brook (Appendix A, Table A4):

- RB02A, downstream from Morton Street, Andover, MA.
- RB01A, approximately 550 feet upstream of confluence with Shawsheen River, Andover, MA.

The fecal coliform bacteria counts at RB02A were < 10 cfu/100 mls in August and 9,600 cfu/100 mls in September. The fecal coliform bacteria counts at RB01A were 7,500 cfu/100 mls in August and 10,000 cfu/100 mls in September.

Fecal coliform bacteria were collected during September and October 2002 from two storm drain locations in Rogers Brook by MRWC as part of the Shawsheen TMDL Implementation Plan project (01-01/MWI, see Appendix F; MRWC 2003b). This part of the project (Part I) focused on the Lower Shawsheen River Watershed in the towns of Andover, North Andover, and Lawrence, MA. This study documented bacteria levels in the end-of-pipe effluents. The data presented in this report are not representative of stream habitat conditions, but do represent source identification of pollutant loadings. Bacteria samples were collected during wet weather conditions. The fecal coliform bacteria counts ranged from 430cfu/100 mls (sample collected during a wet weather event – 1.12 inches of rain) to 21,000cfu/100 mls (sample collected during a wet weather event – 0.68 inches of rain) (MRWC 2003b).

The Andover Department of Public Works discovered that stormdrains in the Rogers Brook subwatershed had high coliform counts possibly caused by illegal wastewater connections (Brander 2002). The Town of Andover currently has a contract to provide sewer service to portions of South Andover. These areas include Rogers Brook, Ballardvale Road and portions of South Main Street, which are all located in this subwatershed (MRWC 2003b).

Because of elevated fecal coliform bacteria levels and best professional judgment (illicit sewer connections), the Primary and Secondary Contact Recreational uses are assessed as impaired for the entire length of this segment.

AESTHETICS

The MRWC conducted a shoreline survey in the summer 1998 between Phillips Academy and Dundee Park in Andover, MA. There were no odors, scum, foam or oily sheens observed by the team. The stream team observed some bank erosion and algae growth on the surface of the water. The stream team did not note any storm drains, however, runoff was observed from roadways and lawns (MRWC 1998).

No objectionable conditions were documented during the 1998 shoreline survey in the upper 0.5 mile reach of Rogers Brook, therefore, the Aesthetics Use is assessed as support. The lower 0.8 mile (including the 0.6 mile culverted portion of the brook) reach of the segment is not assessed for this use.

The drainage area of this segment is approximately 1.48 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):

Residential 52%

Forest 23%

Open Land 19%

Report Recommendations:

• Continue to monitor bacteria levels to identify sources and remediate them.
• Develop and implement an instream habitat restoration/improvement project to improve habitat quality and support aquatic life.
• Follow-up with the Andover Department of Public Works regarding the remediation activities concerning illegal wastewater connections. Follow-up on the progress of sewer service provided by the Town of Andover to portions of South Andover. These areas include Rogers Brook, Ballardvale Road and portions of South Main Street, which are all located in this subwatershed (MRWC 2003b).

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-19 - Shawsheen River)

AQUATIC LIFE
Biology
DFWELE conducted fish population sampling at seven locations in this segment of the Shawsheen River (downstream of Ballardvale Dam, Andover, north of Route 28 bridge, downstream of reservation Road, Andover, upstream of Route 114, South Lawrence, and Loring Street, Lawrence) using a backpack shocker in September and October 1998 and July 2002. A total of 738 fish, representing 13 species, were collected. The samples were dominated by American eel, bluegill, and redbreast sunfish, while fallfish, pumpkinseed, and tessellated darter were abundant. Other species present, including brown trout, chain pickerel, redfin pickerel, largemouth bass, sea lamprey, white sucker, and yellow bullhead were represented by few individuals. The fish assemblage was dominated by macrohabitat generalists and also included fluvial specialists (Richards 2003).

Toxicity
Ambient
Samples were collected by members of the MVPC in June 2002 as part of the Chronic Toxicity Testing project (00-06/104, see Appendix F). The EPA, Office of Environmental Measurement and Evaluation, assisted the MVPC in evaluating the ambient surface water from two sampling locations (SH-6 –Route 28, Andover and SH-7 – Merrimack Street, Lawrence) within this segment (EPA 2002b). Initial samples were collected on 19 June 2002 and two additional samples were collected on 22 June and 24 June 2002 from each location for use on days three and five of testing to provide fresh samples for test renewals. The results of the 7-day, short-term chronic toxicity tests indicated no toxicity for both species with respect to the survival and growth endpoints (Table 17; EPA 2002b). Lab water was utilized as a test control (survival of C. dubia = 100%, survival of P. promelas = 75%).

[See table on page 68 of Water Quality Assessment Report]

Sediment
In January 1997, the EPA, Office of Environmental Measurement and Evaluation, assisted the MADEP in evaluating the sediment quality from one sampling location (SS01 – located at Stevens Street in Andover) within this segment (EPA 1998). Whole sediment toxicity tests were performed according to EPA guidance (EPA 1994). The results of the 10-day exposure tests indicated a lack of toxicity for the freshwater invertebrates (survival of C. tentans = 88% and survival of H. azteca = 75%) with respect to the test endpoints, survival and growth (EPA 1998). Artificial sediment was utilized as a control (.survival of C. tentans = 83% and survival of H. azteca = 81%).

Chemistry – sediment
In January 1997, the EPA, Office of Environmental Measurement and Evaluation assisted the MADEP in evaluating the water and sediment quality at on location (SS01) within this segment (EPA 1998). One sediment sample was collected and analyzed for metals, AVS/SEM, SVOCs, PCB, pesticides, TOC, toxicity, and grain size. The TOC at SS01 was 0.75%. DDE was measured at 8.4mg/kg, this exceeded the L-EL guidelines, but was below the S-EL guidelines (Persaud et al. 1993). None of the analytes measured exceeded the S-EL guidelines.

Although no instream or sediment toxicity was detected, too little data are available to assess the status of the Aquatic Life Use, therefore, it is not assessed.

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Lower Shawsheen Stream Team collected fecal coliform bacteria data (Table 18) during the months of June through September 1998 (six sampling events) from seven sites along this segment (MRWC 1998). Two of the six sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 68 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at six stations on this segment of the Shawsheen River (Appendix A, Table A4).
• SH09, upstream from Central Street bridge Andover, MA.
• SH09A, upstream from Brook Street bridge, Andover, MA.
• SH10, downstream from Route 28 bridge, Andover, MA.
• Pipe at SH10, downstream from Route 28, Andover, MA (sampled once in September).
• SH11, downstream from Route 114 bridge, North Andover/Lawrence, MA.
• SH12, at Merrimack Street (upstream side of culvert entering Merrimack River), Lawrence, MA.
The fecal coliform bacteria counts at SH09 were 89 cfu/100 mls in August and 110 cfu/100 mls in September. The counts at SH09A were 180 cfu/100 mls in August and 110 cfu/100 mls in September. The counts at SH10 were 300 cfu/100 mls in August and 670 cfu/100 mls in September. The bacteria data from the pipe discharging at SH10 was 9,800 cfu/100 mls in September. The counts at SH11 were 970 cfu/100 mls in August and 15,000 cfu/100 mls in September. The counts at SH12 were 680 cfu/100 mls in August and 190 cfu/100 mls in September.

Fecal coliform bacteria were collected during July, September, and October 2002 from five storm drain locations in this segment of Shawsheen River by MRWC as part of the Shawsheen TMDL Implementation Plan Project (01-01/MWI, see Appendix F; MRWC 2003b). This part of the project (Part I) focused on the Lower Shawsheen River Watershed in the towns of Andover, North Andover, and Lawrence, MA. This study documented bacteria levels in the end-of-pipe effluents. The data presented in this report are not representative of stream habitat conditions, but do represent source identification of pollutant loadings. Bacteria samples were collected during dry and wet weather conditions and the fecal coliform bacteria counts ranged from 196cfu/100 mls (sample collected during a dry weather event - 0.0 inches of rainfall) to 38,000cfu/100 mls (sample collected during a wet weather event, approximately 1.12 inches of rainfall; MRWC 2003b).

Fecal coliform, E.coli, and Enterococci bacteria samples were collected by members of the MVPC in April-June 2002 from a two stations in this segment of the Shawsheen River as part of the Chronic Toxicity Testing project (00-06/104, see Appendix F). A total of seven bacteria samples were collected from each site and the fecal coliform counts are summarized in Table 19:

[See table on page 69 of Water Quality Assessment Report]

The upper 2.5 mile reach of this segment of the Shawsheen River is assessed as support for the Primary Contact Recreational Use, although it is also identified with an Alert Status because of elevated fecal coliform bacteria counts. Downstream from the confluence with Rogers Brook, fecal coliform bacteria counts frequently exceeded a geometric mean of 200 cfu/100 mls and, therefore, the Primary Contact Recreational Use is assessed as impaired. The Secondary Contact Recreational Use is assessed as support for the entire segment. However, this use is also identified with an Alert Status because of the extremely high count in the Shawsheen River (DWM September 2000 sample station SH11 was 15,000 cfu/100 mls) and elevated fecal coliform bacteria counts from storm drains into this segment.
The drainage area of this segment is approximately 77.93 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):

Residential 42%
Forest 30%
Open Land 10%

A bacteria TMDL for the Shawsheen River Watershed was completed by Limno-Tech in August 2002 for MADEP and the MRWC (LimnoTech 2002). Data were collected and coordinated through the MRWC and the Merrimack River Watershed Team. The purpose of this TMDL was to establish a fecal coliform TMDL for segments of the Shawsheen River and tributaries that are currently not meeting Massachusetts standards. Additionally, the bacteria TMDL outlined an implementation strategy to abate fecal coliform sources so bacteria criteria can be attained (MADEP 2002).

A Shawsheen Bacteria TMDL Implementation Plan was developed to further identify the sources of bacteria in the watershed and to isolate storm drains with high bacteria counts. Fecal coliform bacteria were collected by MRWC and ESS, Inc. during 2001 and 2002 from storm drain locations in the Shawsheen River Watershed (01-01/MWI, see Appendix F; MRWC 2003a). As part of this implementation plan, two storm drain mapping projects (99-06/MWI and 00-06/MWI, see Appendix F) were completed in this portion of the Shawsheen River by MRWC in 2000. In Phase I, MRWC worked with local town managers and stream team volunteers to develop criteria for mapping the location and describing the condition of 250 storm drains along the mainstem (MRWC 2000a). In Phase II, a developed storm drain map was created using GIS technology for the Shawsheen River Watershed (MRWC 2001b). These data are useful in understanding the extent of non-point source pollution in the watershed and flooding potential for local communities (MRWC 2000a).

Excerpted from the EPA New England National Priorities List (NPL) website (EPA 25 March 2003).
The Reichold Chemicals Inc. site (EPA ID #: MAD001000165) is located at 77 Lowell Junction Road in Andover, Essex County, Massachusetts. The current status of the property is unknown. In November 1930, Watson Park Company purchased the property and began production of phenolic and urea formaldehyde resins on site. Reichold purchased the property in 1953 and continued to produce phenolic and urea formaldehyde resins as well as epoxy resins, hardeners, and other chemicals. In 1986, Reichold sold the property to BTL. BTL continued to produce phenolic resins on the property until the facility closed in February 1990. Prior to 1972, untreated wastewater was discharged into unlined leaching ponds located adjacent to the Shawsheen River and the on-site septic system. According to former Reichold employees, Reichold formerly disposed of drums of process wastes, fill material, gelled resins, and solid filter cake in an on-site landfill from approximately 1963 to approximately 1972. In April 1979, Donald Reed conducted a Hydrogeological Investigation, which documented the presence of phenol in groundwater beneath the Reichold property. The property was classified as a Tier II site under the Massachusetts Contingency Plan (MCP) in March 1986. In 1987, Geraghty & Miller Inc. performed a Hydrogeologic investigation of the Reichold property, which documented the presence volatile organic compounds (VOCs) and phenol in groundwater and soil. Surface water runoff from the property flows directly into the Shawsheen River, which passes through the property. Samples collected from the surface water pathway indicated the presence of six VOCs, 16 SVOCs, and 4 metals. Based on these results, a release of substances to the surface water pathway impacting a wetlands and a fishery has occurred. No other sensitive environments are known to be impacted. Actions taken to address the release to surface water include discontinuing the use of the unlined leaching ponds, and removal and off-site disposal of contaminated soil. The Reichold property is currently in Phase V of the five-phase MCP. Remedial activities, including continued bioremediation of on-site groundwater and periodic groundwater sampling are ongoing under the direct supervision of a Licensed Site Professional (LSP).

Report Recommendations:
• Additional monitoring (e.g., habitat quality) should be conducted to assess the status of the Aquatic Life Use.
• A shoreline survey should be conducted to document aesthetic quality of this segment of the Shawsheen River.
• Implement the recommendations of the Shawsheen Bacteria TMDL.
- septic tank control (identify and remediate local community septic problems)
- urban runoff (collect additional monitoring data to isolate sources of bacteria and implement a control plan)
• Continue to monitor bacteria levels to help implement Phase II stormwater requirements.
• Follow-up with EPA on the status of remediation activities at the NPL site located in this subwatershed.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-18 - Shawsheen River)

AQUATIC LIFE

Biology

DFWELE conducted fish population sampling at three locations in this segment of the Shawsheen River (downstream of Route 129, Billerica, opposite of Mohawk Drive to Bridge Street, Tewksbury, and Bridge Street crossing, Tewksbury) using a backpack shocker in September 1998 and July 2002. A total of 229 fish, representing 13 species, were collected. The samples were dominated by American eel, redbreast sunfish and redfin pickerel. Other species present, including bluegill, banded sunfish, fallfish, largemouth bass, pumpkinseed, rainbow trout, white sucker, creek chubsucker, chain pickerel, and yellow bullhead, were represented by a few individuals. The fish assemblage was dominated by macrohabitat generalists (Richards 2003).

Toxicity

Ambient

Samples were collected by members of the MVPC in June 2002 as part of the Chronic Toxicity Testing project (00-06/104, see Appendix F). The EPA, Office of Environmental Measurement and Evaluation, assisted the MVPC in evaluating the ambient surface water from two sampling locations (SH-3 – located at Route 129 in Wilmington and SH-4 – located at Mill Street in Tewksbury) within this segment (EPA 2002b). Initial samples were collected on 19 June 2002 and two additional samples were collected on 22 June and 24 June 2002 from each location for use on days three and five of testing to provide fresh samples for test renewals. The results of the 7-day, short-term chronic toxicity tests indicated no toxicity for both species with respect to the survival and growth endpoints (Table 12) (EPA 2002b). Lab water was utilized as a test control (survival of C. dubia = 100%, survival of P. promelas = 75%).

[See table on page 53 of Water Quality Assessment Report]

Sediment

In January 1997, the EPA, Office of Environmental Measurement and Evaluation, assisted the MADEP in evaluating the sediment quality from one sampling location (SH08 – Shawsheen River upstream of the Ballardvale Dam, Andover) within this segment (EPA 1998). Whole sediment toxicity tests were performed according to EPA guidance (EPA 1994). The results of the 10-day exposure tests indicated a lack of toxicity for both species tested (survival of C. tentans = 76% and survival of H.azteca = 80%) with respect to the test endpoints, survival and growth (EPA 1998). Artificial sediment was utilized as a control (survival of H. azteca. = 83% and survival of C. tentans = 81%).

Chemistry – sediment

In January 1997, the EPA, Office of Environmental Measurement and Evaluation, assisted the MADEP in evaluating the sediment quality at one location (SH08) within this segment (EPA 1998). The sediment sample was collected and analyzed for metals, AVS/SEM, SVOCs, PCB, pesticides, TOC, toxicity, and grain size. The TOC at SH08 was 3.69%. There was only one L-EL exceedance of a chlorinated pesticide and PCB were not detected. Additionally, several metal concentrations (Cd, Cu, Pb, and Zn) exceeded the L-EL guidelines. None of the analytes measured exceeded the S-EL guidelines.

Although no instream or sediment toxicity was detected, too little data are available to assess the status of the Aquatic Life Use, therefore, it is not assessed.

FISH CONSUMPTION

In 1995 fish toxics monitoring was conducted by DWM at the Ballardvale Impoundment in Andover. The mercury data triggered a site-specific advisory against the consumption of fish from Lowell Junction Pond (locally known as the Ballardvale Impoundment) and the MDPH issued the following fish consumption advisory.

1. “Children younger than 12 years, pregnant women, and nursing mothers should not eat largemouth bass and black crappie from this water body.”
2. “The general public should limit consumption of largemouth bass and black crappie from this water body to two meals per month.”

Because of elevated mercury levels in fish tissue, which resulted in a DPH fish consumption advisory, the Fish Consumption Use is assessed as impaired for the lower 1.1 mile reach of the Shawsheen River through the Lowell Junction Pond (Ballardvale Impoundment), Andover.

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Upper and Middle Shawsheen Stream Teams collected fecal coliform bacteria data (Table 13) during the months of June through September 1998 from four sites along this segment (MRWC 1998). One of the seven sampling events was conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 54 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at five stations on this segment of the Shawsheen River (Appendix A, Table A4).
• SH06A, at the Burlington water intake off of Alexander Road, Billerica, MA.
• SH07, at USGS gage, downstream from Salem Road/Route129 bridge, Billerica/Wilmington, MA.
• SH07A, downstream from Route 38 bridge, Tewksbury, MA.
• SH07B, approximately 350 meters /southwest from Route 93, Andover/Tewksbury, MA.
• SH08, off the upstream side of Ballardvale Dam, Andover, MA.
The fecal coliform bacteria data at SH06A were 50 cfu/100 mls in August and 86 cfu/100 mls in September. The counts at SH07 were 490 cfu/100 mls in August and 4,000 cfu/100 mls in September. The counts at SH07A were 120 cfu/100 mls in August and 110 cfu/100 mls in September. The counts at SH07B were 150 cfu/100 mls in August and 110 cfu/100 mls in September. The counts at SH08 were 99 cfu/100m in August and 140 cfu/100 mls in September.

Fecal coliform, E.coli, and Enterococci bacteria samples were collected by members of the MVPC in April-June 2002 from three stations in this segment of the Shawsheen River as part of the Chronic Toxicity Testing project (00-06/104, see Appendix F). A total of seven bacteria samples were collected from each site. The fecal coliform counts are summarized in Table 14.

[See table on page 55 of Water Quality Assessment Report]

The entire length of this segment is assessed as support for both the Primary and Secondary Contact Recreational uses. The Primary Contact Recreational Use, however, is identified with an Alert Status because of occasional elevated fecal coliform bacteria counts in the vicinity of Route 129, Billerica/Wilmington.
The drainage area of this segment is approximately 65.38 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 40%
Forest 31%
Open Land 9%

A bacteria TMDL for the Shawsheen River Watershed was completed by Limno-Tech in August 2002 for MADEP and the MRWC (Limno-Tech 2002). Data were collected and coordinated through the MRWC and the Merrimack River Watershed Team. The purpose of this TMDL was to establish a fecal coliform TMDL for segments of the Shawsheen River and tributaries that are currently not meeting Massachusetts standards. Additionally, the bacteria TMDL outlined an implementation strategy to abate fecal coliform sources so bacteria criteria can be attained (MADEP 2002).

A Shawsheen Bacteria TMDL Implementation Plan was developed to further identify the sources of bacteria in the watershed and to isolate storm drains with high bacteria counts. Fecal coliform bacteria were collected by MRWC and ESS, Inc. during 2001 and 2002 from storm drain locations in the Shawsheen River Watershed (01-01/MWI, see Appendix F; MRWC 2003a). As part of this implementation plan, two storm drain mapping projects (99-06/MWI, see Appendix F) were completed in this portion of the Shawsheen River by MRWC in 2000. In Phase I, MRWC worked with local town managers and stream team volunteers to develop criteria for mapping the location and describing the condition of 250 storm drains along the mainstem (MRWC 2000a). In Phase II, a developed storm drain map was created using GIS technology for the Shawsheen River Watershed (MRWC 2001b). These data are useful in understanding the extent of non-point source pollution in the watershed and flooding potential for local communities (MRWC 2000a).

A USGS gaging station (01100600) on the Shawsheen River, located at Route 129 on the Billerica/Wilmington border, has been in operation since 1963. The drainage area at the gage is 36.5 square miles. The highest daily mean flow at the gage was recorded at 1850 cfs on 22 October 1996 and the lowest daily mean flow was 0.7 cfs on 19 August 1983 (Socolow et al. 1999, Socolow et al. 2000, Socolow et al. 2001, and Socolow et al. 2002).

Excerpted from the EPA New England National Priorities List (NPL) website (EPA 25 March 2003).
The Roy Bros Haulers (Roy Bros) site (EPA ID #: MAD009870643) is a 4.4-acre active chemical hauler operation located at 764 Boston Road in Billerica, Massachusetts. Since 1948, Roy Bros has operated as a transporter of liquid and dry industrial chemicals, which include chromium, benzene, toluene, methyl ethyl ketone (MEK), and 1,1,1-trichloroethane (TCA). Land use prior to 1948 is unknown. Prior to 1967, Roy Bros discharged wash water from the rinsing of the tanker trucks to a 1,000-gallon septic dry well located north of the building. Sludge and other residues collected from the rinsing of tanker trucks were disposed of in an unlined lagoon area located east of the building. Due to problems with wastewater disposal, chemical spillage, and storage tanks with inadequate containment features, Roy Bros was ordered by the Massachusetts Department of Environmental Quality Engineering (MA DEQE) [currently Massachusetts Department of Environmental Protection (MA DEP)] to begin cleanup, to upgrade the subsurface disposal system, and to construct a pretreatment facility. During a 1981 MA DEQE inspection, MA DEQE personnel noted that sludge from the pretreatment facility was either stored in tanker trucks or disposed of on the property. In 1981, Roy Bros was permitted by MA DEQE to connect to the Billerica sewer system. Surface water runoff on the Roy Bros property flows easterly toward the abutting wetland area which discharges into the Shawsheen River. Historical sediment sampling conducted along the Shawsheen River indicates that the surface water pathway has been impacted by a release of VOCs, SVOCs, and metals from the Roy Bros property. The property is currently in Phase I of the five phase Massachusetts Contingency Plan (MCP) process.

The Sutton Brook Disposal Area (EPA ID #: MAD980520696), which is roughly synonymous with the Rocco's Disposal Area site, is located off South Street on the eastern boundary of Tewksbury, Middlesex County, Massachusetts. Waste disposal activities at the Sutton Brook Disposal Area can be traced back to at least 1957, when an area of the site was used as a "burning dump." In 1966, the Town of Tewksbury was ordered by the Commonwealth of Massachusetts (the Commonwealth) Commissioner of Public Health to operate the landfill using the sanitary landfill method. However, after 1966, there were documented occurrences of landfill burning, uncovered waste areas, the filling in of on-site wetlands, wastes disposed below the water table, and landfill slopes which exceeded operation plans. Due to these violations, the Commonwealth ordered the closure of the landfill in 1979. At the time of its closure, the landfill was accepting in excess of 250 tons of waste per day. Despite the closure order, landfill operations continued until 1982, when official landfill operations were suspended, yet waste acceptance continued through 1988. Numerous investigations of the site by local, state, and federal organizations have revealed the presence of volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), pesticides, polychlorinated biphenyls (PCBs), and inorganic elements in on-site and off-site ground water, surface water, sediment, soil, and VOCs and SVOCs in air samples. During the Winter of 2000-2001, EPA installed 14 groundwater monitoring wells, and obtained samples from 22 monitoring wells in the vicinity of the Rocco Landfill in order to get a current assessment of the condition of groundwater, which may be leaving the site. In addition to the analytical samples, groundwater level measurements were taken at a total of

43 wells. The groundwater analytical data suggest that there is contamination discharging to groundwater from the northern and southern lobes of the Rocco Landfill. It appears that the affected groundwater flows towards Sutton Brook from the south(from the southern lobe, and towards Sutton Brook from the north(from the northern lobe).

Report Recommendations:

• Additional monitoring (e.g., habitat quality) should be conducted to assess the status of the Aquatic Life Use.
• Continue to monitor bacteria levels to help implement Phase II stormwater requirements.
• A shoreline survey should be conducted to document aesthetic quality of this segment of the Shawsheen River.
• Follow-up with EPA on the status of remediation activities at the NPL sites located in this subwatershed.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-09 - Content Brook)

AQUATIC LIFE
Biology
DFWELE conducted fish population sampling at two locations in this segment - 50 meters upstream and 150 meters downstream of Beech Street in Tewksbury and at 150 meters on both sides of Whipple Road in Billerica/Tewksbury - using a backpack shocker in July 2000. A total of 81 fish, representing 11 species, were collected. The samples were dominated by redfin pickerel and fallfish, while banded sunfish, American eel, and pumpkinseed were abundant. Other species present, including bluegill, black crappie, creek chubsucker, chain pickerel, golden shiner, and white sucker, were represented by a few individuals. The fish assemblage was a mix of macrohabitat generalists and fluvial specialists/dependants (Richards 2003).

Too little data are available to assess the status of the Aquatic Life Use, therefore, it is not assessed. Other potential Aquatic Life Use concerns, however, relate to the Superfund and hazardous waste sites in the headwaters of Content Brook. A Feasibility Study (FS) is expected to be final in early 2003 to evaluate potential alternatives for the remediation of the Shaffer Landfill area (EPA 25 March 2003).

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Middle Shawsheen Stream Team collected fecal coliform bacteria data (Table15) during the months of June through September 1998 (seven sampling events) from two sites along this segment (MRWC 1998). Two of the seven sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 57 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at one station from Content Brook (Appendix A, Table A4).
• CB01, upstream/west at Beech Street, Tewksbury, MA.
The fecal coliform bacteria counts at CB01 were 190 cfu/100 mls in August and 110 cfu/100 mls in September.

Although one fecal coliform bacteria count was elevated (2,000 cfu/100 mls) in 1998 near Beech Street, Tewksbury, it is best professional judgment that both the Primary and Secondary Contact Recreational uses for Content Brook are supported (geometric mean for the other samples was less than 200 cfu/100 mls). However, the Primary Contact Recreational Use is identified with an Alert Status because of the one elevated bacteria count.

The drainage area of this segment is approximately 5.8 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):

Residential 45%
Forest 30%
Open Land 8%

DFWELE has proposed that Content Brook be reclassified in the SWQS as a cold water fishery (MassWildlife 2001). In 1988, DFWELE sampled one station west of Whipple Road, Billerica and found four young of the year brown trout (Richards 2003).

The MRWC and the Northern Middlesex Council of Governments presented a planning level, environmental impacts analysis that was conducted for three subwatersheds in the Shawsheen Watershed - Strong Water Brook, Content Brook, and Pinnacle Brook. The goal of the study was to evaluate potential impacts to water quality and quantity based on expected future development and to recommend BMPs to minimize future impacts and maximize protection of watershed functions. A watershed model was used to evaluate potential water-related impacts that are expected with future development (MRWC 2001a). Based on the current conditions of the subwatersheds and results of the watershed modeling, MRWC proposed that future developments meet the following watershed goals: reduce stormwater pollutant loads, maintain groundwater recharge and quality, protect stream channels, prevent increased overbank flooding, and safely convey extreme floods.

Excerpted from the EPA New England National Priorities List (NPL) website (EPA 25 March 2003).
The Iron Horse Park site (EPA ID #: MAD051787323), a 553-acre industrial complex, includes manufacturing and rail yard maintenance facilities, open storage areas, landfills, and wastewater lagoons. A long history of activities at the site, beginning in 1913, has resulted in the contamination of soil, groundwater, and surface water. Middlesex Canal runs along the length of the northern boundary and is drained by Content Brook, which runs through residential areas into the Shawsheen River east of the site. Richardson Pond lies north of the site and is also drained by Content Brook. An unnamed brook, which runs northerly through the site near wastewater lagoons, drains into a marshland near the asbestos landfill. On-site groundwater and surface water are sporadically contaminated with organic and inorganic chemicals, asbestos, and heavy metals including arsenic, cadmium, lead, and selenium. The soil at the site is contaminated with polychlorinated biphenyls (PCBs), petrochemicals, and the same heavy metals as those found in the groundwater. The majority of surface water contamination is located in the vicinity of the now-closed Shaffer Landfill. Environmentally sensitive marshland and wetlands are located near the site and could be subject to contamination. A settlement for Remedial Action for Shaffer Landfill has been completed.

Report Recommendations:
• Additional information (i.e., temperature, habitat quality, etc.) is needed for Content Brook in order to evaluate the proposed designation as a cold water fishery.
• Review recommendations from the environmental impacts analysis final report presented by the MRWC (MRWC 2001a).
• Continue to monitor bacteria levels to help implement Phase II stormwater requirements.
• Additional monitoring (e.g., habitat quality) should be conducted to assess the status of the Aquatic Life Use.
• A shoreline survey should be conducted to document aesthetic quality of Content Brook.
• Follow-up with EPA on the status of remediation activities at the Iron Horse Park site (EPA ID #: MAD051787323).

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-05 - Elm Brook)

AQUATIC LIFE
Habitat and Flow
DWM conducted a habitat assessment in this segment, upstream of Hartwell Road in Bedford, in September 2000. The habitat assessment revealed a channelized waterway, which runs through an extensive wetland of loosestrife and red maple, with instream cover consisting primarily of aquatic macrophytes. Epifaunal substrate was poor consisting of mostly mud, silt and sand. Habitat types included a shallow run with a few deeper pools. Approximately 50 meters down the sampling reach there

was a small beaver dam, which created a slightly impounded area for approximately fifty meters to the base of a larger beaver dam (Maietta 2001).

Habitat quality of Elm Brook near Railroad Avenue and Washington Street, Bedford (station SW7/SW8) was evaluated by ESS, Inc. in August 2001 (ESS 2002). While the instream habitat quality variables (i.e., epifaunal substrate, embeddedness, frequency of riffles, and riparian vegetative zone width) generally scored low, the riparian zone was generally well vegetated and the streambanks were stable. The streambed was comprised of sand and gravel (60 and 35%, respectively). Although no major objectionable conditions were noted, there was some trash observed in the stream.

Biology

DFWELE conducted fish population sampling at two locations in this segment - at Hartwell Road and off Route 62 near Bedford Center, Bedford - using a backpack shocker in June 2000. A total of 107 fish, representing eight species, were collected. The samples were dominated by redfin pickerel and white sucker, while golden shiner, banded sunfish, and American eel were abundant. Other species present, including creek chubsucker, pumpkinseed, and swamp darter, were represented by few individuals (Richards 2003). The fish assemblage was dominated by macrohabitat generalists and also included a mix of fluvial specialists/dependants (Richards 2003).

DWM conducted fish population sampling in this segment upstream of Hartwell Road in Bedford using a backpack shocker in September 2000. A total of 45 fish were collected. Nine species were represented in the sample. The fish community was dominated by redfin pickerel, banded sunfish, and pumpkinseed. It appeared that banded sunfish were more prevalent downstream of the first beaver dam with pumpkinseed taking over in between the two beaver dams. Fish were pooled throughout the entire reach and, therefore, fish assemblage distinctions between the two habitat types could not be made. Other species collected included creek chubsucker, golden shiner, brown bullhead, chain pickerel, American eel, and darter (Maietta 2001).

Toxicity

Ambient

Surface water samples were collected by members of the MVPC in June 2002 as part of the Chronic Toxicity Testing project (00-06/104, see Appendix F). The EPA, Office of Environmental Measurement and Evaluation, assisted the MVPC in evaluating the surface water from one sampling location (EBRf – located at Great Road in Bedford) within this segment (EPA 2002b). Initial samples were collected on 19 June 2002, two additional samples were collected on 22 June and 24 June 2002 from each location for use on days three and five of testing to provide fresh samples for test renewals. The results of the 7-day, short-term chronic toxicity tests indicated a lack of acute toxicity for the freshwater invertebrates (survival of C. dubia = 100% and survival of P. promelas = 93%) with respect to the test endpoints, survival and growth (EPA 2002b). Lab water was utilized as a control (survival of survival C. dubia = 100% and survival of P. promelas = 75%).

Toxicity

Effluent

HAFB conducted 24 whole effluent toxicity tests using C. dubia and P. promelas between February 1996 and November 2001 on their treated effluent (Outfall #001) discharge. No acute toxicity (i.e., the LC50 have all been > 100% effluent) has been detected by either test species (C. dubia, P. promelas) in any of the 24 toxicity tests results submitted since February 1996. However, chronic toxicity to both test organisms has been detected in eight (C. dubia) and four (P. promelas) test events since February 1996. The chronic no observed effect concentrations (CNOEC) to both species ranged from <6.25 to 50%. Neither test organism was consistently more sensitive and chronic toxicity was detected in 46% of the test events.

Sediment

In January 1997, the EPA, Office of Environmental Measurement and Evaluation assisted the MADEP in evaluating the sediment quality from one sampling location (EB02 – 0.5 miles upstream of its confluence with the Shawsheen River) within this segment (EPA 1998). Whole sediment toxicity tests were performed according to EPA guidance (EPA 1994). The results of the 10-day exposure tests indicated no acute toxicity to the freshwater invertebrates (survival of C. tentans = 89% and survival of H.azteca

= 100%) with respect to the test endpoints, survival and growth (EPA 1998). Artificial sediment was utilized as a control (survival of H. azteca. = 83% and survival of C. tentans = 81%).

Chemistry – sediment
In January 1997, the EPA, Office of Environmental Measurement and Evaluation assisted the MADEP in evaluating the sediment quality at one location (EB02) within this segment (EPA 1998). The sediment sample was collected and analyzed for metals, AVS/SEM, SVOCs, PCB, pesticides, TOC, toxicity, and grain size. The TOC at EB02 was 0.21%. There were no detections of chlorinated pesticides or PCB. Additionally, there were no metals concentrations that exceeded the L-EL guidelines. In the sediment sample collected there was no exceedances of the S-EL guidelines in any analyte.

The upper 2.7 miles of Elm Brook are not assessed for the Aquatic Life Use. Channelization of Elm Brook begins just downstream from the Concord/Bedford town lines. In this reach, the habitat assessments indicated poor epifaunal substrates. Embeddedness and lack of riffle habitat were noted. The riparian zone, however, was well vegetated and the streambanks were stable. The Aquatic Life Use is, therefore, assessed as impaired for the lower 2.3 miles of this segment. It should also be noted, however, that no instream chronic toxicity or sediment toxicity was detected.

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Upper Shawsheen Stream Team collected fecal coliform bacteria data (Table 6) during the months of June through September 1998 (seven sampling events) from six sites along this segment (MRWC 1998). Two of the seven sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 37 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at one station from Elm Brook (Appendix A, Table A4):
• EB02, upstream from Great Road bridge, Bedford, MA.
The fecal coliform bacteria counts at EB02 were 470 cfu/100 mls in August and 380 cfu/100 mls in September.

Fecal coliform and E. coli bacteria were collected during September and October 2001 from two storm drain locations in this segment of Elm Brook by ESS as part of the Shawsheen River Watershed Storm Drain Assessment project (01-08/MWI, see Appendix F; ESS 2002). The storm drain study documented end-of-pipe effluents before any mixing occurred within the receiving waterbody. The data presented in the ESS report is not representative of stream habitat conditions, but does represent source identification of pollutant loadings (ESS 2002). A total of four bacteria samples were collected during wet weather conditions. The fecal coliform bacteria counts ranged from 1,200cfu/100 mls to 5,200cfu/100 mls and the E. coli bacteria counts ranged from 800cfu/ml to 4,400cfu/100 mls (ESS 2002). The storm drains sampled in this segment primarily drained industrial and residential areas (ESS 2002).

Fecal coliform, E.coli, and Enterococci bacteria samples were collected by members of the MVPC in April-June 2002 from a one station in Elm Brook near Great Road, Bedford (station EB-RF) in this segment as part of the Chronic Toxicity Testing project (00-06/104, see Appendix F). A total of seven bacteria samples were collected. The fecal coliform counts ranged from 78 cfu/100 mls to 13,000 cfu/100 mls. The geometric mean over the three months of sampling for the fecal coliform bacteria data was 661cfu/100 mls.

The upper 3.0 miles of Elm Brook are assessed as support for the Primary Contact Recreational Use. However, it is identified with Alert Status because the most upstream station had one elevated bacteria count. Downstream from Hartwell Road, Bedford, the Primary Contact Recreational Use is assessed as impaired as a result of elevated fecal coliform bacteria levels and best professional judgment (the lower 2.0 miles of this segment). The Secondary Contact Recreational Use is assessed as support but it is identified with an Alert Status because of one elevated fecal coliform bacteria count.

The drainage area of this segment is approximately 6.0 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Forest 44%
Residential 31%
Transport 7%

There are two NPL sites located in this subwatershed. The site descriptions were excerpted from the EPA New England National Priorities List (NPL) website (EPA 25 March 2003):
The Naval Weapons Industrial Reserve Plant (NWIRP) site (EPA ID #: MA6170023570) is a 46-acre facility that is part of a larger industrial complex located immediately north of Hanscom Air Force Base, which is also on the NPL. NWIRP is operated by Raytheon Co. and was established in 1952 when a missile and radar development laboratory was built. Between 1959 and 1977, the Navy obtained about 43 additional acres from the Air Force. Wastes generated at NWIRP include various volatile organic compounds (VOCs), photographic fixer, waste oil and coolants, lacquer thinner, unspecified solvents and thinners, Stoddard solvent, waste paint, and chromic, sulfuric, nitric, hydrochloric, and phosphoric acids. The Hartwell Road Well Field, part of the municipal water supply for the Town of Bedford, is located less than .5 miles from NWIRP. The three wells in this field were closed in 1984 after VOCs contamination was discovered. The Town of Bedford conducted an investigation that determined that NWIRP was a likely source of the well field contamination. Hanscom Air Base is also a potential contributor to the groundwater contamination in this area. Approximately 11,000 people rely on drinking water wells located within 4 miles of the site. The Shawsheen River, 7 miles downstream of NWIRP, is a source of drinking water for approximately 12,800 people. Nine residential areas and wetlands are located to the east and northeast of the site. There are extensive wetlands and several species of rare plants and wildlife along the Shawsheen River and the Elm Brook, both located downstream of NWIRP. Draft Proposed Plans for the TCE and BTEX plume have been deferred for the time being. In 2003 an insitu thermal treatment system will undergo a pilot test at the TCE plume and a source soil removal will be conducted at the BTEX plume. Documentation of the treatment of chlorinated solvents at the south end of NWIRP Bedford by the adjacent Hanscom Air Force Base groundwater extraction and treatment system through a Memorandum of Understanding with the Air Force is in routing for signature. A monitoring plan has been developed and will commence in the fall of 2002.

The Raytheon Missile Systems Division (Raytheon) site (EPA ID #: MAD981214992) is located at 180 Hartwell Road in Bedford, Middlesex County, Massachusetts. Raytheon began operations on the property in 1958. Raytheon uses a variety of chemicals, including acids, alkali cleaners, copper plating solutions, photographic developers and fixers, epoxy coating solutions [containing volatile organic compounds (VOCs) such as toluene, xylenes, and methyl ethyl ketone], and solvents (including acetone, propanol, 1,1,1-trichloroethane, trichloroethylene, methylene chloride, and Freon). Raytheon handles liquid wastes in satellite storage areas. Wastes in the satellite storage areas were regularly transferred to drums stored in an on-site hazardous waste storage building. Raytheon is licensed by U.S. Environmental Protection Agency (EPA) to handle small quantities of hazardous waste (RCRA ID No. MAD019165406). A number of environmental investigations have been performed at the Raytheon property and its vicinity. Several spills of fuel and hazardous substances have been reported to and remediated under the supervision of the Massachusetts Department of Environmental Quality Engineering (MA DEQE) and its successor, the Massachusetts Department of Environmental Protection (MA DEP). Investigations have documented the release of VOCs and metals to groundwater beneath the Raytheon property. Runoff from the former Raytheon property flows westward to Elm Brook, which discharges to the Shawsheen River.

Report Recommendations:
• Additional monitoring of storm drain discharges to Elm Brook are needed to confirm sources of bacteria.
• Assess the feasibility of potential restorative actions along the riparian corridor, including the river itself.
• Develop and implement an instream habitat restoration/improvement project to improve habitat quality and support aquatic life.
• Continue to monitor bacteria levels to document effectiveness of bacteria source reduction activities.
• Since NPDES discharges to Elm Brook have ceased, additional monitoring of water quality (including turbidity – an impairment identified on the 1998 303(d) List) should be conducted.

• A shoreline survey should be conducted to document aesthetic quality of Elm Brook.
• Follow-up with EPA on the status of remediation activities at the NPL sites that are located in this subwatershed.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-17 - Shawsheen River)

AQUATIC LIFE
Habitat and Flow
Habitat quality of the Shawsheen River downstream from Boston Road/Route 3A (near Ackerson Playground), Billerica (station SW9) was evaluated by ESS, Inc. in August 2001 (ESS 2002). None of the instream habitat quality variables scored low, although the epifaunal substrate was marginal. The streambed was comprised primarily of gravel (80%). No objectionable conditions were noted.

Habitat quality of the Shawsheen River near Churchill Street, Billerica (station SW10) was evaluated by ESS, Inc. in August 2001 (ESS 2002). None of the instream habitat quality variables scored low. The streambed was comprised of cobble, gravel, and boulder (40, 30, 20%, respectively). No objectionable conditions were noted.

Biology
DFWELE conducted fish population sampling at two locations in this segment of the Shawsheen River (downstream of the Middlesex Turnpike, Bedford, and upstream of Route 62, Bedford) using a backpack shocker in September 1998 and July 2002. A total of 197 fish, represented by 14 species, were collected. The samples were dominated by redfin pickerel and American eel. Other species present, including largemouth bass, brown bullhead, bluegill, banded sunfish, brown trout, creek chubsucker, chain pickerel, rainbow trout, swamp darter, white sucker, pumpkinseed, and redbreast sunfish were represented by few individuals. The fish assemblage was dominated by macrohabitat generalists and also included a mix of fluvial specialists/dependants (Richards 2003). In addition, there was one tributary (Webb Brook) to this segment of the river that was sampled; three American eels were observed in July 2002.

Toxicity
Ambient
Surface water samples were collected by members of the MVPC in June 2002 as part of the Chronic Toxicity Testing project (00-06/104, See Appendix F). The EPA, Office of Environmental Measurement and Evaluation assisted the MVPC in evaluating the ambient surface water from one sampling location (SH-2 – located at Route 3A in Billerica) within this segment (EPA 2002b). The initial sample was collected on 19 June 2002 and two additional samples were collected on 22 June and 24 June 2002 for use on days three and five of testing to provide fresh samples for test renewals. The results of the 7-day, short-term chronic toxicity tests indicated a lack of toxicity for both species with respect to the survival and growth endpoints (survival of C. dubia = 90% and survival of P. promelas = 93%; EPA 2002b). Lab water was utilized as a test control (survival of C. dubia = 100%, survival of P. promelas = 75%).

Sediment
In January 1997, the EPA, Office of Environmental Measurement and Evaluation assisted the MADEP in evaluating the sediment quality from three sampling locations (Table 7; EPA 1998). Whole sediment toxicity tests were performed according to EPA guidance (EPA 1994). Although no significant toxicity to either test organism was detected (either survival or growth) compared to the artificial sediment control (Table 7), survival of C. tentans exposed to sediment collected from the river near Route 3A and near the Burlington Pump Station was only 64 and 63%, respectively (EPA 1998).

[See table on page 40 of Water Quality Assessment Report]

Chemistry – sediment

In January 1997, the EPA, Office of Environmental Measurement and Evaluation, assisted the MADEP in evaluating the sediment quality at two locations (VB01, SH06, and SH06A) within this segment (EPA 1998). Three sediment samples were collected and analyzed for metals, AVS/SEM, SVOCs, PCB, pesticides, TOC, toxicity, and grain size. The first sample (VB01) was located below the confluence with Vine Brook, Bedford, MA. The TOC at VB01 was 3.9%. The second sample (SH06) was located near the Paul F. Newman Bridge, Billerica, MA. The TOC at SH06 was 2.8%. The third sample collected (SH06A) was located near the Burlington Pump Station, Billerica. The TOC at SH06A was 4.13%. Several pesticides and organic compounds were measured in quantities that exceed the L-EL guidelines from all three sites (VB01, SH06 and SH06A). Several metals (Cr, Cu, Ni, Pb, and/or Zn) were measured from both VB01 and SH06 in quantities that exceed the L-EL guidelines, but they were below the S-EL guidelines (Persaud et al. 1993). There were no exceedances of the S-EL guidelines in any analyte measured in any of the three sediment samples.

Instream habitat quality in this segment of the Shawsheen River was generally good. With the exception of two sediment toxicity tests (survival of C. tentans was slightly less than 75%), no other instream or sediment toxicity was detected. The Aquatic Life Use is therefore assessed as support for the entire length of this segment. It is identified with an Alert Status because of the slightly low survival of test organisms exposed to Shawsheen River sediments. It should also be noted that unknown toxicity was identified as an impairment cause on the 1998 303(d) List.

PRIMARY AND SECONDARY CONTACT RECREATION

The MRWC and the Upper and Middle Shawsheen Stream Team collected fecal coliform bacteria data (Table 8) during the months of June through September 1998 from seven sites along this segment (MRWC 1998). Two of the seven sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 41 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at one station on this segment of the Shawsheen River (Appendix A, Table A4).

• SH06, downstream from Route 3A bridge, Billerica, MA.

The fecal coliform bacteria data at SH06 was 380 cfu/100 mls in August and 200 cfu/100 mls in September.

Fecal coliform and E. coli bacteria were collected during September 2001 from two storm drain locations in this segment of the Shawsheen River by ESS as part of the Shawsheen River Watershed Storm Drain Assessment Project (01-08/MWI, see Appendix F; ESS 2002). The storm drain study documented end-of-pipe effluents before any mixing occurred within the receiving waterbody. The data presented in the ESS report is not representative of stream habitat conditions, but does represent source identification of pollutant loadings (ESS 2002). A bacteria sample was collected from each storm drain location during wet weather conditions; the fecal coliform bacteria counts were 24,000cfu/100 mls and 60,000/100 mls and the E. coli bacteria counts were 16,000cfu/ml and 54,000cfu/100 mls (ESS 2002). The storm drains sampled in this segment primarily drained industrial and residential areas (ESS 2002).

Fecal coliform, E.coli, and Enterococci bacteria samples were collected by members of the MVPC in April-June 2002 from a three stations (SH-1A – located at Route 3, Bedford, SH1B –Middlesex Turnpike, Bedford, and SH2 –Route 3A, Billerica) in this segment as part of the Chronic Toxicity Testing project (00-06/104, see Appendix F). A total of seven bacteria samples were collected from each site; the fecal coliform counts are summarized in Table 9:

[See table on page 42 of Water Quality Assessment Report]

Based on elevated fecal coliform bacteria levels, the upper 2.1 mile reach of this segment is assessed as impaired for the Primary Contact Recreational Use while the lower 3.6 miles is assessed as support. The Secondary Contact Recreational Use is assessed as support for the entire segment. Because of an elevated bacteria count (exceeding 2000 cfu/100 mls) and elevated fecal coliform bacteria counts from storm drains into this segment of the Shawsheen River the recreational uses are also

identified with an Alert Status.
The drainage area of this segment is approximately 35.31square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 41%
Forest 29%
Open Land 10%

A bacteria TMDL for the Shawsheen River Watershed was completed by Limno-Tech in August 2002 for MADEP and the MRWC (LimnoTech 2002). Data were collected and coordinated through the MRWC and the Merrimack River Watershed Team. The purpose of this TMDL was to establish a fecal coliform TMDL for segments of the Shawsheen River and tributaries that are currently not meeting Massachusetts standards. Additionally, the bacteria TMDL outlined an implementation strategy to abate fecal coliform sources so bacteria criteria can be attained (MADEP 2002).

A Shawsheen Bacteria TMDL Implementation Plan was developed to further identify the sources of bacteria in the watershed and to isolate storm drains with high bacteria counts. Fecal coliform bacteria were collected by MRWC and ESS, Inc. during 2001 and 2002 from storm drain locations in the Shawsheen River Watershed (01-01/MWI, see Appendix F; MRWC 2003a). As part of this implementation plan, two storm drain mapping projects (99-06/MWI and 00-06/MWI, see Appendix F) were completed in this portion of the Shawsheen River by MRWC in 2000. In Phase I, MRWC worked with local town managers and stream team volunteers to develop criteria for mapping the location and describing the condition of 250 storm drains along the mainstem (MRWC 2000a). In Phase II, a developed storm drain map was created using GIS technology for the Shawsheen River Watershed (MRWC 2001b). These data are useful in understanding the extent of non-point source pollution in the watershed and flooding potential for local communities (MRWC 2000a).

Report Recommendations:

• Implement the recommendations of the Shawsheen Bacteria TMDL.
- septic tank control (identify and remediate local community septic problems)
- urban runoff (collect additional monitoring data to isolate sources of bacteria and implement a control plan)
• Continue to monitor bacteria levels to help implement Phase II stormwater requirements.
• A shoreline survey should be conducted to document aesthetic quality of this segment of the Shawsheen River.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-01 - Shawsheen River)

AQUATIC LIFE
Habitat and Flow
Habitat quality was evaluated at six stations in this segment of the Shawsheen River by ESS, Inc. in August 2001 as part of the Shawsheen River Watershed Storm Drain Assessment Project (01-08/MWI, see appendix F; ESS 2002). While the instream habitat quality variables (i.e., epifaunal substrate, embeddedness, sediment deposition, riparian vegetative zone width, and frequency of riffles) generally scored low, the riparian zone was well vegetated and the streambanks were stable. No objectionable deposits, odors, or oils were documented.

Biology
DFWELE conducted fish population sampling at one location in this segment of the Shawsheen River - upstream of Route 4, Bedford - using a backpack shocker in September 1998. A total of 55 fish, representing nine species, were collected. The samples were dominated by American eel and redfin pickerel, while banded sunfish, golden shiner, and pumpkinseed were abundant. Other species present, including white sucker, chain pickerel, bluegill, and swamp darter, were represented by few individuals. The fish assemblage was dominated by macrohabitat generalists (Richards 2003).

Toxicity
Ambient
Samples were collected by members of the MVPC in June 2002 as part of the Chronic Toxicity Testing Project (00-06/104, see Appendix F). The EPA, Office of Environmental Measurement and Evaluation assisted the MVPC in evaluating the surface water from one sampling location (SH-1 located at Page Road in Bedford) within this segment (EPA 2002b). Initial samples were collected on 19 June 2002. Two additional samples were collected on 22 June and 24 June 2002 for use on days three and five of testing to provide fresh samples for test renewals. The results of the 7-day, short-term chronic toxicity tests indicated a lack of acute toxicity for both species with respect to the survival and growth endpoints (survival of C. dubia = 100% and survival of P. promelas = 95%; EPA 2002b). Lab water was utilized as a test control (survival of C. dubia = 100%, survival of P. promelas = 75%).

The habitat evaluations conducted by ESS, Inc. indicated poor epifaunal substrates in this segment of the Shawsheen River. Embeddedness and lack of riffle habitat were noted. The riparian zone, however, was well vegetated and the streambanks were stable. The Aquatic Life Use is, therefore, assessed as impaired for the entire length of this segment. It should also be noted, however, that no instream chronic toxicity was detected (unknown toxicity was identified as an impairment cause on the 1998 303(d) List).

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Upper Shawsheen Stream Team collected fecal coliform bacteria data (Table 5) during the months of June through September 1998 (six sampling events) from two sites along this segment (MRWC 1998). Two of the six sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 31 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at two stations on this segment of the Shawsheen River (Appendix A, Table A4):
• SH01, Summer Street, Bedford, MA.
• SH02, at Page Road (upstream from center cement bridge structure), Bedford, MA.
The fecal coliform bacteria data at SH01 were 89 cfu/100 mls in August and 180 cfu/100 mls in September. The counts at SH02 were 600 cfu/100 mls in August and 330 cfu/100m in September.

Fecal coliform and E. coli bacteria were collected during August, September, and October 2001 from six storm drain locations in this segment of the Shawsheen River by ESS as part of the Shawsheen River Watershed Storm Drain Assessment project (01-08/MWI, see Appendix F; ESS 2002). The storm drain study documented end-of-pipe effluents before any mixing occurred within the receiving waterbody. The data presented in the ESS report is not representative of instream water quality conditions, but does represent source identification of pollutant loadings (ESS 2002). A total of 13 wet weather bacteria samples were collected. The fecal coliform bacteria counts ranged from 110cfu/100 mls to 260,000cfu/100 mls and the E. coli bacteria counts ranged from 110cfu/ml to 260,000cfu/100 mls (ESS 2002). A total of two dry weather samples were collected; the fecal coliform bacteria counts were 2cfu/100 mls and 1,900cfu/100 mls and the E. coli bacteria counts were 1cfu/ml and 1,300cfu/100 mls (ESS 2002). The storm drains sampled in this segment primarily drained large, impervious areas, residential areas, and recreational areas.

Fecal coliform, E.coli, and Enterococci bacteria samples were collected by members of the MVPC in April-June 2002 from one station at Page Road, Bedford (station SH-1) as part of the Chronic Toxicity Testing project (00-06/104, see Appendix F). A total of seven bacteria samples were collected. The fecal coliform counts ranged from 370 cfu/100 mls to 2,600 cfu/100 mls. The geometric mean over the three months of sampling for the fecal coliform bacteria data is 761 cfu/100 mls. Only one sample exceeded 2, 000 cfu/100 mls.

Based on elevated fecal coliform bacteria levels, the Primary Contact Recreational Use is assessed as impaired for the entire length of this segment. Although the geometric mean from the MRWC 1998 bacteria data did not exceed 200 cfu/100 ml, more recent bacteria sampling data (DWM and MVPC) do exceed 200 cfu/100 ml. Furthermore, storm drain discharges to this segment of the Shawsheen River are confirmed sources of bacteria. The Secondary Contact Recreational Use is assessed as support. However, it is identified with an Alert Status because of one elevated fecal coliform bacteria count.

The drainage area of this segment is approximately 13.87 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 34%
Forest 32%
Transport 10%

A bacteria TMDL for the Shawsheen River Watershed was completed by Limno-Tech in August 2002 for MADEP and the MRWC (LimnoTech 2002). Data were collected and coordinated through the MRWC and the Merrimack River Watershed Team. The purpose of this TMDL was to establish a fecal coliform TMDL for segments of the Shawsheen River and tributaries that are currently not meeting Massachusetts standards. Additionally, the bacteria TMDL outlined an implementation strategy to abate fecal coliform sources so bacteria criteria can be attained (MADEP 2002).

A Shawsheen Bacteria TMDL Implementation Plan was developed to further identify the sources of bacteria in the watershed, and to isolate storm drains with high bacteria counts. Fecal coliform bacteria were collected by MRWC and ESS, Inc. during 2001 and 2002 from storm drain locations in the Shawsheen River Watershed (01-01/MWI, see Appendix F; MRWC 2003a). As part of this implementation plan, two storm drain mapping projects (99-06/MWI, see Appendix F) were completed in this portion of the Shawsheen River by MRWC in 2000. In Phase I, MRWC worked with local town managers and stream team volunteers to develop criteria for mapping the location and describing the condition of 250 storm drains along the mainstem (MRWC 2000a). In Phase II, a storm drain map was created using GIS technology for the Shawsheen River Watershed (MRWC 2001b). These data are useful in understanding the extent of non-point source pollution in the watershed and flooding potential for local communities (MRWC 2000a).

A bacteria TMDL for the Shawsheen River Watershed was completed by Limno-Tech in August 2002 for MADEP and the MRWC (LimnoTech 2002). Data were collected and coordinated through the MRWC and the Merrimack River Watershed Team. The purpose of this TMDL was to establish a fecal coliform TMDL for segments of the Shawsheen River and tributaries that are currently not meeting Massachusetts standards. Additionally, the bacteria TMDL outlined an implementation strategy to abate fecal coliform sources so bacteria criteria can be attained (MADEP 2002).

A Shawsheen Bacteria TMDL Implementation Plan was developed to further identify the sources of bacteria in the watershed, and to isolate storm drains with high bacteria counts. Fecal coliform bacteria were collected by MRWC and ESS, Inc. during 2001 and 2002 from storm drain locations in the Shawsheen River Watershed (01-01/MWI, see Appendix F; MRWC 2003a). As part of this implementation plan, two storm drain mapping projects (99-06/MWI, see Appendix F) were completed in this portion of the Shawsheen River by MRWC in 2000. In Phase I, MRWC worked with local town managers and stream team volunteers to develop criteria for mapping the location and describing the condition of 250 storm drains along the mainstem (MRWC 2000a). In Phase II, a storm drain map was created using GIS technology for the Shawsheen River Watershed (MRWC 2001b). These data are useful in understanding the extent of non-point source pollution in the watershed and flooding potential for local communities (MRWC 2000a).

Report Recommendations:

• Continue efforts of the watershed team toward finding bacteria sources and remediating problems.

• Develop and implement an instream habitat restoration/improvement project to improve habitat quality and support aquatic life.

• Implement the recommendations of the Shawsheen Bacteria TMDL

- septic tank control (identify and remediate local community septic problems)
- urban runoff (collect additional monitoring data to isolate sources of bacteria and implement a control plan)

• A shoreline survey should be conducted to document aesthetic quality of this segment of the Shawsheen River.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-08 - Shawsheen River)

AQUATIC LIFE

Habitat and Flow

In support of the stormwater permit development for the HAFB the USGS was contracted by the USAF to install an automatic (phone dial-up) continuous record stream flow gage in the Shawsheen River approximately 0.3 miles downstream from the multipipe outlet structure of Massport and HAFB drainage systems. The gage has a drainage area of 2.09 square miles and is capable of providing flow data every ten minutes, 24 hours per day, on a year round basis. The gage, operational since October 1995, provides streamflow data necessary to gain a better understanding of how streamflow conditions in the Shawsheen River are influenced by climatological events and the effects of stormwater runoff from Hanscom Field. Quarterly water quality monitoring of the Shawsheen River, initiated in September 1995, is also being conducted by USGS at the gage to provide additional instream data.

A Draft TMDL for aquatic life impairment in the Shawsheen Headwaters was prepared by MRWC in October 2002. The objective of this TMDL was to specify reductions in stormwater pollutant loads and other associated stressors so that aquatic life uses could be met. Based on past studies in the watershed (Rizzo Associates, Inc. 1996), the stressors impacting aquatic life/habitat in the headwaters of the Shawsheen include contaminants associated with stormwater runoff, hydrologic modifications, riparian corridor encroachment, and channel alteration (MRWC 2002). The Draft TMDL recommends implementing BMPs designed to enhance ground water recharge and reduce high stormwater flows and pollutant loads (MRWC 2002). The following actions are currently underway:

• USAF contracted MRWC to identify BMPs to be installed on the HAFB property to meet the TMDL surrogate target. The recommendations of BMPs are scheduled to be presented to USAF by December 2002.

• Massport Authority is working on identifying solutions to reduce runoff from the runways.

DWM conducted a habitat assessment in this segment of the Shawsheen River in September 2000. The habitat assessment revealed a channelized waterway with no instream cover for fish other than a small amount of aquatic macrophytes. The streambanks were stable and canopy cover was adequate, however, riparian landuse away from the immediate streambank was predominantly paved (airport service roads) and industrial (base facilities). Epifaunal substrate was poor, consisting almost entirely of sand. There was very little variability in habitat types with a shallow run predominating. There appeared to be an iron floc covering most all surfaces throughout the reach (Maietta 2001).

Biology

In September 2000 DWM conducted fish population sampling in this segment of the Shawsheen River downstream from three large culverts on the HAFB in Bedford using a backpack shocker. A total of 36 fish (19 being young of the year white suckers) were collected. Four species were represented. The fish community was dominated by white sucker and redfin pickerel. Other fish present included two American eels and one pumpkinseed (Maietta 2001). It should be noted that downstream of the sampled reach there are a number of beaver dams which may be acting as barriers to migrating fish, especially under low flow conditions. In addition, these beaver dams, are creating large areas of deeper pool habitats more favorable to “pond species” (Maietta 2001).

Toxicity

Effluent

Battle Road Farm Condominiums has conducted whole effluent toxicity tests on an annual basis between August 1999 and June 2002 on two test organisms (C. dubia and P. promelas). No acute whole effluent toxicity has been detected (i.e., the LC50 have all been > 100% effluent). Based on these results and current permitting requirements the draft permit has increased the frequency of monitoring to two times per year and reduced the whole effluent toxicity testing requirements to one test organism, C. dubia only (Hill 2003).

Sediment

In January 1997, the EPA, Office of Environmental Measurement and Evaluation assisted the MADEP in evaluating the sediment quality from two sampling locations (SH01C – at the outfall pipes on the HAFB property and MP01- at the USGS gage on the HAFB property in Bedford) within this segment of the Shawsheen River (EPA 1998). Whole sediment toxicity tests were performed according to EPA guidance. The results of the 10-day exposure tests (Table 3) indicated a lack of toxicity for the freshwater invertebrates (Chironomus tentans and Hyallela azteca) with respect to the test endpoints, survival and growth (EPA 1998). Artificial sediment was utilized as a control.

[See table on page 25 of Water Quality Assessment Report]

Chemistry – water

The USGS conducted water quality sampling in the Shawsheen River between September 1995 and September 2001 (for the purpose of this report data from 11 surveys conducted between October 1997 and September 2001 have been reviewed) at their gaging station (01100568). These data are published in the Water Resources Data Massachusetts and Rhode Island Water Year 1998, 1999, 2000, and 2001 reports (Socolow et al. 1999, Socolow et al. 2000, Socolow et al. 2001, and Socolow et al. 2002).

DO

Instream DO ranged between 6.9 and 10.9 mg/L, however, these data do not represent worse-case (pre-dawn) conditions.

Temperature

The maximum water temperature (11 September 1999) was 19.5°C.

pH

Instream pH ranged between 6.2 and 7.0 SU with 1 of the 11 measurements (9%) <6.5 SU.

Ammonia-Nitrogen

The ammonia-nitrogen concentrations ranged between 0.23 and 1.2 mg/L as N. All of these measurements were below 4.15 mg/L as N (chronic instream criterion for ammonia at pH of 7.0 and temperature of 20°C) (EPA 1999).

Phosphorus

Total phosphorus concentrations ranged between 0.010 to 0.092 mg/L with a mean of 0.04 mg/L.

Chemistry – sediment

In January 1997, the EPA, Office of Environmental Measurement and Evaluation assisted the MADEP in evaluating the sediment quality at two locations (SH01C and MP01) within this segment (EPA 1998). Two sediment samples were collected with a petit ponar dredge (upper six inches of aquatic substrate) and analyzed for metals, AVS/SEM, SVOCs, PCB, pesticides, TOC, toxicity, and grain size. The first sediment sample (SH01C) was located at the outfall pipes on the HAFB property in Bedford, MA. The TOC at SH01C was 0.52%. DDE (a breakdown product and an impurity in DDT), DDD (an insecticide and DDT breakdown product), DDE (a DDT breakdown product), and dieldrin (an insecticide) measured in quantities that exceeded the L-EL guidelines but were below the S-EL guidelines (Persaud et al. 1993). The second sediment sample (MP01) was located at the USGS gage station on the HAFB property in Bedford, MA. The TOC at MP01 was 0.26%. DDD and dieldrin measured in quantities that exceeded the L-EL guidelines, but were below the S-EL guidelines (Persaud et al. 1993). There were no metals concentrations at either sample location that exceeded the L-EL guidelines. In the two sediment samples collected there were no exceedances of the S-EL guidelines in any analyte.

While no water column and/or sediment quality problems were detected, the habitat assessment revealed a channelized waterway with little to no instream cover for fish and poor epifaunal substrates. Physical alteration (underground/culverted) of the stream channel in this segment of the Shawsheen River has also resulted in a reduction of habitat available for aquatic life. The Aquatic Life Use is, therefore, assessed as impaired for the entire length of this segment.

PRIMARY AND SECONDARY CONTACT RECREATION

The MRWC and the Upper Shawsheen Stream Team collected fecal coliform bacteria data (Table 4) during the months of June through September 1998 (eight sampling events) from two sites along this segment (MRWC 1998). Two of the eight sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 26 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at one station on this segment of the Shawsheen River (Appendix A, Table A4):

• SH01A-US, drainage culvert from HAFB, Bedford, MA.

The fecal coliform bacteria counts at SH01A-US were 360 cfu/100 mls in August and 500 cfu/100 mls in September.

Fecal coliform and E. coli bacteria samples were collected (only during the primary contact season) at the USGS gage (01100568) in Bedford, MA in support of the stormwater permit development for the HAFB property (Socolow et al. 1999, Socolow et al. 2000, Socolow et al. 2001, and Socolow et al. 2002).

• 1998 the fecal coliform bacteria counts ranged from 54 cfu/100 mls to 220 cfu/100 mls (n=3);
• 1999 the counts ranged 1900cfu/100 mls to 3,900 cfu/100 mls (n=3);
• 2000 the counts ranged from 150cfu/100 mls to 6,900 cfu/100 mls (n= 3);
• 2001 the counts were 40cfu/100 mls and 290cfu/100 mls (n=2).

Of the eleven fecal coliform samples collected by USGS between April 1998 and July 2001, four samples exceeded 2,000 cfu/100 mls. These elevated bacteria counts were all associated with wet weather conditions.

Fecal coliform bacteria were collected during July, October, and November 2002 from five storm drain locations in this segment of the Shawsheen River by MRWC as part of the Shawsheen TMDL Implementation Plan project (01-01/MWI, see Appendix F; MRWC 2003a). This part of the project (Part II) focused on the Shawsheen River headwaters on the HAFB property and documented bacteria levels in the end-of-pipe effluents. The data presented in this report are not representative of stream habitat conditions, but do represent source identification of pollutant loadings. Bacteria samples were collected during dry and wet weather conditions. The fecal coliform bacteria counts ranged from 4cfu/100 mls (sample collected during a dry weather event – 0.0 inches of rain) to 1,423cfu/100 mls (sample collected during a wet weather event – 0.68 inches of rain) (MRWC 2003a).

The storm drains sampled in this segment primarily drain the HAFB property.

Based on elevated fecal coliform bacteria levels and best professional judgment, the Primary Contact Recreational Use is assessed as impaired for the entire length of this segment. Although the geometric mean from the MRWC 1998 bacteria data did not exceed 1,000 cfu/100 mls, 36% of the samples collected by USGS (representative of wet weather conditions) exceeded 2,000 cfu/100 mls. The Secondary Contact Recreational Use is, therefore, also assessed as impaired.

AESTHETICS

An overriding objectionable condition (channelized/underground) is not an aesthetic issue according to the use assessment guidance but, rather an aquatic life issue related to habitat quality.

No information is available to assess the Aesthetics Use for this segment of the Shawsheen River.

The drainage area of this segment is approximately 6.59 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):

Residential 37%
Forest 22%
Transport 15%

Report Recommendations:
• Review and implement recommendations of the USAF Habitat TMDL and the Shawsheen Bacteria TMDL (i.e., implementing BMPs designed to enhance groundwater recharge and reduce high stormwater flows and pollutant loads; assess the feasibility of potential restorative actions along the riparian corridor, including the river itself; and develop and implement an instream habitat restoration/improvement project to improve habitat quality and support aquatic life).
• A shoreline survey should be conducted to document aesthetic quality of this segment of the Shawsheen River.
• Follow-up with EPA on the status of remediation activities at the Hanscom Air Force Base/Hanscom Field NPL site (EPA ID # MA8570024424).

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-16 - Unnamed Tributary)

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Lower Shawsheen Stream Team collected fecal coliform bacteria data during the months of June through September 1998 (seven sampling events) from the unnamed tributary at River Street, Andover (station FPR 2.1; MRWC 1998). The fecal coliform counts ranged from 8 cfu/100 mls to 340 cfu/100 mls with a geometric mean of 53 cfu/100 mls.

Based on the low fecal coliform bacteria counts both the Primary and Secondary Contact Recreational uses for this unnamed tributary of the Shawsheen River are supported.

The drainage area of this segment is approximately 3.5 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 46%
Forest 41%
Open Land 3%

Report Recommendations:
• The Stream Team should continue to foster local stewardship and protect this brook.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-12 - Meadow Brook)

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Middle Shawsheen Stream Team collected fecal coliform bacteria data during the months of June through September 1998 (seven sampling events) from Meadow Brook near Pinnacle Street, Tewksbury (station MDB 2.6; MRWC 1998). The fecal coliform counts ranged from 20 cfu/100 mls to 2,000 cfu/100 mls with a geometric mean of 122 cfu/100 mls. Only one sample exceed 400 cfu/100 mls. Two of the seven sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

Although one fecal coliform bacteria count was elevated (2,000 cfu/100 mls) in 1998 near Pinnacle Street, Tewksbury, it is best professional judgment that both the Primary and Secondary Contact Recreational uses for Meadow Brook are supported (geometric mean for the other samples was less than 200 cfu/100 mls). However, the Primary Contact Recreational Use is identified with an Alert Status because of the one elevated bacteria count.

The drainage area of this segment is approximately 4.6 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 39%
Forest 31%
Open Land 9%

Report Recommendations:
• Continue to monitor bacteria levels to identify sources and remediate problems.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-15 - Pinnacle Brook)

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Middle Shawsheen Stream Team collected fecal coliform bacteria data during the months of June through September 1998 (seven sampling events) near Pinnacle Street, Tewksbury near Andover town line (PB 1.3; MRWC 1998). The fecal coliform counts ranged from 3,600 cfu/100 mls to 20,000 cfu/100 mls. The geometric mean for the fecal coliform bacteria data is 8,726 cfu/100 mls. Two of the seven sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

The lower 1.1 mile reach of the brook is assessed as impaired for both the Primary and Secondary Contact Recreational uses because of the extremely high bacteria counts. Based on best professional judgment, the upper 1.0 mile of Pinnacle Brook (upstream of the Piggery operation) is currently not assessed.

The drainage area of this segment is approximately 2.0 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 38%
Forest 33%
Open Land 11%

Numerous complaints since the early 1990s regarding odor problems and potential water quality concerns related to a piggery/manure operation in Andover have been received by the Shawsheen Watershed Team and the Andover Board of Health. The Board of Health is currently working with the property owner to address the issues of concern (Dunn 2003b).

The MRWC and the Northern Middlesex Council of Governments presented a planning level, environmental impacts analysis that was conducted for three subwatersheds in the Shawsheen Watershed - Strong Water Brook, Content Brook, and Pinnacle Brook. The goal of the study was to evaluate potential impacts to water quality and quantity, based on expected future development, and to recommend BMPs to minimize future impacts and maximize protection of watershed functions. A watershed model was used to evaluate potential water-related impacts that are expected with future development (MRWC 2001a). Based on the current conditions of the subwatersheds and results of the watershed modeling, MRWC proposed that future developments meet the following watershed goals: reduce stormwater pollutant loads, maintain groundwater recharge and quality, protect stream channels, prevent increased overbank flooding, and safely convey extreme floods.

Report Recommendations:

• Follow-up with the Board of Health on the status of remediation activities at the piggery/manure operation.
• Review recommendations from the environmental impacts analysis final report presented by the MRWC (MRWC 2001a).
• Additional monitoring (e.g., habitat quality) should be conducted to assess the status of the Aquatic Life Use.
• A shoreline survey should be conducted to document aesthetic quality of Pinnacle Brook.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-06 - Vine Brook)

PRIMARY AND SECONDARY CONTACT RECREATION
The MRWC and the Upper Shawsheen Stream Team collected fecal coliform bacteria data (Table 10) during the months of June through September 1998 (seven sampling events) from five sites along this segment (MRWC 1998). Two of the seven sampling events were conducted during wet weather conditions (Note: high bacteria concentrations were associated with these wet weather conditions).

[See table on page 45 of Water Quality Assessment Report]

In August and September 2000 DWM collected fecal coliform bacteria samples at one station from Vine Brook (Appendix A, Table A4).
• VB01, upstream from Route 62 bridge, Bedford, MA.
The fecal coliform bacteria counts at VB01 were 20 cfu/100 mls in August and 130 cfu/100 mls in September.

Because of elevated fecal coliform bacteria levels (particularly in the upper drainage area and upper reach of this segment) and best professional judgment (sewer overflow that occurs in the town of Burlington near Terrace Hall Road) the Primary Contact Recreational Use is assessed as impaired for the entire length of this segment. The Secondary Contact Recreational Use is assessed as support, although it is identified with an Alert Status because the most upstream sampling location did exceed 2,000 cfu/100 mls in 29% of the samples.

The drainage area of this segment is approximately 10.05 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 42%
Forest 25%
Open Land 9%

Excerpted from the EPA New England National Priorities List (NPL) website (EPA 25 March 2003).
The Microwave Associates Communications Company (MACC) site (EPA ID #: MAD980522601), along with several other parcels, was used for pig farming, agriculture, and sand and gravel mining prior to 1959. From 1987 to the present, the building has been occupied by several computer software development companies. MACC reportedly generated such wastes as trichloroethylene (TCE), 1,1,1-trichloroethane (TCA), methanol, acetone, methylene chloride, cadmium, nickel, chromium, selenium, lead, hydrogen fluoride, acetic acid, hydrogen sulfide, nitric acid, and hydrochloric acid during on-site operations. Solvent wastes were reportedly transported off site by a licensed waste hauler while the remaining wastes were treated at two on-site waste water treatment plants prior to being discharged to the municipal sewer system. In 1979, approximately 175 gallons of TCA were reportedly spilled due to a rupture in a line to a 275-gallon aboveground storage tank. Approximately 35 cubic yards of TCA-contaminated soil were reportedly excavated and treated prior to off-site disposal. Overland surface water flow on the MACC property is toward an unnamed stream located to the west of the property. The unnamed stream flows easterly and discharges to Vine Brook. Historical sediment sampling conducted along the unnamed stream indicates that the surface water pathway has been impacted by a release of pesticides, polychlorinated biphenyls (PCBS) and inorganic elements from the MACC property.

The former RCA Corp. (RCA) site (EPA ID #: MAD001060698) is located at 183 Bedford Street (formerly 163 Bedford Street), in the Town of Burlington, Massachusetts. Between 1958 and 1994, the property was used as an industrial facility, primarily for manufacturing and testing military electronics equipment. Prior to 1958, the property was used for agricultural purposes, which included a piggery and a small quarry for sand and gravel, located in the southwestern portion of the property. The hazardous waste generated at RCA resulted from a variety of manufacturing activities. Numerous studies, including groundwater monitoring reports, a Phase I Environmental Assessment, and Phase I and II Site Investigation Reports, have been conducted on the RCA property. As part of these studies, groundwater data has been collected from 63 monitoring wells and 22 subsurface points on the RCA property between 1986 and 1994. Surface water and sediment samples have also been collected. Eighteen possible source areas were identified as a result of these studies, consisting of material storage areas or waste disposal areas associated with past on-site processes. Volatile organic compounds (VOCs), including: 1,1,1-trichloroethane (1,1,1-TCA); trichloroethene (TCE); toluene; ethylbenzene; and xylenes; were detected at concentrations significantly above background in groundwater samples collected in a former paint disposal area located on the eastern side of the property, and metals, including: chromium, copper, arsenic, nickel and zinc were detected at concentrations significantly above background in sediment samples collected from Vine Brook downstream of this area. In addition, VOCs (1,1,1-TCA, TCE, ethylbenzene and xylene) and metals (chromium, copper, arsenic and zinc) were detected at concentrations significantly above background in subsurface soil samples collected from the former paint disposal area and a former acid disposal area located on the southwest portion of the property. Response Action Outcome Statements, a Risk Characterization, and Phase a IV investigation are currently being prepared by IT Corporation in accordance with MA DEP directives.

The former Tech Weld Corp. (Tech Weld) site (EPA ID #: MAD021721105) is located at 70 Blanchard Road in Burlington, Massachusetts. Operations consisted of manufacturing and repair of vehicle storage tanks for the chemical and petroleum industries. Cleaning wastewater was discharged into a subsurface leaching bed or an oil/water separator, and then discharged into an intermittent stream located on the eastern side of the property. In 1975, the Burlington Department of Public Works and Board of Health, and the Massachusetts Water Resources Commission ordered that Tech Weld cease direct discharging to the leach bed, and remove contaminated soils in the area. Subsequent actions regarding these directives are unknown. Continued groundwater monitoring at the property identified the following contaminants: 1,1-dichloroethane; trans 1,2-dichloroethylene; tetrachloroethylene; trichloroethylene; 1,1-dichloroethylene; acetone; and benzene. During 1986 and 1987, the Tech Weld building was demolished, and the current office complex was constructed on the property.

The former U. S. Windpower site (EPA ID #: MAD101186419) is located at 160 Wheeler Road in Burlington, Massachusetts. In 1989 and 1990, the former manufacturing building was demolished and replaced with a six-story office complex (approximately 26,000 square feet). The building is currently occupied by Siemens-Nixdorf Corporation, and the address of the property has changed to 200 Wheeler Road. During manufacturing operations conducted by the various on-site companies, chlorinated solvents were reportedly discharged into several wash sinks located within the building. The sinks were connected to a storm and roof drainage system, which discharged to leaching beds located on the eastern portion of the property. The actual quantities of wastes that were disposed and dates of disposal are unknown. In 1999, MA DEP approved installation of a soil gas and groundwater recovery and treatment system, which is currently located on the property. Results of the recovery and treatment system are reported to MA DEP every 6 months as part of Phase IV investigations currently on-going on the property.

Report Recommendations:

- Continue to monitor bacteria levels to help implement Phase II stormwater requirements.
- Monitoring should be conducted to assess the status of the Aquatic Life Use.
- A shoreline survey should be conducted to document aesthetic quality of Vine Brook.
- Follow-up with EPA on the status of remediation activities at the NPL sites located in this subwatershed.
- Follow-up with North East Regional Office of the MADEP on the status of the Wakefield Sand & Gravel discharge and wetland violations.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-11 - Long Meadow Brook)

Too little data are available to assess the designated uses of Long Meadow Brook.
The drainage area of this segment is approximately 0.75 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 48%
Forest 22%
Open Land 18%

Report Recommendations:
• Establish a Stream Team to obtain additional data and to foster local stewardship.

Shawsheen River Watershed 2000 Water Quality Assessment Report (MA83-13 - Sandy Brook)

Too little data are available to assess the designated uses of Sandy Brook. However, the Aquatic Life Use is identified with an Alert Status because of the small drainage area of the watershed and the presence of water withdrawals.
The drainage area of this segment is approximately 1.1 square miles. Land-use estimates (top three) for the subwatershed (map inset, gray shaded area):
Residential 70%
Forest 17%
Open Land 7%

Report Recommendations:
• Establish a Stream Team to obtain additional data and to foster local stewardship.
• Biological monitoring (i.e., benthic macroinvertebrate, fish population, habitat assessment) should be conducted to evaluate whether or not there are any instream impacts associated with water withdrawals. If deemed necessary, conduct an inflow/outflow analysis for Sandy Brook.

Appendix E – Engineering Site Visits Memo

Stormwater Control Measure Evaluation

Shawsheen River Watershed-Based Plan

December 2024

PREPARED FOR

Merrimack River Watershed Council,
Lawrence, MA

PREPARED BY

Horsley Witten Group, Inc.
112 Water Street | 6th Floor
Boston, MA 02109

Table of Contents

Appendices

1 INTRODUCTION

The Merrimack River Watershed Council (MRWC) contracted with Horsley Witten Group (HW) to evaluate the potential for stormwater control measures (SCMs) at five sites in the Shawsheen River Watershed. This work is part of a larger effort by MRWC and the Merrimack Valley Planning Commission (MVPC) to develop a watershed-based plan (WBP) for the Shawsheen River. The WBP study area focuses on the lower segments of the Shawsheen River flowing through Tewksbury, Andover, North Andover, and Lawrence to its confluence with the Merrimack River. The objective of HW's SCM evaluation was to identify opportunities to reduce nonpoint source pollution into the Shawsheen River.

The Shawsheen River and its tributaries (within the watershed study area) are classified in the Massachusetts Surface Water Quality Standards (314 CMR 4.00) as Class B waters with warm water fisheries, designated as habitat for fish, other aquatic life, and wildlife and for primary and secondary contact recreation. The lower river segment (MA83-19) is listed on the Massachusetts Integrated List of Waters (2022) as impaired due to benthic macroinvertegrates, curly-leaf pondweed, fish passage barrier, *Escherichia coli* (E. coli), and fecal coliform. The next upstream segment (MA83-18) is listed as impaired due to curly-leaf pondweed, fecal coliform, E. coli, and dissolved oxygen. These segments are covered by the 2002 Bacteria Total Maximum Daily Load (TMDL) for the Shawsheen River Basin, which identifies discharges from municipal separate storm sewer systems (MS4) as a source of E. coli. The Shawsheen River is a tributary to the Merrimack River (MA84A-04), which is impaired due to E. coli, PCBs in fish tissue, and total phosphorus (TP). As permittees under the Massachusetts General Permit for Stormwater Discharges from Small Municipal Separate Storm Sewer Systems (MS4 Permit), Tewksbury, Andover, North Andover, and Lawrence are required to develop phosphorus source identification reports and retrofit evaluations, and to implement municipal stormwater retrofits to reduce phosphorus loading to the Merrimack River and its tributaries.

This technical memorandum describes HW's assessment approach, key findings, and recommendations. MWRC and MVPC will integrate these findings and recommendations, as applicable, into the Shawsheen River WBP. The next step for HW will be to prepare conceptual (10%) designs for two of the recommended SCMs.

2 APPROACH

The purpose of HW's SCM evaluation was to identify potential retrofits to reduce stormwater impacts on the Shawsheen River and its tributaries. The assessment consisted of three main elements, which are further described below:

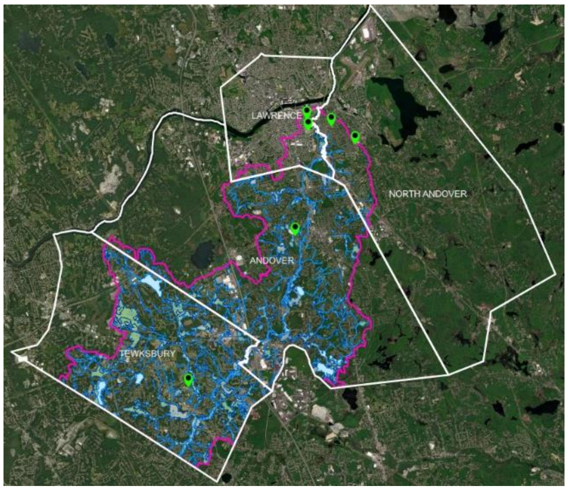
1) <u>Desktop analysis and stakeholder discussions</u>: Background review, discussions with MWRC, MVPC, and stakeholders, and GIS mapping analysis to narrow down locations for site visits.

2) <u>Field reconnaissance</u>: Targeted visits to five pre-selected sites to observe potential sources of nonpoint source pollution and recommend actions for pollution prevention, erosion control, green stormwater infrastructure (GSI), and restoration practices.

3) <u>Calculations</u>: Planning-level estimates of pollutant load reduction and costs for seven SCMs.

2.1 Desktop Analysis and Stakeholder Discussions

MVPC completed a GIS analysis of parcels and rights-of-way that identified priority locations that scored well on MVPC's criteria for hydrologic conditions, property ownership, water quality impairments, and environmental justice. HW reviewed MVPC's GIS analysis and suggested further refinements to prioritize publicly owned parcels and rights-of-way that contained over a half-acre of impervious cover and were not dominated by wetlands or forests. HW then joined in discussions, led by MRWC, with the WBP technical advisory committee and stakeholder group. With HW's assistance during those discussions, MRWC and stakeholders prioritized five sites that represented good opportunities to mitigate nonpoint source pollution to the Shawsheen River.



In preparation for visits to those five sites, HW compiled and reviewed data for each site, including drainage and utility plans, aerial imagery, and GIS mapping of wetland resource areas, hydrologic soil groups, topography, land uses, land ownership, impervious surfaces, and water, sewer, and drainage infrastructure.

2.2 Field Reconnaissance

On November 20, 2024, three HW staff were joined by MRWC, MVPC, and stakeholders for visits to the sites listed in **Table 1**. Atkinson Elementary School was added to the itinerary after HW found that there were limited opportunities at Thomson Elementary School. During the site visits, HW recorded observations using ESRI's Field Maps software on tablets and cell phones. Documentation included descriptions of existing conditions and mitigation opportunities; photographs; sketches of potential retrofits where applicable; and locations plotted on the GIS map. HW also recorded information provided by stakeholders on site uses, planned projects, drainage issues, constraints, and preferences.

Table 1. Sites Visited

Municipality	Site Name
Lawrence	Shawsheen Road and Costello Park
	South Lawrence East Elementary School
North Andover	Thomson Elementary School
	Atkinson Elementary School
Andover	Andover High School
Tewksbury	Livingston Street and Saunders Recreations Areas

2.3 Calculations

For seven of the recommended SCMs (those with the best opportunities for pollutant reduction), HW estimated TP, total nitrogen (TN), total suspended solids (TSS), and bacteria load reductions. TP, TN, and TSS load reductions were estimated using pollutant load export rates and BMP performance curves provided in the MS4 Permit and EPA Region 1's BMP Accounting and Tracking Tool. Bacteria load reduction was estimated using E. coli loading rates and performance curves from *Tisbury MA Planning Level GI SCM Performance Curves for Estimating Cumulative Reductions in SW-Related Indicator Bacteria*. Costs were estimated using EPA Region 1 *Methodology for Developing Cost Estimates for Opti-Tool* and best professional judgement.

3 FINDINGS

Detailed findings are provided in the appendices: Appendix A – Summary Tables; Appendix B – Map Figures; and Appendix C – Field Data Summary Sheets. The sections below summarize HW's key observations and recommendations.

3.1 Key Issues Observed

Large impervious areas lacking trees and stormwater controls

Our team observed many roofs, parking lots, and roads that drain to wetlands or streams without stormwater treatment before discharge, and many parking lots and roads that lack trees.

Parking lot at Andover High School

Shawsheen Road, Lawrence

Trash, dog waste, and degraded habitat in stream buffers and wetlands

Our team observed dog waste and litter in Costello Park, and significant litter and debris in the riverfront zone along Shawsheen Road in Lawrence. We also observed many locations with degraded habitat and invasive species within stream buffers and wetlands.

Trash mixed with leaves above the Shawsheen River near South Lawrence East Elementary School

Narrow stream buffer at Saunders Recreational Area, Tewksbury

Stormwater outfall and channel erosion

Our team observed erosion at a 60-inch outfall and along the downstream channel leading to the Shawsheen River, near South Lawrence East Elementary School.

Erosion at 60-inch outfall to Shawsheen River in Lawrence

3.2 Recommended Mitigation Actions

Based on our observations in the field and conversations with MWRC, MVPC, and stakeholders, HW recommends several policy and operational improvements and GSI retrofits. Tables summarizing HW's field observations, recommendations, pollutant load reduction estimates, and cost estimates are provided in **Appendix A**. Map figures illustrating the locations are provided in **Appendix B**.

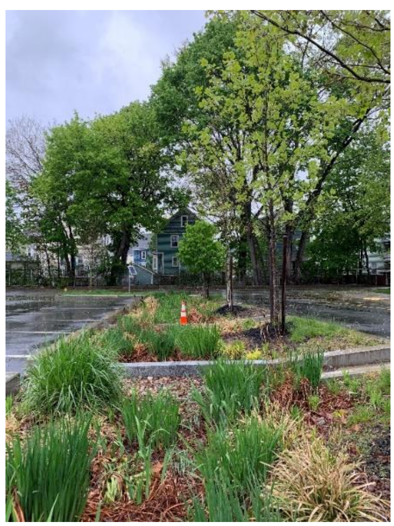
Non-structural practices

1. Stabilize eroding slopes, banks, and channel bottom at the 60-inch outfall in Lawrence. Evaluate stream channel conditions and options for upstream detention storage.
2. Clean up trash along Shawsheen road and improve public education, in languages appropriate to the neighborhood, for trash and pet waste management.
3. Restore vegetated stream buffers where they have been cleared (e.g., mowed lawns) and manage invasive plants in wetlands and vegetated stream buffers.
4. Target barren, unvegetated streetscapes and public properties for tree planting and care.

GSI retrofits

Our team identified several locations that can potentially be retrofit to redirect runoff into small-scale GSI practices. These SCMs were selected both for their suitability for the given site and for their potential to be replicated in similar settings across the watershed. The photos below illustrate the types of SCMs that could be installed at potential GSI retrofit sites.

Educational bioretention basin at elementary school



Parking lot bioretention swale with trees

Streetscape infiltration tree trench

Appendix A. Summary Tables

Table A-1. Summary of Site Visit Observations and Recommentations

Site ID	Site Name	Existing Conditions	Proposed Solutions	Other Notes
A-1	AHS North Parking Lot	Existing grass island in the parking lot north of Andover High School. Raised garden bed for pollinator garden created and maintained by students.	Add inlets on upgradient side of island. Create depressed bioretention area in island, possibly with overflow structure to drainage network or flow in-flow out system. Work with students to transplant pollinator plants into bioretention area, add native plants, and integrate living lab/educational elements.	Parking lot drains down to island.
A-2	AHS East Parking Lot Island	Large asphalt parking lot east of Andover High School with closed drainage system and no stormwater treatment or trees. One way in and out. Tight backing out of east parking stalls. Old light poles in middle of center parking stalls.	Regrade parking lot and install bioswale/infiltration tree trench as center parking island running west to east. Move light poles, replace with modern solar lighting. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-3 and A-4.	Parking lot will likely be updated as part of high school renovations.
A-3	AHS East Parking Lot	Large asphalt parking lot east of Andover High School with closed drainage system and no stormwater treatment or trees. Grass island at bottom of parking lot.	Add surface inlets to island, create a bioretention area in the island with connection to drainage system. Possibly add chambers. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-2 and A-4.	If planning to repave parking lot, think about gutter lines.
A-4	AHS Tennis Courts	Paved strip between Andover High School east parking lot and tennis courts. No trees or shade. The spectators have requested shade structures.	Regrade lot and direct runoff from south edge into infiltration tree trench along tennis court. Plant trees that provide shade and are suitable for tennis courts. Design with hardscape permeable surface above trench and around tree wells for tennis spectators. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-2 and A-3.	
A-5	AHS Moraine St	Paved parking spaces along Moraine St south of Andover High School. Slope to east drops 6-7 ft to vegetated area. Invasive species present (Bittersweet). Runoff currently overtops asphalt berm in corner of the last parking space or continues down Moraine St.	Install a catch basin inlet at back corner of last parking space to convey runoff toward a new forebay and wet swale at bottom of slope. Design forebay to overflow to a wet swale and then out to wetland. Include invasive species management in design.	
A-6	AHS South Parking Lot West End	Large paved parking lot to southeast of Andover High School. Minimal landscape islands and no trees in parking lot. One oil-water separator shown on site plan. Multiple closed drainage systems discharge into wetland south of the parking lot.	Construct infiltration tree trenches within existing grassed landscape island and along southwest shoulder of parking lot. Connect to existing catch basins. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network.	

Site ID	Site Name	Existing Conditions	Proposed Solutions	Other Notes
L-1	Costello Park	Three catch basins on Shawsheen Rd discharge through an 8-inch pipe at a granite headwall in Costello Park. Runoff continues along an informal swale down to and across the paved river trail. Pedestrians walk along the flow path to the river trail.	Construct an infiltrating bioretention basin with sediment forebay at the existing outfall. Formalize a pedestrian path around the bioretention basin to the river trail.	
L-2	Shawsheen Rd Street Trees	No trees or tree lawn on west side of Shawsheen Rd, Lawrence. Wide sidewalk (~8 ft) and wide road (~40 ft) with a parking lane and two travel lanes that are not striped. Dense residential neighborhood with Costello Park across the street. Stakeholders noted problems with fast driving and inconsistent sidewalks (missing in some areas).	Reconfigure right of way with addition of tree lawn and street trees along west side of Shawsheen Rd. Integrate with Safe Routes to School sidewalk and bike lane improvements.	This road is on the list for a future Safe Routes to School grant application.
L-3	Shawsheen Rd Litter	Litter all along Shawsheen Rd, particularly in section between Farnham St and E Boxford St near South Lawrence East Elementary School.	Focus trash management efforts on this neighborhood, including cleanups, education, and trash and recycling bins with lids. Beautify and formalize parking and path areas to encourage stewardship.	
L-4	Outfall @ S Lawrence East School	60-inch outfall into channel to Shawsheen River. Severe erosion, scouring under outfall structure and banks up to ~4-5 ft height. Channel ~ 400 ft to river. Flowing despite dry weather, fed by natural springs and pond at old railyard.	Stabilize outfall structure and channel banks and bottom. Add energy dissipation at outfall and along channel. Integrate upstream detention storage as part of Grafton St culvert improvements.	Planned culvert replacement/upsizing in upper catchment from Grafton St, Winthrop Ave area could increase peak flow at outfall unless detention storage is added.
L-5	S Lawrence East School Low Point	Low point along asphalt path behind South Lawrence East Elementary School. Erosion within lawn areas on both sides of path, sand accumulation on path.	Grade in swales and depressions on both sides of path to infiltrate runoff and prevent erosion. Revegetate eroding areas.	
L-6	S Lawrence East School Parking Lot	Steep, paved parking lot with green islands and trees, located south of South Lawrence East Elementary School. Drains to catch basin.	Construct infiltration tree trench in northeast corner of parking lot. Pipe catch basins in parking lot and driveway into tree trench. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network.	

Site ID	Site Name	Existing Conditions	Proposed Solutions	Other Notes
L-7	Shawsheen Park Parking Lot	Large paved parking lot with no grassed islands or trees. Catch basin in northeast corner. Sediment accumulation indicates ponding runoff. Lawn and paved path to the east.	Install paved inlet at northeast corner of parking lot to divert runoff into sediment forebay and bioretention basin in lawn and path area. Reroute paved path around bioretention basin. Integrate living lab/educational elements into design.	
NA-1	Atkinson School Front Lawn	Rooftop runoff ponds in front of North Andover Atkinson Elementary School building, likely due to flat terrain and lack of drainage (possibly high groundwater as well). School recently experienced flooding into building.	Create dry swale/soil filter along front of building with underdrain and yard drain to direct runoff away from building, filter roof runoff, and improve drainage.	
NA-2	Atkinson School Parking Lots	Runoff from paved parking lots at North Andover Atkinson Elementary School flows northwest to two catch basins on Beacon Hill Blvd and overland into large open green space.	Original proposal was to construct a bioretention basin in the open green space. Based on redevelopment plans for the proposed North Andover Recreation Complex, a bioretention basin may not be feasible. Instead, consider permeable pavement or subsurface chambers under the parking lot, staying within the Atkinson Elementary School parcel and outside the limit of work for the Recreation Complex.	If Recreation Complex design plans change, consider bioretention basin in open green space.
T-1	Livingston St Recreation Area Parking Lot	Large paved parking lot at Livingston St Recreation Area in Tewksbury. Deteriorating asphalt and sediment accumulation at low point indicate ponding. Sediment berm at low point prevents runoff from draining out of parking lot. Fallen headwall in adjacent lawn may have been an inlet for parking lot runoff. Parking lot is heavily used during spring-fall and maintained during winter.	Remove sediment berm and install paved flume to direct runoff out of parking lot toward lawn. Construct sediment forebay and bioretention area to treat parking lot runoff. Design basin as shallow depression with gentle side slopes and mowable grass to allow green space to still be used by summer camps.	
T-2	Livingston St	Multiple catch basins along Livingston St connect into closed drainage system that outfalls to unnamed stream.	Construct infiltration tree trenches within right-of-way, connect to existing catch basins. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network. Consider including tree trench installation as part of planned Livingston St sidewalk upgrades.	Designs are in progress for sidewalk improvements along Livingston St.

Site ID	Site Name	Existing Conditions	Proposed Solutions	Other Notes
T-3	Saunders Recreation Area Unnamed Stream	Runoff from gravel parking lot at Saunders Recreation Area flows overland toward unnamed stream to south. Stream is channelized through a wetland. Narrow vegetated buffer around stream with invasive plants. Mowed grass between vegetated buffer and parking lot. Drivers often park on lawn. Parking lot is heavily used during football season and Town has no plans to pave it.	Manage invasive plants along the stream. Widen stream buffer by planting native species within existing mowed lawn area. Install "Do Not Mow - Naturalized Area" and "No Parking" signs.	

Table A-2. Planning-Level Calculations for Select Recommended Green Stormwater Infrastructure Retrofits

Site	Site Location	SCM Description	Drainage Area (ac)	Impervious Area (%)	Estimated Load Reduction					Cost Estimates ($)			
					TN [1] (lb/yr)	TP [1] (lb/yr)	TSS [1] (lb/yr)	Bacteria [2] (% Removal)	Bacteria [2] (E. coli Billion CFU/yr)	Construction[3]	Design & Permitting [3]	O&M [3]	Total Life-Cycle Cost [4]
A-2, A-3, A-4	Andover High School east parking lot	Parking lot island bioswale, trees, infiltration tree trench, and bioretention basin	1.4	100%	20.7	2.4	519.8	98%	12	$302,000	$53,000	$3,000	$415,000
A-6	Andover High School south parking lot, west end	Parking lot infiltration tree trenches	0.8	80%	9.6	1.1	242.6	98%	5	$141,000	$35,000	$3,000	$236,000
L-1	Costello Park, Lawrence	Bioretention basin, formalized pedestrian path	2.1	50%	13.8	2.1	444.4	90%	1,630	$80,000	$24,000	$3,000	$164,000
L-6	South Lawrence East School parking lot	Parking lot infiltration tree trenches	0.7	50%	5.3	0.6	136.5	83%	3	$41,000	$7,000	$3,000	$108,000
L-7	Shawsheen Park parking lot, Lawrence	Parking lot bioretention basin	0.4	100%	5.5	0.6	138.6	100%	3	$76,000	$14,000	$3,000	$150,000
NA-2	Atkinson School parking lot, North Andover	Parking lot subsurface infiltration chambers	0.4	100%	6.2	0.7	155.9	98%	3	$84,000	$15,000	$3,000	$159,000
T-2	Livingston Street, Tewksbury	Streetscape infiltration tree trenches	0.6	100%	8.3	0.9	213.3	83%	4	$63,000	$21,000	$3,000	$144,000
				Sub-Total:	**69.5**	**8.4**	**1851.2**	**--**	**1660.2**	**$787,000**	**$169,000**	**$21,000**	**$1,376,000**

Notes:

1. TN, TP, and TSS load reductions estimated using methodology from the MA MS4 Permit Appendix F Attachment 3 and EPA Region 1 BMP Accounting and Tracking Tool

2. Bacteria load reduction estimated using methodology from Tisbury MA (2019) Planning Level GI SCM Performance Curves for Estimating Cumulative Reductions in SW-Related Indicator Bacteria

3. Planning-level costs estimated using EPA Region 1 (2016) Methodology for Developing Cost Estimates for Opti-Tool and best professional judgement. Expressed in 2024 dollars. Costs are only for SCMs and do not include additional site work. Estimates are meant for comparison and prioritization and should not be used as the basis for specific funding requests or project budgeting.

4. Life-cycle cost represents the capital and O&M costs over a 20-year life span.

Appendix B. Map Figures

Horsley Witten Group
Sustainable Environmental Solutions

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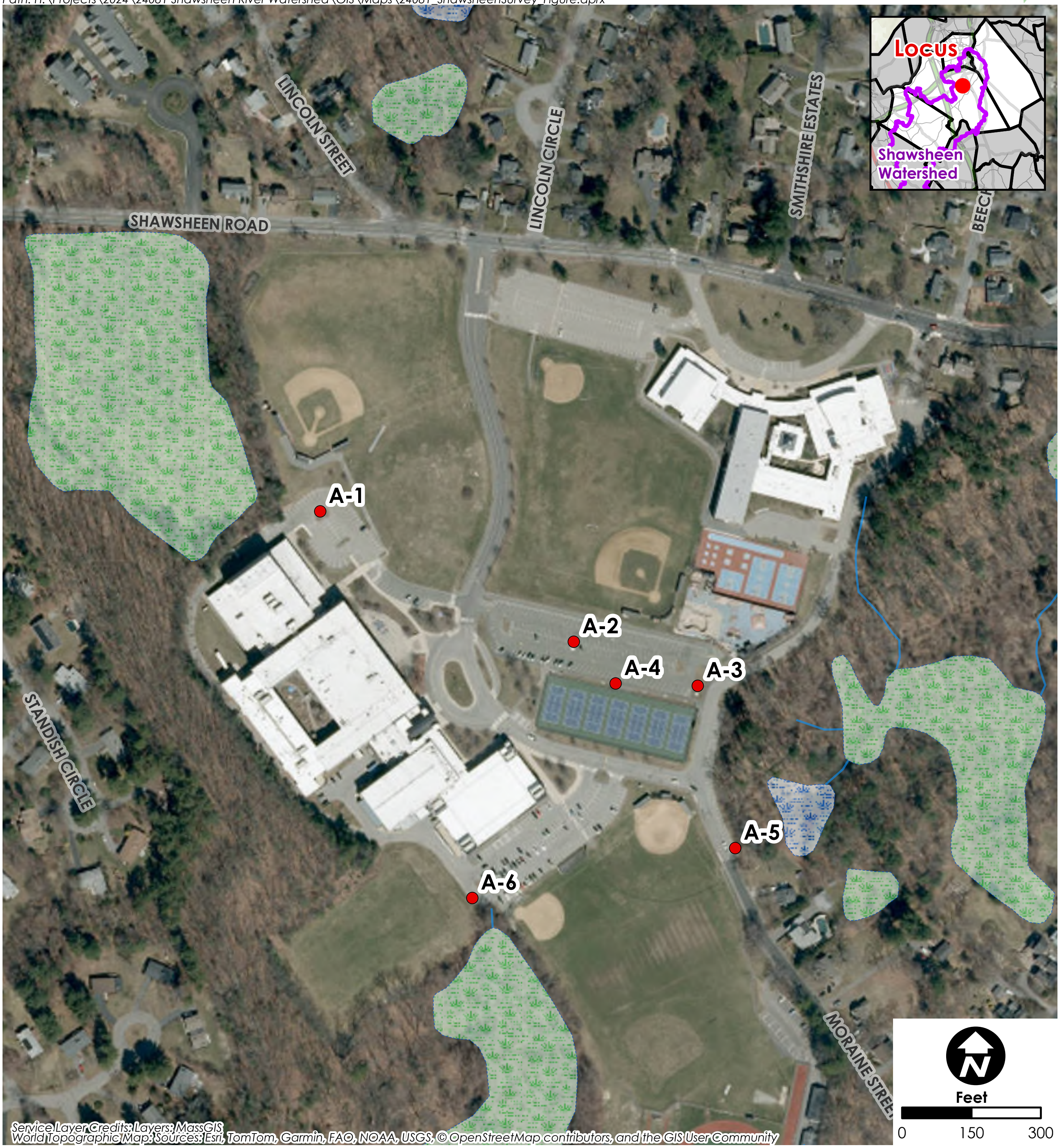

Date: 12/12/2024
Data Sources: Bureau of Geographic Information (MassGIS), ESRI

This map is for informational purposes and may not be suitable for legal, engineering, or surveying purposes.

- Survey Point
- Shawsheen River (NHD)
- Shawsheen Watershed (MassGIS)
- Municipal Boundary

MassDEP Wetlands (2005)
- Hydrologic Connection
- Wetland Limit
- Marsh/Bog
- Wooded marsh

Shawsheen River Watershed

Figure 1
Field Survey Sites

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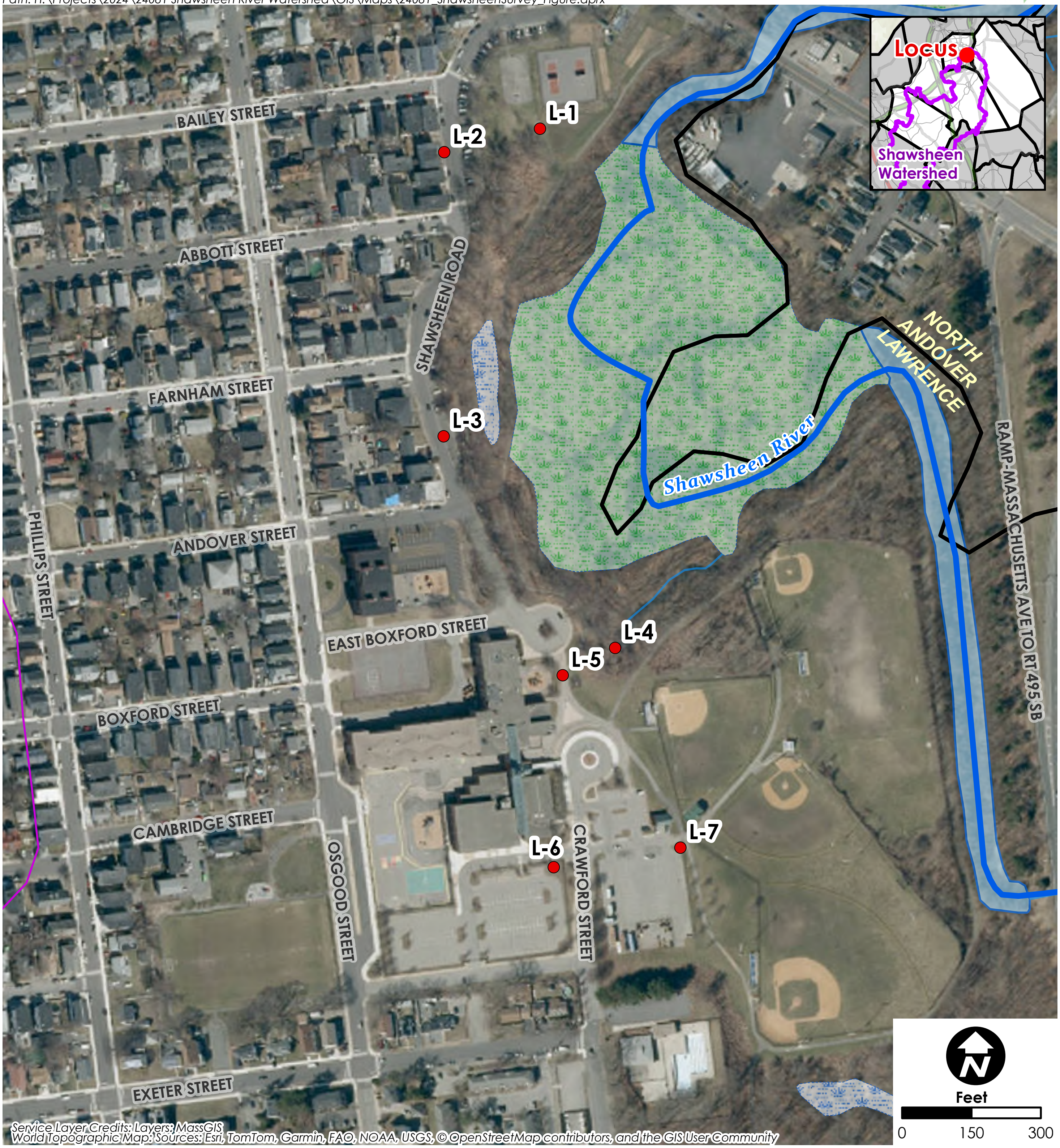

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MassDEP Wetlands (2005)

- Shoreline
- Hydrologic Connection
- Wetland Limit
- Marsh/Bog
- Wooded marsh
- Open Water

Shawsheen River Watershed

Figure 2
Field Survey Sites

Horsley Witten Group
Sustainable Environmental Solutions

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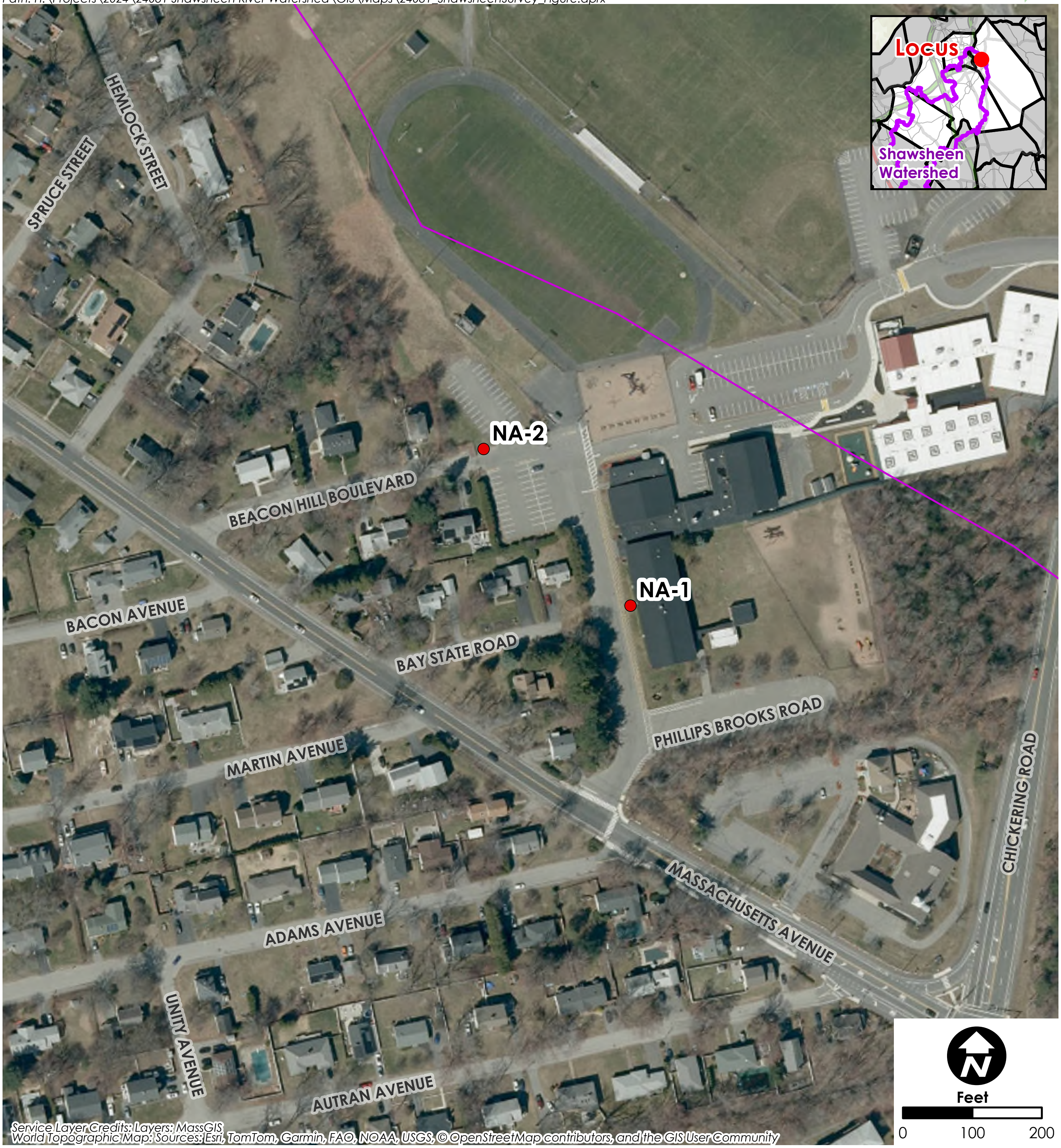

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- Survey Point
- Shawsheen River (NHD)
- Shawsheen Watershed (MassGIS)
- Municipal Boundary

Shawsheen River Watershed

Figure 3
Field Survey Sites

Horsley Witten Group
Sustainable Environmental Solutions

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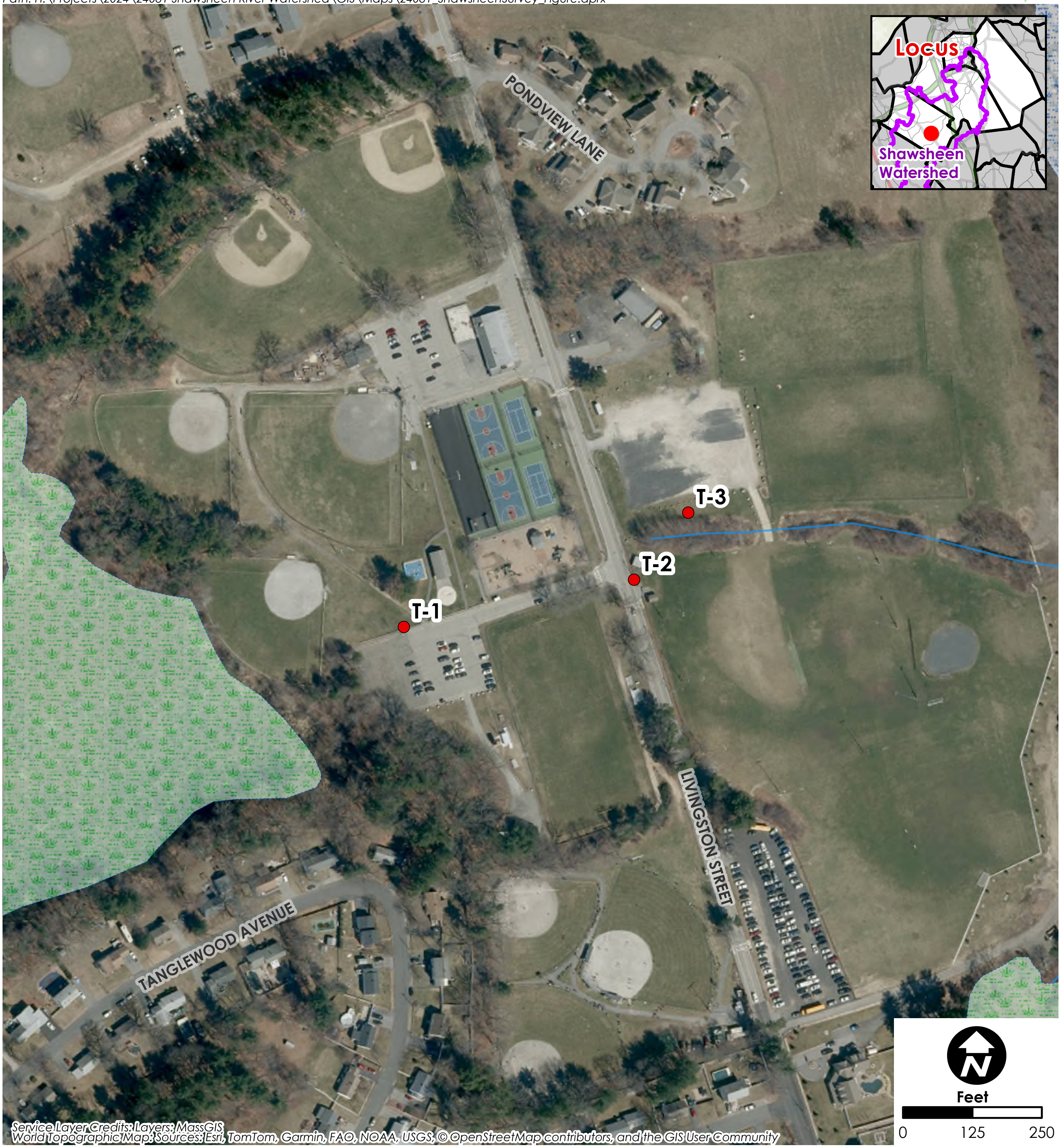

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- Municipal Boundary

MassDEP Wetlands (2005)
- Hydrologic Connection
- Wetland Limit
- Marsh/Bog
- Wooded marsh

Shawsheen River Watershed

Figure 4
Field Survey Sites

Appendix C. Field Data Summary Sheets

Site A-1: AHS North Parking Lot

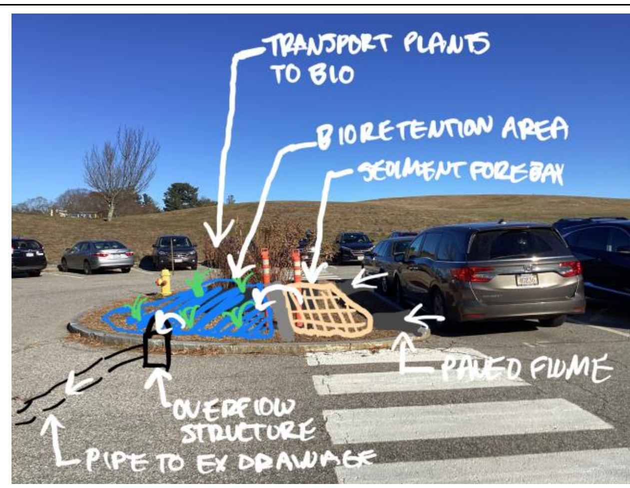
DESCRIPTION

Existing Conditions:
Existing grass island in the parking lot north of Andover High School. Raised garden bed for pollinator garden created and maintained by students.

Proposed Solutions:
Add inlets on upgradient side of island. Create depressed bioretention area in island, possibly with overflow structure to drainage network or flow in-flow out system. Work with students to transplant pollinator plants into bioretention area, add native plants, and integrate living lab/educational elements.

Other Notes:
Parking lot drains down to island.

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: JLV

Site A-2: AHS East Parking Lot Island

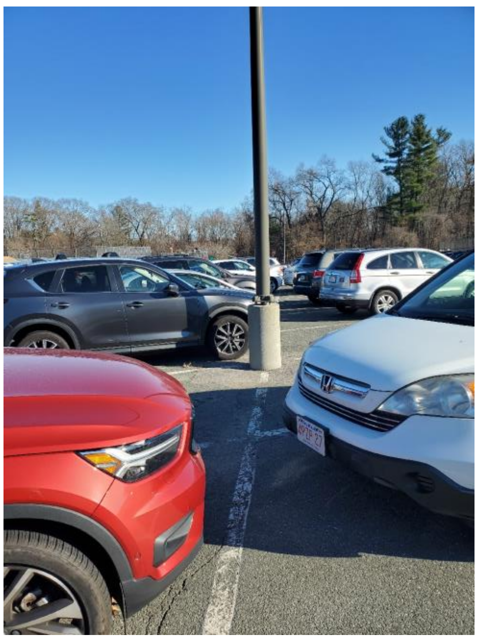
DESCRIPTION

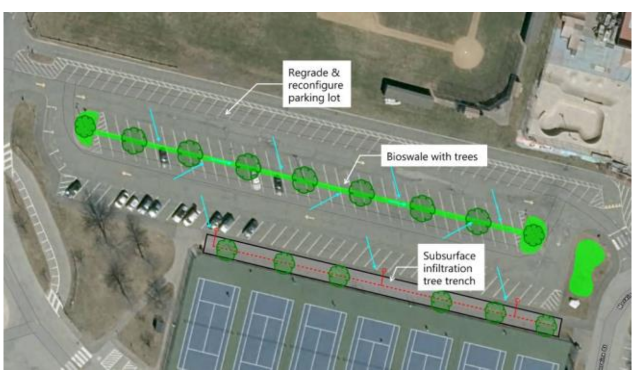
Existing Conditions:
Large asphalt parking lot east of Andover High School with closed drainage system and no stormwater treatment or trees. One way in and out. Tight backing out of east parking stalls. Old light poles in middle of center parking stalls.

Proposed Solutions:
Regrade parking lot and install bioswale/infiltration tree trench as center parking island running west to east. Move light poles, replace with modern solar lighting. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-3 and A-4.

Other Notes:
Parking lot will likely be updated as part of high school renovations.

PHOTOS/SKETCHES





Date Assessed: 11/20/2024

Assessed by: LK

Site A-3: AHS East Parking Lot

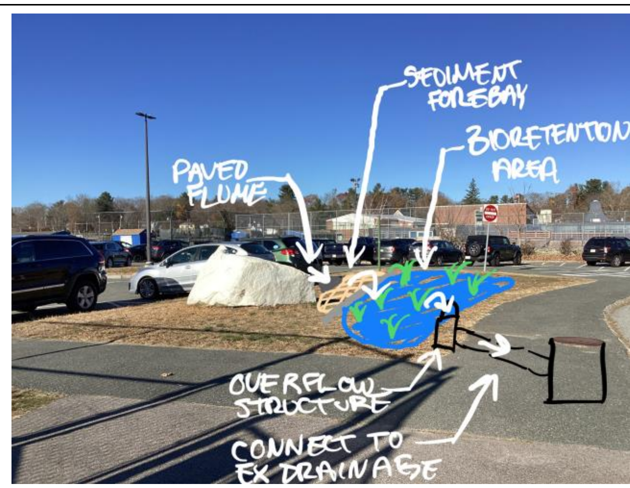
DESCRIPTION

Existing Conditions:
Large asphalt parking lot east of Andover High School with closed drainage system and no stormwater treatment or trees. Grass island at bottom of parking lot.

Proposed Solutions:
Add surface inlets to island, create a bioretention area in the island with connection to drainage system. Possibly add chambers. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-2 and A-4.

Other Notes:
If planning to repave parking lot, think about gutter lines.

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: JLV

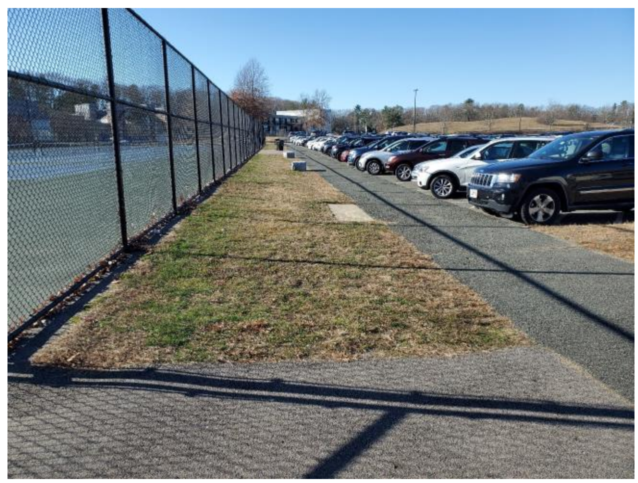
Site A-4: AHS Tennis Courts

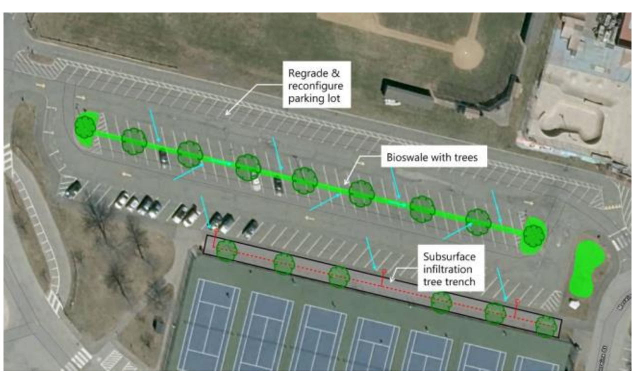
DESCRIPTION

Existing Conditions:	Proposed Solutions:
Paved strip between Andover High School east parking lot and tennis courts. No trees or shade. The spectators have requested shade structures.	Regrade lot and direct runoff from south edge into infiltration tree trench along tennis court. Plant trees that provide shade and are suitable for tennis courts. Design with hardscape permeable surface above trench and around tree wells for tennis spectators. Integrate improvements into high school renovations/parking lot upgrades. May be combined with A-2 and A-3.

Other Notes:

PHOTOS/SKETCHES





Date Assessed: 11/20/2024

Assessed by: LK

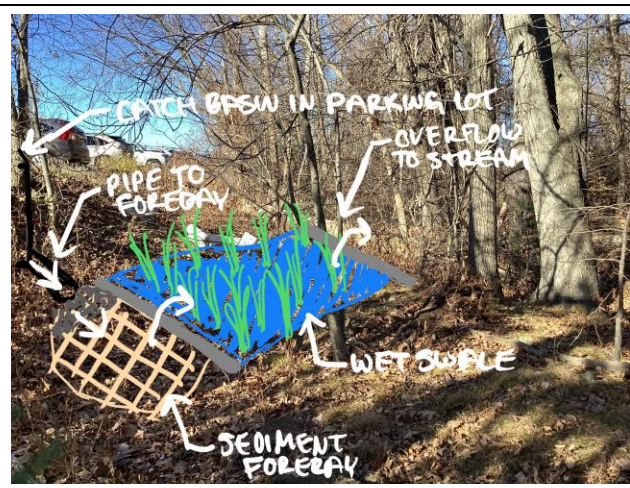
Site A-5: AHS Moraine St

DESCRIPTION

Existing Conditions:	Proposed Solutions:
Paved parking spaces along Moraine St south of Andover High School. Slope to east drops 6-7 ft to vegetated area. Invasive species present (Bittersweet). Runoff currently overtops asphalt berm in corner of the last parking space or continues down Moraine St.	Install a catch basin inlet at back corner of last parking space to convey runoff toward a new forebay and wet swale at bottom of slope. Design forebay to overflow to a wet swale and then out to wetland. Include invasive species management in design.

Other Notes:

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: JLV

Site A-6: AHS South Parking Lot West End

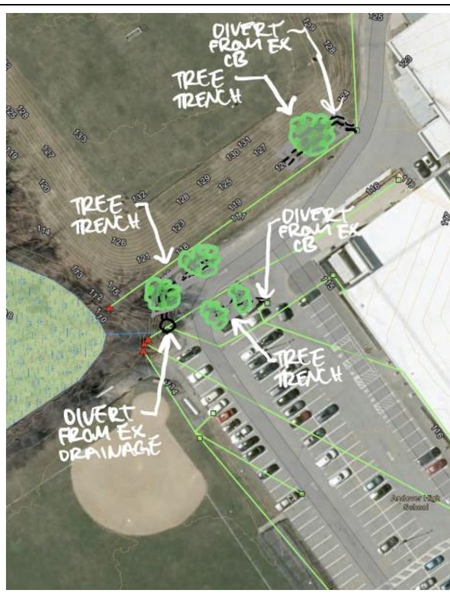
DESCRIPTION

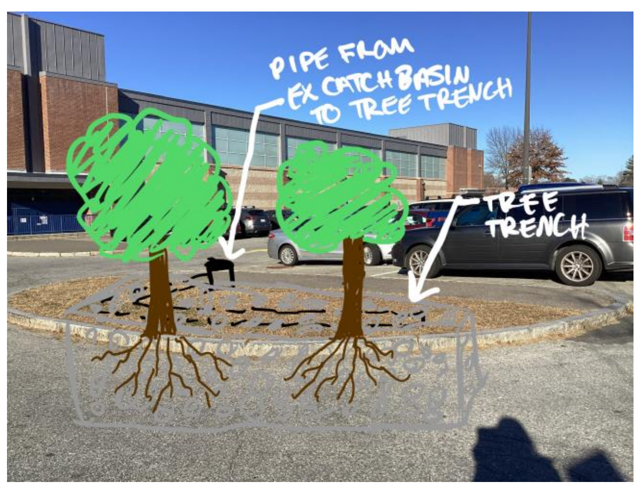
Existing Conditions:
Large paved parking lot to southeast of Andover High School. Minimal landscape islands and no trees in parking lot. One oil-water separator shown on site plan. Multiple closed drainage systems discharge into wetland south of the parking lot.

Proposed Solutions:
Construct infiltration tree trenches within existing grassed landscape island and along southwest shoulder of parking lot. Connect to existing catch basins. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network.

Other Notes:

PHOTOS/SKETCHES





Date Assessed: 11/20/2024

Assessed by: JLV

Project Field Summary Sheet

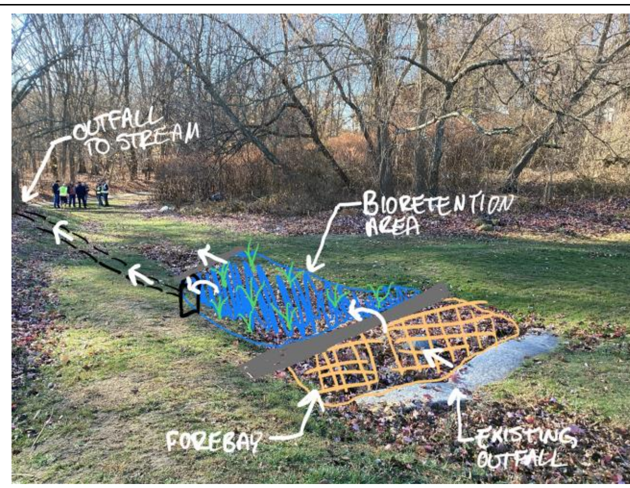
Site L-1: Costello Park

DESCRIPTION

Existing Conditions:	Proposed Solutions:
Three catch basins on Shawsheen Rd discharge through an 8-inch pipe at a granite headwall in Costello Park. Runoff continues along an informal swale down to and across the paved river trail. Pedestrians walk along the flow path to the river trail.	Construct an infiltrating bioretention basin with sediment forebay at the existing outfall. Formalize a pedestrian path around the bioretention basin to the river trail.

Other Notes:

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: JLV

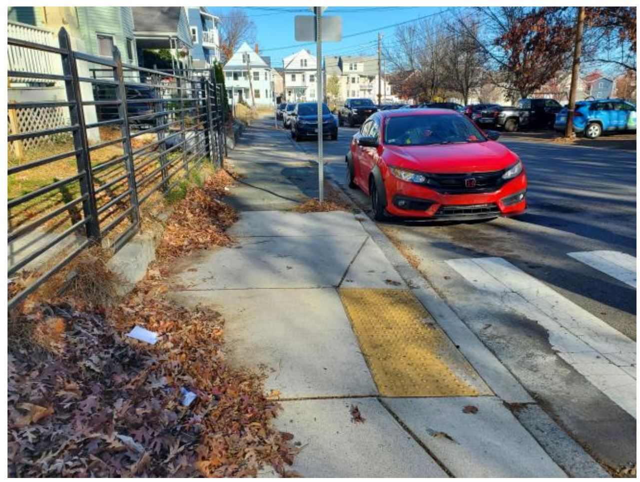
Site L-2: Shawsheen Rd Street Trees

DESCRIPTION

Existing Conditions:	**Proposed Solutions:**
No trees or tree lawn on west side of Shawsheen Rd, Lawrence. Wide sidewalk (~8 ft) and wide road (~40 ft) with a parking lane and two travel lanes that are not striped. Dense residential neighborhood with Costello Park across the street. Stakeholders noted problems with fast driving and inconsistent sidewalks (missing in some areas).	Reconfigure right of way with addition of tree lawn and street trees along west side of Shawsheen Rd. Integrate with Safe Routes to School sidewalk and bike lane improvements.

Other Notes:
This road is on the list for a future Safe Routes to School grant application.

PHOTOS/SKETCHES



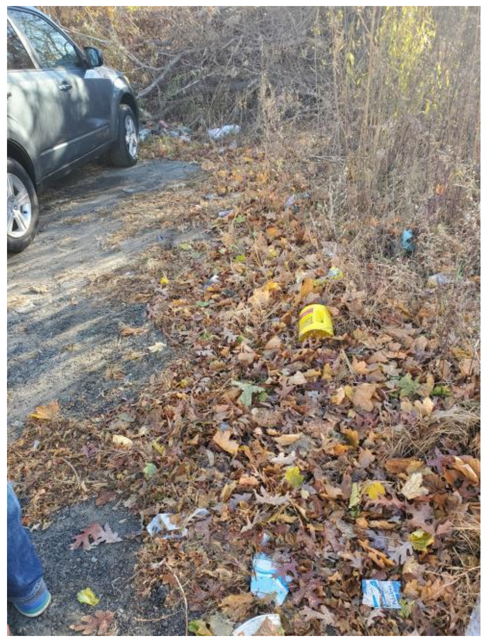
Date Assessed: 11/20/2024

Assessed by: LK

Site L-3: Shawsheen Rd Litter

DESCRIPTION	
Existing Conditions: Litter all along Shawsheen Rd, particularly in section between Farnham St and E Boxford St near South Lawrence East Elementary School.	**Proposed Solutions:** Focus trash management efforts on this neighborhood, including cleanups, education, and trash and recycling bins with lids. Beautify and formalize parking and path areas to encourage stewardship.
Other Notes:	

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: LK

Site L-4: Outfall @ S Lawrence East School

DESCRIPTION

Existing Conditions:
60-inch outfall into channel to Shawsheen River. Severe erosion, scouring under outfall structure and banks up to ~4-5 ft height. Channel ~ 400 ft to river. Flowing despite dry weather, fed by natural springs and pond at old railyard.

Proposed Solutions:
Stabilize outfall structure and channel banks and bottom. Add energy dissipation at outfall and along channel. Integrate upstream detention storage as part of Grafton St culvert improvements.

Other Notes:
Planned culvert replacement/upsizing in upper catchment from Grafton St, Winthrop Ave area. That project could increase peak flow at outfall unless detention storage is added.

PHOTOS/SKETCHES




Date Assessed: 11/20/2024

Assessed by: LK

Site L-5: S Lawrence East School Low Point

DESCRIPTION

Existing Conditions:
Low point along asphalt path behind South Lawrence East Elementary School. Erosion within lawn areas on both sides of path, sand accumulation on path.

Proposed Solutions:
Grade in swales and depressions on both sides of path to infiltrate runoff and prevent erosion. Revegetate eroding areas.

Other Notes:

PHOTOS/SKETCHES

Date Assessed: 11/20/2024

Assessed by: LK

Site L-6: S Lawrence East School Parking Lot

DESCRIPTION

Existing Conditions:	Proposed Solutions:
Steep, paved parking lot with green islands and trees, located south of South Lawrence East Elementary School. Drains to catch basin.	Construct infiltration tree trench in northeast corner of parking lot. Pipe catch basins in parking lot and driveway into tree trench. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network.

Other Notes:

PHOTOS/SKETCHES

Date Assessed: 11/20/2024

Assessed by: JLV

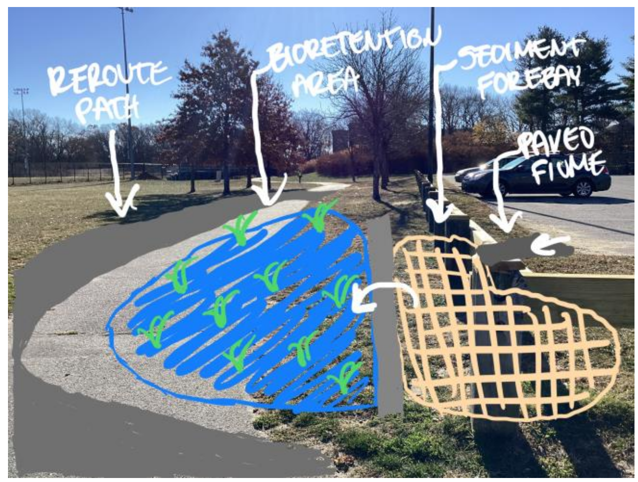
Site L-7: Shawsheen Park Parking Lot

DESCRIPTION

Existing Conditions:	Proposed Solutions:
Large paved parking lot with no grassed islands or trees. Catch basin in northeast corner. Sediment accumulation indicates ponding runoff. Lawn and paved path to the east.	Install paved inlet at northeast corner of parking lot to divert runoff into sediment forebay and bioretention basin in lawn and path area. Reroute paved path around bioretention basin. Integrate living lab/educational elements into design.

Other Notes:

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: JLV

Site NA-1: Atkinson School Front Lawn	
DESCRIPTION	
Existing Conditions: Rooftop runoff ponds in front of North Andover Atkinson Elementary School building, likely due to flat terrain and lack of drainage (possibly high groundwater as well). School recently experienced flooding into building.	**Proposed Solutions:** Create dry swale/soil filter along front of building with underdrain and yard drain to direct runoff away from building, filter roof runoff, and improve drainage.
Other Notes:	
PHOTOS/SKETCHES	
	

Date Assessed: 11/20/2024

Assessed by: LK

Site NA-2: Atkinson School Parking Lots

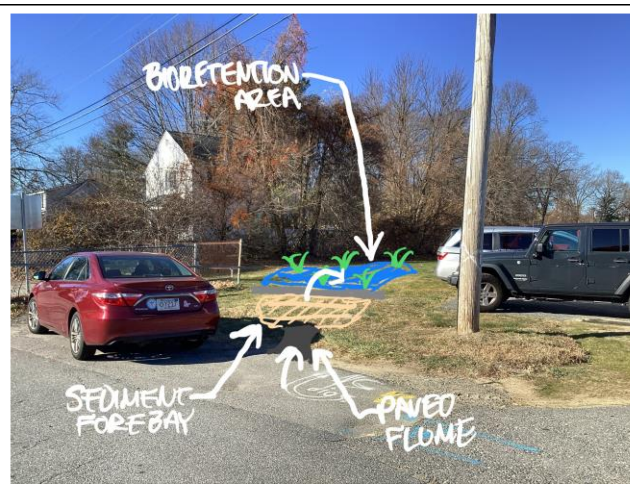
DESCRIPTION

Existing Conditions:
Runoff from paved parking lots at North Andover Atkinson Elementary School flows northwest to two catch basins on Beacon Hill Blvd and overland into large open green space.

Proposed Solutions:
Original proposal was to construct a bioretention basin in the open green space. Based on redevelopment plans for the proposed North Andover Recreation Complex, a bioretention basin may not be feasible. Instead, consider permeable pavement or subsurface chambers under the parking lot, staying within the Atkinson Elementary School parcel and outside the limit of work for the Recreation Complex.

Other Notes:
If Recreation Complex design plans change, consider bioretention basin in open green space.

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: LK

Site T-1: Livingston St Recreation Area Parking Lot

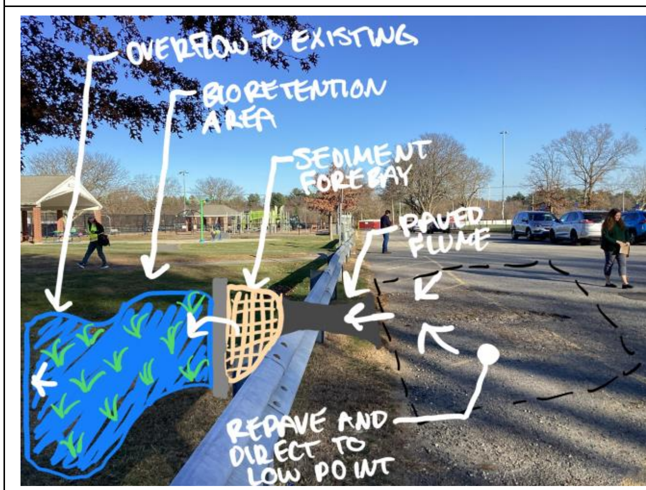
DESCRIPTION

Existing Conditions:
Large paved parking lot at Livingston St Recreation Area in Tewksbury. Deteriorating asphalt and sediment accumulation at low point indicate ponding. Sediment berm at low point prevents runoff from draining out of parking lot. Fallen headwall in adjacent lawn may have been an inlet for parking lot runoff. Parking lot is heavily used during spring-fall and maintained during winter.

Proposed Solutions:
Remove sediment berm and install paved flume to direct runoff out of parking lot toward lawn. Construct sediment forebay and bioretention area to treat parking lot runoff. Design basin as shallow depression with gentle side slopes and mowable grass to allow green space to still be used by summer camps.

Other Notes:

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: LK

Site T-2: Livingston St

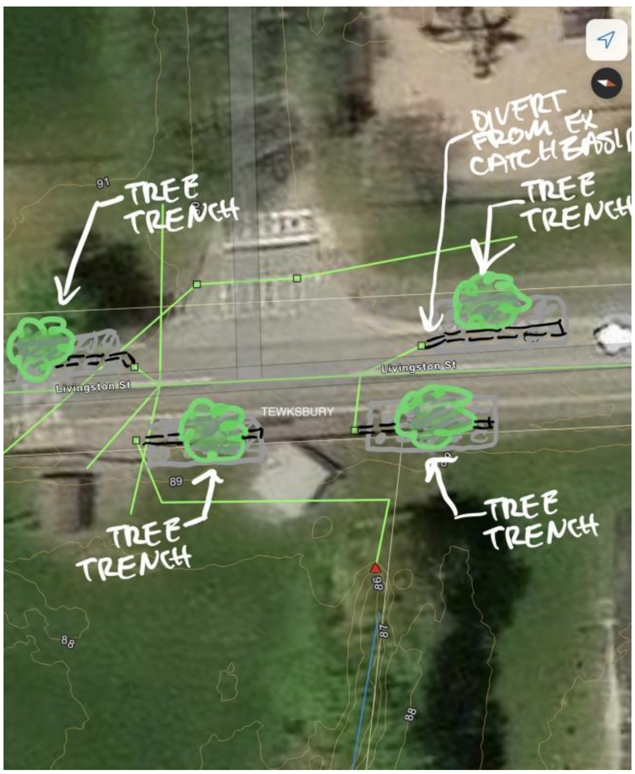
DESCRIPTION

Existing Conditions:
Multiple catch basins along Livingston St connect into closed drainage system that outfalls to unnamed stream.

Proposed Solutions:
Construct infiltration tree trenches within right-of-way, connect to existing catch basins. Divert the first 0.5 to 1 inch of runoff volume into tree trenches and allow larger flows to continue through existing drainage network. Consider including tree trench installation as part of planned Livingston St sidewalk upgrades.

Other Notes:
Designs are in progress for sidewalk improvements along Livingston St.

PHOTOS/SKETCHES



Date Assessed: 11/20/2024

Assessed by: JLV

Site T-3: Saunders Recreation Area Unnamed Stream

DESCRIPTION

Existing Conditions:
Runoff from gravel parking lot at Saunders Recreation Area flows overland toward unnamed stream to south. Stream is channelized through a wetland. Narrow vegetated buffer around stream with invasive plants. Mowed grass between vegetated buffer and parking lot. Drivers often park on lawn. Parking lot is heavily used during football season and Town has no plans to pave it.

Proposed Solutions:
Manage invasive plants along the stream. Widen stream buffer by planting native species within existing mowed lawn area. Install "Do Not Mow - Naturalized Area" and "No Parking" signs.

Other Notes:

PHOTOS/SKETCHES

Date Assessed: 11/20/2024

Assessed by: LK